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Environmental Impact to the Conservation of the Indus River Dolphin (*Platanista minor*)

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Abstract: The Indus river Dolphin is one of the world's most endanger cetaceans with a total population of just a few hundreds individuals. Ecological interest in the species was aroused in the 1970's and inter mittend but largely un- coordinated monitoring of a number as continued never since. Barrages cutting the river in to biologically up stream combine with the pressure associated with a growing population in a Third World country pollution such as fragmentation and literacy combine to put the species under threat. The establishment of a dolphin Reserve between the Guddu and Sukkur barrages in Sindh has made a positive contribution to dolphin conservation but a more proper approach is advocated here. Accepting that little can be done to improve the natural impacts, approaches reducing the pollution load of the river water, particularly in low flows, by natural filtration are advocated.

Key words: Platanista, river dolphin, pollution, indus

INTRODUCTION

The Indus River represents one of the major water distribution systems of south East Asia and is the most important river of Pakistan (Ittekkot *et al*., 1986). In Pakistan, like other countries of the world, the level of pollution of fresh water bodies, the especially the rivers, is often no longer within safe limits for human consumption. Water is said to be universal solvent because most of the biochemical reactions take place in it, thus making it essential for all forms of life (Ahmed *et al*., 1989). Surface water is a visible natural resource and is intensively used for various purposes in all countries of the world. The major sources of surface water contamination are municipal and industrial discharges and agricultural run off. The direct and indirect effects of fishing and pollution, both domestic and industrial, have reduced the population to a few hundred individuals in the central section of the main Indus River (Gachal and Slater, 2003). Surface water pollution is one of the major problems particularly in developing countries. In many countries, the treated water from lakes and other sources is being used for drinking and various other purposes. If polluted water is not properly treated, it gives rise to serious health problems for human beings, animals and aquatic life (Gachal and Slater , 2002; Khan and Khan, 1980) The food resources may very along the river. Pollution from agriculture, industrial chemical and human waste which might have physiological effects on dolphins or their prey or in extreme cases might prove fatal (Gachal and Slater, 2004).

The Indus River is an important source of livelihood of millions of people. It mainly supplies water for drinking purposes to towns and agriculture side along its entire route (Tahir *et al*., 1990). The Indus River system naturally supports a great variety of flora and fauna. Pilleri (1972) described the water quality of the river as good for human consumption as well as the animal life in the Indus River. (Leen *et al*., 1990) and Dudgeon (1992) showed concern for the water quality of Asian Rivers. Else where Rozengurt (1993) quoted the decline of the Sardine catch due to the ecological degradation of the Nile River in Egypt.

The World Conservation Union regards this species as vulnerable (Klinowska, 1991; Reeves and Leatherwood, 1994; Smith *et al*., 1994) said the species is threatened by rapid deterioration of the habitat due to pollution, construction of dams, mining and directed and incidental catch.

However, the present study is aimed at evaluating the pollution status of the river through physico-chemical analyses dolphin population. Further, Indus river water, sewage and industrial effluents were collected for analysis from Rohri, Sukkur, Guddu locations in the Sindh provinces of Pakistan. It is also a part of this project to explore the ecology of Indus dolphin, which is endemic to the Indus river system to determine the effect of seasonal variations on some physico-chemical parameters of the river ecosystem.

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MATERIALS AND METHODS

Water samples were collected every month for a period of nine-months (April to November 1999) from midstream at the depth of 100 cm from 13 to 14 locations between Sukkur, Rohri and Guddu according to standard water sampling procedure (Table 1).

Water samples were collected in polyethylene litre screw cap containers, which were cleaned sequentially with detergent wash, tap water rinse, 24 h soak in 1% HNO_3 and several distilled water rinses, then dried, capped and labeled. Each container was filled to the brim with river water and effluents to avoid any space. The samples were transported to the laboratory as quickly as possible and various water quality physico-chemical parameters were determined by standard methods. Physico-chemical parameters like pH, conductivity, temperature (air and water), total dissolved solids, alkalinity, hardness, residue (total, volatile, fixed), Dissolved Oxygen (DO), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) were subsequently evaluated in laboratory.

