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A study on seasonal variations in the environmental parameters of Karwar waters, Karnataka, India- A Hydrographical Profile

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Abstract

In the present study the environmental parameters like air and water temperature, hydrogen ion concentration (pH), salinity (ppt), dissolved oxygen (mg/l) and nutrients (µmol) were studied at Muduga,Majali and Tilmati. Knowledge of nutrients availability, their fluctuation with seasons at different sites relating to their contributory sources, utilization levels will be of great value to assess the productivity potential of marine ecosystem. Seasonally mean air temperatures varied from (28.0°C to 29.5°C), mean water temperatures varied from (26.4 °C to 27.7 °C.), mean salinity values varied from (28.5 ppt. to 34.2 ppt.) and pH ranged from (7.1 to 7.5), variation in dissolved oxygen content was from (4.6 mg/l to 5.39 mg/l), the range of inorganic nutrients viz. nitrites, nitrates, ammonium, phosphates and iron content were (3.57 µmol to 5.94 µmol), (9.47 µmol to 11.11 µmol), 12.63µmol to18.4 µmol), (0.60 µmol to 1.46 µmol), (0.20 µmol to 0.35 µmol) respectively. Principal Component Analysis (PCA) was used to represents the maximum amount of variations in the environmental parameters.

Key words : Physico-chemical parameters, seasonal variations, PCA.

Uttara Kannada has varied geographical features with thick forests, perennial rivers, mangrove forests admist river estuaries, captivating sandy and rocky beaches at various taluks like Binga, Ankola, Kumta, Karwar and Bhatkal harbours rich biota of flora and fauna with a coastline of 140kms having a well-developed port Karwar. Karwar is the head quarters of Uttara Kannada, a town which lies 15kms South of Karnataka –Goa border. Rocky shores (beaches) are the intertidal areas which consists of solid rocks where often biologically rich environment prevails with different diverse habitats ranging from sheer vertical rocks to sheltered tidal pools (rocky and sandy pools, boulders, steep rocky cliffs and platforms). The hydrological study is a prerequisite to study the prevailing environmental condition and distribution of aquatic organisms. The fluctuating environmental parameters study previews the decreased species abundance, diversity and adaptability in the species. Present

study therefore, has been aimed to study climatic and hydrological parameters of three inshore surface waters stations along the coast of Karwar for a period of thirteen months from Jan 2018 to Jan 2019.

The present study was carried out along the coast of Karwar, India.Three study stations environmental parameters were recorded during varied seasons namely pre-Monsoon, Monsoon and post-Monsoon.

Study area :

Study station 1 :

Majali is a village in Karwar Taluk in Uttara Kannada, District of Karnataka State. It is located 12kms towards North from district headquarters, Karwar. The rocky intertidal region of Majali beach with Lat 14°53'54.42" N and Long 74°05' 45.65"E having sandy as well as rocky shoreline submerged and exposed rocks which harbours enormous rich macro algae and associated fauna. The rock surface was moist till spray zone due to high wave action. The rocks consists of many crevices in which the algal species adhere themselves and plays a great hidden places for faunal species especially crabs.

Study station 2 :

Tilmati Beach with Lat 14°53''58.38''N and Long 74°05''30.56" E is suitated1.5 kms besides Majali beach having dead shells and black soil with rocky boulders, gravel beds and submerged rocks. This beach is an attractive and tourists place due to special feature of shore having Black soil.

Study station 3 :

Muduga Beach with Lat14° 44' 44.47"N and Long 74°13'39.48"E is occupied half way by Naval base housing colonies and on other side of the beach consists of Fish meal centre adjacent to fishing port. The Stony division constructed dividing the beach halfway pave way to back waters with rich mangrove plantations having rich nutrient soil. The main sampling area consists of huge boulders generally rough in nature in upper littoral area. Initial appearance of the beach showed low algal diversity and absence of different habitats. The lower shore described small boulders in sub littoral areas contributing to geomorphology lacking good algal diverse species.

