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Seasonal variations of hydrographic parameters off the Chennai coast, India

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ABSTRACT

The environment plays a major role in determining the abundance of fishes in a particular region and it helps to predict the probable fishing zone. This environment variables includes temperature, salinity, pH, TSS, DO(Dissolved Oxygen), chlorophyll a, b and c, primary productivity, gross and net, nutrients, phosphate, nitrate and ammonia. These parameters were estimated using standard procedures. These parameters in a particular fishing zone varies from season to season. This seasonal variations of these parameters and its relationship with each other are studied in Ennore, (Lattitude, 80°19′31"E, and Longitude, 13°14′51"N). an industrially polluted area along Chennai coast. Factor analysis is done to remove the redundant highly correlated variables from the data, replacing the entire data with uncorrelated variables. During the post monsoon season, the 4 components extracted by factor analysis indicates that the nutrient, nitrate, chlorophyll b, TSS and dissolved oxygen are important variables deciding the photosynthetic activity, in summer season, 3 components were extracted and the variables that decide photosynthetic activity includes nutrient nitrate, temperature and nutrient ammonia. In pre-monsoon season, 5 components were extracted by factor analysis and the deciding variables include pH, chlorophyll, c, chlorophyll a, chlorophyll b and salinity. In monsoon season, 3 components were extracted and the deciding variables include TSS, DO and temperature for the photosynthetic activity to take place. The eigen values worked out in all the 4 seasons are above 1 and are reliable. The eigen value is highest in the post monsoon component tested, 4.39 and the least eigen value, 1.05 is in the pre monsoon season. Pre monsoon season among all seasons shows highest percentage of cumulative variance. In the post monsoon season, the variables N-Nitrate, chlorophyll b, TSS and DO in the components 1, 2, 3 & 4 decide the growth of phytoplankton with 12% loss of information. In the summer season, the variables, N-Nit, temp., and N-amm., in the components 1, 2 and 3 are the deciding factors for the growth of phytoplankton with 26% loss of information. In the post monsoon season, the variables, pH, chlorophyll c, chlorophyll a, chlorophyll b and salinity in the components, 1, 2, 3, 4 and 5 respectively decides the phytoplankton growth with 11% loss of information. In the monsoon season, the variables, TSS, DO and salinity in the components 1, 2 and 3 decide the growth of phytoplankton with 22% loss of information. These variables are representative of all original 11 variables and the components are not linearly correlated with each other. The size of the data from 11 variables can be reduced to three components by using factor analysis with the principal components extraction.

Key words: *Seasonal variation, Phytoplankton, Environment, Ennore, Factor analysis,seawater*

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Introduction

Environmental variables along the seacoast play a major role in determining the productivity of the coast. The productivity varies from one particular area to the other along the coast. The productivity of a coast determines the availability of the nutrients, phosphate, ammonia and nitrate. The determination of the nutrients and the productivity in the ocean, Ennore for the year 2008-2011 were made. The selected hydrographic variables and its relationship with the productivity are discussed. The productivity determines the healthy living of the fishes of that particular region. Ennore is normally an industrially polluted region of Chennai and the study of hydrographic variables becomes inevitable to ascertain the health of the ocean. The dumping of sewages at several points of Chennai with reference to Ennore had decreased the dissolved oxygen and regular monitoring of these regions for dissolved oxygen and other inter related hydrographic variables, such as temperature, salinity, pH, TDS and TSS are monitored.

