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ECOLOGICAL IMPACTS ON THE POPULATION OF MARSH CROCODILES (*CROCODYLUS PALUSTRIS*) IN CHOTIARI WETLAND COMPLEX SANGHAR, SINDH: A SURVEY REPORT

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ABSTRACT

In this study, an ecological survey of the impacts on Marsh Crocodiles (*Crocodylus palustris*) in Chotiari Wetland Complex Sanghar was carried out during the month of January to December 2008. In order to assess, the microbial contamination, detection of pollutant indicator organisms in the water samples, using different physico-chemical parameters were performed. The level of different physico-chemical parameters like as temperature, electrical conductivity, total dissolved solids, calcium, magnesium, bi carbonate, chloride, sodium, potassium, sulphur, carbonate, biological oxygen demand and dissolved oxygen were monitored in water samples collected from Chotiari Wetland Complex to assess the impact of toxic pollutants. Toxic chemical contaminants were estimated below the detection limit, while another several chemicals were found within the range set by World Health Organization. The degree of contamination, proximity to pollution source and the metabolic ability of Marsh Crocodile suggest that the species are at threatened from the environmental contamination by the study of heavy metals. Marsh Crocodiles are considered endangered around the world due to the increase pollution and alteration of their habitat.

Keywords: Endangered species, pollution, metabolic, toxic, contamination.

INTRODUCTION

The Chotiari Wetland Complex (CWC) is an artificial water reservoir which is located at 20km North East of the Sanghar city, at 69'4E Longitudes and 26' 1"N Latitudes. It was constructed in December 2002 which covers an area of about 86km$_2$. The CWC is built upon small lakes, which are in many numbers. It has the total capacity of water storage is 0.75 million acre feet. The CWC received water from the Nara canal through Ranto canal escapes during the flood season. The depth of the reservoir is from 15' to 30' ft with sandy and salty bottom, which provides a suitable, surface for the growth of algae and aquatic plant species. The Chotiari Wetland Complex is a unique wetland complex and ecologically rich area. The Wetland complex is characterized by a mosaic of diverse habitats including forest, fresh and brackish water lakes, agricultural lands, rangelands, sand dunes scrub, reed beds, fish farms and swamps. Despite a very hot and arid climate zone the area is biologically most diverse and rare in the region. The reservoir has high ecological significance as it is home to many internationally important and endangered species listed in the IUCN Red List. The reservoir has support among important mammalian Endangered species of Hog Deer (*Axis porcinus*) and Fishing Cat (*Prionailurus viverrinus*) and two Vulnerable species of Chinkara (*Gazella bennettii*) and Smooth coated Otter, *Lutrogale viverrinus* (Sheikh *et al.,* 2004). There are two Vulnerable species, Marbled Teal (*Marmaronetta angustirostris*), a globally migratory birds, visit and breeds in this reservoir and also Pallas's Fish-Eagle (*Haliaeetusleucoryphus*), a Vulnerable bird resides on the site (Birdlife International, 2012; IUCN, 2012). The globally Endangered species of the wetland complex site is the Marsh Crocodile (*Crocodylus palustris*) (WWFP, 2007). Ecological studies on the lakes of Sindh like as CWC is very few. Ecological studies were carried out on Chotiari Wetland Complex by Leghari *et al.* (1995), Jafri (1997), Leghari *et al*. (1999) can be mentioned in this connection. Ecological changes in aquatic life depend upon the physico-chemical environmental characteristics of water bodies. The present study provides the information about the influence of physico-chemical factors on aquatic biodiversity as well as on population of Marsh Crocodiles. Before the construction of Chotiari reservoir, some biological and limnological studies on the Bakar lake complex were carried out by Jafri (1997), Leghari *et al.* (1997), Leghari *et al.* (1999) and Leghari and Khuhawar (1999). The present study was carried out on water quality and its impacts on natural productivity of Chotiari reservoir after its construction.

MATERIALS AND METHODS

Water samples and sediments were collected from the midstream. Eight sampling stations were selected from the entire lake for water sampling. Samples were

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collected from Fish farm 1, and 2, Jadupur, Simni, Nara Canal (right side), NWC (outlet), NWC (inlet) and Fauji Fish farm. Sampling was carried out 7:00am to 5:00pm at monthly intervals. Physical factors such as temperature of water, depth and transparency (secchi disk measurement was carried out at the sampling station). In the laboratory, chemical factors the mercury thermometer for reading of the temperature was dipped into the samples to a depth of 15 cm for 2-5 minutes, pH of water was measured with Orion Model 420 A pH meter, electrical conductivity, total dissolved solids and salinity of water was measured by WTW 320 conductivity meter, total alkalinity, total hardness, chlorides and phosphate were determined by using the standard methods for the examination of water and waste water (APHA, 1976), calcium, carbonate, bi-carbonate of water was measured with titration method (2310), magnesium was measured with Fluorometric determination method, potassium was measured with spectrometer and biological oxygen demand was measured with Winkler method and dissolved oxygen was measured with oxygen meter (Jenway Model 9071).

RESULTS

Values for physico-chemical parameters in water samples were collected from eight sampling stations from the entire CWC for water sampling and its associated areas. Water samples were collected from Fish farm 1, and 2, Jadupur, Simni, Nara Canal (right side), NWC (outlet), NWC (inlet) and Fauji Fish farm (CWC) in the month of January to December 2008 (Table 1-12).

