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SEASONAL VARIATIONS IN PHYSICO-CHEMICAL PARAMETERS OF MANGROVE WATER, KUNDAPUR, SOUTHWEST COAST OF INDIA

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Abstract: Mangrove forest is a component of wetlands that has been recognized as one of the most productive ecosystem. Seasonal variations in physicochemical characteristics of mangrove water, Kundapur, southwest coast of India, were studied at four different stations for a period of two years during April-2010 to March-2012. Water quality analysis was made following the methods prescribed by APHA, 2005. Atmospheric and surface water temperatures (°C) varied from 24°C to 30°C and 23°C to 29°C respectively. Seasonal variations of different parameters investigated were as follows: Dissolved Oxygen (2.43 to 10.97 mg/l), pH (6.19 to 8.42), Electrical Conductivity (0.23 to 29.8 ms^{-1}), Carbon Dioxide (0.55 to 4.4 mg/l), Biological Oxygen Demand (0.1 to 6.51 mg/l), Potassium (0.064 to 20.33 mg/l), Calcium (0.161 to 42.34 mg/l), Magnesium (0.251 to 113.14 mg/l), Sodium (0.022 to 878.04 mg/l), Bicarbonate (0.839 to 115.376 mg/l), Carbonate (Nil), Chloride (0.704 to 380.70 mg/l). A seasonal variation in these parameters was observed throughout the study period and monthly comparisons were made as monsoon, pre-monsoon and post-monsoon. The results of the present investigations are compared and discussed with available literature pertaining to this field. Present investigation reveals that there is a fluctuation in the physico-chemical characters of the water; this will be due to entry of rain water, ebb and flow and change in the temperature and salinity as season changes.

Key words: Mangrove forest, Monsoon, Pre-monsoon, Post-monsoon, Ebb and flow, Water quality analysis

INTRODUCTION

Mangroves are coastal wetland forests established at the intertidal zones of estuaries, backwaters, deltas, creeks, lagoons, marshes and mudflats of tropical and subtropical latitudes. Approximately one fourth of the world's coastline is dominated by mangroves that are distributed in 112 countries and territories comprising a total area of about 181,000 km^2 *(Saravanan, 2005)*. The mangrove water was slightly alkaline and contained high amounts of pH, total hardness, calcium, magnesium, chloride, total inorganic and organic phosphate, ammonium, nitrite and nitrate *(V. Ramamurthy et al., 2012)*. Mangroves forest grows well along the river bank, estuaries and coastaline with the presence of brackish water or where saline and fresh water meets. Mangroves forest is a type of wetland and is considered as one of the most productive ecosystems in the tropic, high in value and has multiple roles and functions (WWF, 2011; Karami *et al., 2009)*. Mangrove has unique features and special adaptations like breathing roots, buttresses and above ground roots that allow and enable them to live and survive in the mud, anaerobic condition; and salty water (Seca Gandaseca *et al*., 2011).The study of mangrove regions is necessary as they are highly productive and play an important role as breeding and nursery grounds for many commercially important fishes especially shrimps (Kathiresan and Bingham, 2001). Distribution of nutrients determines the fertility potential of water mass (Panda *et al*., 1989; Bragadeeswaran *et al*., 2007). The regular and periodic changes in the climate synchronized with season are ultimately reflected in the environmental parameters also, which in turn have a direct or indirect influence over the planktonic population (Saravanakumar *et al*., 2008). When river water mixes with seawater, a large number of physical and chemical processes take place, which may influence of water quality (Muduli Bipra Prasanna *et al.,* 2010).

Study area

Kundapura is located 445 kilometers west of Bangalore and 36 kilometers north to Udupi (13° 37' 24" N latitude and 74° 41' 30" E longitude and 58 ft. Asl). The average annual rainfall is 4344 mm and actual of 4182 mm. The Haladi is the main river in this area. It descends from the Western Ghats to the Arabian Sea. It slows down as it reaches the coast and spreads out into wide estuaries, lagoons, and backwaters with extensive mudflat and small patches of mangrove forest. The mouth of the estuaries and creek are narrow and prominently open to the sea. Many fish and prawn farms are located in the vicinity of the mangrove areas. Mangrove forest is particularly well developed in this river near Gangolli. Much of the intervening coastline is sandy beach backed by coastal dunes, but there are some short stretches of rocky shore. Four study sites were selected along the bank of Haladi River; these are Herikudru, Uppinakudru, Jaladi and Hemmadi (Fig. 1, Table 1).

