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Evaluation of water quality of mangrove ecosystems of Kundapura, Udupi district, Karnataka, Southwest coast of India.

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Abstract
The present study was carried out to evaluate the physico-chemical parameters of four selected sites of mangrove ecosystem, located at Kundapura, of Udupi district, Karnataka, Southwest coast of India, for a period of one year from August-2010 to July-2011. The physicochemical parameters play a vital role in the mangrove ecosystems. 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 with literature values and investigation reveals that there is a fluctuation in the physico-chemical characters of the water, this will be due to ebb and flow and change in the temperature and salinity as season changes.

Keywords: Mangrove ecosystem, physico-chemical parameters, seasonal variation, monsoon, pre-monsoon, post-monsoon, ebb and flow.

INTRODUCTION

Mangroves are the salt tolerant forest ecosystem found mainly in tropical and subtropical intertidal regions of the world. They are the woody plants that occupy estuaries and intertidal zones (*Walter, 1961*). They stabilize the shoreline and act as a bulwark against the encroachment by the sea (*Banerjee et al., 2004*). Mangrove ecosystem acts as a buffer between near shore and lagoonal or estuarine environments with regard to the influence of freshwater discharge and salinity regime (*Ramanathan, 1997*). Estuarine and coastal areas are complex and dynamic aquatic environment (*Morris, et al.,* 1995). When river water mixes with seawater, a large number of physical and chemical processes take place, which may influence of water quality.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 a 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. The seasonal variations in the water quality as well as the biological component of these systems are influenced heavily by anthropogenic stress exerted by the developmental activities carried out along the coast, which alter the health of the ecosystem. Due to these activities the existence of rich biodiversity in this ecosystem is under threat. During the last three decades, mangrove ecosystems have been receiving much global importance and attention by scientific communities, environmentalists as well as coastal zone managers (*Naskar and Mandal, 1999; Singh and Odaki, 2004).* In coastal Karnataka the mangroves grow well on silty and clay muds or mixture of these soils. Under the canopy of 'mangals' the substrate undergoes physico chemical alteration which determines the formation of zones within the habitat. Zonation is a common phenomenon in mangroves influenced by several factors like frequency of flooding, soil type, salinity, nutrient content, permeability, drainage, plant and animal interaction.

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MATERIALS AND METHODOLOGY

Study area

The southwest coast of India in general and the Karnataka coast in particular mangrove vegetation is found in three districts viz., Dakshina Kannada, Udupi and Uttara Kannada in the estuarine regions of the principal rivers. The total coastal line in Karnataka is approximately 320 kms which represents varied geomorphological feature in the form of long beaches, sometimes intercepted by rocks forming attractive beaches. Sometimes coastal land is dissected by the rivers joining sea with the formation of shallow lagoons or estuaries. In Dakshina Kannada and Udupi districts, ten main rivers join the Arebian Sea. Those are Netravathi, Gurupur, Udyavar, Mulki, Pavanje, Sita, Swarna, Varahi, Chakra, Sowparnika and Baindur rivers.

The selected area for the study is Kundapura.Geograpically Kundapura is located 445 kms west of Bangalore and 36 kms north to Udupi (13° 37' 24" N Latitude and 74° 41' 30" E Longitude and 58 ft. asl). The annual rainfall 4848 mm normal and actual of 4182 mm. Kundapura forest division falls both in Udupi and Dakshina Kannada district. It has about 105 km coastal stretches, starting Shiroor in

Kundapura Taluk to Mulky of Mangalore Taluk. There are two sub divisions and eight ranges. However only four ranges of this division are touching coastal area are having mangroves. They are Byndoor, Kundapura, Udupi and Moodbidri.

Chakra, Varahi, Kubja, Sowparnika estuarine complex of the Kundapura Taluk

The river complex is formed by several smaller streams that meet and form a broad estuary to north of the Kundapura town and fall into the sea at Gangolli.

Fig 1. Map showing the geographical location of study sites

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'

Water sampling and preservation

The present study was carried out for a period of one year from August 2010 to July 2011. 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 p^H were measured at the place of sampling sites using standard mercury thermometer and microprocessor based pocket p^H 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, carbonates, bicarbonates, chloride, calcium hardness, magnesium hardness, sodium absorption ratio and residual sodium carbonate, 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 ^oC and µmhos/cm respectively.