Temperature of air/water °C: It is the major physical parameter which is directly related to chemical reaction in water bodies. The temperature of water bodies is an important parameter that directly affects the aquatic biodiversity and it also reduces the dissolved oxygen in water resources. It was observed that the highest temperature of air recorded during the month of June 47.37°C and the lowest value was found during the month of January 22.37°C (Table 13). Temperature of water was recorded highest in the month of July 44.37 and the lowest was found in the month of February 20.37 (Table 13).

pH: The lowest ranged of pH was recorded from the month of June and September. The higher level of pH increased in the month of January and February. The observed pH range of CWC water is 6.66 to 8.09, (Table 13).

Electrical Conductivity: The value of conductivity was recorded highest 978 us/cm in December and lowest 567 us/cm in October (Table 13). However, fluctuation observed in samples is due to water flow in the observed site. The standard level for electrical conductivity is 400 us/cm, as the water quality depends on TDS.

Table 1. Physico-chemical Analysis of water for the month of January 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	11	11	16	16	20	20	25	25	
Time	11.00	12.30	10.3	12.40	2.00	5.00	11.00	1.00	
Temp: Air ◦C	21	22	18	21	22	20	19	22	24.37
Temp: H_2O ◦C	18	18	16	16	20	18	17	20	21.37
pH	7.97	7.43	8.32	8.68	7.40	7.90	8.71	8.32	8.09
EC mu/scm	751	131	1275	420	338	367	332	1187	600.12
TDS mg/l	405	7.99	688	226	148	212	193	568	404.87
Turbidity	13.5	160	42	10.5	91	17.8	7.5	7.2	416.4
Ca mg/l	32	35	20	12	20	31	29	42	27.62
Mg meq/l	34	11	53	32	18	19	16	73	32
Hardness mg/l	240	105	270	160	136	127	117	354	188.62
HCO_3ppm	140	70	335	135	132	162	93	209	159.5
Alkalinity mg/l	2.8	1.4	6.7	2.7	3.2	4.7	1.6	4.6	3.46
Cl mg/l	70	32	166	35	57	71	43	102	72
Na meq/l	73	6	158	19	7	28	17	113	52.62
K mg/l	4	2	21	5	3	5	7	8	6.87
SO_4 mg/l	131	6	65	25	6	15	6	208	57.75
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	10	0	0	0	0	0	1.25
BOD mg/l	3.5	3.1	3.2	3.8	3.0	3.3	3.6	3.7	3.4
DO mg/l	7.3	7.2	7.6	7.1	7.0	7.5	7.2	7.4	7.28

Table 2. Physico-chemical Analysis of water for the month of February 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	12	12	16	16	20	20	27	27	
Time	11.00	12.35	1.40	5.20	2.30	4.00	11.30	2.30	
Temp: Air ◦C	20	21	22	19	22	21	21	22	23.37
Temp: H_2O ◦C	17	18	18	16	19	18	18	19	20.37
pH	7.80	8.40	8.12	8.60	7.50	7.62	8.80	8.35	8.14
EC mu/scm	755	1890	1255	435	352	370	335	1205	824.62
TDS mg/l	408	885	680	235	160	195	190	570	415.37
Turbidity	13.7	21.7	56	10.2	91	19.0	8.1	8.1	28.47
Ca mg/l	34	48	18	17	23	30	27	43	30
Mg meq/l	35	58	56	36	19	18	18	76	39.5
Hardness mg/l	238	305	258	170	148	116	122	372	216.12
HCO_3ppm	140	140	320	138	142	162	90	230	170.25
Alkalinity mg/l	2.7	7.1	6.2	2.5	3.7	4.6	2.1	4.7	4.2
Cl mg/l	72	137	160	31	59	80	41	93	84.12
Na meq/l	76	165	152	23	7	29	21	113	73.25
K mg/l	5	23	23	6	3	7	9	12	11
SO_4 mg/l	132	170	60	23	5	14	6	230	80
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	0	0	0	0	0	0	0
BOD mg/l	3.4	3.0	3.1	3.5	3.2	3.6	3.7	3.8	3.41
DO mg/l	7.2	7.0	7.1	7.4	7.1	7.3	7.5	7.6	7.27

Table 3. Physico-chemical Analysis of water for the month of March 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	06	06	13	13	20	20	26	26	
Time	11.20	12.50	12.00	1.00	10.45	2.00	2.30	4.30	
Temp: Air ◦C	30	31	32	32	30	32	33	32	23.37
Temp: H_2O ◦C	26	27	28	28	26	28	28	28	29.37
PH	7.51	7.15	7.09	7.78	6.78	7.23	8.85	8.12	7.56
EC mu/scm	896	474	457	1492	572	408	330	1190	727.37
TDS mg/l	483	255	247	804	308	220	158	560	379.37
Turbidity	58	53	222	12.0	102	10.8	7.3	7.3	59.05
Ca mg/l	56	44	60	24	67	67	28	43	48.62
Mg meq/l	36	19	12	74	13	8	17	73	31.5
Hardness mg/l	36	19	12	74	13	8	126	376	83
HCO_3ppm	200	145	170	430	150	140	94	228	194.62
Alkalinity mg/l	4.0	2.8	3.4	8.6	3.0	2.8	2.1	4.7	8.42
Cl mg/l	90	42	32	166	83	22	45	88	71
Na meq/l	65	20	13	164	26	29	21	118	57
K mg/l	4	3	2	17	4	2	5	8	5.62
SO_4 mg/l	116	36	12	78	18	32	7	207	63.25
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	0	0	0	0	0	0	0
BOD mg/l	3.0	3.2	3.4	3.7	3.1	3.6	3.8	3.3	3.38
DO mg/l	6.5	6.3	6.7	6.2	6.8	6.4	6.9	6.1	6.48