MATERIALS AND METHODS

Monthly water samples were collected from 4 different sampling sites. The water samples were collected between 8.00 a.m. to 9.00 a.m. using wide mouth sterile transparent plastic jar of five liter capacity and usually from 10-15 cm depth from the water surface. For the analysis of dissolved oxygen and BOD, water samples were collected by BOD bottles of 300ml capacity. The manganous sulphate and the alkali iodide reagent were added immediately at the collection site to fix the samples for studying dissolved oxygen. The samples were analyzed in the laboratory. Samples for BOD were incubated in laboratory for five days at 20°C (Trivedy and Goel. 1984). The water temperature, air temperature and pH were measured at the place of sampling sites using standard mercury thermometer and microprocessor based pocket pH meter. Immediately after arrival into the laboratory the conductivity of the samples were measured with the help of a digital conductivity meter. For the study of potassium, sodium,

Table 1. Study sites

Study sites	Latitude	Longitude	Elevation
Site-1. Herikudru	13°38'28"N	74°42'01"E	28'
Site-2. Uppinakudru	13°39'21"N	74°41'59"E	25'
Site-3. Jaladi	13°39'41"N	74°42'16"E	16'
Site-4. Hemmadi	13°40'46"N	74°41'20"E	32'

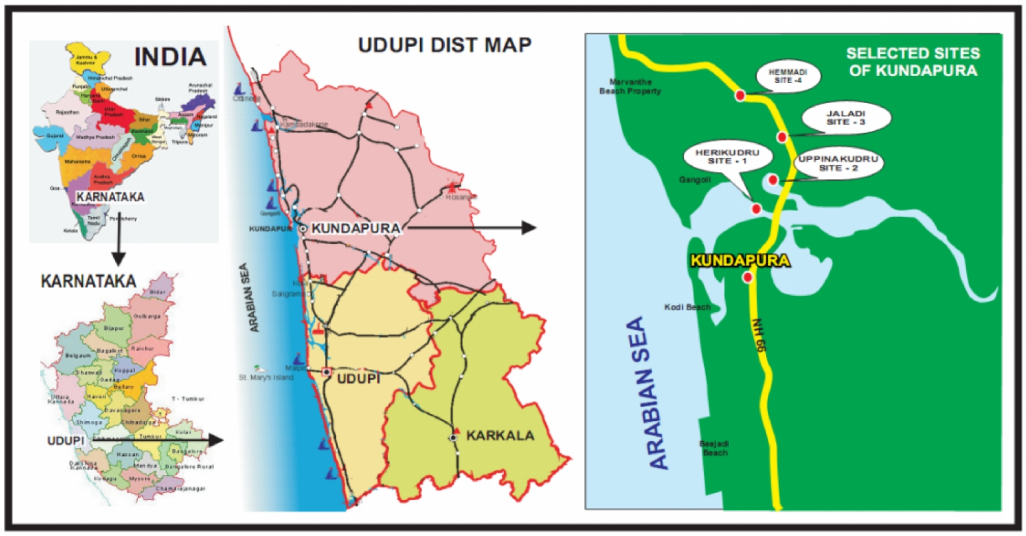

Fig. 1 Study site locations

carbonates, bicarbonates, chloride, calcium hardness, and magnesium hardness, the samples were analyzed in the laboratory by following standard methods of American Public Health Association (APHA, 2005). The results of analysis were expressed as mg/l except temperature and conductivity measured as ^{o}C and ms^{-1} respectively.

Statistical analysis: The data are obtained statistically analyzed mean ± standard deviation. All the data were analyzed statistically applying for all the studied parameters.

RESULTS AND DISCUSSION

The avarage values of various Physico-chemical parameters ie., April 2010 to March 2011 and April 2011 to March 2012 are depicted in Table 1, Fig. 2; Table 2 and Fig. 3, respectively. Air temperature ranged from 24°C (monsoon and post monsoon) to 30°C (pre-monsoon). Air temperature reaches its maximum during summer and minimum during monsoon and winter. The surface water temperature varied from 23°C (monsoon and post monsoon) to 29°C (pre monsoon). There was a steady increase in temperature from March to May, which peaked during May. All the stations showed similar trend with similar seasonal changes. Generally surface water temperature is influenced by the intensity of solar radiation, evaporation, isolation, freshwater influx and cooling and mix up with ebb and flow from adjoining neritic waters (Govindasamy *et al.*, 2000).

