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IMPACT OF PLANKTON DIVERSITY ON THE WATER QUALITY INDEX IN A LAKE AT THIRUMAKUDAL NARASIPURA MYSORE DISTRICT

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Abstract: The relationship between Water Quality Index (WQI) and the plankton diversity in polluted lake (Alagudu Lake) of Mysore district has been studied. Eight physico-chemical parameters and 21 plankton species were considered for the study. ISO 3166 alpha 2 coding was applied to the lake. The quality of water was rated as good for only two months, while it was rated as medium for rest of the months. Very few plankton species dominated the lake and had no significant impact on the WQI. *Navicula veneta, Navicula rhynococephala, Nitzschia punctata, Gomphonema hybridense and Pinnularia achrosphaeria* were the principal components of the lake water. Among the physico-chemical parameters, total nitrogen and change in water temperature had a major role. WQI is mainly determined by the physical and chemical parameters.

Keywords: Water Quality Index, Alagudu lake, Plankton Diversity, PCA biplot

I. INTRODUCTION

Water Quality Indices (WQI) are widely used to evaluate the suitability of potable water. They serve as tools for management strategies and improvement of water quality. Sanchez *et al*.,(2007), Prati (1971), Schaeffer *et al*.,(1977), Ott (1997), Abbasi (2002) have all used WQI indices in determining the quality of lake waters. The indices are numeric expressions used to transform large quantities of ecological data related to water quality into a single number. This allows easy characterization of the water for any purpose.. The National Sanitation Foundation (NSF) is one such useful index involving very few parameters for calculation (Brown *et al*., 1970). The index was developed to provide a tool for simplifying the report on water quality data (Liou *et al.,* 2003) A few of the researchers who have made use of the WQI in this area are Hosmani *et al*,(2010), Deviprasad and Siddaraju(2012), Giriappannavar and Patil (2013). Although there seems to be some work on the WQI, there is absolutely no report on the relationship between WQI and plankton diversity.

The present paper deals with the interrelationship of WQI and plankton diversity in a polluted lake of Mysore District. Further new techniques and software have been employed in the analysis of the data and its presentation. The description of the lake closely follows the ISO 3166 coding method.

II. MATERIALS AND METHODS

Alagudu lake is located 55^0latitude and 12.3” longitude, South of Mysore district in Tiramakudal Narasipura Taluk of Mysore district. It lies on the National Highway No. 212 at a distance of 30 kms from Mysore. It has a catchment area of 150 acres with a maximum depth of 6 meters when full. The soil beneath the lake is red loamy. The lake supports abundant aquatic vegetation. Dumping of domestic and animal waste into the lake is common. The water is used for aquaculture. ISO 3166 alpha 2 codes are two letter country codes defined in ISO 3166-1 published by International Organization for Standardization(ISO) to represent special areas of geographical interest.(1974). Centre for Lake Conservation, Environmental Management and Policy Research Institute (EMPRRI) , Bangalore formulated coding systems for lakes based on the ISO regulations .The same has been used for the coding of Alagudu Lake and is represented in the Fig. Below:

Eight water quality parameters (Table 1)were analysed for 12 months using the methods described in APHA, 1998. The WQI was calculated online (xls.swrp.osr.pdx.edu/teacher.info). The resultant values were compared to the Standard WQI Legend. The collection, preservation, identification and enumeration of plankton species were as per the methods described by Hosmani(2010). The 3D PCA biplot was obtained by subjecting the data to the *sofwaretyopic.inforrmer.com.pcsoftware*

III. RESULTS AND DISCUSSION

A. WATER QUALITY STANDARDS

The standards include both natural lakes and artificial reservoirs having capacities of more than 10 million m^3. Water quality parameters were used to establish the standards and are divided into separate classes and standards are set for water quality parameters such as pH and COD. Five classes are set for nitrogen and phosphorus. Five water quality standards are defined on the basis of daily average values. However, standards for total nitrogen and phosphorus are defined as annual averages. Standards for pH and coli forms have the same scientific basis as those for rivers. Based on these values a 100 point index is divided into different ranges corresponding to the general and descriptive terms as shown in the Table 2.The results of the WQI are presented in Table 1.

