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Arc GIS Based Study of Effects of Sea Tidal Water and Industrial Effluent on Shallow Lakes and Lagoons of Coastal Areas of Badin, Sindh, Pakistan

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Abstract: Coastal wetlands of district Badin, Sindh, Pakistan, are being deteriorated by sea water intrusion and mega drains carrying industrial and municipal effluents. Lack of fresh water supply to wetlands has worsened the environmental ecosystem degradation of coastal area of Badin. Left bank outfall drainage system carries industrial and municipal waste which before to be disposed of into Arabian Sea through Shah Samando creek, contaminates a lot of coastal wetlands and Ramsar recognized lagoons. The present study was carried out to evaluate the physico-chemical analysis of the twelve (12) wetlands of Badin coastal area. Arc GIS was used for mapping and interpretation. Average results obtained were E.C. 18.8 mS/cm , TDS 10447 mg/L, D.O 5.5 mg/L , Salinity 12.3, Chlorides 6376.7 mg/L, Hardness 1814.3 mg/L , Alkalinity 211 mg/L, Phosphates 0.2066 mg/L, Nitrates 2.81mg/L, Ni0.0177mg/L, Cd 0.0189 mg/L, Zn 0.0332mg/L, Cu 0.0719 mg/L, Fe 0.0531 mg/L ,Na 2667.4 mg/L, Ca 447 mg/L, Mg 223.9 mg/L, K 111.8 mg/L. Results confirmed that the wetlands have been contaminated by sea water and industrial effluents of Left Bank Outfall Drain.

Keywords: Wetlands, Badin coastal area, lakes, Lagoons, Drains, LBOD (Left Bank Outfall Drains), GIS (Geographic Information System).

1. INTRODUCTION

Wetlands are known as biological supermarkets for their biodiversity producing a characteristic rich food web. They are considered as the most productive ecosystems and bio life sanctuaries in the world. Wetlands are globally important ecosystems, occupying 6% of the Earth's surface and supporting approximately 20% of all living organisms (Guoli Song *et al.* 2011; Furlonge *et al.* 2015). The riparian wetlands, are recognized to be important sinks, as filters, retaining heavy metals that can have toxic effects on biota (Zhang*et al.* 2010). Coastal wetlands are comprised of marshes, swamps, mangroves and other coastal plant communities. The wet land ecosystems are, natural guards for the protection of shorelines from erosion, reducing agents of storm pressures, collector of sediment retention, regulators for water quality, preserver of biodiversity, source for carbon sequestration and nutrient recycling (Larson *et al.* 1989; Barbier 1991; IUCN 2004; Brander *et al.* 2006; Vincy *et al.* 2012; Sarkar and Upadhyay 2013). Wetlands are integral part of the global ecosystem as they can prevent or reduce the severity of flood, feed ground water, and provide unique habitats for flora and fauna (Zhang *et al.* 2010). Wetlands exhibit enormous diversity according to their genesis, geographical location, water regime and chemistry, dominant species, and soil and sediment characteristics (Infascelli *et al.* 2013; Bassia *et al.* 2014). Issues related to wetlands degradation, management, restoration have attracted much attention among a wide variety of researchers both on natural and social sciences (Li Xuemei *et al.* 2015).

2. BACKGROUND HISTORY

Coastal district Badin, Sindh, Pakistan, has abundance of Wetlands, a term collectively used for lagoons, small lakes (sweet or saline) and tidal lakes. It has two Ramsar recognized lagoons. Coastal wetlands are nursery grounds for shrimps and fish. They are breeding grounds for migratory birds of Central Asia in winter seasons (Mac Donald 1980; LBOD, 2005; IUCN 2006; EIA 2012; SIDA 2013). The environmental conditions of the coastal district Badin aggravated when mega drainage network system Left bank outfall drain (LBOD) was introduced in 1980s. LBOD, carrier of agriculture run off, industrial and municipal waste water of different districts, passing through wetlands, ends into Arabian Sea (LBOD 2005; Shafique 2007; SIDA 2012). Waste water of LBOD due to poor infrastructure and breeches, before reaching into Arabian Sea, pollutes a lot of wetlands interconnected shallow lake of the coast (IUCN 2004; LBOD 2005; EIA 2012; SIDA 2013; Qureshi and Mastoi 2015). The wetlands get effluents of 15 Sugar mills of four districts including Badin, through different main and link drains during December to march (Shafique, 2007; DDRMP 2007; Qureshi and Mastoi 2015). During these months small fish is found dead. The wetlands of study areas are losing their

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collective potential and ecological activities due to polluted industrial and municipal waste water and sea tidal water **(Fig.1)**. This study intends to investigate quality condition of water of the Wetlands and to identify contaminant sources.