Methods and Materials

The sampling station selected was Ennore (S1) industrially polluted area. The samples were collected between 9.30 am to 11.30 am during low tide from the sampling station for a period of 4 years, 2008-2011. The number of samples collected were 12/month/station. The sea water samples were collected for the months from Jan-Dec at two different stations, Ennore in properly labelled bottles for the period 2008-2011. The sample labelled bottles were stored in the refrigerator for analysis purposes at 0°C. The study station is Ennore (Lattitude, 80°19'31"E, and Longitude, 13°14'51"N). Temperature was measured using mercury-thermometer, (Range- 0 ºC-100 ºC, 76 mm, 1 mm) salinity using Salinometer, (Model N ERMA Refractrometer), pH using pH meter, (Model N.H 198107), dissolved oxygen using Winkler's method (titrimetric method), total soluble solids (Model N H198302) using residue filtration method, chlorophyll 'a', 'b' and 'c' using Spectrophotometric method, primary productivity, gross and net was measureed using light and dark bottle method, the nutrients, phosphate was estimated using ascorbic acid method, ammonia was estimated using phenol hypochlorite method and nitrate was estimated using Moris and Riley method (Kaladharan *et al.,* 2001). The sampling design adopted was Randomized Block Design (RBD). The sampling depth was 10m. The statistical analysis performed SPSS software. The data were collected at equal intervals of 1month for the months from Jan-Dec'08-2011. The physiochemical parameters, temperature, pH, salinity, dissolved oxygen, nutrients such as total phosphorous, nitrate, and silicate were estimated by adopting standard procedures (Strickland and Parsons, 1972).

Results and Discussion

Factor Analysis

This factor analysis is done to remove the redundant, highly correlated variables from the data, replacing the entire data with a smaller number of uncorrelated variables (SPSS 16.0 version, 2007).

Post monsoon season

The first principal component (PC1**)** explaining about 39.91% variance showed possible utilization of N-Phos by the phytoplankton for photosynthetic activity**.** This was indicated by the positive loadings for chlorophyll b and chlorophyll c and negative for N-phos (Table 1). The second principal component (PC2, 21.133% variance) was related to the inputs of chlorophyll b to the coastal water as the temperature and salinity values came down. The increase in pH and DO value increased the chlorophyll a, b & c. The third principal component (PC3) with variance,

Table 1. Extraction Method: Principal Component Analysis.

		Component			
SNo.	Env. par	1	2	3	4
1	Temp	0.61	-0.62	0.32	-0.10
2	sal	0.79	-0.50	-0.003	0.33
3	pH	0.70	0.37	-0.36	0.29
4	D.O	-0.19	0.44	0.59	0.49
5	tss	0.67	0.08	0.65	-0.22
6	Chl-a	0.19	0.83	0.12	0.07
7	Chl-b	0.40	0.87	-0.06	0.01
8	Chl-c	0.41	0.32	0.17	-0.76
9	N-Phos	-0.85	0.26	-0.19	-0.17
10	N-Nit.	0.87	0.10	-0.21	0.24
11	N-Amm	-0.73	-0.02	0.43	0.31
	Total	4.39	2.65	1.34	1.28
	% of varia	39.91	24.13	12.22	11.69
	cumu %	39.91	64.05	76.27	87.96

12.22% showed that the increase in dissolved oxygen increased the N-Amm, the fourth principal component (PC4) for 11.69% variance showed an inverse relationship between N- phos and salinity, pH and dissolved oxygen. The total cumulative percentage of variance ranged from 39.91% to 87.96% for the post monsoon season of all the four years tested. The eigen values are shown in a graph for the individual components (Fig. 1).

Fig. 1. Eigen values in a screen plot of post monsoon season

a) 4 components extracted, post monsoon season

The scatter plot matrix shows that the first component has a skewed distribution, which is because N-Nitrate is skewed (Fig. 2). Principal components extraction using a log transformed N- nitrate value might give better results. A separation in the third component is explained by the fact that chlorophyll b is a binary variable, there appears to be a relationship between the first and the third component,

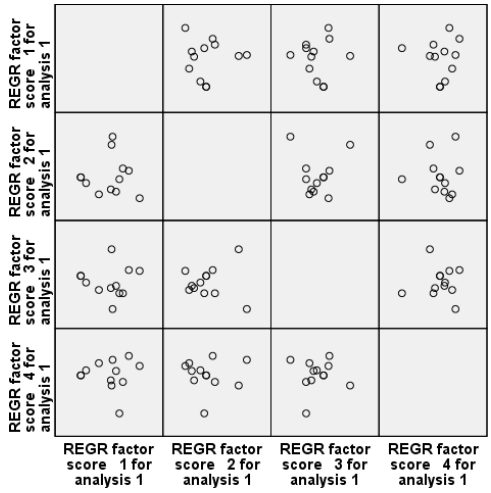

Fig. 2. Scatter Plot matrix of Post monsoon season

hence log transformed N-Nit. values are necessary. Correlation of the hydrographic variables in 4 different seasons are given below (Table 2).

