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Variation in Physico-chemical Characteristics of Water Quality of Bhindawas Wetland, Jhajjar, Haryana, India

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Abstract

Present study was carried out to find spatial and temporal variation in the water quality of Bhindawas wetland and its recipient drain No. 8 at two month intervals over one year period from July 2010 to may 2011. Total nine sampling sites were selected from the study area. Seven sites selected from various parts of wetland, including wetland inlet and outlet. In addition, two sites were selected from drain no.8, which is adjacent to a wetland and a recipient of wetland outlet water. Range of pH, temperature, electrical conductivity, total dissolved solids, total suspended solids and turbidity varied from 6.45-8.26, 14-35.4ºC, 216-1963 µmho/cm, 142-1282 mg/l, 7.8-94mg/l and 4-62 NTU, respectively. Cationic concentration, viz. sodium, potassium˙ calcium and magnesium varied from 16-102, 2-63, 14-131 and 4-60 mg/l, respectively. Whereas, anionic concentration, viz. bicarbonate, chloride and sulphate varied from 48-666, 9-199 and 25-187 mg/l, respectively. Variation in dissolved oxygen was from 2.8 to 8.6 mg/l. Variation in total phosphorus, ammonia, nitrate, total alkalinity and total hardness were in the range of from below detection limit (BDL)-0.99, BDL-0.69, BDL-2.04, 40-576 and 54-576 mg/l, respectively. Heavy metals like copper, nickel, lead and total chromium were found below detection limit (BDL).

Keywords: Water quality, Heavy metals, Bhindawas wetland.

Introduction

Wetlands are categorized as inland and coastal. In addition to these, man-made wetlands have also been included under wetland classes. History showed that surface water resources have played an important role in development of human civilization. Wetlands are probably the earth's most important fresh water resources which provide food and habitat for many aquatic lives including threatened and endangered species[1]. Increased industrialization, urbanization and agricultural activities during the last few decades have deteriorated the surface and groundwater quality[2]. Nutrients loading in aquatic ecosystem are enhanced by agricultural development[3]. The runoff from agricultural fields is an important source of nutrients that affect water quality, biodiversity, and disturbed the functioning of the receiving water bodies[4,5]. Human activities of different types therefore create threats for many of the world's wetlands. Long-term nutrient retention in wetlands is mediated by accretion of new sediments above the soil surface, due to settling of particulate organic and inorganic materials. Wetland vegetation, water flow and wind are the controlling factors for suspended sediment flux within wetland[6]. Wetland vegetation decrease water velocity decreases the turbulence intensity and also directly traps suspended sediment on stems and leaves[7].

India is rich in wetlands wealth; they are distributed all over the country. Varying estimates of wetland area have been given by different agencies. Ministry of Environment and Forests, Govt. of India estimated that wetlands occupy about 4.1 million hectares (ha) area, excluding mangroves in the country[8]. Where Space Application Centre, Ahmedabad estimated the wetland area in the country about 8.27 million hectares by using satellite remote sensing data. This excludes paddies and river/canals. Out of these, 4.02 million hectares wetlands area is inland[9]. Wetland status of Haryana in terms of open water and aquatic vegetation estimated around 14216 ha and 2245 ha, respectively[10]. A number of studies have been carried out on physico-chemical and heavy metals status of freshwater water bodies[11-15].