Temperature (air and water) was measured with a mercury thermometer, visibility by (Secchi disc), using a WTW 320 conductivity bridge for conductivity, salinity and TDS, Orion 420A pH meter was used for pH determination.

Dissolved Oxygen by Winkler method, hardness, chloride and alkalinity by titrimetry or by titration with standard EDTA, silver nitrate and hydrochloric acid respectively, residues (total, fixed and volatile) by gravimetry, COD by dichromate reflux oxidation method.

Biological oxygen demand was evaluated by Winkler method (samples were placed in temperature-controlled incubator at 20°C for five days (model cooled orbital incubator 0-70°C GallanKamp).

RESULTS

Water samples collected from Indus River sites were analyzed in the laboratory for physico-chemical parameters.

pH: pH values have been observed at Sukkur, Rohri and Guddu from the months of March to September, 1999, but suddenly decreased from the month of May to September due to higher dissolution of salts in the river water when river was at its highest flow. Observed pH range of Indus River water is 6.5 to 8.13 (Table 1-4). The permissible pH limit recommended by WHO for drinking, irrigation waters and fish population is 6.5-8.5.

Conductivity: Conductance values of water samples are indicative of presence of electrolyte concentrations and are greatest during low flow of the Indus River. Sample 13 had highest conductivity 5650 $\mu S\ cm^{-1}$ in September and lowest 205 $\mu S\ cm^{-1}$ in sample 12 in July 99 (Table 1-5). However, fluctuation observed in the samples is due to water flow in the river. The standard for electrical conductivity is 400 $\mu S\ cm^{-1}$, as the water quality depends on TDS. However, WHO standard for TDS ranges between 500-1500 ppm.

Alkalinity: The lowest and highest values of alkalinity of Indus river were observed in March and August, respectively and ranged between 25-113 mg L^{-1} (s-1, S-9, Table 1 and 5), respectively. However, fluctuation observed in alkalinity values (Table 2-4 and 6) indicate the presence of variable amounts of carbonates, bicarbonates, borate, hydroxide in the Indus river. Acceptable alkalinity values ranges between 30-500 mg L^{-1}.

Hardness: The values of hardness ranged from 208 mgL^{-1} in August to a minimum of 42.66 mg L^{-1} in September (Table 4 and 7). The permissible limit for hardness is 100 mg L^{-1} for drinking water as recommended by WHO.

Total Dissolved Solids (TDS): The amount of total dissolved solids was found to be 3616 mg L^{-1} (S-13) in September, 99 and 131 mg L^{-1} (S-14) in the month of June, 99 (Table 4 and 7). Total dissolved solids values showed a fluctuating trend at all locations throughout the period of study. Maximum of 400 mg L^{-1} of TDS is permissible for diverse fish population. But, our findings at different location of Indus river water are potentially threat to aquatic life particularly fish growth.

Chloride: The lowest and highest values of chloride contents were observed in September 782 and 32.61 mg L^{-1} in May 99 respectively (S-14, S-13, Table 2 and 7). Fluctuation in chloride contents was noted at different locations during the study period. However, WHO recommended the permissible limit of 250 mg L^{-1} for drinking water.

Chemical Oxygen Demand (COD): Chemical Oxygen Demand (COD) of the river water samples were determined. The lowest and highest values of COD ranged between 10 to 400 mg L^{-1} in the months of September and July 99 respectively (Table 5 and 7). High values showed the presence of organic pollutants in the river water samples, which are susceptible to oxidation. High COD values are a threat to river life. A COD value