(b) Summer season

Four factors were developed for the summer season with eigen values higher than 1, with 74.82%, total variance 7(Table 3). First principal component (PC1, 31.93% variance) explained the high amount of tss with the utilization of chlorophyll a, b, c and N-phos (Table 1). The second principal component (PC2, 23.11% variance) depicted negative loadings of N-phos with the increase in the temperature and salinity. The third principal component, (PC3, 19.78% variance) shows utilization of the nitrate with the increased release of ammonia for the increased photosynthetic activity. The eigen values of the summer season is shown in a screen plot (Fig. 3). The scatter plot matrix is shown in Fig. 4.

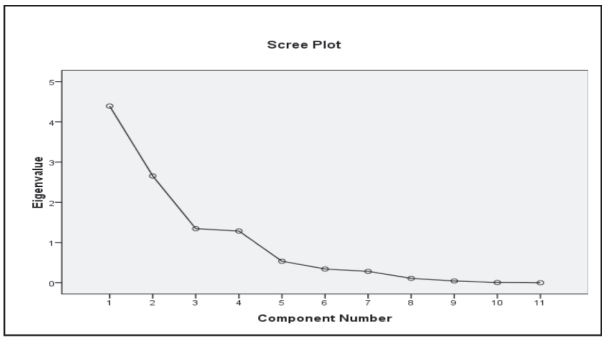

Fig. 3. Eigen values of the summer season in a screen plot

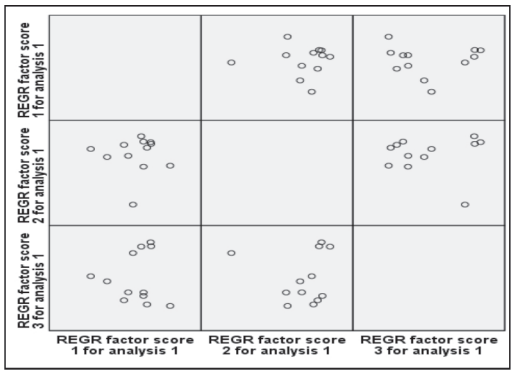

Fig. 4. Scatter Plot matrix of Summer season

(c) Pre-monsoon season

The PCA analysis of the coastal water extracted five components with eigen values higher than 1 with 89.37% variance. There were 5 components extracted in this season (Table 4). The first principal

