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Original Research Paper

Variations in Hydrochemical Characteristics of Two Distinct Wetlands of Central Gujarat, India

J. I. Nirmal Kumar and Cini Oommen
P.G. Department of Environmental Science and Technology, Institute of Science and Technology for Advanced Studies and Research (ISTAR), Vallabh Vidyanagar-388 120, Gujarat

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Correlation coefficients

ABSTRACT

An assessment of hydrochemical parameters was carried out in two distinguishing wetlands of central Gujarat, India for the period of one year from June 2007 to May 2008. Water quality parameters like temperature, pH, dissolved oxygen, Secchi depth, total solids and total dissolved and suspended solids, free carbon dioxide, phenolphthalein alkalinity, total alkalinity, carbonates, bicarbonates, total hardness, calcium and magnesium hardness, chloride, phosphate, sulphate and nitrate were investigated during the study period. Chloride, phosphate, sulphate and nitrate of water were greater in Khodiyar than Malwar wetland because of high wastes and sewage inflow. Moreover, monthly variation of hydrochemical characters was found higher during summer and lower during monsoon months in both the wetlands. Correlation coefficients were calculated among the various physico-chemical variables. Sulphate and nitrate showed a positive correlation with phosphate at Khodiyar, whereas sulphate and chloride correlated positively with nitrate at Malwar wetland. Dissolved oxygen showed a negative correlation with temperature, phosphate and other parameters in both the wetlands.

INTRODUCTION

Wetlands are important habitats because small-scale heterogeneity in hydrology and soil conditions results in a wide variety of ecological niches (Silvertown et al. 1999). They are of ecological importance due to their hydrologic attributes and their role as ecotones between terrestrial and aquatic systems. The attributes of wetlands include high productivity, sources, sinks and transformers of numerous chemical, biological and genetic materials, and valuable habitats for fisheries, wildlife and birds (Shaltout & Al-Sodany 2008). Wetland ecosystems are among the most productive ecosystems in the biosphere. High microbial and macrophytes productivity in wetlands can be attributed partly to adequate water supply, high organic matter loading, and high sediment nutrient and organic matter concentrations. Wetlands serve important biological, environmental quality and socio-functions such as flood storage, ground-water recharge, sediment trapping, retention and removal of nutrients and pollutants, and wildlife and recreational habitat (Metzler & Tiner 1992, Tiner 1998).

Wetlands are of inestimable value for the supply of goods and services to society (Mitsch & Gosselink 2000) but they are threatened globally (Maltby 1991). Conservation associations worldwide have noted and described the alarming changes in these important habitats. This led to the convention on wetlands known as Ramsar Convention (Shaltout & Al-Sodany 2008). Although there are general guidelines for the successful establishment and maintenance of wetlands (Mitsch & Gosselink 1993, Roggeri 1995), there is no formal concrete definition of good water quality for wetland lakes. Rather, the functional characteristics of a particular wetland lake are generally used to ascribe qualitative definitions of water quality suitability for particular ecological or environmental

components. Knowledge of wetland hydrology is essential to understanding, quantifying, and evaluating wetland functions and processes (Howard-Williams 1985, Carter 1986). Thus, the present piece of study is focused on variations in hydrochemical characters of two significant wetlands of central Gujarat named Khodiar and Malwar. Location of the wetlands is shown in Fig. 1.

Wetlands are gradually gaining attention worldwide, considerable work is being carried out on wetlands in various countries of the world. In recent past Martin Merino-Ibarra et al. (2007) studied physical and chemical limnology of a wind-swept tropical highland reservoir. Mitsuru Hirota et al. (2007) emphasized net primary productivity and spatial distribution of vegetation in an alpine wetland, Qinghai-Tibetan Plateau. Hambright et al. (1998) carried out general water chemistry and quality in a newly-created subtropical wetland lake. In Gujarat state, Rana & Nirmal Kumar (1992) and Nirmal Kumar et al. (2005, 2008) explored physico-chemical characteristics of water and sediments, diversity of macrophytes and planktons of certain wetlands of central Gujarat. Nirmal Kumar & Shailendra Viyol (2008) studied the influence of hydrogeochemistry on methane emission from two tropical wetlands of central Gujarat.