Table 1: Physico-chemical analysis of Indus River water March 1999

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Time	12.35	12.40	1	1.50	2	2	2.25	2.40	3.20	3.25	4	4.37	4.40
Temp: Air (°C)	38.	38	38	35	35	35	36	36	35	35	35	31	31
Temp: H_2O(°C)	35.	35	35	25	25	28	28	28	28	28	25	25	25
Visibility (cm)	2.	6	3.2	3	1	1	2.5	1	2	2	2.5	1	2
pH	6.96	7. 54	7. 54	6.37	7.46	7.2	7.3	6.9	7.4	7.4	7.8	7.2	7.64
Conductivity (µS cm^{-1})	1523	465	465	474	1251	2900	466	880	823	1507	456	688	464
Salinity (mg L^{-1})	0.5	Nil	Nil	Nil	0.4	1.3	Nil	0.2	0.1	0.5	Nil	0.1	Nil
TDS (mg L^{-1})	974.72	297.6	297.6	303.4	800.64	1856	298.24	563.2	526.72	964.48	291.84	440.32	296.96
Dissolved O_2 D/O (mg L^{-1})	Absent	11.66	10.11	12.5	A	A	9.52	A	A	A	12.5	A	12.11
Hardness(mg L^{-1})	136	63.2	63.2	64.6	112	227.32	66.66	86	85.32	135.32	70	78	68
Chloride (mg L^{-1})	122.22	37.78	37.78	41	96.88	270.58	37.78	86.24	76.78	105.14	31	51	34.24
Alkalinity (mg L^{-1})	363	115	115	130	113.3	346.65	101.65	241.65	191.65	410	123.3	215	131
BOD (mg L^{-1})	o	4.88	4.88	o	5.59	o	5.11	o	1.19	o	7.5	o	6.54
Total residue (mg L^{-1})	800	400	400	600	1200	1600	600	1200	600	600	200	2600	600
Fixed residue (mg L^{-1})	400	200	200	200	600	400	200	600	400	400	100	2400	200
Volatile residue (mg L^{-1})	400	200	200	400	600	1200	400	600	200	200	100	200	400
COD (mg L^{-1})	200	170	170	210	190	20	30	40	90	10	40	40	40

BOD: Biological Oxygen Demand, COD: Chemical Oxygen Demand, TDS: Total Dissolve Solids, S: Sample = S1, Rohri, S2 Rohri mix, S3 Mid River, S4 Bunder road, S5 Thermal Sukkur, S6 Mirani mosque, S7 Sadbelo (pumping station), S8 Sukkur Regent, S9 Purano Sukkur, S10 Makrani paro, S11 Begari, S12 Guddu Thermal, S13 Guddu channel 1, S14 Guddu channel 2. A: Absent: o: Out of range

Table 2: Physico-chemical analysis of Indus River water April

Sample sites parameters	S1	S2	S 3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	10.4	11.4	11.4	11.4
Time	3.35	3.45	4.10	10am	10.30	5.30	6.15	6.20	6.35	6.40	11am	6	6.30
Temp: Air (°C)	40	40	38	32	33	37	35	35	35	35	33	37	34
Temp:H_2O (°C)	29.5	28.4	27.8	31	31	28.5	28.1	27.6	28.8	28.2	30.8	33.6	33.2
Visibility (cm)	3	1	7	1	2	6	7.5	2	1	2	2	5	4
pH	7.06	7.38	7.5	6.87	7.07	7.7	7.23	7.31	7.50	7.33	7.36	8.13	7.7
Conductivity (µS cm^{-1})	1014	1265	303	1951	1409	320	450	566	1583	832	2297	310	321
Salinity (mg L^{-1})	0.3	0.4	0.0	0.8	0.5	0.0	0.0	0.0	0.6	0.1	0.3	0.0	0.1
TDS (mg L^{-1})	648.96	809.6	193.92	1248.69	901.76	204.8	288	362.24	1013.12	532.43	766.08	198.4	205.44
Dissolved O_2 D/O (mg L^{-1})	A	A	7.75	A	6.52	7.4	2.39	5	A	4	A	7.24	6.52
Hardness (mg L^{-1})	92	97.2	59.2	171.2	125.2	53.2	82.4	74	124.6	100.6	47.2	123.2	53.2
Chloride (mg L^{-1})	335.35	448.8	65.93	477.15	323.3	73.02	120.53	103.53	414.34	165.19	188.59	110.6	46.79
Alkalinity (mg L^{-1})	93	56	56	63	63	40	43	70	50	56	53	66	66
BOD (mg L^{-1})	o	o	6.8	o	o	5.43	1.88	3.40	o	o	o	6.15	5
Total residue (mg L^{-1})	600	800	400	1200	1000	400	400	400	1000	600	800	600	400
Fixed residue (mg L^{-1})	400	400	200	800	600	200	200	200	600	400	400	400	200
Volatile residue (mg L^{-1})	200	400	200	400	400	200	200	200	400	200	400	200	200
COD (mg L^{-1})	40	40	40	40	140	250	180	180	60	60	50	80	50