RESULT AND DISCUSSION

Air temperature ranged from 24^oC (monsoon and post monsoon) to 29^oC (pre monsoon). Air temperature reaches its maximum during summer and minimum during monsoon and winter. The surface water temperature varied from 23^oC (monsoon and post monsoon) to 27^oC (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*). In the present study, summer peaks and monsoonal troughs in air and water temperature were noticed, as observed earlier by several workers in the west coast of India (*Desai, 1992; Arthur, 2000*).

The p^H values were varied from 6.19 (in site-1 in the month of June) to 7.18 (in site-3 in the month of March) 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 p^H values during different seasons of the year is attributed to factors like removal of CO_2 by photosynthesis through bicarbonate degradation, dilution of seawater by freshwater influx, reduction of salinity and temperature and decomposition of organic matter (*Upadhyay, 1988 ; Rajasegar, 2003*).

The electrical conductivity was found maximum in the month of May i.e. 29.8 (ms) and minimum in the month of July i.e. 0.26 (ms).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.*

The maximum value of dissolved oxygen concentration was observed in site- 2 in the month of June i.e. 8.53 mg/l (monsoon) where as the minimum value of dissolved oxygen was found in the site-2 in the month of March i.e.2.43mg/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 *Das et al., (1997) and 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 4.4mg/l. The maximum value (4.4 mg/l, in site-1 and 2) was recorded in the month of April and minimum value (0.55mg/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.10.045 mg/l in the month of November 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 November in site- 4 i.e. 27.521 and the minimum values were observed during the month of August in site- 2 i.e. 0.302 mg/l. 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 May in site-1 i.e. 652.17 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 is all the sites and in all the season expect the site-1 in the month of September.

The values of chlorides range from 0.704 mg/l to 310.917 mg/l. The maximum value (310.917mg/l) was recorded in the month of May in site-4 (summer) and minimum value (0.704 mg/l) in the month of August in site-1(monsoon). In the present study maximum chloride value is observed in summer. Similar results were reported by *Swaranlatha and Narsing rao-1998*.

The maximum sodium absorption ratio was observed during the month of May i.e.182.72 mg/l in site-1 and minimum sodium absorption ratio was observed during the month of August i.e. 2.213 mg/l in site-2.The residual sodium carbonate was observed during the months of August in site- 2 and 4 i.e. 0.469mg/l and 0.005mg/l and absent in all the months from September to July.

Table 2. Average values of physico- chemical parameters of water: (August-2010 to July-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
PH	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	0.07±0.23	00	00	00
Chloride	104.44±121.84	63.10±73.98	112.06±126.50	120.92±139.89
Sodium absorption ratio	87.26±59.28	55.27±43.31	108.18±56.91	122.67±40.14
Residual sod carbonate	00	0.05±0.15	00	0.0005±0.0016

Note: All the parameters are in mg/L except air and water temperature (°C), pH, electrical conductivity (μmhos/cm).

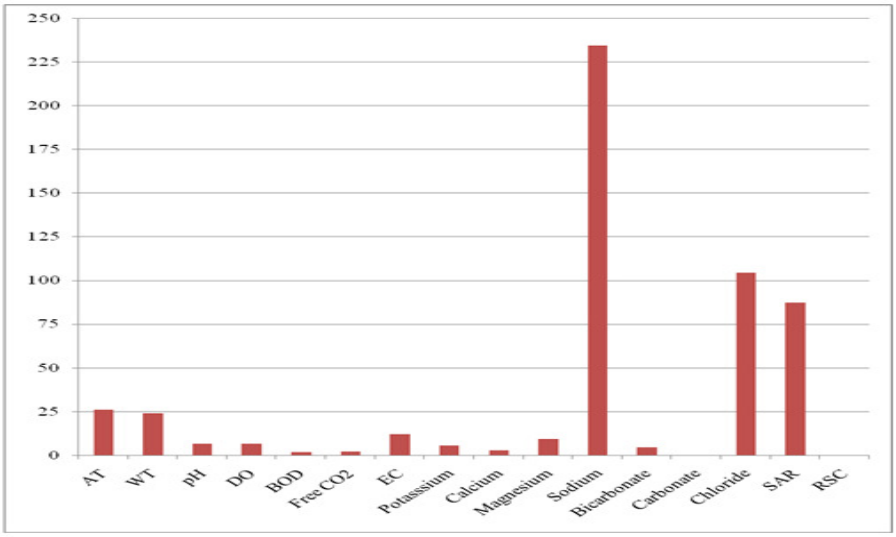

Fig 2.Graph showing the average values of physico-chemical parameters of site-1.