Table 4. Physico-chemical Analysis of water for the month of April 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	02	02	07	07	15	15	23	23	
Time	2.20	4.15	11.00	1.45	11.15	2.30	1.00	2.00	
Temp: Air ◦C	35	34	33	35	34	35	36	36	38.37
Temp: H_2O ◦C	32	31	30	32	31	32	32.6	32.6	35.37
pH	7.87	7.92	7.89	8.64	7.50	7.74	8.45	8.30	8.03
EC mu/scm	745	1856	1216	413	326	367	332	1216	808.87
TDS mg/l	426	894	672	218	147	192	178	570	412.12
Turbidity	14.3	12.8	47	10.2	81	17.6	7.5	7.8	24.77
Ca mg/l	36	41	18	14	20	34	24	43	28.75
Mg meq/l	38	62	58	28	15	18	13	73	38.12
Hardness mg/l	247	320	260	156	132	113	102	358	211
HCO_3ppm	146	156	320	128	130	158	81	209	166
Alkalinity mg/l	2.9	7.3	6.3	2.4	3.2	4.1	1.5	4.1	3.97
Cl mg/l	78	152	158	31	48	80	34	89	83.75
Na meq/l	81	61	154	17	7	29	16	113	59.75
K mg/l	5	8	20	5	4	5	7	8	7.75
SO_4 mg/l	138	187	68	28	7	11	4	206	81.12
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	8	0	0	0	0	0	1
BOD mg/l	3.6	3.2	3.0	3.5	3.1	3.4	3.0	3.8	3.32
DO mg/l	7.5	7.1	7.0	7.2	7.3	7.1	7.4	7.6	7.27

Table 5. Physico-chemical Analysis of water for the month of May 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	02	03	14	14	19	19	24	24	
Time	2.20	2.35	11.00	2.30	2.15	4.00	2.00	4.20	
Temp: Air ◦C	42	43	42	44	43	42	44	43	45.37
Temp: H_2O ◦C	39	40	39	41	40	39	41	40	42.37
pH	7.80	7.87	7.81	8.56	7.30	7.81	8.35	8.21	7.96
EC mu/scm	730	1800	1193	406	320	374	326	1205	794.25
TDS mg/l	421	840	654	209	140	196	170	564	399.25
Turbidity	14.6	12.4	45	10.0	76	17.9	7.1	7.2	23.77
Ca mg/l	32	37	17	16	21	31	22	40	27
Mg meq/l	37	57	52	29	17	17	12	70	36.37
Hardness mg/l	241	312	253	150	127	108	96	351	204.75
HCO_3ppm	142	149	305	120	122	151	89	203	160.12
Alkalinity mg/l	2.7	7.1	6.1	2.1	3.1	4.3	1.7	4.3	3.92
Cl mg/l	72	146	152	29	53	83	38	83	82
Na meq/l	84	63	149	19	6	26	14	107	58.5
K mg/l	6	7	18	5	4	6	6	7	7.37
SO_4 mg/l	130	180	62	26	6	10	4	200	77.25
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	13	0	0	0	0	0	1.62
BOD mg/l	3.2	3.1	3.0	3.4	3.1	3.5	3.2	3.0	3.18
DO mg/l	6.3	6.0	6.1	6.2	6.0	6.4	6.1	6.0	6.13

Table 6. Physico-chemical Analysis of water for the month of June 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	03	08	08	17	17	24	24	29	
Time	2.00	1.00	4.40	12.00	2.00	2.00	4.45	2.30	
Temp: Air ◦C	44	43	42	44	45	42	41	45	47.37
Temp: H_2O ◦C	41	40	39	41	41	39	38	41	44.37
pH	7.70	7.81	7.76	8.50	7.70	7.88	8.26	8.10	7.96
EC mu/scm	715	1780	1182	418	310	367	321	1195	786
TDS mg/l	416	825	645	200	133	186	178	552	391.87
Turbidity	14.0	12.1	41	10.3	71	17.3	7.0	7.4	22.51
Ca mg/l	30	34	16	19	20	36	24	52	28.87
Mg meq/l	32	53	50	30	15	15	10	81	35.75
Hardness mg/l	235	307	247	154	123	105	87	347	200.62
HCO_3ppm	136	140	298	116	120	143	82	195	153.75
Alkalinity mg/l	2.9	7.3	6.4	2.4	3.4	4.6	1.5	4.7	4.15
Cl mg/l	70	138	146	32	58	87	33	76	80
Na meq/l	80	58	141	17	7	25	12	102	55.25
K mg/l	5	6	16	4	5	8	7	6	7.12
SO_4 mg/l	125	172	60	23	5	13	5	190	74.12
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	10	0	0	0	0	0	1.25
BOD mg/l	2.2	2.0	2.3	2.6	2.1	2.4	2.5	2.8	2.36
DO mg/l	5.3	5.1	5.0	5.4	5.2	5.6	5.7	5.8	5.38