The pH values were varied from 6.19 (in site-1 in the month of June) to 8.42 (in site-3 in the month of April) during monsoon and summer season. P^{H} in surface waters remained alkaline and slightly acidic throughout the study period in all the stations with the maximum values occurring in the summer and winter seasons and minimum values occurring in the monsoon season. Generally, fluctuations in pH values during different seasons of the year is attributed

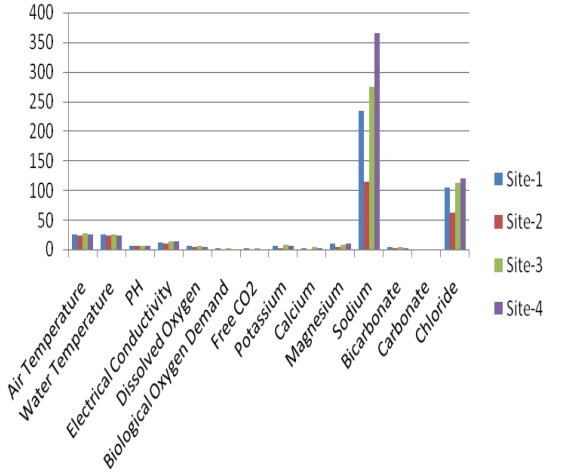

Fig. 2. The average values of physico- chemical parameters of water. (April-2010 to March-2011)

Table 2. Average values of physico- chemical parameters of water:(April-2010 to March-2011)

Parameters	Site-1	Site-2	Site-3	Site-4
Air Temperature	26 ± 2.57	25.55±1.42	26.16±1.5	26.72±1.25
Water Temperature	24.55± 1.33	24±1	24.55±1.23	25.05±0.95
P^{H}	6.69±0.33	6.75±0.35	6.69±0.38	6.73±0.36
Electrical Conductivity	11.94±10.19	11.08±10.97	13.89±13.12	15.56±13.61
Dissolved Oxygen	6.46±1.27	6.32±1.66	6.44±1.06	6.09±0.98
Biological Oxygen Demand	1.62±1.47	1.58±1.93	1.89±0.902	1.57±1.67
Free CO_2	2.17±1.23	2.10±1.22	1.88±0.79	1.76±0.82
Potassium	5.40±4.73	3.47±3.20	6.74±6.88	7.22±5.43
Calcium	2.85±1.93	2.36±2.07	3.90±2.39	3.51±3.24
Magnesium	9.40±8.45	5.48±5.07	8.48±7.71	12.04±9.85
Sodium	234.52±229.913	114.27±115.68	273.95±181.03	364.70±229.40
Bicarbonate	4.50±4.76	3.02±2.00	3.18±2.53	3.48±2.23
Carbonate	00	00	00	00
Chloride	104.44±121.84	63.10±73.98	112.06±126.50	120.92±139.89

Note: All the parameters are expressed in mg/l except air and water temperature (°C), electrical conductivity (ms^{-1}).

Table 3. Average values of physico- chemical parameters of water:(April-2011to March-2012)

Parameters	Site-1	Site-2	Site-3	Site-4
Air Temperature	27.59±1.59	27.31±1.76	27±1.73	27.59±1.59
Water Temperature	25.68±1.79	25.5±1.65	24.68±1.52	25.90±1.51
p^H	7.59±0.48	7.60±0.46	7.81±0.45	7.68±0.44
Electrical Conductivity	18.62±9.59	10.17±6.77	17.40±11.59	18.56±10.37
Dissolved Oxygen	6.48±1.50	7.78±1.76	5.28±1.58	6.60±1.99
Biological Oxygen Demand	0.79±0.51	0.92±0.66	1.06±0.73	1.25±0.96
Free CO_2	0.8±0.28	0.6±0.16	0.85±0.51	0.8±0.28
Potassium	6.61±3.53	4.29±2.83	6.12±3.56	6.90±3.52
Calcium	17.24±15.48	12.55±11.69	16.21±15.03	14.99±13.74
Magnesium	40.43±38.09	26.63±24.74	42.25±42.96	37.91±38.19
Sodium	297.85±278.83	108.73±100.0	273.87±278.98	248.38± 268.11
Bicarbonate	3.78±1.29	3.23±1.25	3.65±1.28	3.66±1.07
Carbonate	00	00	00	00
Chloride	188.17±109.57	96.44±84.04	157.55±108.6	177.16±111.09

Note: All the parameters are expressed in mg/l except air and water temperature (°C), electrical conductivity (ms^{-1}).

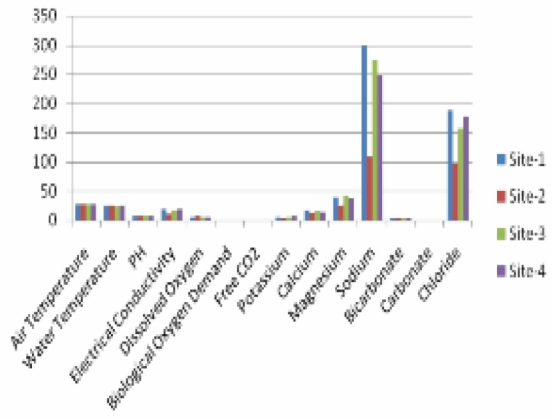

Fig. 3. showing the average values of physico-chemical parameters of water: (April-2011 to March-2012)

to factors like removal of CO2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter (Rajasegar, 2003). The recorded high pH values might be due to the influence of seawater penetration and high biological activity (Balasubramanian and Kannan., 2005).