STUDY AREA

Khodiyar Wetland: Sewage and domestic wastewaters of Anand and Vallabh Vidyanagar townships are accumulated at one place and formed this permanent wetland. It is situated 5-8 kms away from Anand town and is a shallow highly organically polluted pond having a depth of 2-4 feet, occupying 800 ha area. The distinguishing hydro and geochemical properties of the wetland, caused due to the sewage received, makes it an important bird area (IBA). However, this wetland is supported by abundant aquatic vegetation; *Eichhornia crassipes* a free floating, *Ipomoea aquatica* root submerged floating and *Typha latifolia* a marshy species are mostly dominant round the year. Besides, the wetland is a host to a large number of resident and migratory birds like flamingoes, egrets, shelducks, purple moorhens, white and black ibises; pheasant tailed and bronze winged jacana, sarus cranes, etc. This water body is surrounded by Khodiyar village and Hanumanji temple which is frequently visited by the devotees.

Malwar Wetland: It is located about 7 kms from Anand near Kanjari-Boriyavi railway station. It is a natural wetland which collects runoff water from nearby areas during monsoon. The wetland is

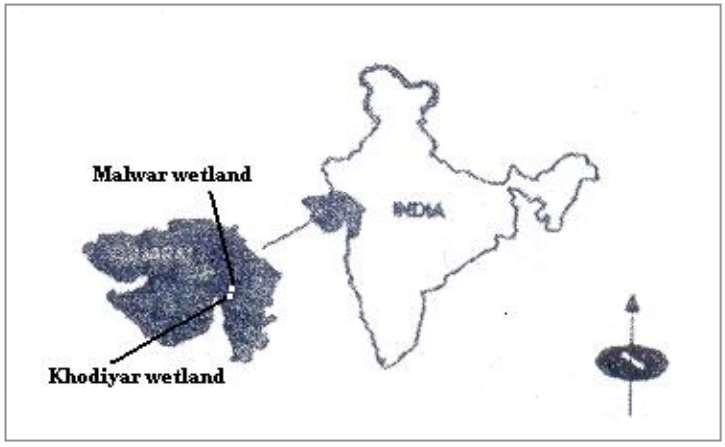

Fig. 1: Location of Khodiyar and Malwar wetlands.

surrounded by two villages namely Kanjari and Boriyavi and receives waste from both the villages. The wetland is 5 ft deep, covers an area of 30 ha and is dominated by aquatic species *Potomogeton*, *Eichhornia crassipes* and *Azolla*. An important fuse and ceramic tile factory, Ravikiran Ceramics Pvt. Ltd. is located near the wetland, which dumps its waste into it. This renders interesting hydro and geochemical properties to the wetland. A temple is also located at the outskirts of the wetland. The wetland is also host of varied avifauna like purple moorhens, white and black ibises, cormorants, and pheasant tailed jacana.

MATERIALS AND METHODS

Hydrochemical monitoring of the wetlands consisted of monthly sampling from June 2007 to May 2008 from two stations in both the wetlands. All sampling was conducted between 07:00 and 10:00 hour local time. The collected sample waters were placed into 2-L plastic bottles, stored in ice box and transported to the laboratory within 2 hours where they were processed according to standard methods specific for each parameter (APHA 1998, Trivedy & Goel 1987). Physical parameters like pH, temperature, Secchi-disc transparency and dissolved oxygen (DO) were performed in the field. The rest of the parameters like total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), free carbon dioxide, phenolphthalein alkalinity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, phosphate, sulphate and nitrate were analysed in the laboratory.

RESULTS

Hydrochemical characters of Khodiyar wetland: The hydrochemical parameters of Khodiyar wetland are shown in Figs. 2 and 3 for Sites 1 and 2. Water temperature varied between 12°C and 31°C during the study period. Maximum water temperature of 31°C was found in the month of May 2008 at Site 2, while the minimum temperature in the month of January 2008 at Site 2. Values for pH remained close to neutral throughout the investigated period but highest value of 8.0 was observed in the month of May at Site 2. Dissolved oxygen varied between 1.60 mg/L and 4.83 mg/L at Site 2 in May and January, respectively. Total hardness ranged between 182 mg/L and 678 mg/L, lowest being at Site 1 in October and highest at Site 2 in December. The lower and higher values of calcium hardness were measured as 71.40 mg/L in October and 329.7 mg/L at Site 1 in December, respectively. Magnesium hardness ranged between a minimum of 110.60 mg/L at Site 1 in October 2007 and a maximum of 443.3 mg/L at Site 1 in April. The lowest concentration of chloride was measured as 28.40 mg/L in September at Site 1, and highest as 320.92 mg/L in March at Site 2. The total phosphorus varied between 1.75 and 6.65 mg/L, the lowest in month of February at Site 1, and the highest in May at Site 2. Sulphate concentration ranged between a lowest of 14.50 mg/L at Site 1 in September and highest of 114.45 mg/L at Site 1 in December. The lowest and highest values of nitrate were 0.15 mg/L in May at Site 2 and 0.33 mg/L in September at Site 1 respectively. The values of hydrochemical properties were higher at Site 1 as compared to Site 2, whereas monthly variations revealed that the greater values were during summer months.