Environmental parameters :

The coast receives torrential rain during Monsoon with low saline conditions whereas the pre-Monsoon season depicts extreme temperatures and saline profiles. Post-Monsoon season experiences a moderate climate condition with stable environmental parameters. The pH, Water temperature (WT), Air temperature (AT), Salinity (SA) and Dissolved oxygen (DO) using pH meter, Thermometer, Refractometer and DO meter respectively. Nutrients analysis was done using nutrient analysis methods following APHA[1] guidelines. Principal Component Analysis (PCA) was used to depict the fluctuations of environmental parameters in different seasons among varied study stations.

The seasonal variations in the physico-chemical parameters were recorded from three study stations. Seasonal variability of different environmental features is chiefly controlled by the regime of the rainfall dividing the year into

Fig. 1. Map showing location of the study area

three distinct seasons: pre-Monsoon (February-May), Monsoon (June - September) and post-Monsoon (October - January).

Air temperatures measured in ºC, overall ranged from (24.0 ºC to 32.5 ºC). At Majali, the minimum mean temperature recorded was 25.1ºC in Monsoon and maximum was 31.3ºC in pre-Monsoon. At Tilmati, the minimum mean temperature recorded was 26.2 ºC in Monsoon and maximum was 32.5ºC in pre-Monsoon. At Muduga, the minimum mean temperature recorded was 24 ºC in post-Monsoon and maximum was 32ºC in pre-Monsoon.In general, the study stations showed similar air temperature variations (Table-1).

Water temperatures measured in ºC, overall ranged from (22ºC to 31ºC). At Majali, the minimum mean temperature recorded was 24.3ºC in Monsoon and maximum was 29ºC in Monsoon. At Tilmati, the minimum mean temperature recorded was 25.2 ºC in Monsoon and maximum was 31.0ºC in pre-Monsoon. At Muduga, the minimum mean temperature recorded was 22 ºC in post-Monsoon and maximum was 30.1ºC in pre-Monsoon.In general, the study stations showed similar water temperature variations (Table-1). There was a progressive increase in the air and water temperature during pre-Monsoon with peak value of 32.5ºC .With the onset of monsoon, a sudden fall in temperature (24.3ºC) was observed. The temperature remained low during monsoon,a gradual increase in the water temperature was noticed at the end of monsoon.The temperature both air and water remained high during the rest of the period. Similar observations of was being recorded by Kannan and Kannan[6], Alvarez Borrego and Alvarez Borrego[2] had suggested the temperature variations as a function of solar irradiance, tidal currents and atmospheric variations.

Salinity ranged from 15 ppt to 35 ppt. At Majali, the minimum salinity recorded was

15ppt in Monsoon and maximum was 35ppt in pre-Monsoon. At Tilmati, the minimum salinity recorded was 30 ppt in Monsoon and maximum was 35ppt in pre-Monsoon and post-Monsoon. At Muduga, the minimum salinity recorded was 30 ppt in Monsoon and maximum was 35ppt in pre-Monsoon and post-Monsoon. In general, the study stations Muduga and Tilmati showed similar salinity variations while Majali showed steep variation in salinity (Table-1). Seasonal variation in the salinity was very large showing a variation of 15ppt to 35ppt during the period of observation. Salinity was high during pre-Monsoon reaching 35 ppt, with the onset of monsoon the salinity dropped sharply and remained low until with minimum value of 15 ppt. Decrease salinity increases the solubility of oxygen in the water, which probably appears to be the main cause for the increase in the concentration of dissolved oxygen during monsoon.

Dissolved oxygen ranged from 3.6 mg/ L to 6.6 mg/L. At Majali, the minimum dissolved oxygen recorded was 4.2 mg/L in pre-Monsoon and maximum was 6.6 mg/L in Monsoon. At Tilmati, the minimum dissolved oxygen recorded was 3.9 mg/L in post-Monsoon and maximum was 5.5 mg/L in Monsoon. At Muduga, the minimum dissolved oxygen recorded was 3.6 mg/L in post-Monsoon and maximum was 5.2 mg/L in post-Monsoon.In general, the study stations all study stations showed different trends in dissolved oxygen parameter (Table-1). The dissolved oxygen values were dropped sharply reached almost stable during pre-Monsoon and post-Monsoon. The values increased during Monsoon. It is interesting to mention that the annual variation of dissolved oxygen was in contrast with the variation in salinity. Similar maximum observations were reported by Ramamurthi[8] in Madras coastal waters and Ganapati and Venkatasalam[4] at Vishakapatnam observed a direct relationship between the two parameters *i.e* oxygen and temperature. Kalaiarasi *et al.,*[5], and Satpathy[10] reported that maximum dissolved oxygen value was noticed during monsoon period coincided with minimum salinity value with negative correlation analysis, similar observations were recorded in present study.