Table 7. Physico-chemical Analysis of water for the month of July 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	07	07	16	16	22	22	29	29	
Time	2.00	4.45	2.15	4.30	11.00	2.00	2.00	4.40	
Temp: Air ◦C	40	39	41	38	37	39	38	37	43.37
Temp: H_2O ◦C	37	36	37.5	35.5	34	36	35.5	34	40.37
pH	7.87	7.80	7.57	8.50	7.10	7.74	8.30	8.10	7.87
EC mu/scm	785	1850	1140	415	336	368	320	1186	800
TDS mg/l	415	820	640	217	144	186	160	556	392.25
Turbidity	14.2	12.6	40	10.4	71	16.9	7.5	7.8	22.55
Ca mg/l	27	35	14	19	20	28	25	45	26.62
Mg meq/l	31	50	46	31	18	19	16	80	36.37
Hardness mg/l	235	305	257	155	123	105	90	342	201.5
HCO_3ppm	136	142	297	126	120	145	80	200	155.75
Alkalinity mg/l	2.3	7.5	6.6	2.5	3.5	4.1	1.9	4.7	4.13
Cl mg/l	65	137	157	34	56	80	42	80	81.37
Na meq/l	74	57	154	21	5	23	16	100	56.25
K mg/l	5	6	16	8	5	9	7	6	7.75
SO_4 mg/l	123	172	60	35	7	14	5	190	75.75
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	10	0	0	0	0	0	1.25
BOD mg/l	2.9	2.6	3.0	2.8	2.7	3.3	3.0	2.8	2.88
DO mg/l	5.6	5.3	5.2	5.7	5.4	5.9	5.1	5.6	5.47

Table 8. Physico-chemical Analysis of water for the month of August 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	02	02	10	10	18	18	25	25	
Time	2.20	4.25	11.00	2.00	2.00	4.40	12.00	2.30	
Temp: Air ◦C	36	34	35	37	38	34	35	37	39.37
Temp: H_2O ◦C	32	30	31	32	32	30	31	32	35.37
pH	6.7	6.8	6.5	6.2	7.5	6.6	6.1	6.9	6.66
EC mu/scm	720	1040	1136	390	300	350	315	1190	680.12
TDS mg/l	400	820	643	200	130	180	158	530	382.62
Turbidity	14.0	12.7	41	10.8	70	17.5	7.0	7.0	22.5
Ca mg/l	26	32	20	19	20	30	20	35	25.25
Mg meq/l	32	60	48	32	15	16	10	76	36.12
Hardness mg/l	235	308	243	158	123	103	90	340	200
HCO_3ppm	150	154	300	130	120	140	82	195	158.87
Alkalinity mg/l	2.9	7.4	6.6	2.8	3.5	4.0	1.8	4.1	4.13
Cl mg/l	78	153	158	35	50	87	40	78	84.87
Na meq/l	70	52	152	23	7	21	17	90	54
K mg/l	5	6	21	6	4	6	7	8	7.87
SO_4 mg/l	120	187	68	35	6	12	6	180	76.75
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	15	0	0	0	0	0	1.87
BOD mg/l	2.9	2.7	2.6	2.8	3.0	2.4	2.5	2.3	2.65
DO mg/l	6.80	6.63	6.50	6.45	6.30	6.70	6.56	6.72	6.58

Table 9. Physico-chemical Analysis of water for the month of September 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	03	03	11	11	19	19	26	26	
Time	11.00	2.00	2.00	4.50	2.30	3.30	11.10	2.15	
Temp: Air ◦C	32	34	33	31	30	29	32	34	35.37
Temp: H_2O ◦C	28	30	30	27	26	26	28	30	31.37
pH	6.95	7.10	7.40	7.70	7.15	7.92	7.80	7.56	7.44
EC mu/scm	700	1700	1150	380	310	337	312	1175	758
TDS mg/l	390	810	620	206	135	208	180	543	386.5
Turbidity	14.0	12.0	39	11.0	72	17.3	7.9	7.1	22.53
Ca mg/l	36	33	61	20	20	37	28	36	33.87
Mg meq/l	40	50	46	31	22	20	16	78	37.87
Hardness mg/l	230	300	240	157	134	114	100	364	204.87
HCO_3ppm	136	141	320	130	132	160	96	193	163.5
Alkalinity mg/l	2.9	7.5	6.4	2.9	3.8	4.7	1.8	4.8	4.35
Cl mg/l	70	140	143	32	60	90	42	89	83.25
Na meq/l	75	60	140	20	7	30	18	103	56.62
K mg/l	10	9	21	6	5	8	8	8	9.37
SO_4 mg/l	123	185	67	30	8	13	5	190	77.62
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	0	0	0	0	0	0	0
BOD mg/l	3.8	3.9	3.8	3.4	3.2	3.5	3.0	3.3	3.48
DO mg/l	5.2	5.6	5.1	5.7	5.3	5.8	5.0	5.9	5.45