Correlation coefficient analysis showed that at Site 1, temperature correlated positively with phosphate (0.087). Phosphate showed positive correlation with sulphate (0.401) and nitrate (0.006). However, DO correlated negatively with temperature (-0.746) and phosphate (-0.365). At Site 2, temperature and pH correlated positively (0.531). Also phosphate and sulphate correlated positively with temperature (0.146 and 0.370 respectively). At this site also, DO correlated negatively with temperature (-0.721) and phosphate (-0.121).

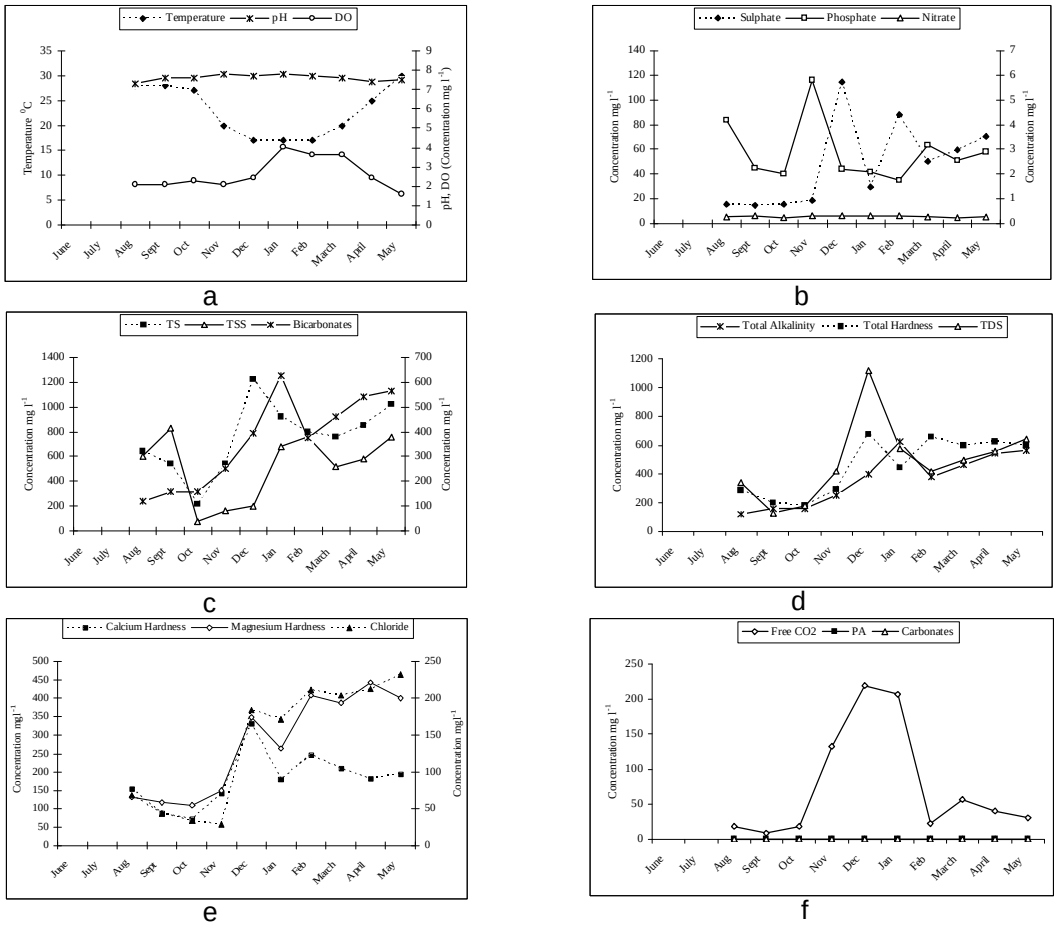

Fig 2: Monthly variation in hydrochemical parameters in Khodiyar wetland from June 2007 to May 2008 at Site 1.