Table 3: Physico-chemical analysis of Indus River water May 1999

Sample sites parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	16.5	16.5	16.5	16.5	16.5	16.5	16.5	17.5	17.5	17.5	18.5	18.5	18.5
Time	5.5	5.10	5.35	10	6	6.10	6.30	11	11.30	12	8	12.10	12.35
Temp: Air (°C)	37	37	37	36	35	35	35	33	34	37	30	42	43
Temp:H_2O (°C)	34	34	33	30.5	30	30	29	30	30.1	30.9	27	35	36
Visibility (cm)	1	2	5	3	4	1	1	2	1	1	4	4	3
pH	6.87	6.87	7.62	6.81	6.96	6.65	6.81	6.91	6.89	6.71	8.04	7.70	7.74
Conductivity (µS cm^{-1})	1052	1052	247	494	312	970	977	1857	1164	1861	238	237	239
Salinity (mg L^{-1})	0.3	0.3	0.0	0.0	0.0	0.2	0.2	0.7	0.3	0.7	0.0	0.0	0.0
TDS (mg L^{-1})	673.28	673.28	158.08	316.16	199.68	620.8	625.28	1188.48	744.94	1191.04	152.32	151.08	190
Dissolved O_2 D/O (mg L^{-1})	A	A	7.24	1.44	6.59	A	A	A	A	A	5.79	5.72	5.36
Hardness (mg L^{-1})	94	94	47.2	66.6	62	80.6	82	175.2	114.2	167.2	54.6	44.6	53.2
Chloride (mg L^{-1})	229	216.95	58.84	58.84	75.15	174.41	177.25	39.7	158.10	555.14	37.57	37.57	32.6
Alkalinity (mg L^{-1})	50	50	56	83	63	70	56	56	56	60	53	50	50
BOD (mg L^{-1})	o	o		3.62	o	3.98	o	o	o	o	2.89	5.72	5.36
Total residue (mg L^{-1})	700	700	300	300	250	800	600	1200	700	1200	300	240	280
Fixed residue (mg L^{-1})	600	600	200	200	200	600	400	800	500	1000	200	200	180
Volatile residue (mg L^{-1})	100	100	100	100	50	200	200	400	200	200	100	40	100
COD (mg L^{-1})	190	190	130	160	170	60	210	220	200	200	240	230	230

Table 4: Physico-chemical analysis of Indus River water June 1999

Sample sites parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	10.6	11.6	11.6	11.6	11.6
Time	1.15	1.20	1.30	1.50	2	2.5	2.10	2.15	2.20	9.30	10.	12	12.10
Temp: Air (°C)	46	46	46	44	44	45	45	46	46	36	37	46	47
Temp:H_2O (°C)	33	33	35.4	35.3	35.2	35	35	35.5	35.6	25	25	35.2	36
Visibility (cm)	1	2	4	1	1	1	2	2	2	1	1	4	4
pH	6.37	6.25	7.50	6.61	6.53	6.65	6.9	6.78	6.7	6.78	6.63	7.43	6.88
Conductivity (µS cm^{-1})	1054	1036	237	530	968	2660	1373	774	810	1358	1210	207	226
Salinity (mg L^{-1})	0.2	0.2	0.0	0.0	0.2	1.1	0.4	0.1	0.1	0.4	0.3	0.0	0.0
TDS (mg L^{-1})	648.96	809.6	193.92	1248.69	901.76	1702.4	288	362.24	1013.1	532.4	766	198.4	205
Dissolved O_2 D/O (mg L^{-1})	A	A	7.75	A	6.52	7.4	2.39	5	A	4	A	7.24	6.52
Hardness (mg L^{-1})	80.66	90.7	42.66	62.7	78.7	182.7	94.7	76.7	90.7	74.7	105.3	46.7	44.7
Chloride (mg L^{-1})	179.6	186.67	66.2	122.89	115.80	562.47	285.96	80.35	87.44	252.87	115.8	59.09	77.99
Alkalinity (mg L^{-1})	93.33	73.3	63.3	73.3	83.4	83.3	93.3	63.3	113.3	53.3	63.4	53.3	73.3
BOD (mg L^{-1})	o	o	4.34	o	o	o	o	o	o	o	o	5.50	2.46
Total residue (mg L^{-1})	860	820	260	380	680	1580	860	500	530	910	800	200	180
Fixed residue (mg L^{-1})	480	420	100	300	340	1200	460	260	300	460	460	100	100
Volatile residue (mg L^{-1})	380	400	160	80	340	380	400	240	230	450	340	100	80
COD (mg L^{-1})	200	240	300	180	100	260	220	170	200	110	60	40	40