pH varied from 7.1to7.8 among different study stations.pH and salinity showed similar correlation trend in fluctuations. Nutrients like nitrate (NA), nitrite (NI) and ammonium (AMM) measured in micromoles kept fluctuating throughout the sampling period among three study stations. Nitrate-(7.28 to 15.48); Nitrite-(0.66 to 15.21); Ammonium-(2.15 to 28.41). Phosphate and Iron content was in optimum range at all study stations (Table-1). Comparatively higher pH values were recorded during pre-monsoon when the water salinity was high. During monsoon pH decreased coinciding with heaviest rainfall and lowest salinity value. The reverse observation were reported by Thangaraj[11] and Murugan and Ayyakkannu[7].

Kalaiarasi *et al.*[5], reported maximum nitrate value observed in pre-Monsoon and minimum value was observed in Monsoon seasons,attributed to higher activity of oxidation of ammonia form of nitrogen to nitrite and subsequently to nitrate during Summer season. Whereas in present study opposite observations were recorded, might be due to variations of different parameters at particular study stations.

Table-1 Seasonal variations in physico- chemical parameters of Karwar coast

Parameters		Mpom	Mprem	Mmon	Tpom	Tprem	Tmon	M Upom	M Uprem	M Umon
Air temp	Min	26.1	28.3	25.1	27.4	29.1	26.2	24	24.5	26
	Max	30.1	31.3	30.6	30.2	32.5	31.4	30.2	32	29.2
Water temp	Min	25	26.2	24.3	26	28.2	25.2	22	23	24
	Max	28	28.3	29	29.4	31	29.4	29.1	30.1	28.2
Dissolved oxygen	Min	5	4.2	5.5	3.9	4	5.3	3.6	3.7	4.5
	Max	5.3	6.5	6.6	5.3	5.3	5.5	5.2	4.1	5
Salinity	Min	26	33	15	34	34	30	33	34	30
	Max	34	35	31	35	35	33	35	35	33
pH	Min	7.2	7.4	7.1	7.2	7.6	7.1	7.4	7.5	7.1
	Max	7.4	7.5	7.3	7.6	7.8	7.3	7.5	7.7	7.3
Nitrate	Min	14.2	7.28	11.29	6.19	6.19	6.9	7.28	10.9	8.37
	Max	15.48	15.48	15.47	7.28	7.28	8.01	9.1	15.47	14.2
Nitrite	Min	1.98	1.32	0.66	5.29	1.98	3.96	2.64	1.32	0.66
	Max	3.3	2.31	3.3	15.21	9.2	13.21	3.96	3.3	3.96
Ammonium	Min	12.38	21.6	10	4.3	4.3	2.15	4.3	20.6	29.1
	Max	28	27	22.6	8.6	8.6	3.01	28.41	25.8	31.5
Phosphate	Min	0.33	0.33	1.65	0.33	0.33	1.55	0.16	0.16	0
	Max	1.65	0.99	2.83	1.55	0.91	2.31	0.49	0.82	0.23
Iron content	Min	0.4	0.1	0.2	0.4	0.1	0.2	0.3	0.1	0.2
	Max	3.1	3.4	0.4	3.1	3.4	0.4	0.3	0.3	0.2

Principal Component Analysis (PCA) is a dimension reduction method used to reduce the dimension of multivariate data sets transforming them into smaller clusters of similar observations which represents the maximum amount of variations. The length of the array of different parameters signify the strength of environmental parameter in particular cluster. The PCA loadings indicate the directions with strength of the variations of environmental parameters in entire data set along biplot 1 and 2, which depicts the correlation. Principal Component Analysis shows plot of clusters of sites with respect to seasons based on similarities in environmental parameters. It signifies the most variation in the environmental parameters represented as principal component axis inform of arrows that indicate the direction in which the parameter increases and correlation in terms of loading plots also indicating the magnitude of each parameters. Longer the loading plot, stronger is the relationship. In the present study, ten environmental parameters were analyzed with different sites and seasons. All ten environmental parameters assessed were from three study