The well-known wetlands(shallow, fresh , saline lakes and lagoon) of coastal area of Badin including, are Nurri (Narerri), Pateji, Shakoor, Cholri, Mehro, Sanhro, Chorhadi, Waryaro, Bakradi, Bakar, Mandhar, Narahi, Dahee, Shaikh Kerio, Phoosna, Charvo, Khango, Jari, Jaffarali, Nira, Soomar, Soomro, Kandri (IUCN 2006; EIA 2012). Most of them have dried and dead. Some of them have been severely degraded due to pollution. Some are being near to dying due to no recharging feeding water. The usage of Arc GIS application is a recent tendency in research. It is extensively used and simply understood in all field.

3. METHODOLOGY

Water samples were collected from twelve (12) different wetlands (shallow fresh and saline lakes and lagoons) near coastal area of district Badin. Samples were collected between 1–2nd September at 10 to 5 pm in 2013. Samples were taken from 1. Mehro Dhandh, 2 Jubho Dhandh, 3 Sanhro Dhandh, 4 Sandho Dhandh, 5 Waryaro Dhandh, 6 Chorhadi Dhandh, 7 Pateji Dhandh,8 Bakradi Dhandh,9 Khana Dhandh,10 Bajorerro Dhandh,11 Kanderri Dhandh,12 Shah-koor Dhandh. All samples were collected in well washed 1.5 L plastic bottles. The Orion 5 Star Conductivity meter (Orion, Inc., Boston, MA, USA) was used to determine Dissolved oxygen. E. C. and TDS were determined by using pre calibrated Orion 115 conductivity meter. Latitude and longitude were recorded using GPS eTrex Legend Garmin. Chlorides, hardness and alkalinity were determined through titration with standard silver nitrate, EDTA, and hydrochloric acid respectively. Ortho-phosphates were determined using spectrophotometer by reducing ascorbic acid method to molybdenum blue. Nitrates were determined brucine method using spectrophotometer (APHA 1989). The concentration of Iron, Copper, Zinc, Cadmium, Nickel, Cobalt, sodium, calcium, magnesium and potassium were determined by Flame Atomic Absorption Spectrophoto-meter (FAAS). Arc GIS software was used for analyzing, mapping and interpretation of data (Baalousha 2011; Arnous and El-Rayes 2013). A point feature showing the position of the sampling area of wetlands was prepared by using coordinates of GPS of the sampling locations. KMZ files were prepared and exported GIS. The result values of water quality were digitized and categorized into different graduated circles with selected colors.

Table 1 Showing the Physico-Chemical Parameters of Wetlands of Coastal Area

1	Sample codes	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	Average
2	Location Names	Mehro Dhandh	Jubho Dhandh	Sanhro Dhandh	Sandho Dhandh	Waryaro Dhandh	Chorhadi Dhandh	Pateji Dhandh	Bakradi Dhandh	Khana Dhandh	Bajorerro Dhandh	Kanderri Dhandh	Shah-koor Dhandh	
3	Latitude	N 24° 22.953	N 24° 17.992	N24° 19.989	N 24° 20.926	N24° 20.904	N 24° 22.281	N24°18.543	N24°20.854	N24°29.025	N24°25.216	N24°18.944	N24°17.771	
4	Longitude	E068 °40.258	E068 °4138 2	E068° 35.582	E068 °47.413	E068 °47.510	E068° 48.176	E068°46 536	E068°46. 071	E068°47. 711	E068°47. 725	E068°59. 771	E069°.04. 756	
Physico-chemical parameters														
5	EC (mS/cm	3.97	4.32	9.45	12.68	0.983	1.010	31.8	96.7	2.49	23	25.21	14.55	18.8
6	TDS (mg/L)	2030	2200	5200	7060	473	488	17700	53760	1230	12900	14200	8130	10447
7	D.O mg/L	5.63	2.3	4.8	7.33	8.56	8.47	3.9	4.6	9.6	7.1	2.6	1.1	5.5
8	Salinity (%)	2.1	2.3	5.3	7.3	0.5	0.5	19.8	70.7	1.3	13.9	15.5	8.5	12.3
9	Chlorides mg/L	897.59	1035	2694.2	3459.92	212.7	311.96	12762	32968	486	7600	9926	4168	6376.7
10	Hardness mg/L	356	358	971	890	220	150	3900	8580	302	2343	2375	1327	1814.3
11	Alkalinity mg/L	300	150	360	280	240	252	140	160	190	200	150	110	211
12	Phosphates mg/L	0.02	0.01	0.48	0.21	0.16	0.27	0.29	0.02	0.45	0.34	0.01	0.22	0.2066
13	Nitrates mg/L	3.9	2.1	3.5	3.1	3.1	3.2	1.2	0.82	5.4	4.6	0.2	2.6	2.81