Table 5: Physico-chemical analysis of Indus River water July 1999

Sample sites parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7	3.7	3.7	3.7	3.7
Time	12.5	12.10	1.10	1.30	1.55	2	2.10	2.25	2.30	2.35	2.45	2.45	1.45
Temp: Air (°C)	42	42	46	47	47	47	47	47.5	47.5	47.5	47	42	42
Visibility (cm)	1	2	4	2	1	1	2	1	1	1	2	4	4
pH	6.15	6.25	7.63	6.58	6.56	6.24	6.73	6.50	6.52	6.82	6.97	7.82	7.68
Conductivity (µS cm^{-1})	3100	902	217	554	851	842	1006	573	1063	1463	307	207	224
Salinity (mg L^{-1})	1.2	0.1	0.0	0.0	0.1	0.1	0.2	0.0	0.2	0.5	0.0	0.0	0.0
TDS (mg L^{-1}) Hardness	1984	577.28	138.88	354.64	544.64	538.88	643.84	366.72	683.52	936.32	196.48	132.48	143.36
Chloride (mg L^{-1})	661.49	158.10	65.93	73.02	151.01	104.85	193.55	94.29	200.64	243.18	56.72	63.81	42.54
Alkalinity (mg L^{-1})	63	46	53	63	83	63	53	63	53	63	60	63	63
BOD (mg L^{-1})	o	o	5.14	o	o	o	o	o	o	o	4.35	4.35	4
Total residue (mg L^{-1})	3020	980	360	500	580	640	660	480	720	940	260	260	280
Fixed residue (mg L^{-1})	2320	700	180	300	300	340	360	260	400	500	200	140	160
Volatile residue (mg L^{-1})	700	280	180	200	280	300	300	220	320	440	60	120	120
COD (mg L^{-1})	330	360	90	400	100	80	20	10	10	10	10	10	30
Temp:H_2O (°C)	33	33	36	36	35.5	35.5	35.5	36	36	36	35.5	35	34

Table 6: Physico-chemical analysis of Indus River water August 1999

Sample sites parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	3.8	3.8	3.8	3.8
Time	1.30	1.35	1.45	1.55	2	2.10	2.20	2.25	2.30	12.10	1.40	1.50	2 PM
Temp: Air (°C)	37	37	36	36	36	37	37	37.5	37.5	38	38	35	35
Temp: H_2O (°C)	33	32.6	32.6	32.5	32.5	32.6	32.9	32.7	32.6	33	32.6	32.6	32.9
Visibility (cm)	1	2	4	2	2	2	1	1	2	1	2	4	4
pH	6.80	6.69	7.21	6.82	6.85	6.54	6.60	6.74	6.46	6.88	6.65	6.82	7.21
Conductivity (µS cm^{-1})	861	891	251	2850	2190	964	1153	3070	2140	1341	136	270	270
Salinity (mg L^{-1})	0.1	0.1	0.0	1.2	0.8	0.2	0.3	1.3	0.8	0.4	0.4	0.0	0.0
TDS (mg L^{-1})	551.04	570.24	160.64	1824	2118	616.96	737.92	1964.8	1369.6	858.24	871.04	172.8	172.8
Dissolved O_2 D/O (mg L^{-1})	4.34	A	7.24	A	A	A	A	A	A	A	A	3.69	5.20
Hardness (mg L^{-1})	80.66	82.66	54.66	158.66	120.66	92.7	90.7	208.7	145.33	110.7	106.7	58.7	46.66
Chloride (mg L^{-1})	278.63	257.60	52	853.16	673.55	165.43	101.62	470.30	356.86	193.79	618.95	44.90	56.72
BOD (mg L^{-1})	1.83	o	3.67	o	o	o	o	o	o	o	o	3.69	5.20
Total residue (mg L^{-1})	800	880	300	1800	1680	800	1020	2420	1540	1080	1040	360	350
Fixed residue (mg L^{-1})	460	480	160	1200	1000	400	560	1400	820	540	530	220	200
Volatile residue (mg L^{-1})	340	400	140	600	680	400	460	1020	720	540	510	140	150
COD (mg L^{-1})	60	40	70	40	10	30	40	20	20	50	50	70	60

0.5 mg L^{-1} indicates very clean stream. The permissible level recommended by World Health Organization ranges 10-15 mg L^{-1}.