Table 2. Correlation table of different seasons of hydrographic variables

	Post monsoon season											
SNo.	PCor	Temp	SAL	pH	D.O	TSS	Chl-a	Chl-b	Chl-c	N-Pho	N-Nit.	N-Am
1	Temp	1.00	0.77	0.12	-0.24	0.57	-0.32	-0.33	0.16	-0.60	0.33	-0.34
2	SAL		1.00	0.52	-0.25	0.36	-0.29	-0.16	-0.10	-0.83	0.68	-0.45
3	pH			1.00	0.00	0.15	0.29	0.56	0.03	-0.46	0.85	-0.44
4	D.O				1.00	0.06	0.32	0.29	-0.12	0.05	-0.23	0.44
5	TSS					1.00	0.33	0.30	0.53	-0.62	0.46	-0.21
6	Chl-a						1.00	0.72	0.19	0.05	0.26	-0.12
7	Chl-b							1.00	0.45	-0.10	0.46	-0.33
8	Chl-c								1.00	-0.18	0.14	-0.44
9	N-Pho									1.00	-0.69	0.52
10	N-Nit.										1.00	-0.56
11	N-Am											1.00
	Summer season											
SNo	P. Cor	Tem.	Sal	pH	D.O	tss	Chl-a	Chl-b	Chl-c	N-Pho	N-Nit.	N-Am
1	Temp	1.00	0.37	0.06	0.02	0.55	-0.29	-0.03	-0.10	-0.59	-0.00	-0.02
2	SAL		1.00	0.20	0.05	0.03	0.19	0.05	0.048	-0.65	-0.24	-0.65
3	pH			1.00	0.35	0.41	-0.12	-0.48	-0.40	-0.32	0.53	0.05
4	D.O				1.00	0.12	-0.08	-0.55	-0.48	0.36	0.67	-0.14
5	TSS					1.00	-0.80	-0.37	-0.33	-0.42	0.38	0.53
6	Chl-a						1.00	0.04	0.08	0.08	-0.22	-0.54
7	Chl-b							1.00	0.81	-0.01	-0.40	-0.15
8	Chl-c								1.00	0.13	-0.32	0.10
9	N-Pho									1.00	0.29	0.25
10	N-Nit.										1.00	0.35
11	N-Am											1.00
	Pre monsoon season											
SNo.	P Cor	Tem	Sal	pH	D.O	TSS	Chl-a	Chl-b	Chl-c	N-Pho	N-Nit.	N-Am
1	Temp	1.00	-0.36	0.67	0.60	0.05	0.10	0.19	0.48	-0.41	0.22	0.04
2	Sal		1.00	-0.03	-0.00	-0.15	0.31	-0.11	0.07	0.55	0.11	-0.13
3	pH			1.00	0.60	0.52	-0.33	0.06	0.37	-0.46	0.43	-0.37
4	D.O				1.00	0.43	0.26	0.00	0.20	-0.54	-0.01	0.13
5	TSS					1.00	-0.48	-0.13	-0.28	-0.64	-0.05	-0.04
6	Chl-a						1.00	-0.22	0.28	0.10	-0.12	0.21
7	Chl-b							1.00	-0.27	0.30	-0.58	0.17
8	Chl-c								1.00	0.06	0.57	-0.15
9	N-Pho									1.00	-0.16	0.02
10	N-Nit.										1.00	-0.34
11	N-Am											1.00
	Monsoon season											
SNo.	P. Cor	Temp	Sal	pH	D.O	TSS	Chl-a	Chl-b	Chl-c	N-Ph	N-Ni	N-A
1	Temp	1.00	0.31	0.19	0.41	-0.03	0.39	0.32	0.30	0.02	-0.04	-0.60
2	Sal		1.00	0.23	-0.04	-0.10	-0.03	-0.11	-0.11	-0.25	0.17	0.09
3	pH			1.00	-0.60	0.75	0.35	0.33	0.34	-0.69	0.45	0.17
4	D.O				1.00	-0.69	0.11	0.10	0.08	0.51	-0.51	-0.46
5	TSS					1.00	0.51	0.52	0.53	-0.48	0.33	0.34
6	Chl-a						1.00	0.99	0.98	-0.24	0.15	0.19
7	Chl-b							1.00	0.99	-0.25	0.14	0.21
8	Chl-c								1.00	-0.26	0.21	0.2
9	N-Pho									1.00	-0.53	-0.25
10	N-Nit.										1.00	-0.01
11	N-Am											1.00

component, (PC1, 30.44% variance) indicated possible utilization of phosphate by the phytoplankton. This was demonstrated by the positive loadings of chlorophyll c and negative for N-phosphate. The second principal component, PC2, 21.06% variance showed that an increase in n-nitrate leads to decrease in dissolved oxygen and tss. The third principle component PC3, 16.16% variance showed that a decrease in nitrate may be due to pre monsoon season rain in coastal waters and a increase in the ammonia. The fourth component PC4, 12.14% variance showed that the increase in chlorophyll b leads to a decrease in do and tss being used for photosynthesis. The fifth principal component, PC5, 9.56% variance, showed an increase in salinity with an decrease in temperature. The eigen values of the pre monsoon season of the individual components are graphically shown (Fig. 5). Scatter plot matrix of pre-monsoon season is shown in the graph (Fig. 6).

Table 3. Extraction Method: Principal Component Analysis.