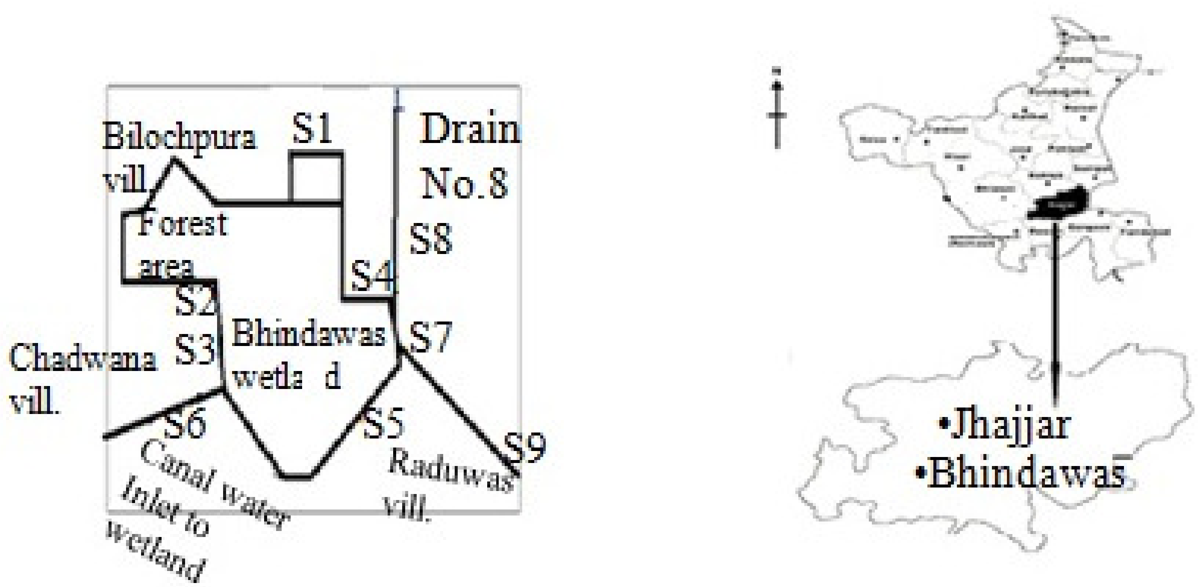
However, there is no information available regarding the water quality of Bhindawas wetland, which is the largest water body in the Haryana state and now converted in to the eutrophic lake. Keeping in view of degradation of water quality of Bhindawas wetland the present study was undertaken to find out the variation in water quality, heavy metals content in the wetland at different time intervals from July 2010 to May 2011.

Material and Methods

Study Area and Sampling Location: Bhindawas bird sanctuary is a low-lying area in district Jhajjar (Haryana). It is located 15 Km away from Jhajjar district headquarters and 80 Km from Delhi located at 76^0 31' East and 28^0 32' West. Map of Bhindawas wetland showed in figure 1. Mean minimum and maximum temperature are 7˚C (January) and 40.5˚C (May & June), whereas mean annual rainfall is 444 mm in the study area. Birds are the main attraction of the wetland complex. More than 30,000 varieties of migratory birds belonging to over 250 species and resident birds visit the wetland throughout the year. The sanctuary is spread over an area of 1074 acres. The peripheral embankment was man-made and basically constructed to store the escaped water of the Jawaharlal Nehru Canal through an escape channel at the time of power failure in the Pump House made on the canal. Excess water of the wetland is siphoned off in the drain No. 8 through outlet channel. Drain No. 8 is a recipient of storm water as well as sewage, because some of the towns have a combined system of disposal for sewage and storm water.

Water sampling and Analysis: A total of nine sites were selected for sampling, seven sites were marked from wetland, including inlet and outlet of wetland and two sites marked on the drain No. 8 (figure-1). The study was carried for a period of one year (July 2010 to May 2011). Samples of water were collected in July before the monsoon rains, September, November, January, March and May 2011 at two months interval. A total of fifty four samples were collected during the study period. Sites S1, S2, S3, S4, and S5 were located within a wetland and shows in figure-1. Site S6 was selected on canal water channel inlet to wetland before it meets with the wetland. Site S7 was located on outlet point before joining point with drain No. 8. Site S8 was located on drain no. 8, upstream of the joining point of outlet. Site S9 was located on drain No. 8 downstream of the joining point of outlet.