Table 10. Physico-chemical Analysis of water for the month of October 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	05	05	13	13	20	20	28	28	
Time	12.30	1.30	12.00	2.00	12.30	2.30	12.00	2.40	
Temp: Air ◦C	27	27	28	29	29	30	28	30	30.37
Temp: H_2O ◦C	24	24	25	26	26	26	25	26	27.37
pH	8.52	8.45	8.92	8.72	7.92	7.76	8.78	8.40	8.43
EC mu/scm	1196	283	688	282	283	347	279	1178	567
TDS mg/l	645	152	370	152	152	198	158	623	306.25
Turbidity	7.3	267	0.2	7.7	5.9	18.3	6.1	7.8	40.03
Ca mg/l	32	32	24	20	20	29	23	29	26.12
Mg meq/l	73	5	34	10	12	19	13	81	30.87
Hardness mg/l	380	100	200	90	100	118	107	392	186.87
HCO_3ppm	240	110	130	90	90	2.7	94	238	124.33
Alkalinity mg/l	4.8	2.2	2.6	1.8	1.8	42	1.6	4.3	7.63
Cl mg/l	100	37	83	32	32	23	37	116	57.5
Na meq/l	102	17	66	22	17	17	19	109	46.12
K mg/l	8	3	6	4	4	6	5	7	5.37
SO_4 mg/l	208	20	93	6	6	11	8	223	71.87
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	20	10	20	26	17	0	11.62
BOD mg/l	4.0	4.3	4.2	4.7	4.5	4.1	4.4	4.3	4.31
DO mg/l	4.0	4.4	4.2	4.3	4.1	4.1	4.5	4.4	4.76

Table 11. Physico-chemical Analysis of water for the month of November 2008.

	S1	S2	S3	S4	S5	S6	S7	S8	Mean
Date	04	04	12	12	23	23	30	30	
Time	2.00	4.00	2.30	4.00	2.00	4.15	1.40	4.30	
Temp: Air ◦C	32	30	31	29	30	28	26	24	35.37
Temp: H_2O ◦C	28	26	27	26	26	25	23	21	31.37
pH	8.62	7.99	8.45	7.98	7.85	7.85	7.15	8.42	8.03
EC mu/scm	1408	243	767	359	1930	300	310	1180	812.12
TDS mg/l	792	131	413	194	940	170	180	657	434.62
Turbidity	0.5	160	8.9	17.2	80	7.5	5.6	7.8	35.93
Ca mg/l	16	24	36	24	224	18	21	36	49.87
Mg meq/l	53	11	32	16	58	13	11	68	32.75
Hardness mg/l	260	105	220	125	799	98	95	368	258.75
HCO_3 ppm	400	70	140	120	360	87	87	232	187
Alkalinity mg/l	8.0	1.4	2.8	2.4	7.20	1.9	96	43	20.33
Cl mg/l	195	32	80	35	202	37	38	108	90.87
Na meq/l	192	6	96	18	66	28	16	109	66.37
K mg/l	22	2	6	5	2	5	4	9	6.87
SO_4 mg/l	28	6	124	10	288	7	6	196	83.12
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	0	30	0	12	22	0	8
BOD mg/l	4.3	4.7	4.0	3.9	3.7	4.1	4.2	4.5	4.17
DO mg/l	5.6	5.2	5.1	5.3	6.1	6.2	6.0	5.4	5.61

Total dissolved solids (TDS): The TDS level was observed highest 435.12mg/l in December and the lowest level was observed 306.25mg/l in August (Table 13).

Turbidity: It was observed that the level of turbidity highest 59.05 in March and lowest 17.93 was recorded in December (Table 13).

Calcium: The level of calcium was recorded highest 49.87mg/l in March while lowest level was recorded 26.1 mg/l in October (Table 13).

Magnesium: The level of magnesium in water samples were recorded highest of 39.5meq/l in February while lowest level was recorded 30.87meq/l in October (Table 13).

Hardness: The highest range of hardness were observed 266.12mg/l in December and lowest ranged were observed 8 mg/l in March (Table 13).

Bi Carbonate: The level of bi carbonate in water sample was recorded highest 216.12mg/l in December while the lowest level of bi carbonate was recorded 124.33mg/l in October (Table 13).

Alkalinity: The highest ranged were observed 20.33mg/l in November and the lowest level was observed 3.46mg/l in January (Table 13).

Chloride: The level of chloride in water samples were recorded highest 101.75mg/l in December while the lowest was recorded 57.5mg/l during the month of the October (Table 13).

Sodium: The level of sodium in water samples were recorded highest 73.25meq/l in February while lowest level was recorded 46.12meq/l in October (Table 13). The Sodium concentration increases during the winter while the level of sodium decreases during the summer season.

Potassium: The level of potassium in water samples were recorded highest 11mg/l in February while lowest level was recorded 5.62mg/l in March (Table 13).

Sulphate: The level of sulphate in water samples were recorded highest 83.12mg/l in November while lowest level was recorded 57.75mg/l in January (Table 13).

Arsenic: It was observed that the level of arsenic in water samples recorded zero in every month of the year (Table 13).

Table 12. Physico-chemical Analysis of water for the month of December 2008.