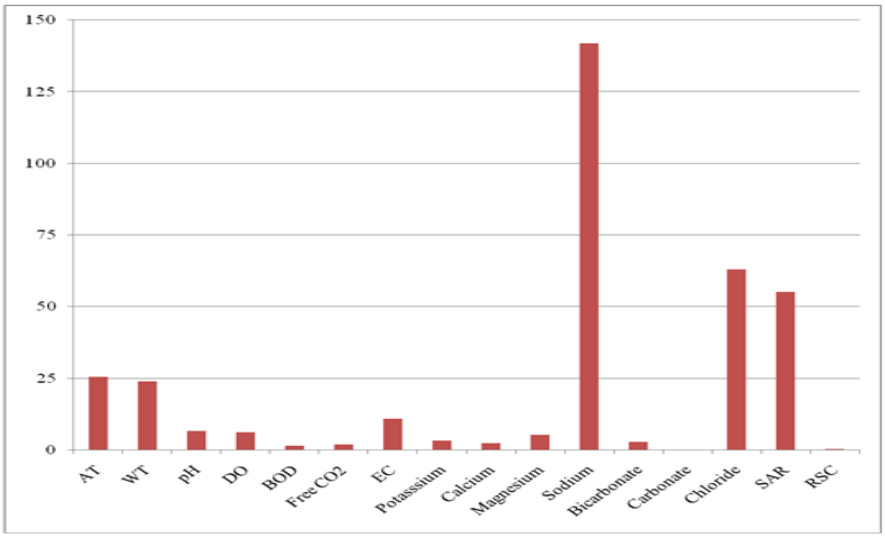

Fig 3.Graph showing the average values of physico-chemical parameters of site-2.

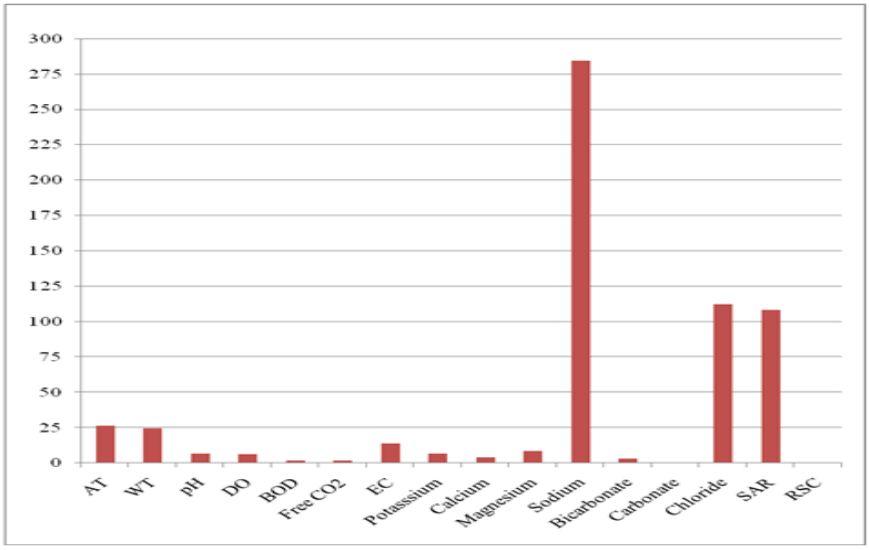

Fig 4.Graph showing the average values of physico-chemical parameters of site-3.

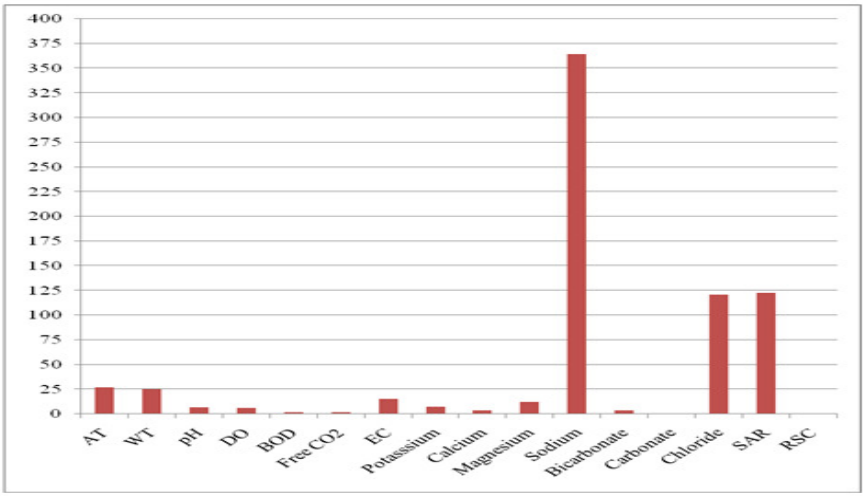

Fig 5.Graph showing the average values of physico-chemical parameters of site-4.