An integrated sample of the site was prepared by mixing of triplicates samples collected from site. From each site, at two months interval field data like temperature, dissolved oxygen and pH were measured in the forenoon at the sites. Surface water temperatures were measured using a thermometer. Electrical conductivity and pH were measured using Systonic soil and water testing kit. Dissolved oxygen was measured by the modified Winkler's method. For the analysis of other parameters, surface water samples were collected in clean Jerry cans and kept in an ice box and transported immediately to the laboratory. The water samples were filtered using a Millipore filtering system and physico-chemical parameter, viz. total suspended solids (TSS), total dissolved solids (TDS), turbidity, sodium (Na^+), potassium (K^+), chloride (Cl^{-1}), total alkalinity (TA), bicarbonate (HCO_3^{-1}), total hardness (TH), calcium (Ca^{2+}), magnesium (Mg^{2+}), sulphate (SO_4^{-2}), total phosphate (PO_4), ammonia (NH_3) and nitrate (NO_3) were analyzed according with Standard Methods of Examination of Water and Waste as prescribed by the American Public Health Association[16]. Concentrations of metals (µg/l) in all the samples were measured by Z-6100 polarized Zeeman atomic absorption spectrophotometer (Hitachi). Pb was measured at a wavelength of 217 nm, Ni at 232.0 nm, Cd at 228.8 nm, Fe at 248.3 nm, Zn at 213.9nm, Cr at 357.9 and Cu at 324.8 nm. The minimum concentrations of metals that could be detected were 10 µg/l for each metal. The significant of correlations between means of different water parameters were calculated by SPSS software.



S1=Near Bilochpura village
S2=Between Bilochpura and Chadwana village
S3=Near Chadwana village
S4=Near Sahajapur village
S5=Near Raduwas village
S6=Wetland inlet
S7=Wetland outlet
S8=Drain No.8 upstream to wetland
S9=Drain No.8 downstream to wetland

Figure-1
Map of study area showing the location of sampling sites

Results and Discussion

Variation in pH, Temperature, Electrical Conductivity and Total Dissolved Solids: The pH, Temperature, electrical conductivity (EC) and total dissolved solids (TDS) content showed the significant spatial and temporal variations. Temporal ranges of different water parameters at various sites have been mentioned in table-1. In terms of pH 83% samples were alkaline and 17% samples were acidic in nature. Maximum pH value was 8.26 during January 2011 at S3 site and minimum was 6.45 during July 2010 at S9 site. The fluctuations in pH during different seasons of the year could be due to the consequences of flood in year 2010 and removal of CO_2 by photosynthesis. Reduction in pH during the summer season (July) could be due to higher rates of organic material decomposition[17]. The maximum temperature was 35.4ºC during the month of July at sampling site S5 and minimum 14ºC during the month of January at sampling sites S1 and S8. Generally, intensity of solar radiation and evaporation influenced the surface water temperature. The recorded highest value during the summer could be attributed by high solar radiation[18,19]. Variations in EC and TDS were observed, minimum 216 µmho/cm and 164 mg/l during the month of July at S6 (inlet to the lake) site and maximum were found 1963 µmho/cm and 1282 mg/l, respectively during the January at S8 (drain No. 8 upstream to lake outlet) site. The reason for the fluctuation in EC and TDS could be due to the runoff water received by wetland from the surrounding area during monsoon season. Correlation analysis revealed that pH was significantly negatively correlated with phosphorus and zinc and significantly positively correlated with dissolved oxygen with r value of 0.743. The highest value of correlation was observed between EC and TDS (r=1) could be due to the fact that conductivity depends on total dissolved solids. TDS also showed the significantly positively correlated with anions (r values between TDS and Na^+, K^+, Ca^{2+}, Mg^{2+} were 0.937, 0.895, 0.958 and 0.944) and cations species (r values between TDS and Cl^-, HCO_3, SO_4 were 0.953, 0.878 and 0.897).

Variation in Turbidity and Total Suspended Solid (TSS): Turbidity and TSS concentration in the wetland depends on the seasons and the anthropogenic activities at different sites. Temporal ranges of turbidity and TSS have been given in table 1. Minimum turbidity and TSS were 4 NTU and 7.8 mg/l at S3 site during the month of March and maximum 62 NTU and 94 mg/l at S7 site during the month of September, respectively. Turbidity showed the significant positive correlation with TSS (r= 0.922).