	S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**Mean**
Date	06	06	14	14	20	20	29	29	
Time	2.00	3.30	12.00	2.00	12.30	2.30	2.00	4.00	
Temp: Air ◦C	22	21	21	22	20	21	22	20	24.62
Temp: H_2O ◦C	20	19	19	20	18	19	20	18	22.37
pH	8.50	8.16	8.25	7.58	7.50	7.71	7.50	8.56	7.97
EC mu/scm	1395	1890	752	530	340	368	315	1316	978.25
TDS mg/l	780	920	453	245	147	192	176	568	435.12
Turbidity	0.8	1.3	8.3	11.7	89	17.9	7.2	7.3	17.93
Ca mg/l	18	213	31	17	23	26	25	32	48.12
Mg meq/l	58	56	28	38	18	16	13	54	35.12
Hardness mg/l	270	715	236	186	132	135	113	342	266.12
HCO_3ppm	416	370	180	153	131	183	94	206	216.62
Alkalinity mg/l	8.3	7.46	2.6	3.2	3.4	4.8	1.5	4.5	4.47
Cl mg/l	191	213	87	56	49	84	43	91	101.75
Na meq/l	186	94	95	27	7	29	21	108	70.87
K mg/l	23	18	8	4	3	7	6	8	9.62
SO_4 mg/l	26	235	139	28	6	15	5	206	82.5
As ppb	0	0	0	0	0	0	0	0	0
Co_3 ppm	0	0	0	0	0	0	0	0	0
BOD mg/l	3.6	3.2	3.5	3.7	3.1	3.0	3.8	3.4	3.41
DO mg/l	6.2	6.0	6.4	6.1	5.9	5.7	6.3	6.1	6.08

Carbonate CO3: The highest value of carbonate was observed in October 11.62 and lowest value was observed in March 1 (Table 13).

Biological oxygen demand (BOD): The highest value of the BOD was observed 4.31mg/l in October and lowest ranged were observed 3.38mg/l in March (Table 13).

Dissolved Oxygen: The level of DO was recorded highest 7.28mg/l in January and lowest ranged was observed 4.76 mg/l in October 2008 (Table 13).

DISCUSSION

The Chotiari Wetland Complex is a shallow water lake, having a sandy and salty depth. The depth and area of CWC is variable depending upon the influx of water. The water level varies with the seasonal change in the quantity of water which enters into the lake. Present depth has been recorded from 15-30 ft and its level decrease to 8-18 ft in the dry season. Seasonal fluctuation of physico-chemical parameters, a similar rise in dissolved oxygen in winter season has been reported by different researchers (Singh *et al*., 1980). According to Rao (1986) due to causes of reduction in microbial decomposition of dead organic matter, low organismal respiration demand, increased growth of submerged macrophytes and solubility of atmospheric oxygen by reduction in temperature. The results of pH and alkalinity values indicated that the lake water remained slightly alkaline throughout the period of study due to the inflow of sufficient amount of water through the Ranto canal (Nara canal). The permissible limits of hardness by WHO is recognized 200mg/l. The hardness of lake water has measured little high from the given guideline of WHO (1984). This increase of hardness in the water could be due to the inflow of rain water. Salinity, conductivity and TDS were substantially higher; this probably indicates that there could be some contamination of domestic sewage and agricultural waste water supply from the Ranto canal (Nara Canal). The chloride is a pollution indicating parameters i.e. related to sewage contamination with the degradation products. In the reservoir amount of chloride was recorded in normal range. The WHO gives 250mg/l of chloride as an acceptable amount in the drinking water. However, the level of Ca, Mg, Na, K, SO_4, HCO_3, CO_3, COD and BOD was detected in elevated concentration compared to the maximum acceptable limits (Table 13). The salinity of water is the main factor which can be effected on the aquatic life of plants and animals (Khuhawar and Mastoi, 1995) have also reported higher salinity of water in the lake. The seedlings of commercial fish species in CWC like *Labeo rohita, Cirrhinus mirgla* and *cattla cattla* are very sensitive and cannot be tolerated at the higher range of salinity. The physico-chemical variables of CWC when compared with other lakes of Sindh, such as Keenjhar lake, (Chloride 38.9mg/l, salinity 0.05mg/l, alkalinity 20mg/l, Khuhawar *et al*., 1998), Haleji lake, (Alkalinity 525mg/l, chloride 75mg/l, TDS 338mg/l, Khuhawar *et al*., 1998), Hamal lake (Hardness 670mg/l, chloride 1750mg/l, alkalinity 275mg/l, (Khuhawar *et al*., 1998), Bakar lake [TDS 580mg/l, alkalinity 550 mg/l, hardeness 210mg/l (Jafri *et al*., 1997)] and Hub Dam [Transparency 2.1-3.3 m, pH 6.8-7.5, dissolved oxygen 3.1-5.3mg/l, salinity 0.15-25ppt., dissolved solids 50ppm (Iqbal and Kazmi, 1988)] indicated that all these lakes still retain the typical fresh water characteristics despite progressive eutrophication.