Biological Oxygen Demand (BOD): Biological oxygen demand level was determined during the study period from March 99 to September. Values of BOD reflecting organic pollution was highest in low flow conditions but within the range 2.74-4.61 mg L^{-1} in April to September 1999 (Table 1- 5).

Dissolved Oxygen (DO): The lowest and highest values of dissolved oxygen were evaluated (Table 2 and 7). Whereas, minimum and maximum value ranges allowed by

Table 7: Physico-chemical analysis of Indus River water September 1999

Sample sites parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13
Date	2.9.99	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	3.9	3.9.	3.9
Time	12.30	12.35	12.40	12.45	12.50	1	1.5	1.10	1.25	1.30	1.40	4	4.15
Temp: Air (°C)	32	38	38	38	38	38	38	38	40	40	40	37	37
Temp:H_2O (°C)	32	32	32	32	32	32	32	33.7	33.7	33.7	33.7	28	28
Visibility	1	2	4	2	2	1	2	2	2	1	2	4	4
pH	6.61	6.76	7.54	6.71	7.03	6.58	6.99	6.51	7.46	6.39	6.46	7.91	6.41
Conductivity (μS cm^{-1})	1767	1484	251	1527	365	545	436	2150	3480	949	905	246	5650
Salinity (mg L^{-1})	0.6	0.5	0.0	0.5	0.0	0.0	0.0	0.8	0.0	0.2	0.1	0.0	0.6
TDS (mg L^{-1})	1130.9	949.76	160.7	977.3	233.6	349	279.04	1376	2227.2	607.36	579.2	168.96	3616
Dissolved O_2 D/O (mg L^{-1})	A	A	7.14	A	3.043	A	A	A	6.30	A	A	6.81	A
Hardness (mg L^{-1})	150.66	122.66	48.66	116.7	62.66	62.7	56	138.66	50	84.66	94	36.7	638
Chloride (mg L^{-1}	229.24	172.52	108.7	163.1	44.90	94.6	73.26	215.06	51.99	108.71	94.53	51.99	782.26
Alkalinity	46.66	36.66	31.66	36.66	41.66	41.7	43.33	31.7	41.7	26.66	31.7	31.7	36.66
BOD (mg L^{-1})	o	o	3.91	o	o	o	o	o	2.89	o	o	3.623	o
Total residue (mg L^{-1})	1860	1680	260	1300	500	900	600	3600	400	1120	1040	300	3200
Fixed residue (mg L^{-1})	1260	1000	160	800	250	500	320	2500	240	620	600	200	2000
Volatile residue (mg L^{-1})	600	680	100	500	250	400	280	1100	160	500	440	100	1200
COD (mg L^{-1})	30	10	60	20	30	20	20	10	30	20	20	20	30

WHO lies 4-7 mg L^{-1} dissolved oxygen for drinking water and fishes, respectively.

Total, fixed and volatile residue: The river and its tributaries receive effluent discharges as they pass near the villages and towns. Indus River water is used for agricultural purposes in lower Sindh. Arain and Khuhawar (1982) examined the transport of carbon and minerals from Kotri to Arabian Sea.

Total residue values were estimated from March to September but within the range 250-3600 mg L^{-1}, in the months of August, September and May 99 (Table 3, 6 and 7). The volatile residue varied between 100-2000 mg L^{-1} (Table 4 and 7). Fixed residue in water samples ranged 40-1200 mg L^{-1} (Table 3, 4 and 7). Indus River carried a lot of silt and suspended solids, which pushes high total residue and fixed residue (Dewani *et al*., 1997; Ittekkot *et al*., 1986) also reported similar observations below Kotri barrage.