		Component		
SNo.	Env. par	1	2	3
1	Temp	0.19	0.77	0.14
2	sal	-0.21	0.73	-0.46
3	pH	0.65	0.03	-0.27
4	D.O	0.60	-0.26	-0.49
5	tss	0.72	0.49	0.45
6	Chl-a	-0.51	-0.21	-0.66
7	Chl-b	-0.76	0.04	0.39
8	Chl-c	-0.68	-0.08	0.45
9	N-Phos	0.01	-0.93	0.05
10	N-Nit.	0.76	-0.29	-0.06
11	N-Amm	0.44	-0.27	0.774
	Total	3.51	2.54	2.17
	% of varia	31.93	23.11	19.78
	cumu %	31.93	55.04	74.82

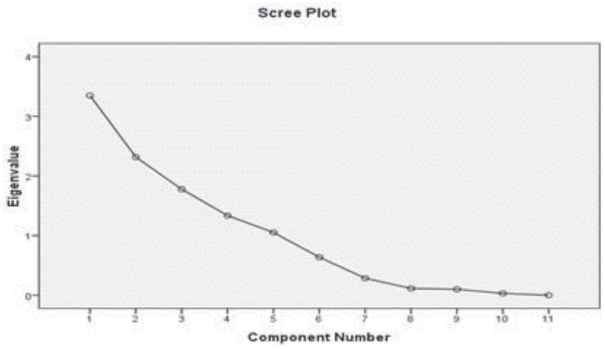

Fig. 5. Eigen values of the pre-monsoon season in a screen plot

a. 5 components extracted-pre-monsoon season

(d) Monsoon season

The PCA analysis of the coastal waters extracted from 3 components with eigen values higher than 1 with 78.73% variance (Table 5). The first principal component, PC1, 38.77% variance, indicated a negative loading of N-phosphate with an increased chlorophyll a, b & c due to monsoon, northwest monsoon showers, the second principal component, PC2, with 24.08% variance showed an increased do most favourable for the growth of fish with decreased release of ammonia. The third principal component, PC3, with a variance of 15.87% a posi-

Table 4. Extraction Method: Principal Component Analysis.

		Component				
SNo.	Env.par.	1	2	3	4	5
1	Temp	0.74	0.10	0.49	0.27	-0.24
2	SAL	-0.38	0.52	-0.08	0.26	0.67
3	pH	0.87	0.13	-0.08	0.39	0.13
4	D.O	0.72	-0.11	0.43	-0.04	0.45
5	TSS	0.59	-0.50	-0.42	-0.08	0.36
6	Chl-a	-0.16	0.38	0.69	-0.43	0.27
7	Chl-b	-0.19	-0.46	0.35	0.76	-0.05
8	Chl-c	0.35	0.77	0.25	0.09	-0.19
9	N-Phos	-0.79	0.32	0.10	0.41	0.05
10	N-Nit.	0.41	0.71	-0.36	-0.07	-0.22
11	N-Amm	-0.13	-0.39	0.57	-0.26	-0.11
	Total	3.34	2.31	1.77	1.33	1.05
	% of var.	30.44	21.06	16.16	12.14	9.56
	cumu %	30.44	51.50	67.66	79.80	89.37