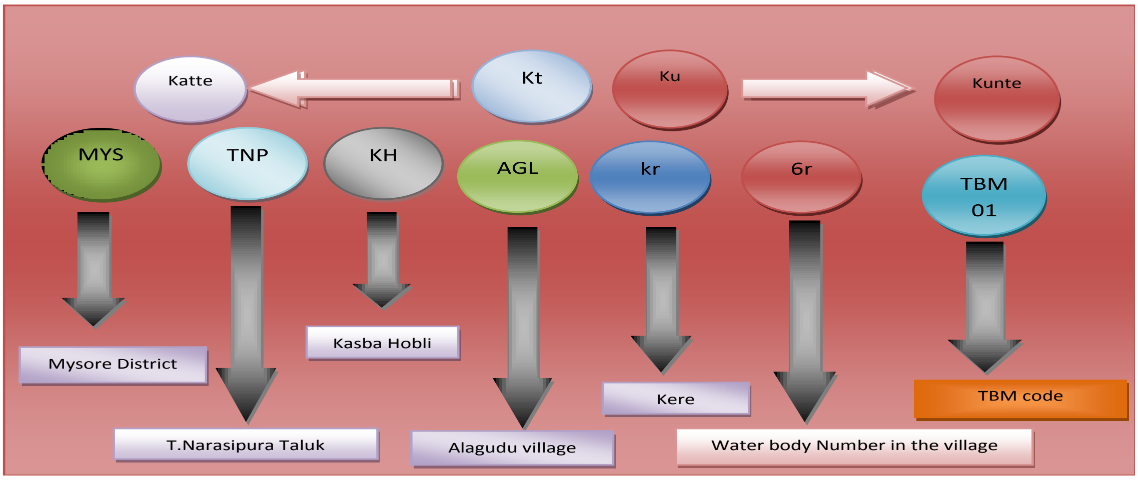

Figure 1: Coding of lake (Mysore district, T. Narasipura Taluka, Kasba Hobli, Alagudu Village, Kere, Water body number in the village is 6r and the code is TBM 1)

B. pH

Generally, pH of lake waters is around 7, except in estuaries. At most intake facilities the pH is around 7.0. When the pH is more than 8.5, it interferes with chlorination during water treatment plant. To ensure prevention of corrosion in the treatment plant and distribution system, maintaining pH between 6.5 and 8.5 is desirable. If pH is outside the above-mentioned range, it may cause irritation of eyes and adversely affects the growth of plants. Low pH severely affects the plants due to the dissolution of salts, while high pH causes discoloration of plant leaves and phytoplankton. Generally the optimum pH range for proper plant growth is between 6.5 and 7.5; therefore the pH standard for agricultural use is set as 6.5-7.5 for lakes and rivers. The pH of the water in the present study varied between a minimum of 6.0 during January and a maximum of 9.2 during the months of April and November.

C. CHANGES IN WATER TEMPERATURE ^{0C}

Water temperature fluctuation was moderate varying between a minimum of 2^0C to a maximum of 6^0C during January. However values of temperature decreased extremely during September. This may have an effect on the plankton growth and on the dissolved oxygen levels.

D. DISSOLVED OXYGEN (mg/L)

Generally, the Dissolved Oxygen concentration in clean lakes is more than 7.5 mg/l. The DO standards for fisheries are set at 7.5 mg/l between 6 and 7.5 for some fish species. In some cases existing plankton cause lower DO at night, therefore the allowable DO limit is 5 mg/l. For conservation of the environment, DO should be kept at more than 2 mg/l to prevent anaerobic conditions that cause bad odours. The saturation of DO in the lake water was highest during the month November and was least during September. During the remaining months it fluctuated between 23% and 64 %. DO mg/L was transformed to % saturation using change in water temperature values.

E. BIOCHEMICAL OXYGEN DEMAND (mg/L)

Biochemical Oxygen demand is a measure of the quantity of oxygen used by microorganisms in the oxidation of organic matter. In lake ecosystems the natural source of organic matter can be the excess growth of plankton and other aquatic vegetation and in addition human influence. Run off from residential areas which carry excess organic waste can increase the oxygen demand? Organisms that are more tolerant of lower dissolved oxygen levels may replace a diversity of organisms feeding on the dead algae. In most cases if the dissolved oxygen level drops below 5 ppm, fish will be unable to live for very long. Abnormally high levels of aerobic bacterial activity in a lake drop the level of dissolved oxygen. Generally this occurs when there is some sort of abnormal pollution such as domestic sewage and fertilizer runoff. Natural sources of organic compounds can also come into aquatic systems by means of floods and erosion of soil surrounding the lake. The levels of Biochemical Oxygen Demand in the lake were at a minimum of 0.9 ppm with a highest value of 4.6 ppm during January. In contrast to these values the Dissolved oxygen saturation levels were highest during November and January with the least saturation levels during September.