Table 13. Over all mean of Parameters of the Water Analysis 2008.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temp: of air	22.37	23.37	23.37	38.37	45.37	47.37	43.37	39.37	35.37	30.37	35.37	24.62
Temp: of H_2O	21.37	20.37	29.37	35.37	42.37	44.37	40.37	35.37	31.37	27.37	31.37	22.37
pH	8.09	8.14	7.56	8.03	7.96	7.96	7.86	6.66	7.44	8.43	8.03	7.59
EC mu/scm	600.12	824.62	727.4	808.87	794.25	786	800	680.12	758	567	812.12	978.25
TDS mg/l	404.87	415.37	379.4	412.12	399.25	391.87	392.25	382.62	386.5	306.25	434.62	435.12
Turbidity	41.4	28.47	59.05	24.77	23.77	22.51	22.55	22.5	22.53	40.03	35.93	17.93
Ca mg/l	27.62	30	48.62	28.75	27	28.87	26.62	25.25	33.87	26.12	49.87	48.12
Mg meq/l	32	39.5	31.5	38.12	36.37	35.75	36.37	36.12	37.87	30.87	32.75	35.12
Hardness mg/l	188.62	216.12	83	211	204.75	200.62	201.5	200	204.87	186.87	258.75	266.12
HCO_3 ppm	159.5	170.25	194.6	166	160.12	153.75	155.75	158.87	163.5	124.33	187	216.62
Alkalinity mg/l	3.46	4.2	8.42	3.97	3.92	4.15	4.13	4.13	4.35	7.63	20.33	4.47
Cl mg/l	72	84.12	71	83.75	82	80	81.37	84.87	83.25	57.5	90.87	101.75
Na meq/l	52.62	73.25	57	59.75	58.5	55.25	56.25	54	56.62	46.12	66.37	70.87
K mg/l	6.87	11	5.62	7.75	7.37	7.12	7.75	7.87	9.37	5.37	6.87	9.62
SO_4 mg/l	57.75	80	63.25	81.12	77.25	74.12	75.75	76.75	77.62	71.87	83.12	82.5
As ppb	0	0	0	0	0	0	0	0	0	0	0	0
Co_3 ppm	1.25	0	0	1	1.62	1.25	1.25	1.87	0	11.62	8	0
BOD mg/l	3.4	3.41	3.38	3.32	3.18	2.36	2.88	2.65	3.48	4.31	4.17	3.41
DO mg/l	7.28	7.27	6.48	7.27	6.13	5.38	5.47	6.58	5.45	4.76	5.61	6.08

At CWC the process of eutrophication is high at its due to the shallowness of the basin, but the range of many chemical parameters has gone up, beyond the permissible limits, recommended by the WHO (1984). Irrigation system of Pakistan, which in one of the largest contagious system in the world, is now facing the enormous problems. The shortage of water is the major problem, along with water logging, water salinity, water quality, over exploration of ground water and sea water intrusion.

Recently a study conducted at the Chotiari Reservoir, and Rais *et al*. (2011) reported that 32 species of reptiles including three species of freshwater turtles, 15 snakes, 13 lizards and one crocodile. While Rock Python and Indian Marsh Crocodile were recorded as Threatened Species. Crocodile focuses its attention on of major issue is water pollution concerned directly with the human health to polluted water (Chang *et al*., 2012). The Crocodile receives legal protection, but poor enforcement of hunting rules, profitable foreign trade in skins, loss of habitat and food resources directly effects his population (Chang *et al*., 2012). A survey was conducted by the Zoological Survey of Pakistan, five hundred specimens were recorded at Makhi and Baqar Dhand of the Chotiiari reservoir (www.wildlifeofpakistan, 2013).

The quality of water is the major factor to determine the diversity and health of aquatic flora and fauna (Gachal *et al*., 2001). The indiscriminate uses of agricultural chemicals enhanced chemical pollution in aquatic resources (Gachal and Slater, 2003; Gachal *et al*., 2004, 2006). Excess fertilizers used in the field runoff into the courses causes' uncontrolled algal growth and eutrophification and pesticides in water may kill aquatic life including fish which is the feeding of Crocodiles.

CONCLUSION

Based on present study, the site is faced by many shortcomings in impact and prediction. The major threat is faced to crocodiles and other key species of the wetland complex, destruction of their habitats. The seasonal flooding of the reservoir can destroy the nesting and eggs of crocodiles (Santiapillai *et al.,* 2001). Increased water level in the wetland complex not only inundated the fertile land but also caused excessive water seepage to western and southern areas of the site and its adjoining agricultural lands became waterlogged, salinized and barren. In the reservoir the fish stocks are slowly depleting due to the practices of unsustainable and overfishing. The change in the quality of water was recorded that the hazardous chemicals were found during the analysis of water in the laboratory, which result the harmful effect on the Marsh Crocodiles. The various fishing camps or nets can also found in the Chotiari Reservoir and its surroundings. It is evidence that the remaining population of Marsh Crocodile in Chotiari Reservoir is disturbed with the interaction of a large number of people such as boats, fishing nets; forest clearing fires usually reduces the suitability of the habitat for the crocodiles. It was observed that after the construction of the reservoir the major income resources of local people the agriculture lands, fish stocks of lakes and rangelands have been adversely affected and also the livelihoods of the people. The reservoir has enhanced poverty in local communities and the local communities are struggling to generate their source of income on marginalized natural resources, due to these practices the negative impacts on the habitats and its associated biodiversity.