Hydrochemical characteristics of Malwar wetland: The hydrochemical parameters of Malwar wetland have been shown in Figs. 4 and 5 for Site 1 and 2. Water temperature varied between 18°C and 30°C during the study period. Maximum temperature of 30°C was achieved in the month of May 2008 at Site 2, while the minimum in the month of January and February 2008 at Site 1. Values for pH remained close to neutral throughout the investigation period but highest value of 8.1 was observed in the month of May at Site 2. Dissolved oxygen varied between 2.01 mg/L at Site 2 in May and 7.2 mg/L at Site 1 in January, respectively. Total hardness ranged between 200 mg/L and 464 mg/L, lowest being at Site 1 in September and highest at Site 2 in February. The lowest and highest values of calcium hardness were recorded as 73.5 mg/L in September and 153.3 mg/L at Site 1 in May, respectively. Magnesium hardness ranged between a minimum of 124.4 mg/L at Site 1 in September and a maximum of 333.8 mg/L at Site 2 in February. The lowest concentration of chloride was achieved as 89.46 mg/L in September at Site 2 and highest as 336.54 mg/L in May at Site 1. The total phosphorus varied between 0.01 and 2.21 mg/L being lowest in month of December at Site 1 and the maximum in October at Site 1. Sulphate concentration ranged between a lowest of 11.97 mg/L at Site 2 in October and highest of 82.61 mg/L at Site 2 in May. The lowest and highest values