F. TURBIDITY (NTU)

Turbidity is the measure of water clarity, or the amount of suspended materials suspended in water that can decrease the passage of light through the water. Suspended materials include soil particles, planktonic algae, microbes and other organisms. Turbidity can also affect the colour of the water. High turbidity increases water temperatures because suspended particles absorb more heat. This in turn can reduce the concentration of dissolved oxygen because warm water holds less dissolved oxygen in comparison to cold water. Higher turbidity also reduces the amount of light penetration in the water which reduces algal photosynthesis and the production of dissolved oxygen. Turbidity level of the water was least during the month of March, October and November and the water quality index and ranking was classified as Good

G. PHOSPHATES AND NITRATES (mg/L)

Phosphates and nitrates occur in small amounts in all aquatic environments and are required to maintain the growth and metabolism of aquatic plants including algae. . However, in access these two nutrients can be harmful. Significant portions of the dissolved minerals consist of phosphates and nitrates. Levels of phosphates and nitrates that are intolerable to local organisms of the lake have been known to deplete dissolved oxygen resulting in the formation of algal blooms. The main cause of destruction of lake ecosystems is due to eutrophication brought about by high amounts of phosphates and nitrates (Ansar and Khad, 2005). Yanamadala,(2005) has reported that high levels of phosphates and nitrates have an impact on the overall health of the water and its organisms. Small differences exist between the levels of phosphates and nitrates and phosphates levels are not affected by the season as nitrate is (Balogh *et al*., 2006). If high phosphates and nitrates continue to pour into a lake the quality of water dwelling organisms and that of the water itself will continue to decline.(Engel *et al*., 1994). Techniques of removal of dissolved phosphorous from storm water runoff, are being developed to reduce pollution that goes into water bodies (Kreuzer, 2000). It is of interest to note that the lake water under study did not have high levels of both phosphates and nitrates

H. COLI FORMS (CFU)

Coli form bacteria themselves are not necessarily harmful to humans, but they have been used as indicators for pathogenic bacteria. Coli form organisms should be non-existent in drinking water and the most probable number (MPN) should not exceed l/100ml. The council on living environment in the Ministry of Health and Welfare reports that removal rate of coli forms is about 99% and 95% in slow and rapid sand filtrations, respectively. The removal rate in rapid sand filtration can be improved to from 98 to 99% with highly proper maintenance. The standard was set as 1000 MPN/100ml for class 2 water supply in which rapid sand filtration systems are operated with conventional maintenance, considering that follow up with chlorination can safely function at 50 MPN/100ml level. For class 3 water supply in which high level maintenance can be expected, the limit is around 2500-5000 MPN/100ml. Therefore, the standard was set as 5000 MPN/100ml. For bathing, 1000 MPN/100ml was established as the standard. In the present study the *E. coli* were expressed as Colony Forming Units (CFU) which is required data for the software. When the *E.coli* were almost zero the water quality was rated as good.

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Vol. 2, Issue 5, May, 2013

I. WATER QUALITY INDEX

Except for the months of March, October and November the water quality index was less than 72.4, which was rated as good. During the rest of the months the water quality was rated as medium. The index was at its least during January. The fluctuation may be related to the unequal number of planktonic algae that occurred in the lake during the study period. These relations are discussed below.

J. PLANKTON DIVERSITY (organisms/ml)

Twenty one species of algae were recorded in the lake during the study period. Diatoms dominated the population. *Navicula venata*, *Navicula rhynococephala*, *Nitzschia punctata*, *Gomphonema hybridense* and *Pinnularia acrosphaeria* were the most dominant species (Table 3).The remaining species showed variations in their distributions. Only 2 species of desmids were recorded which is an indication that the water was highly polluted. This is because many workers have suggested that Desmids are indicators of good water quality. One species each of Chlorococcales and Cyanophyceae occurred in the lake.

TABLE 1.
PHYSICO- CHEMICAL PARAMETERS FOR ALAGUDU LAKE (JANUARY TO DECEMBER, 2012)
ISO CODE : MYS/TNP/KH/AGL/KR/6R:TBM 01

Parameters/Month	PH(Units)	Temp. Change ^{0}C	DO(%saturation)	BOD(mg/L)	Turbidity(NTU)	T. P(mg/L-P)	N(mg/L N-No3)	*E. coli*(CFU/100ml)	Water Quality Index	Water Quality Rating
January	6.0	6	64	4.6	3.12	0.2	0.15	7	57.3	Medium
February	6.8	4	32	1.8	3.12	0.11	0.18	18	67.3	Medium
March	8.3	4	55	0.9	11.6	0.10	0.12	11	72.4	Good
April	9.2	3	61	1.4	34.9	0.12	0.15	8	67.9	Medium
May	7.8	2	30	1.4	31.6	0.40	0.13	13	63.3	Medium
June	8.4	-1	40	2.1	87	0.40	0.11	15	60.3	Medium
July	8.2	4	59	1.6	102	0.10	0.0	18	66.1	Medium
August	8.6	3	34	1.6	136	0.4	0.2	1	62.6	Medium
September	8.5	-10	12	1.4	41.3	0.12	0.4	6	58.2	Medium
October	8.4	2	41	2.2	3.8	0.12	0.12	0	74.2	Good
November	9.2	-2	74	3.6	1.9	0.2	0.4	0	77.6	Good
December	6.8	-2	23	1.6	1.9	0.40	0.16	15	65.2	Medium