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REFERENCES

APHA. 1976. Standard methods for the examination of water and waste water (14th edi.). Washington, DC, USA.

Birdlife International. 2001. Detailed species accounts from the Threatened birds of Asia: The Birdlife International Red Data Book.

Birdlife International. 2012. Marmaronetta angustirostris. In: IUCN 2012. IUCN Red List of Threatened Species.

Chang, MS., Gachal, GS., Qadri, AH. and Sheikh, MY. 2012. Bio-ecological status, Management and Conservation of Marsh Crocodiles *(Crocodylus palustris)* in Deh Akro 2, Sindh–Pakistan. Sindh Univ. Res. Jour. Sci. Ser. 44(2):209-214.

Chang, MS., Gachal, GS., Qadri, AH., Jabeen, T., Baloach, S. and Sheikh, MY. 2012. Distribution and Population Status of Marsh Crocodiles, C*rocodilus Palustris* in Nara Desert Wildlife Sanctuary (NDWS) Sindh, Pakistan. Sindh Univ. Res. Jour. Sci. Ser. 44 (3): 453-456.

Gachal, GS. and Slater, FM. 2001. Dolphins down the drain. Wildlife. 19:36-37.

Gachal, GS. and Slater, FM. 2003. Historical and current status of the Indus River Dolphin (*Platanista minor*) Owen 1853: its conservation and future. Sindh University Research Journal Sci. Ser. 35(1):51-62.

Gachal, GS. and Slater, FM. 2004. Barrages, biodiversity and the Indus River Dolphin. Pakistan Journal of Biological Sci. 7 (5):797-801.

Gachal, GS., Slater, FM., Memon, ZN., Qadri, AH. and Zuhra. 2006. If the pollution load of the river can be reduced then it would benefit both human and wildlife dependent upon river. Pakistan Journal of Biological Sci. 9:127-134.

Iqbal, M. and Kazmi. 1988. Ecology of limnetic crustacean zooplankton in Hub lake. M. Phil. Thesis, Department of Zoology, University of Karachi. pp117.

Jafri, SIH. 1997. Final report on Fisheries survey of Chotiari reservoir (Sanghar) and Tidal link lakes (Badin). Department of Fresh Water Biology and Fisheries, University of Sindh, Jamshoro. 12-61.

Khuhawar, MY. and Mastoi, GM. 1995. Studies on some physic-chemical parameters of Manchar lake Sindh. J. anal. and Envi. Chem. 3:66-71.

Khuhawar, MY., Mastoi, GG., Jehanger, TM. and Komber, M. 1998. Study on some Wetlands of Sindh. (Proceedings) Impact of environmental pollution on lakes of Sindh. MUET Jamshroro. 12-17.

Leghari, MK., Sultana, K. and Haga, M. 1995. Diatoms from unexplored Diamer face of Nanga Parbat Part I. Biologia. 41:11-12.

Leghari, MK., Sahito, GA., Arbani, SN. and Leghari, MY. 1997. Ecological survey of phytoplankton in Fresh water lake, Bakar (Distt, Sanghar), Sindh, Pakistan, Sindh Univ. Res. J. Sci. Sr.). 29:83-94.

Leghari, SM., Jafri, SIH., Mahar, MA., Lashari, KH., Ali, SS., Khuhawar, MY. and Jehangir, TM. 1999. Biodiversity of Chotiari reservoir (Distt. Sanghar) Sindh, Pakistan. Proc. Semi. Aq. Biodiv. Pakistan. Eds. Kazmi, QB. and Kazmi, MA. MRCC and Department of Zoology, University y of Karachi. 139-157.

Leghari, MK. and Khuhawar, MY. 1999. Seasonal variation of phytoplankton: part-I freshwater lake Bakar District Sanghar, Sindh. Pakistan J. Plant Sci. 5(2):159-171.

Rais, M**.,** Khan, MZ**.,** Abbass, D., Akber, G., Nawaz, R. and Islam, S. 2011. A qualitative study on wildlife of Chotiari Reservoir, Sanghar, Sindh, Pakistan. Pakistan Journal of Zoology. 43 (2):237-247.

Rao, RJ. 1986. Studies on the seasonal and diel variation in some physic-chemical conditions of a fresh water pond under prawn culture. Proc. Nat. Symp. Fish and Env. 96-102.

Santiapillai, C. and de Silva, M. 2001. Status, Distribution and Conservation of Crocodiles in Srilanka: Biological Conservations. 97(3):305-318.

Sheikh, KM. and Molur, S (eds.) 2004. Status and Red List of Pakistan's Mammals. Based on the Conservation Assessment and Management Plan. IUCN Pakistan. pp312.

Singh, RN., Srivasta, NP. and Desai, VR. 1980. Seasonal and diurnal variations in physic-chemical conditions of water and plankton in lotic sector of Rihand reservoir (U.P) J. in Land Fish. India. 12:100-111.

WHO. 1984. Guidelines for drinking water quality (Vol. II), Geneva. pp327.

WWF. 2007. Preliminary Baseline Environmental Assessment Report of Indus for All Program Sites. Indus Eco-region Conservation Program.

www.wildlifeofpakistan. 2013. www.wildlifeofpakistan com/ReptilesofPakistan/crocodilesofpakistan.htm.

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