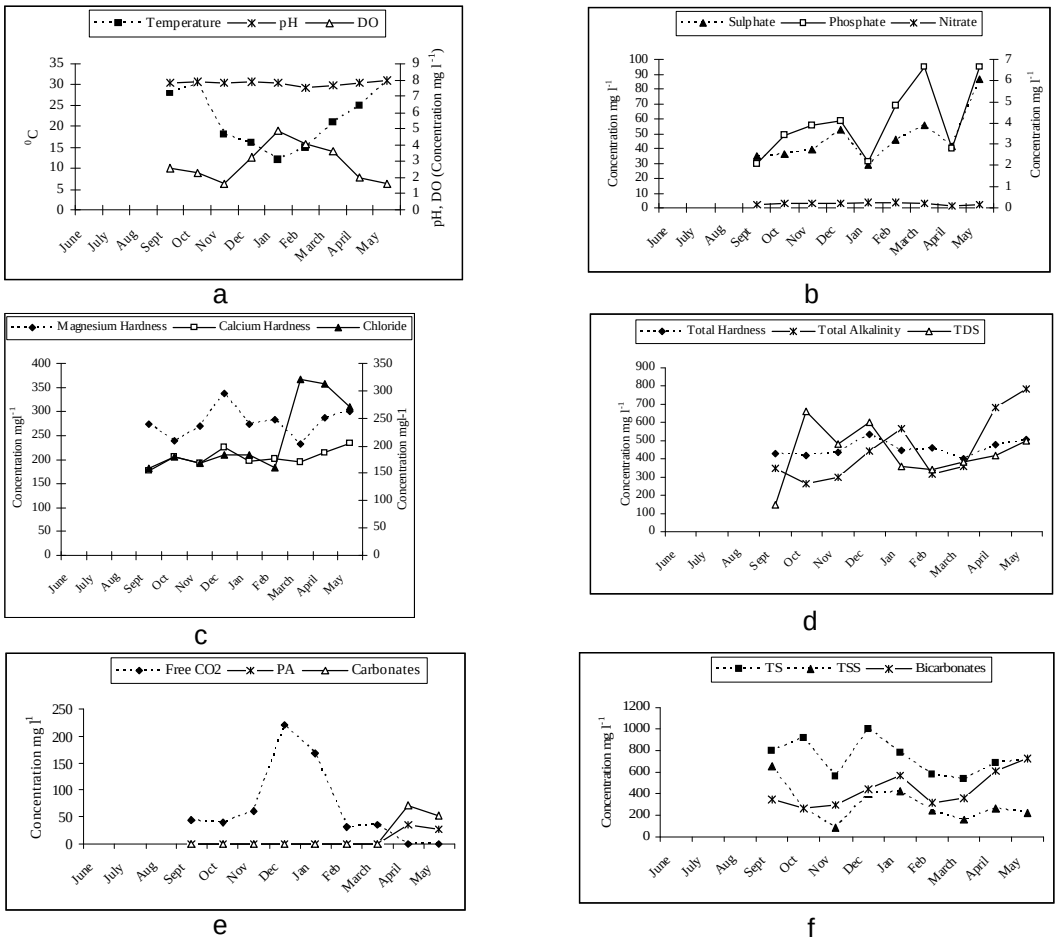

Fig. 3: Monthly variation in hydrochemical parameters in Khodiyar wetland from June 2007 to May 2008 at Site 2.

of nitrate were measured as 0.02 mg/L in October at Site 1 and 0.54mg/L in the month of March at Site 2, respectively. The values of hydrochemical properties were higher at Site 1 as compared to Site 2.

Correlation coefficient analysis showed that at Site 1, temperature correlated positively with phosphate (0.468). Nitrate showed positive correlation with sulphate (0.899) and chloride (0.864). However, DO correlated negatively with temperature (-0.739) and phosphate (-0.538). At Site 2, temperature and phosphate correlated positively (0.435) with each other. Also nitrate showed positive correlation with sulphate (0.728) and chloride (0.792). DO showed negative correlation with nitrate (-0.063), temperature (-0.646) and phosphate (-0.094).

The average values of physicochemical characters of Khodiyar and Malwar wetlands are shown in Table 1. The results indicate higher values for Khodiyar wetland, which can be attributed to fertilizer runoff, domestic wastes and detergent wastewater discharges from Anand city and Vidya Nagar educational township. Water temperature was higher at site 1 of Khodiyar than the two sites of Malwar. Khodiyar wetland shows an average value of DO as low as 1.61 mg/L at Site 1. In contrast to Malwar wetland it shows an average value of nearly 4 mg/L at both the sites. Phenolphthalein alkalinity,