Variation in Cationic Concentration: Mainly Na^+, $K^{+,}$ Ca^{2+} and Mg^{2+} contribute the cations. The dominance of cations during the study period were found in the order; Na > Ca > Mg > K. The cationic concentration viz. Na^+, $K^{+,}$ Ca^{2+} and Mg^{2+} were ranged from 16 to 102 mg/l, 2 to 63 mg/l, 14 to 131 mg/l and 4 to 60 mg/l, respectively (table-1). The highest value of Na^+ cation was observed in September (S3 site), K^+, Ca^{2+} and Mg^{2+} in May (S1 site), while lowest values of Na^+, K^+, Ca^{2+} and Mg^{2+} were observed during July (S1, S7, S6 and S2 sites), respectively. Solubility of potassium is lesser than sodium in most of the water bodies, due to its greater resistance to weathering and formation of clay minerals. Because of its low solubility, its concentration is much lower than Na[20]. Calcium serves a primary role in the carbonate buffering of aquatic ecosystems. It occurs in water in ionic form and as suspended particulates, mainly $CaCO_3$[21]. Although it is the predominant compound in many interior waters, $CaCO_3$, is also one of the least soluble. Only a small amount can be dissolved in pure water, but in the presence of carbonic acid it is mobilized as the soluble $Ca(HCO_3)_2$[22]. Sodium and potassium were significantly positively correlated with calcium, bicarbonate and nitrate.

Variation in Anionic concentration: Mainly CO_3^{-2}, HCO_3^{-1}, Cl^{-1} and SO_4^{-2} contribute the anions in water. Results have been shown in table-1. Carbonates were absent during the study period. Values of other anions viz. HCO_3^{-1}, Cl^{-1} and SO_4^{-2} were varied from 48 to 666 mg/l, 9 to 199 mg/l and 25 to 187 mg/l, respectively (table-1). The highest contents of HCO_3^{-1}, Cl^{-1} and SO_4^{-2} were observed during May, January, September at S1, S8, S3 sites and lowest contents of HCO_3^{-1} and Cl^{-1} were observed during July at S6 and S1, where SO_4^{-2} showed during the month of May at S6 site, respectively. Anion chemistry shows bicarbonate was abundantly present in most of samples. Bicarbonates are the most common in water, since they are formed by the action of carbon dioxide on the basic material such as the salts of calcium and potassium in the soil. Source of sulphate in water is the biological oxidation of sulphur compounds. The excess amount of sulphate (more than 600 mg/l) in drinking water cause a cathartic effects in living organisms[23]. Chloride was observed significantly positively correlated with K (r=0.846), Ca (r=0.942), Fe (r=0.798), Na(r=0.934) and Mg (r=0.891), whereas bicarbonate was significantly positively correlated with Na (r=0.628), K (r=0.950), Ca (r=0.920), Mg (r= 0.960) and Cl (0.777). Sulphate was also significantly positively correlated with Na (r= 0.871), K (r= 0.66), Ca (r= 0.796), Mg (r= 0.744), TH (r= 0.778) and HCO_3 (r=0.702).

Variation in Dissolved Oxygen: The dissolved oxygen (DO) in water is either due to atmospheric diffusion or due to photosynthetic activity of aquatic plants. Dissolved oxygen in water gets depleted by organic and inorganic enrichment from external source. The rate of dissolution is also varies with temperature. In the present study dissolved oxygen level recorded from 2.8 mg/l in July at S9 site to 8.6 mg/l in January at S6 site (table-1). Chakraborty et al.[24] observed the higher concentration of DO level (5.6 mg l^{-1}) in the coastal waters of South Andaman, India during the winter season. Similarly, in the present study dissolved oxygen level was higher during January and lower during July; it could due to a presence of lower temperature in January month. Dissolved oxygen was generally well aerated along the canal water inlet to the lake (S6) and showed the higher level. Whereas, lower concentration of DO was observed in drain No.8, it could due to the consequence of organic pollutant. Dissolved oxygen level above 5 mg/l rarely harmful to aquatic life, whereas concentration below 2 mg/l is considered a hypoxia threshold[25]. Oxygen was significantly negatively correlated with TH (r= -0.671) and phosphorus (r= -0.699).

Variation in Total Phosphorus: The major sources of phosphorus are domestic sewage, detergent, agriculture effluents with processes. During the study period variation in phosphorus was observed from BDL (below detection limit) in September at S1site to 0.99 mg/l in July at S8 site (drain No. 8) (table-1). Drain No.8 was recipient of agricultural runoff and sewage effluent of some urban area, which contributed the higher phosphorus in drainage water. Phosphorus value was higher during the summer season in Bhindawas wetland, generally influenced by higher evaporation rates in summer season, which concentrate the waters phosphorus, whereas in monsoon season wetland waters were diluted by rain waters. Smith et al.[26] categorized the water bodies on the bases of presence of total phosphorus. They demonstrated that the mean total phosphorus concentration less than 0.010 mg/l is characterized as oligotrophic status, ranging from 0.010 to 0.030 mg/l is mesotrophic status, ranging from 0.030 to 0.040 mg/l is eutrophic status, and more than 0.040 mg/l is hypertrophic status. The temporal means of total phosphorus level for the wetland as well as drain No.8 were higher. All the sampling stations shown more than 0.040 mg/l, which revealed that wetland and drain were hypertrophic in nature.