Tariq *et al*. (1996) described the Indus River as a dump house for all types of waste products streaming into river via its tributaries. The Government of Pakistan says the occurrence of massive fish kills and the destruction of lower aquatic forms due to indiscriminate use of pesticides in the agricultural fields along Indus River banks and are due to the release of industrial pollutants into water bodies.

Pilleri (1972) described the river water quality as good aquatic habitat. Since the species gained legal protection and international status and regular monitoring took place. Leen *et al*. (1990) and Dudgeon (1992) have showed the concern for the water quality of Asian Rivers. Rozengurt (1993) quoted the decline of the sardine catch due to ecological degradation of Nile River in Egypt.

Chaudhry *et al*. (1999) reported 7% annual rise in the use of fertilizer and 190% increase in the imports of pesticides between 1981 and 1987. The indiscriminate use of agricultural chemical leads to chemical pollution of the environment and may kill all animal life including fish and bioaccumulate through the food chain leading to dolphin contamination (Gachal and Slater, 2002).

DISCUSSION

The Indus River represents one of the major water distribution systems of south East Asia and most important river of Pakistan Ittekkot *et al*. (1986). The Indus River, in Pakistan is one of the world's largest rivers in terms of drainage basin area (970,000 km), discharge and sediment load. The loss of fresh water inputs and release of industrial and domestic waste are probably the most serious ecological threats. Indus River carried lot of silt and suspended solids, which pushes high total residue and fixed residue (Dewani *et al*., 1997). Voltile residue represented the organic matter presented in the total residue. Ittekkot *et al*. (1986) also reported similar observations below Kotri barrage. Arain and Khuhawar (1982) examined the transport of carbon and minerals from Kotri to Arabian Sea. The Indus river has a maximum amount of total residue 3600 mg L^{-1} in September 1999.

Jaleel *et al*. (1991) voiced concern about the deteriorating state of fresh water with respect to metal pollution. Chaudhry *et al*. (1999) showed that pollution on River Ravi a tributary of the Indus has caused a drop in fish production of 5,000 tones per year, a consequence of pollution, which will be reflected throughout the food chain.

Total Dissolved Solids (TDS) in Indus River (S-13) had a maximum range 3616 mg L^{-1} in September 1999 and Chemical Oxygen Demand (COD) has high value 400 mg L^{-1} in July 1999. Where as hardness has the maximum of 208 mg L^{-1} in August 1999 due to high values

of TDS. Biological oxygen demand (BOD) has the elevated value reflecting the organic pollution in flow conditions of the River as the large quantities of feacal material floating on the River surface was noted in December 1999 (Table 7).

However, unregulated sewage, industrial effluent and agricultural run off find their way into the Indus River at various places. Consequently, the Indus River acts as a dump house for all types of waste products streaming into it (Tariq *et al*., 1996). This all leads to high oxygen demand and depletion of oxygen level in the water body with harmful effects on aquatic life.

The River Indus and its tributaries suffer considerable pollution, some continuous as in the case of sewage and other sources. The increasing need for freshwater for industrial and domestic use is the main reason for the dolphins endangered status (Gachal and Slater, 2004). It is probable that a more wide-ranging approach to dolphin conservation might be of more value. If the pollution load of the river can be reduced then it would benefit both human and wildlife dependent upon river. A solution to the pollution problem needs to be relatively low cost. Wherever there is human habitation and/or industry along the river there is a generally untreated foul water discharge into the waterway. In many parts of the world, particularly in Europe and North America polluted waters are treated by passing them through natural or constructed wetlands (Perttu, 1993).

In a number of areas along the Indus, particularly in upper Sindh, sewage or industrial discharges could be diverted away from the river into underutilized areas peripheral to the river. Depending on the volume and pollution load of the effluent, the water could be allowed to rejoin the main river at varying distances from the input point having passed through this peripheral treatment area. The treatment area should be initially planted with wetland plants, particularly woody species and these allowed to develop and where possible to be harvested successionally as fuel. Such a filter system would reduce the BOD, COD as well as bacterial and chemical pollutants to an environmentally acceptable level (Gachal and Slater, 2002). The area would also have value as a fuel resource and as a wetland for wildlife. This holistic approach of cleaning the environment to the benefit of all river users could have a positive effect upon dolphin population by controlling pollution in the food chain.