Table 2 . Showing Physico Chemical Properties of Wetlands of Coastal of Badin

S.No	Sampling Stations													
1	Sample codes	S-1	S-2	S-3	S-4	S-5	S-6	S-7	S-8	S-9	S-10	S-11	S-12	
2	Location Names	Mehro Dhandh	Jubho Dhandh	Sanhro Dhandh	Sandho Dhandh	Waryaro Dhandh	Chorhadi Dhandh	Pateji Dhandh	Bakradi Dhandh	Khana Dhandh	Bajororro Dhandh	Kanderri Dhandh	Shah-koor Dhandh	Average values
3	Latitude	N 24° 22.953	N 24° 17.992	N24° 19.989	N 24° 20.926	N24° 20.904	N 24° 22.281	N24°18.543	N24°20.854	N24°29.025	N24°25.216	N24°18.944	N24°17.771	
4	Longitude	E068 °40.258	E068 °41382	E068° 35.582	E068 °47.413	E068 °47.510	E068° 48.176	E068°46536	E068°46.071	E068°47.711	E068°47.725	E068°59.771	E069°.04.756	
5	Ni (mg/L)	ND	0.024	0.0337	0.0252	ND	ND	0.020	0.016	ND	ND	0.002	0.003	0.0177
6	Cd(mg/L)	0.0340	0.0280	0.0210	0.0684	ND	0.0184	0.0320	0.0020	0.0014	0.0012	ND	0.0212	0.0189
7	Zn (mg/L)	0.0434	0.052	0.0303	0.0296	0.0103	0.0283	0.0462	0.032	0.0284	0.0325	0.026	0.0398	0.0332
8	Cu (mg/L)	0.0659	0.046	0.2723	0.1480	ND	ND	0.136	0.062	0.032	0.052	0.006	0.0430	0.0719
9	Fe (mg/L)	0.0475	0.040	0.314	0.0419	0.0163	0.0294	0.0165	0.0145	0.0268	0.0320	0.0134	0.046	0.0531
10	Na (mg/L)	667.8	690	1529.6	1824	160.6	563	4336	12260	182	3742	4102	1952	2667.4
11	Ca (mg/L)	160	154	180	320	100	180	810	1970	106	492	524	368	447
12	Mg (mg/L)	99	102	247	35	122	43	390	784	78	308	344	135	223.9
13	K (mg/L)	37.6	38	79.6	63.4	24.4	31	185	510	34	128	139	72	111.8

4. RESULT AND DISCUSSIONS

E.C

The results of concentration of E.C are presented with graduated black circles in **(Fig.1).** The size of circles increases as the concentration of E.C increases. The value of conductivity was found to be within 0.98 -96.7mS/cm. The value of EC is high in all sampling locations of wetlands. The sample locations S-5, S-6 are shallow lakes, with fresh water reservoir. Both wetlands are recharged by nearby distributary. Sample location S-8 showed maximum values of conductivity. Results confirmed that sea tidal water reaches wetlands and increases accumulation of salts.