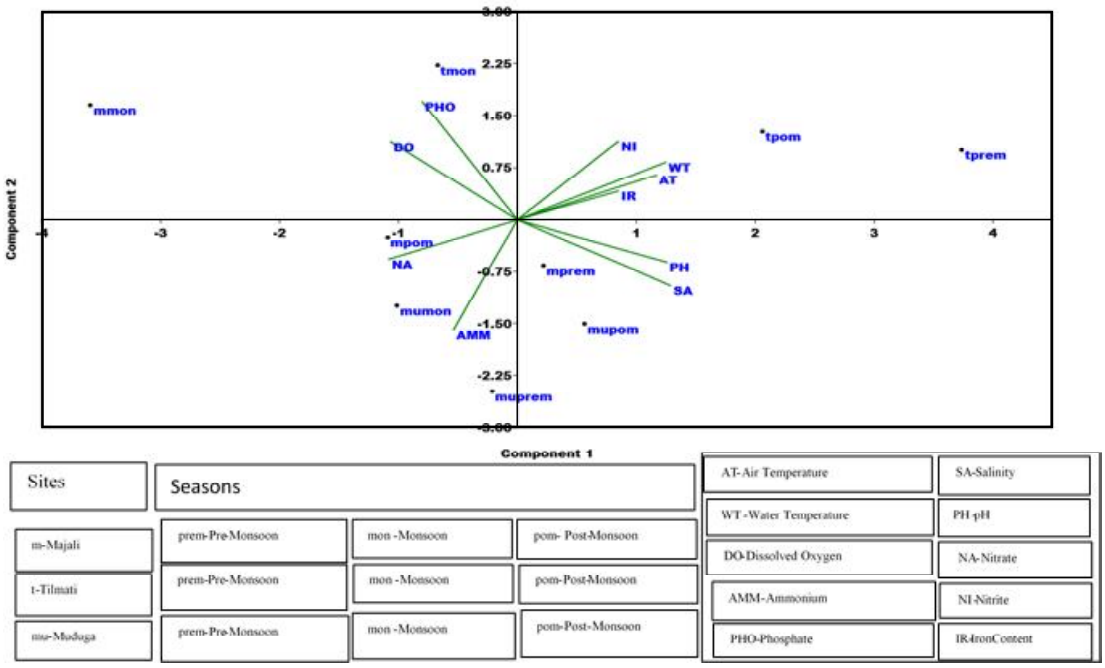

Fig. 2. Scatter plot of PCA grouping results of similarities between all three sites with respect to season on basis of physico-chemical environmental factor

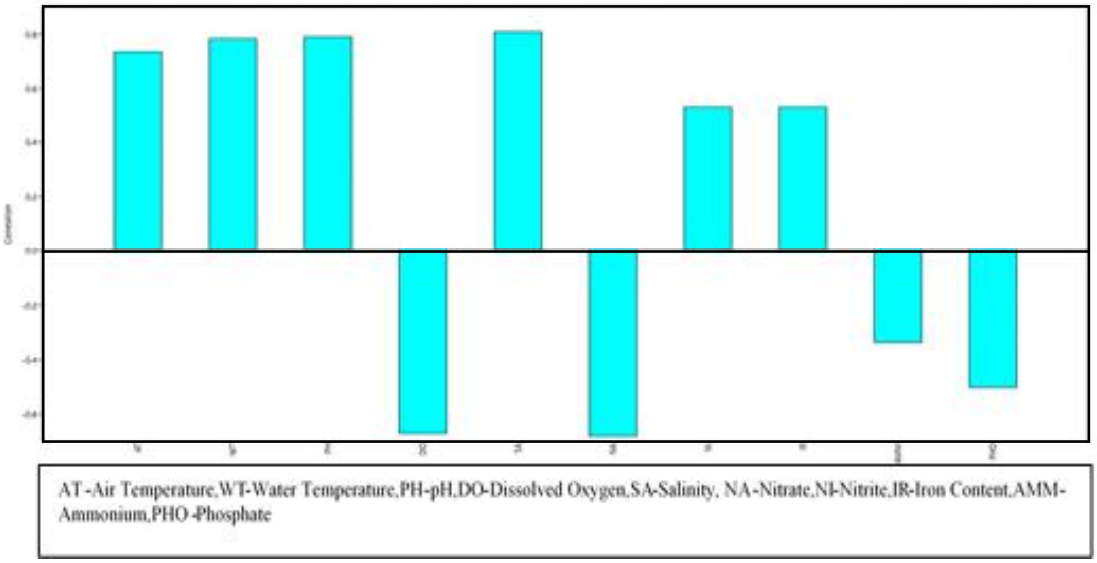

Fig. 3. Correlation loading plot PC 1 of Environmental parameters.

sites Majali, Tilmati and Mudga for following seasons Pre-Monsoon, Monsoon and Post-Monsoon.