Variation in Ammonia and Nitrate: The ammonification of the organic matter is the most important source of ammonia. In present study ammonia was found (table-1) from BDL (below detection Limit) during July, March and May at all the sites, while some sampling sites during September, November and January also showed the BDL concentration. Absence of ammonia in July, March and May at all the sites, could be due to the ammonia oxidizing micro-organisms were highly active in summer season, which convert the ammonia in to the nitrite and then nitrate. The maximum concentration of ammonia was 0.69 mg/l in November at S3 site. The biological oxidation of organic nitrogenous substances is the most important source of the nitrate. While other source of nitrate in water includes runoff from agricultural fields and atmospheric nitrogen fixation by the nitrogen fixing organism. Nitrate recorded from BDL during July at S4 and S8 site to 2.04 mg/l during September at S8 site, respectively (Table 1). Ammonia was positively correlated with alkalinity (r=0.787).

Variation in Total Alkalinity and Total Hardness: Most of the alkalinity in natural waters is formed due to dissolution of carbon dioxide in water. Carbonates and bicarbonate thus formed, are dissociates to yield hydroxyl ions. During the study period, total alkalinity and total hardness were recorded from 40 to 576 mg/l and 54 to 576 mg/l, respectively (table-1). The lowest contents of total alkalinity and total hardness were found during July at S6 and S2 sites and highest values were during March and May at S1 site, respectively. Wetzel[27] demonstrated that the high alkalinity values are indicative of the eutrophic nature of the lake and it might be due to the presence of excess of CO_2 produced as a result of decomposition processes. Total hardness was significantly positively correlated with HCO_3 (r=0.939), alkalinity (r=0.912), K (r=0.929), Ca (r=0.995), Cl (r=0.934) and Mg (r=0.993).

Variation in the Heavy Metals: The study area is surrounded by agriculture field, while drain no. 8 is recipient of urban sewages and storm water. Keshin[28] demonstrated that fertilizers and pesticides used in agricultural activities cause the lead (Pb) and mercury (Hg) pollution in Eskipazar, Turkey. Whereas, Pattaih and Kiran[29] reported higher concentrations of heavy metals (Cu, Zn, Pb, Cd and Ni) than WHO standards in Jannapura lake, Karnataka, which received untreated domestic wastewater from residential area. So, it was hypothesized that significant quantities of heavy metals got transported through the agricultural runoff containing residues of organo-metallic in wetland and urban sewages in drain. But during the study period the heavy metal like copper, nickel, lead and total chromium were found BDL (below Detection limit) throughout the study period, whereas Iron and zinc were present in all the samples. Variation in zinc of different months at different sampling sites was (Table 1) from 10µg/l during January at S2 to 64 µg/l during July at S5 site. Iron was found from 38 µg/l in July at S1 to 1241 µg/l in January at S8 (table-1). The results are good agreement with study of Ahmad et al.[30], who reported the lower concentration of heavy metals in water of wadi Namar dam lake, Soudi Arabia. Iron was significantly positively correlated with Cl and pH, whereas zinc was significantly positively correlated with phosphorus.

Conclusion

Water quality of Bhindawas wetland showed the higher concentration of TDS, turbidity, total phosphorus and nitrate during the study. The ionic concentration in the wetland water was higher during the rainy season, while it was lower at the water inlet to wetland (site 6). Water quality of drain No. 8 was degraded than wetland and improved by the dilution from the wetland outlet. The concentration of phosphorus indicated that the wetland is hypertrophicated. The present work on water quality helps in better understanding of variation in water quality parameters at bimonthly intervals in this wetland system. These results could be used in future for the formulation of restoration, conservation and management programs. The present work suggests desiltation of the Bhindawas wetland, managing the growth of weed species in the lake scientifically and proper development of outlet of wetland based on the siphon system may be prevent the water entry from the drain. Deweeding should be practiced at regular interval to control the nutrients level and silt deposition.