The electrical conductivity was found maximum in the month of May i.e. 29.8 (ms^{-1}) and minimum in the month of August i.e. 0.23 (ms^{-1}).The maximum and minimum values of electrical conductivity is due to fresh water influx and mix up with ebb and flow. Similar results were reported by Rita Chauhan *et al.*, 2008; Prabhahar *et al.*, 2011.

The maximum value of dissolved oxygen concentration was observed in site- 4 in the month of June i.e. 10.97 mg/l (monsoon) where as the minimum value of dissolved oxygen was found in the site-2 in the month of March i.e.2.43 mg/l (summer). Season wise observation of dissolved oxygen showed an inverse trend against temperature and salinity. It is well known that temperature and salinity affect dissolution of oxygen in seawater (Vijayakumar *et al.*, 2000). In the present investigation, higher values of dissolved oxygen were recorded during monsoon months in all the stations. Relatively lower values found during summer could be mainly due to reduced agitation and turbulence of the coastal and estuarine waters. Higher dissolved oxygen concentration observed during the monsoon season might be due to the cumulative effect of higher wind velocity coupled with heavy rainfall and the resultant freshwater mixing.

Similar results were reported by Saravanakumar *et al.* (2007).

The maximum value of B.O.D was observed in site- 2 in the month of March i.e. 6.51 mg/l where as the minimum value of B.O.D was found in the site-4 in the month of January i.e.0.1 mg/l. BOD is an indicator for the amount of the biodegradable organic substances. BOD also accounts the oxygen that is required in organic matter decomposition (Amadi *et al.*, 2010). BOD value will rise when there is more organic matter such as leaves; wood, waste water or urban storm water runoff took place at the river water (Seca Gandaseca *et al.*, 2011).

The value of free CO_2 ranges from 0.55 to 4.4 mg/l. The maximum value (4.4 mg/l, in site-1 and 2) was recorded in the month of April and minimum value (0.55 mg/l) in the month of June and July in all the selected sites. This may be depends upon alkalinity and hardness of water body. The value of CO_2 was high in April. This could be related to the high rate of decomposition in the warmer months. Similar results were reported by S. A. Manjare *et al.*, 2010.

The maximum calcium content was found in site-4 i.e.42.34 mg/l in the month of April and minimum value found in site-2 i.e.0.161 mg/l in the month of August. Calcium values are indicative of intense of chemical weathering in the Indian sub continent. Calcium concentration is highest in estuaries due to the influx of riverine source. Similar results were reported by Rita Chauhan *et al.*, 2008.

Magnesium content varies among different sites. Maximum values of magnesium were observed during the month of April in site- 3 i.e. 113.14 and the minimum values were observed during the month of August in site- 1 i.e. 0.251 mg/l. Similar results were reported by Ramamurthy *et al., 2012*. The maximum potassium content observed during the month of November in site-3 i.e. 20.33 mg/l and minimum potassium content observed during the month of July in site-4 i.e. 0.064 mg/l.

The maximum sodium content observed during the month of April in site-1 i.e. 878.04 mg/l and minimum sodium content observed during the month of July in site-2 i.e. 0.022 mg/l. The high sodium values are largely due to the proximity of sea. The present data also reveals the potassium was lower than the sodium. This may be due to preferential absorption and incorporation into silicate minerals. Similar results were reported by Rita Chauhan *et al., 2008*.

The maximum bicarbonate content observed during the month of May i.e. 15.376 mg/l in site-1 and minimum bicarbonate content observed during the months of August i.e. 0.839 mg/l in site-4. The high value in summer is due to the mixing of sea water and low value during rainy season is due to inflow of fresh water. The carbonate content was absent in all the sites and in all the seasons.

The values of chlorides range from 0.704 mg/l to 380.70 mg/l. The maximum value (310.917 mg/l) was recorded in the month of April in site-1 (summer) and minimum value (0.704 mg/l) in the month of August in site-1 (monsoon). In the present study maximum values of chloride reaches in summer seasons. Similar results were reported by Swaranlatha and Narsing rao, 1998.

CONCLUSIONS

As the season changes there is a fluctuation in the physicochemical characters of the water, this will be due to ebb and flow, flushing of rain water, change in the temperature and salinity as season changes. In addition, intense pollution from both agricultural inputs and shrimp culture ponds deteriorate the water quality of mangrove ecosystem. The mangrove forest of the area must always be protected and conserved. Continuous monitoring of water quality of the river water at the area also should be done to monitor the water quality status. All agencies involved include the local communities play an important role and should be more effective to prevent the destruction of the mangrove forest ecosystem and the aquatic environment of the mangrove forest. The present information of the physico-chemical characteristics of water would form a useful tool for further ecological assessment and monitoring of these coastal ecosystems.

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