Table 3. Seasonal average values of the physico-chemical parameters of water

	Air temperature			Water temperature			PH		
site	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon
1	25.5	25	26	24	23.5	26	6.25	6.81	6.85
2	24.75	26.25	27	24.25	24	25	6.41	6.98	7.06
3	25.75	25	27.5	24.25	22.25	25.66	6.30	6.97	7.12
4	26	26.5	28.16	24.62	24.5	27	6.36	7.03	7.03
Ave	25.5	25.68	27.16	24.28	23.56	25.91	6.33	6.94	7.02
STDEV	±0.54	±0.80	±0.912	±0.25	±0.96	±0.83	± 0.06	±0.09	±0.11

Table 4. Seasonal average values of the physico-chemical parameters of water

	Dissolved Oxygen			Biological Oxygen Demand			Free CO_2		
site	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon
1	7.40	6.75	5.01	0.53	1.38	3.08	1.37	2.64	3.08
2	7.19	6.85	4.80	0.71	3.72	3.18	1.37	2.64	2.71
3	7.40	6.25	5.69	1.27	2.73	2.73	1.37	2.64	2.05
4	6.69	6.4	5.07	1.21	2.89	2.50	1.37	2.64	1.68
Ave	7.17	6.66	5.14	0.93	2.68	2.92	1.37	2.64	2.38
STDEV	±0.33	±0.28	±0.38	±0.36	±0.96	±0.35	0	0	±0.62

Table 5. Seasonal average values of the physico-chemical parameters of water

	Electrical Conductivity			Potassium			Calcium		
site	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon
1	2.55	13.54	23.4	0.57	8.85	7.88	1.16	5.38	3.41
2	0.65	19.02	19.71	0.26	5.48	5.34	2.09	19.73	2.44
3	1.06	19.8	25.86	0.3	13.75	7.03	2.97	21.82	4.23
4	1.40	25.65	27.73	5.51	6.54	9.38	6.21	52.63	4.30
Ave	1.41	19.50	24.17	1.66	8.65	7.40	3.11	24.89	3.60
STDEV	±0.81	±4.95	±3.46	±2.57	±3.67	±1.68	±2.19	±19.88	±0.87

Table 6. Seasonal average values of the physico-chemical parameters of water

	Magnesium			Sodium			Bicarbonate		
site	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon
1	0.96	17.37	15.35	23.11	264.47	418.47	2.37	0.93	8.53
2	0.64	7.41	10.63	3.88	553.8	261.77	2.09	1.98	4.96
3	0.95	11	16.06	49.32	319.03	413.04	1.80	1.63	4.50
4	3	20.89	18.66	102.92	120.46	502.71	2.075	2.67	5.90
Ave	1.30	14.16	15.17	44.81	314.44	399.0	2.08	1.80	5.97
STDEV	±0.91	±6.08	±3.34	±42.98	±180.22	±100.27	±0.23	±0.72	±1.80

Table 7. Seasonal average values of the physico-chemical parameters of water

	Carbonate			Chloride			SAR		
site	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon	Monsoon	Post monsoon	Pre monsoon
1	0.233	0	0	5.16	185.05	183.06	42.74	91.14	133.38
2	0	0	0	4.67	47.95	151.11	29.96	129.97	102.06
3	0	0	0	6.49	114.57	226.94	95.55	271.48	130.62
4	0	0	0	4.26	117.74	278.57	98.44	105.95	158.08
Ave	00.058	0	0	5.15	116.33	209.92	66.67	149.63	131.03
STDEV	±0.11	0	0	±0.97	±55.98	±55.32	±35.41	±82.79	±22.92

CONCLUSION

As the season changes there is a fluctuation in the physico-chemical characters of the water, this will be due to ebb and flow, change in the temperature and salinity as season changes. The present water quality of Kundapura mangrove ecosystem reveals that salinity plays a dominant role in controlling the water quality. In addition, intense pollution from both agricultural inputs and shrimp culture ponds deteriorate the water quality of mangrove ecosystem. 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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