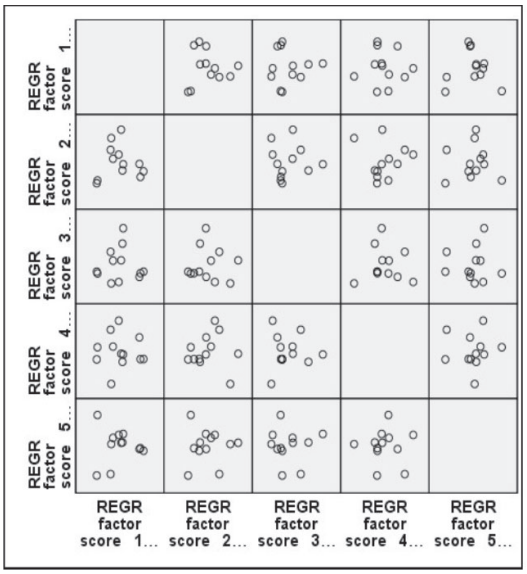

Fig. 6. Scatter Plot matrix of pre-monsoon season

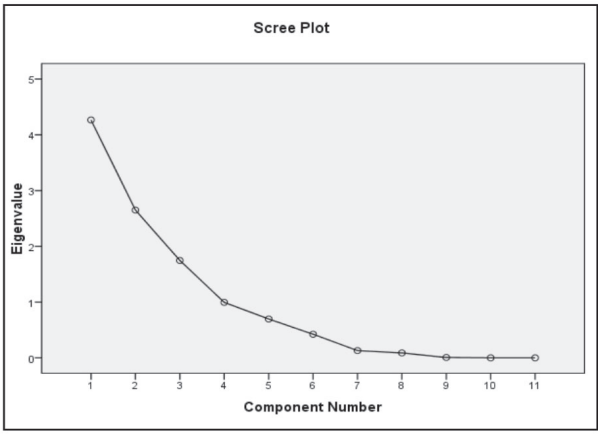

Fig. 7. Eigen values of the pre-monsoon season in a screen plot

tive temperature effect with an increased salinity causes an increase in the do and decreased n- phos for the photosynthetic activity. Eigen values of the pre-monsoon season are graphically shown. (Fig. 7). Scatter Plot matrix of the monsoon season is shown as below (Fig. 8).

a. 3 components extracted-monsoon season

Conclusion

The eigen value is highest in the post monsoon component tested, 4.39 and the least eigen value, 1.05 is in the pre monsoon season. Pre monsoon season among all seasons shows highest percentage of cu-

Table 5. Extraction Method: Principal Component Analysis.

Component SNo.	Env.par.	1	2	3
1	Temp	0.19	0.65	0.66
2	sal	0.09	-0.10	0.66
3	pH	0.76	-0.27	0.42
4	D.O	-0.43	0.84	0.05
5	tss	0.82	-0.26	-0.16
6	Chl-a	0.80	0.55	-0.17
7	Chl-b	0.80	0.53	-0.23
8	Chl-c	0.81	0.50	-0.22
9	N-Phos	-0.66	0.42	-0.28
10	N-Nit.	0.49	-0.39	0.32
11	N-Amm	0.34	-0.42	-0.58
	Total	4.26	2.64	1.74
	% of varia	38.77	24.08	15.87
	Cumu %	38.77	62.86	78.73

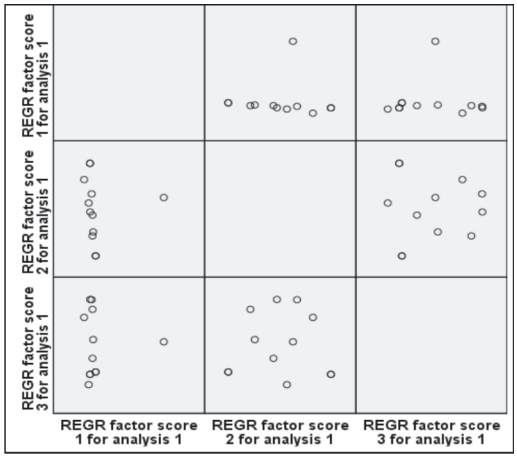

Fig. 8. Scatter Plot matrix of mosoon season

mulative variance. In the post monsoon season, the variables N- Nitrate, chlorophyll b, tss and do in the components 1, 2, 3&4 decide the growth of phyto plankton with 12% loss of information. In the summer season, the variables, N-Nit, temp., and N-amm., in the components 1, 2 and 3 are the deciding factors for the growth of phytoplankton with 26% loss of information. In the post monsoon season, the variables, pH, chlorophyll c, chlorophyll a, chlorophyll b and salinity in the components, 1,2,3,4 and 5 respectively decides the phytoplankton growth with 11% loss of information. In the monsoon season, the variables, tss, do and salinity in the components 1, 2 & 3 decide the growth of phytoplankton with 22% loss of information. These variables are representative of all original 11 variables and the components

are not linearly correlated with each other. The size of the data file from 11 variables can be reduced to three components by using factor analysis with the principal components extraction. The results are reliable with the eigen values greater than 1.

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