Table-1
Temporal ranges (n= 6) of the water physico-chemical parameters in Bhindawas wetland (July 2010 to May 2011)

Parameters	S1	S2	S3	S4	S5	S6	S7	S8	S9
pH	6.62-8.2	6.96- 7.68	6.5- 8.26	6.83- 8.18	7.11- 7.9	6.82- 8.24	6.78- 7.78	6.7- 7.45	6.45- 7.75
Temp.	14 – 35.2	16.2- 35	14.5- 35.2	15 - 34.8	14.5 - 35.4	14.5- 35.4	15.5- 34.8	14 - 34.8	14.5- 34.6
EC	3 41-1319	286 - 923	334 - 1577	272 - 687	247 - 718	216–845	360 - 680	376 - 1963	349 - 962
Turbidity	8 - 29	12 - 12	4 - 27	5 - 42	8 - 60	13 - 42	5 - 62	7 - 40	7 - 27
TSS	12-60	19 - 48	8 - 72	9 - 74	10 - 83	25 - 86	9 - 94	10 - 68	9 - 58
TDS	224-875	188 - 608	226 - 1030	179 - 448	161 - 472	142 - 565	237 - 446	246 - 1282	230 - 607
Na^+	18-98	22 - 101	16 - 102	25 - 46	20 – 60	18 - 95	26 - 48	35 - 102	28 - 72
K^+	7-30	6 – 33	8 – 45	6 – 30	5 – 34	4 – 25	2 – 40	8 – 42	5 –38
Ca^{2+}	17-131	15 - 56	16 - 68	15 - 66	18 - 42	14 - 45	19 - 82	17 - 95	20 - 62
Mg^{2+}	8-60	4 - 21	9 - 46	7- 28	9 - 24	5 - 17	12 - 28	8 - 45	9 - 26
Cl^{-1}	9 –106	10-88	22 – 123	10 – 101	14 – 81	11 – 121	14 – 117	13 – 199	20 – 158
HCO_3^{-1}	100–666	92 – 256	90 – 368	73 – 248	83 – 195	48 – 183	109 – 317	122 – 473	112 – 329
Alk.	81-576	76 - 210	74 - 302	60 - 204	68 - 106	40 - 150	90 - 260	100 - 338	92 - 270
TH	67-576	54 - 226	85 - 359	65 - 280	94 - 203	56 - 182	97 - 322	75 - 422	87 – 304
DO	5.2–8	4.6 – 6.8	4.2 – 7.4	5.4 – 6.8	4.6 - 8	6.2 – 8.6	3.6 - 7	3.2 – 6.1	2.8 – 6.8
SO_4^{-2}	27–142	27 – 125	28– 187	33 – 69	26 – 78	25 – 126	34 – 81	45 – 123	41 – 95
PO_4	BDL– 0.74	0.03–0.75	0.06 – 0.97	0.04–0.89	0.10–0.90	0.10–0.7	0.03 – 0.74	0.06–0.99	0.11–0.95
NH_3	BDL–0.51	BDL – 0.41	BDL – 0.69	BDL – 0.33	BDL – 0.21	BDL – 0.21	BDL – 0.36	BDL – 0.36	BDL – 0.64
NO_3^-	0.08–1.12	0.11–0.75	0.17–1.02	BDL – 0.88	0.14–0.83	0.18–0.88	0.14 – 0.59	BDL – 2.04	0.70–0.85
Fe	38 – 299	54 – 240	73 – 512	101 – 273	105 – 242	73 – 744	102 – 645	132–1214	94–477
Zn	14 – 45	10 – 56	16 – 51	12 – 43	13 – 64	14 – 53	11 – 56	20 – 58	13 – 62
Cu, Ni, Pb, Cr (µg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

All parameter in mg/l, except Temp.:ºC, EC: µ mho/cm, Turbidity: NTU, Fe, Zn, Cu, Ni, Pb, Cr: µg/ l, BDL: below detection limit, S1 to S9 are sampling sites

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