REFERENCES

Ahmed, N., S. Ahmed, B. Khan, S. Noor and M.S. Khan, 1989. Variation of selected metals in fresh water. Sci. Intl. (Lahore) 1: 354-359.

Arain, R. and M.Y. Khuhawar, 1982. Carbon Transport in the Indus River, Preliminary Results. In: SCOPE/UNEP Transport of Carbon and Minerals in Major World Rivers, Part 1, Volume 52, Degens, E.T. (Ed.)., Mitt Geolpalaont Univ., Hamburg, pp: 449-454.

Chaudhry, A.A., M.A. Maan and M. Akbar, 1999. Conservation of the Indus Dolphin in the River Indus, Punjab, Pakistan. Punjab Wildlife Research Institute, Faisalabad, Pakistan, pp: 47.

Dewani, V.K., I.A. Ansari and M.Y. Khuhawar, 1997. Preconcentration and determination of metal contents in Hyderabad city sewage and Phulleli canal. Proc. 3rd Natl. Sym. Modern Trends in Contemporary Chem., pp: 21-24.

Dudgeon, D., 1992. Endangered ecosystems: A review of the conservation status of tropical Asian Rivers. Hydrobiologia, 248: 167-191.

Gachal, G.S. and F.M. Slater, 2002. A holistic approach to the conservation of the Indus river dolphin. Pak. J. Sci. Ind. Res., 45: 53-58.

Gachal, G.S. and F.M. Slater, 2003. Historical and current status of the Indus river dolphin: Its conservation and future. Sindh Univ. Res., (Sci. Ser) 35: 51-62.

Gachal, G.S. and F.M. Slater, 2004. Barrages, Biodiversity and the Indus river Dolphin. Pak. J. Biol. Sci., 7: 797-801.

Ittekkot, V., S. Safullah and R. Arain, 1986 . Carbon transport by Indus River. Sci. Total Environ., 58: 93-97.

Jaleel, T., M. Jaffar and M. Ashraf, 1991. Levels of selected heavy metal in commercial fish from five fresh water lakes. Pak. Toxicol. Environ. Chem., 33: 133-140.

Khan, M.A. and S.A. Khan, 1980. Heavy metal analyses of the River Ravi. Sci. Intl. (Lahore), 1: 400-405.

Klinowska, M., 1991. Dolphins, Porpoises and Whales of the World. The IUCN Red Data Book. IUCN, Gland, Switzerland and Cambridge, UK., pp: 97-107.

Leen, G., M. Hinrichsen and A. Markham, 1990. Atlas of the environment. Arrow Books Limited and Worldwide Fund for Nature, London, pp: 189-108.

Perttu, K.L., 1993. Biomass production and nutrient removal from municipal wastes using willow vegetation filters. J. Sci. For., 1: 57-70.

Pilleri, G., 1972. Original description of the Gangetic dolphin, Platanista gangetica, attributed to William oxburgh. Bull. Br. Mus. Nat. Hist., 21: 345-348.

Reeves, R.R. and S. Leatherwood, 1994. Dolphins, Porpoises and Whales: 1994-1998 Action Plan for the Conservation of Cetaceans. IUCN/SSC Cetacean Specialist Group. IUCN, Gland, Switzerland.

Rozengurt, M.A., 1993. Watershed management: The effects of water development on estuarine and coastal zone ecosystems in the United states and other countries presented to the Environment and Energy Study Conference. United States Congress Orange Country California, pp: 75-86.

Smith, B.D., R.K. Sinha, U. Regmi and K. Sapkota, 1994. Status of Ganges river dolphins *(Platanista gangetica)* in the Karnali, Mahakali, Narayani and Sapta Kosi rivers of Nepal and India in 1993. Marine Mammal Sci., 10: 368-375.

Tahir, S.S., T.G. Kazi and G.H. Kazi, 1990. Analysis of Indus River water from Kotri barrage to delta. J. Anal. Environ. Chem., 1: 15-18.

Tariq, J., M. Ashraf, M. Jaffar and M. Afzal, 1996. Pollution status of the Indus River, Pakistan, through heavy metal and macronutrient contents of fish, sediment and water. Water Res., 30: 1337-1344.