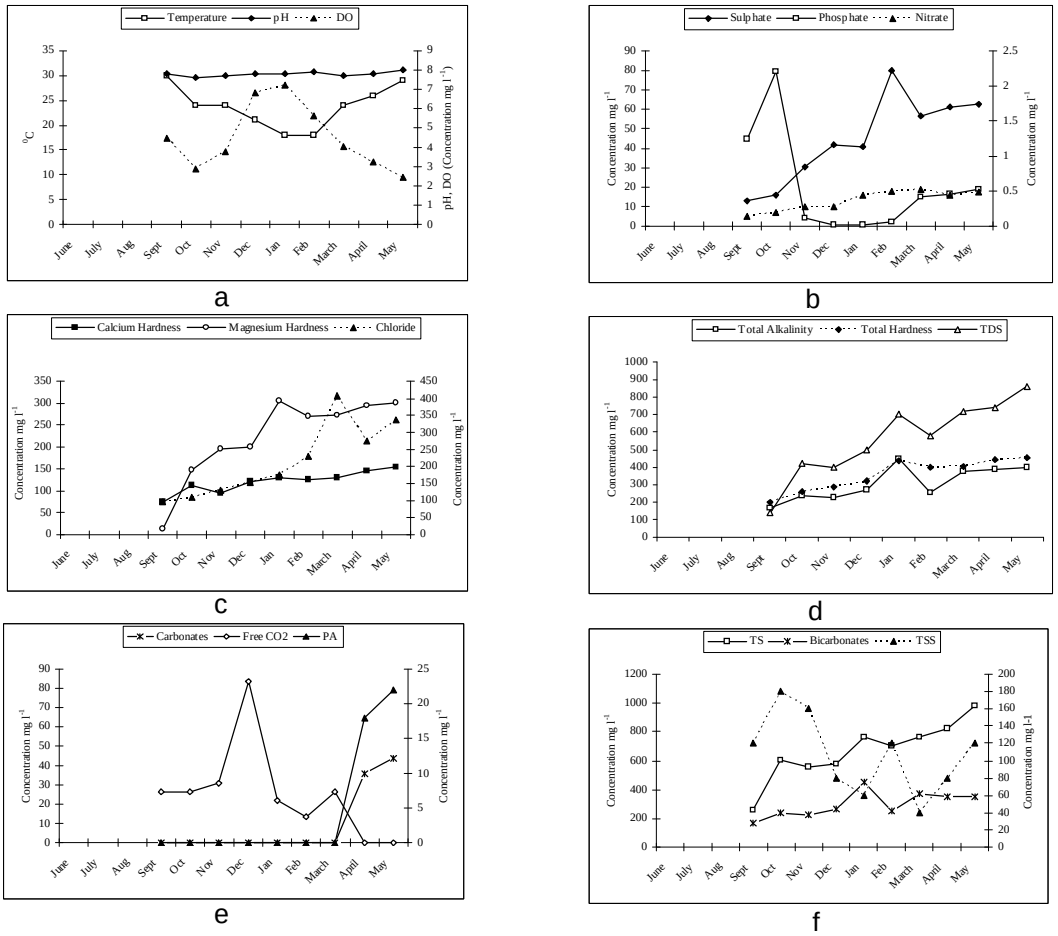

Fig. 4: Monthly variation in hydrochemical parameters in Malwar wetland from June 2007 to May 2008 at Site 1.

however, shows higher values in Malwar wetland with 4.44 mg/L at Site 1 and that of 10.44mg/L at Site 2.

The parameters like hardness, carbonates, solids, phosphate, sulphate and chloride followed the same trend; nitrate being the only exception. Phosphate showed an average value of 2.89 mg/L at Site 1, and 4.06 mg/L at Khodiyar, whereas at Malwar it was 0.56 mg/L at Site 1 and 0.26 mg/L at Site 2. Khodiyar showed much higher value of 70.59 mg/L for sulphate at Site 1 and 46.80 mg/L at Site 2. The values were comparatively lower for Malwar at Site 1 (44.59 mg/L). However at Site 2 it showed a slight increase with a value of 48.10 mg/L. Nitrate was an exception with a lower value at Khodiyar (0.27 mg/L and 0.20 mg/L at Site 1 and 2, respectively) and comparatively higher values at Malwar (0.37 mg/L and 0.32 mg/L).

DISCUSSION

Wetlands exhibit different water quality status depending on the geological formation in the catchment and the inflows including wastewater (Bendell-Young et al. 2000). It is evident that the main-