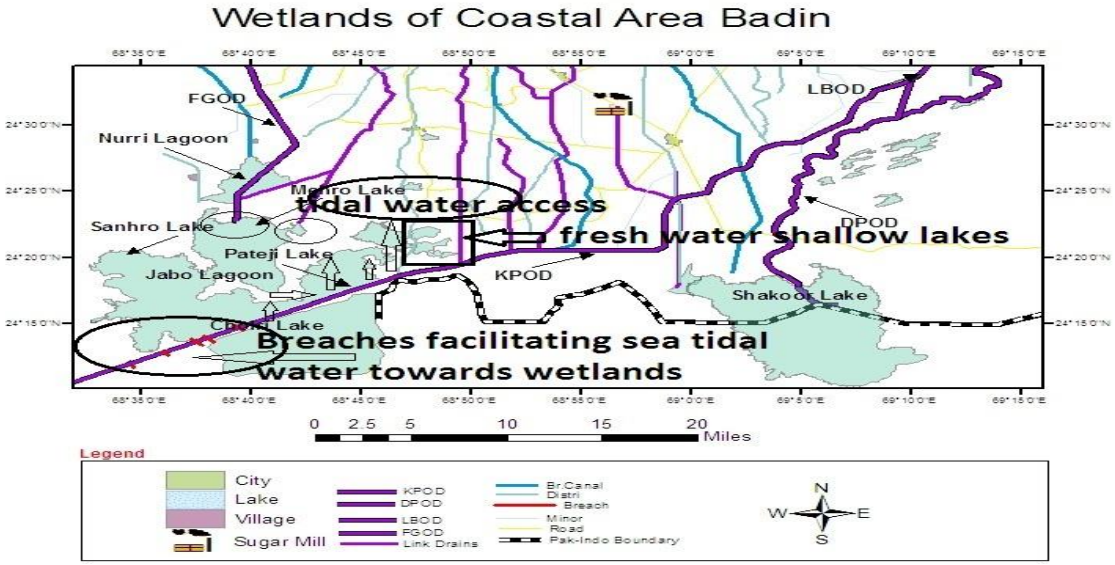

Fig. 1 showing area of study

TDS

The results of concentration of TDS shown in **(Fig. 2)** are represented with graduated black circles. The values of TDS were found to be within range of 473 -53760 mg/L. The low TDS concentration in sample locations S-5(473 mg/L), S-6(488 mg/L) was found. Both shallow lakes are fresh water lakes. Both lakes are being fed by a small distributary. Sample locations S-3,S-4,S-7,S-8,S-10,S-11,S-12 showed high values of TDS than, NEQS (3500 mg/L) for industrial and municipal effluent Pakistan (EIA 2012). Sample site, S-8, was found to be brine in nature (TDS more than 35000 mg/L).It confirms that the area is under Sea tidal water intrusion. It is also confirmed the wetlands were receiving more speedy Sea tidal water through damaged tidal link and cholri weir area.