PCA diagram with correlation in loading plot of environmental parameters are represented in (Fig. 2). Loading plot shows the correlation of each environmental parameters with each other, a small angle implies positive correlation, large angle implies negative correlation and ninety degree indicates no correlation.The parameters that correlated with the first PCA axis explained for 42.75% of the variability with eigen value 4.27 whereas that correlated with second axis accounted 25.95% of variability with eigen value 2.59. A PCA plot shows the variation in each Principal Component Axis which captures maximum information of the environmental parameters which include component axis1 (horizontal) &component axis 2 (vertical) which incurred maximum correlation between parameters and species. The opposite direction and smaller drawn loading plots from the zeroth axes signifies the inverse correlation and same direction and simultaneous side by side plot describes direct correlation.

The PCA measurements allowed classification of physico chemical parameters into two clusters representing three study sites and seasons. The analysis assessed states based on similarities in physico chemical parameters clusters classified include, cluster 1-Tilmati pre-Monsoon,Tilmati post-Monsoon, Majali pre-Monsoon and muduga post-Monsoon whereas cluster 2 Tilmati Monsoon, Majali Monsoon, Muduga Monsoon, Majali post-Monsoon and Muduga pre-Monsoon with respect to Principal Component Axis 1 which ultimately states dissimilarities between clusters (Fig. 2). Cluster 1 is influenced by Nitrite, Water and Air temperatures, pH and Salinity. Cluster 2 is influenced by Phosphate, Dissolved Oxygen, Nitrate and Ammonium parameters (Fig. 3). In the study six environmental parameters showed maximum positive correlation in terms of loading plot for sites with respect to seasons namely air and water temperature, pH, salinity, iron content and nitrite. The loading values which were positively correlated was air temperature (0.735), water temperature (0.783), pH(0.789), salinity (0.80), nitrite and iron content (0.53). The loading values which were maximum negatively correlated was dissolved oxygen (0.66), nitrate (0.67), and phosphate (0.50) and minimum negative correlation was ammonium (0.33). PCA diagram for individual physico-chemical parameters from all three sites plotted on two component axis (Fig. 2,3) depicts the following results. The loading plots explains the relationship between the environmental factors, which suggests inverse relation of pH and ammonium ions. If the pH concentration lowers then more of ammonia is converted to ammonium ions where at high pH, ammonium ions spilt to ammonia and hydrogen ion which aid in increase of ph. Similarly it states direct relationship between water and air temperatures which is inversely proportion to dissolved oxygen. Relation between ammonium, nitrite and dissolved oxygen states presence of increase of ammonium ions utilize the dissolved oxygen (decline) to produce nitrite. Nitrite is inversely proportional to nitrate; nitrite and ammonium is inversely proportional to each other. Dissolved oxygen and salinity inversely proportional. Similar observations were recorded by Bandekar and Haragi 3 while studying the physico-chemical parameters in Karwar coastal water,central West coast of

India.

An extensive work on hydrographical parameters revealed that the physical, chemical and biological features are adapted to a seasonal rhythm, changes are dependent upon the ample of rainfall leading to large changes in temperature, salinity, flow pattern, dissolved oxygen and nutrients. An attempt was made to determine a correlation matrix of the environmental parameters. Positive correlation was observed between temperature and salinity and between pH and salinity, while negative correlation was found between dissolved oxygen and salinity and pH and dissolved oxygen. Environmental parameters determine the number and percentage of the flora and fauna, their replenishment during various seasons. Occurrence of almost various species indicate that the fairly homogenous environmental parameters within a location and between sites. The season availability of the bio-diversity is influenced by variations in the environmental parameters.

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