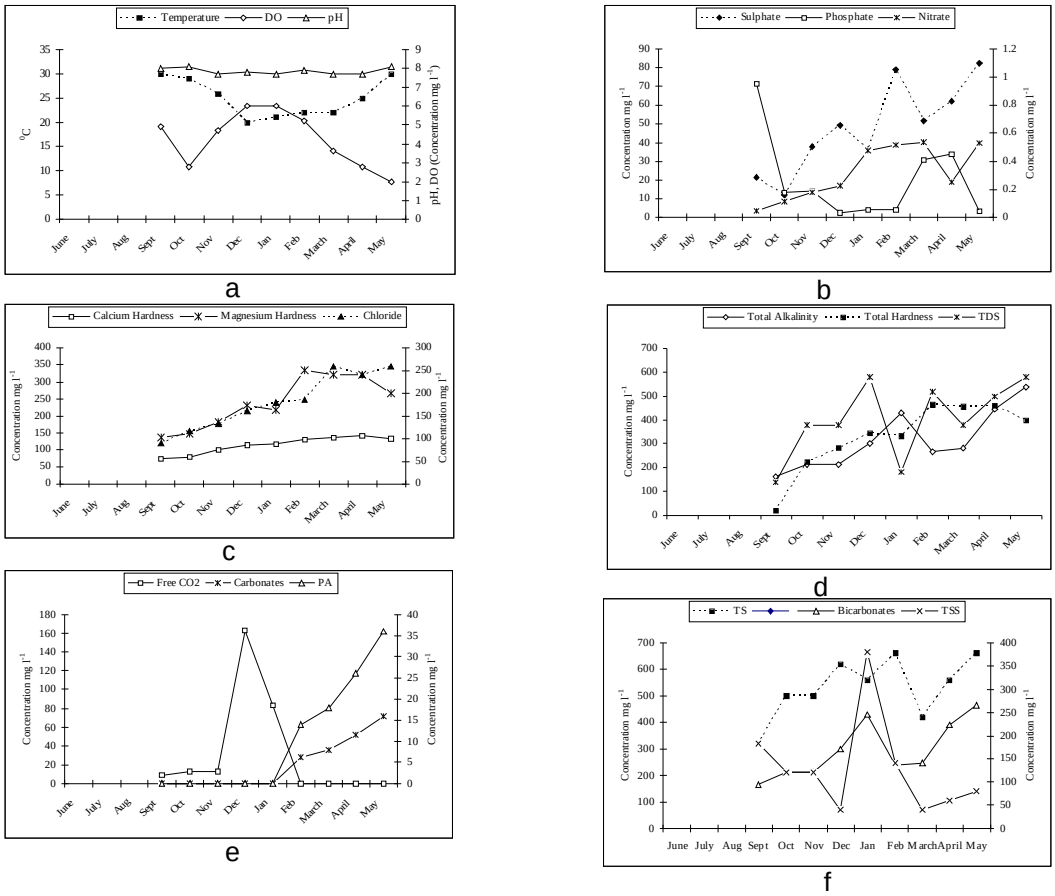

Fig. 5: Monthly variation in hydrochemical parameters in Malwar wetland from June 2007 to May 2008 at Site 2.

tenance of healthy conditions in aquatic systems is dependent on the physico-chemical properties of water and biological diversity. The temperature of the water body is an important parameter influencing the water quality. In both, Khodiyar and Malwar wetlands, temperature varied according to the seasonal fluctuations of atmospheric temperature with maximum during summers and minimum during winters (Nirmal Kumar et al. 2005). Dissolved oxygen is an important parameter of aquatic systems, which is essential to the aerobic metabolism of all aquatic organisms (Wetzel 1975). In summer with the increase in water temperature, there was reduction in DO, whereas in winter months due to decrease in temperature, the level of DO increased. These results were in conformity with Ahmed Masood & Krishna Murthy (1990) and Srivastava et al. (2003). Comparatively low values of DO in the Khodiyar wetland indicate an oxygen deficient condition, which could be due to the respiratory activity of the biota present there (Alom & Zaman 2006). The free carbon dioxide in any water body varies somewhat rapidly due to biological activity. In the present study, the increase in free carbon dioxide during early winter can be attributed to the higher rate of decomposition during the season and the favourable temperature (Sukhija 2007). Low quantity of water level during spring, summer and premonsoon may be the reason for increase of chloride, which corroborated with the study of Sukhija (2007). Higher values of hardness were observed during summer, which may be due

Table 1: Average values of physicochemical variables of Khodiyar and Malwar wetlands.

SrNo.	Parameters	Khodiyar wetland		Malwar wetland	
		Site 1	Site 2	Site 1	Site 2
1	Temperature	30	21.78	23.78	25
2	pH	7.50	7.80	7.79	7.86
3	DO	1.61	2.87	4.50	4.23
4	TS	1020	731.11	668.89	533.33
5	TDS	640	431.78	562.22	404.22
6	TSS	380	299.33	106.67	129.11
7	Free CO_2	30.80	66.49	25.42	31.29
8	PA	0	6.93	4.44	10.44
9	Total Alkalinity	564	450.44	306.67	316.44
10	Carbonates	0	13.87	8.89	20.89
11	Bicarbonates	564	436.58	297.78	295.56
12	Total Hardness	594	456.89	355.74	332.56
13	Calcium Hardness	193.20	179.20	120.87	113.87
14	Magnesium Hardness	400.80	277.69	222.43	239.69
15	Chloride	232.80	215.36	212.20	180.34
16	Phosphate	2.89	4.06	0.56	0.26
17	Sulphate	70.59	46.80	44.59	48.10
18	Nitrate	0.27	0.20	0.37	0.32

All values in mg/L except pH and temperature (°C).

to low water level and high rate of decomposition and evaporation, thus, concentrating the salts (Chatterjee & Raziuddin 2007). High concentrations of nutrients like phosphate, sulphate, chloride, nitrate, and others were recorded in Khodiyar wetland than Malwar wetland. High phosphate concentration indicates fertilizer runoff, domestic waste discharge and detergents. Similar observations were also made by Khare et al. (2007). The monthly variation of hydrochemical properties also indicated that concentration of nutrients was greater during warmer months in both the wetlands, which could be attributed to high atmospheric temperature, evaporation and high amount of entry of wastes from surrounding villages, which corroborated with the findings of Ranjan et al. (2007).

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