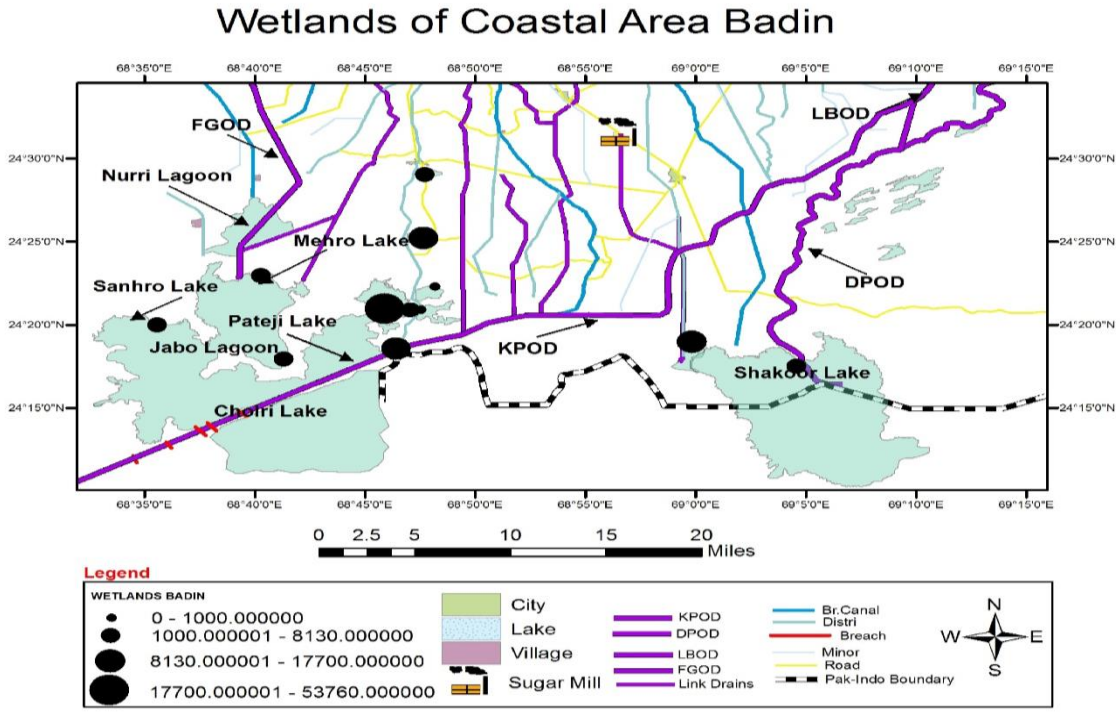

Fig. 2 showing concentration of TDS

Hardness, alkalinity, chlorides, phosphates, nitrates

The results of concentration of hardness and alkalinity as shown in Table 1, were in the range of 150 –8580 and 110-300 mg/L respectively. The results of concentration of Chlorides were found within range of 12.7 – 32968 mg/L. The results of the concentration of phosphates were found in the range of 0.01 -0.48 mg/L. The results of concentration of nitrates were found in the range of 0.2 - 5.4 mg/L. The main source of nitrates in water was agriculture runoff carried by LBOD. The result of Nickel concentration ranged between 0.003 -0.0337 mg/L. Nickel is carcinogenic if present in high concentration. Water pipes, also contribute significant amount of nickel to environment. The nickel in the water can be due to the contamination from municipal sewage sludge, waste water from sewage treatment plants and groundwater near landfill sites.

The results of cadmium ranged between 0.002-0.068 mg/L. Cadmium is very toxic heavy metal for humans as well as environment. The major sources of Cd contaminations are batteries, fertilizers, electroplating, smelting, paint pigments, mining and alloy industries (Iqbal *et al.* 2007). The results of copper concentration ranged from 0.006-0.272 mg/L. Water contamination of copper occurs due to industrial pollution. Copper contamination in drinking water occurs due to corrosion of the copper pipes. Stomach intestinal distress such as nausea, vomiting, diarrhea, and stomach cramps are the health problems associated with copper contamination in water. Copper is also essential, micronutrient and is required by the body in very small amount (Shakirullah *et al.* 2005; WHO 1993; Farid *et al.* 2012). The results of Iron concentration as ranging from 0.0134- 0.314 mg/L. Results of Na, Ca, Mg, and K concentration of as shown in table 1, were 160.6- 4336, 100 -1970, 35- 784, 24.4 - 510 mg/L respectively. Sodium, calcium, magnesium, and potassium were found in following order Na> Ca> Mg> K.

5. CONCLUSION

It was concluded that extremely alarming values of E.C and TDS indicated that wetlands have been polluted by Sea tidal water. Saline intrusion by sea tidal water was found to be major source for the contribution of contamination to interconnected wetlands of coastal areas of district Badin. The concentration of phosphates and nitrates was contributed by LBOD as carrying agriculture run off too. It was observed that wetlands were not properly charged with fresh water,hence wetlands were lacking in vegetaion and losing importance for water fowl. Wetlaands were no more found sound for breeding fish and shrimps.The damaged cholri weir and tidal link has facilitated speedy water of sea tides into interconnected wetlands.Alarming situation indicated by E.C. and TDS confirms that more fertile lands will turn into barren in future.It is very imortant that these wetlands should be recharged by fresh water and protected from tidal water intrusion ,in order to save ecology of wetlands.The present study concluded that wetlands of study area were partially polluted with heavy metals contributed by mega drains like LBOD, KPOD. It was also concluded that wetlands were playing role as heavy metal pollution sink, huge quantity of water dilute the heavy metal concentration carried by LBOD.

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