Over all Water Quality Index=60.34; Water quality Rating=Medium

TABLE 2:
WATER QUALITY INDEX LEGEND

Range	Quality
90-100	Excellent
70-90	Good
50-70	Medium
25-50	Bad
0-25	Very bad

TABLE 3

Although the study indicates the distribution of plankton and the importance of the physico-chemical complexes, it does no indicate the relationship between these two sets of parameters. In order to achieve this goal a 3-D Scatter plot for interrelations of the Physico-chemical parameters and distribution of plankton species for the months of January to December, 2012 are plotted as shown in Fig. 2. (XLSwww.swrp.esr.pdx.edu/teacher info-software was used.).

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Vol. 2, Issue 5, May, 2013

TABLE 3.
DISTRIBUTION OF PLANKTON FOR ALAGUDU LAKE (JANUARY TO DECEMBER, 2012)

Months	*Navicula veneta*	*Nav. rhynococephala*	*Nitzschia punctata*	*Gomp. hybridense*	*Pinn. acrospheria*	*Navicula raiosa*	*Pleuro .angulatum*	*Pinnularia similis*	*Navicula virudula*	*Cymbella aspera*	*Cymbella tumida*	*Gomp .gracile*	*Nitzschia obtusa*	*Cos. moniliforme*	*Cymbella cistula*	*Fragilaria capucina*	*Cymboplura haukii*	*Cos. punctatum*	*Pediastrum simplex*	*Rhopolodia gibba*	*Chroococcus minor*
Jan	27	24	23	00	00	21	14	28	35	15	15	04	22	00	18	28	24	00	00	12	00
Feb	26	26	15	00	13	27	00	35	00	00	00	09	00	00	20	00	00	00	15	23	23
Mar	29	14	19	20	10	20	16	00	00	22	22	00	22	24	31	00	10	00	00	00	00
Apr	15	19	18	12	06	00	12	00	00	13	13	07	25	22	02	00	15	00	00	00	00
May	24	18	13	14	09	00	13	20	15	15	15	00	00	00	00	20	00	06	00	00	15
Jun	23	37	16	28	11	29	00	00	00	14	14	00	32	00	00	00	00	00	20	24	16
Jul	14	00	00	15	19	00	00	07	19	10	10	03	12	14	00	00	29	14	17	17	00
Aug	31	26	25	25	17	28	20	20	32	12	12	07	18	00	00	15	20	12	08	08	00
Sep	17	24	00	34	20	23	27	12	37	03	03	18	10	27	20	14	00	00	10	10	00
Oct	25	25	00	21	17	00	30	14	00	00	00	00	00	16	16	00	00	23	07	07	22
Nov	34	36	10	00	13	32	00	00	20	00	00	14	00	25	00	36	00	16	00	00	00
Dec	22	00	13	25	00	26	28	11	32	00	00	18	00	00	00	20	00	24	00	00	30

TABLE 4:
FACTOR VALUES FOR THE TABLE OF PARAMETERS

F1	F2	Factor values	Parameters	Months	Rank after arrangement
0.003	0.240	0.243	pH(Units)	January	18
0.406	0.156	0.617	Temp. Change 0C	February	5
0.125	0.168	0.293	DO(% saturation)	March	14
0.018	**0.523**	0.541	BOD(mg/L)	April	7
0.190	0.123	0.313	Turbidity(NTU units)	May	13
0.001	0.081	0.082	T. Phosphorous(mg/L)	June	25
0.612	0.026	0.638	Nitrogen(mg/L)	July	4
0.170	0.049	0.219	*E. coli*(CFU/100ml)	August	19
0.071	0.004	0.075	WQI	September	26
0.046	**0.414**	0.460	*Navicula veneta*	October	10
0.014	0.055	0.069	*Nav. rhynocephala*	November	26
0.179	**0.475**	0.654	*Nitzschia punctata*	December	3
0.007	**0.408**	0.415	*Gomphonema hybridense*		12
0.012	**0.448**	0.460	*Pin. acrosphaeria*		9
0.101	0.143	0.244	*Navicula radiosa*		16
0.174	0.014	0.188	*Pleurosigma angulatum*		21
0.004	0.124	0.127	*Pinnularia similis*		23
0.150	0.093	0.243	*Navicula virudula*		17
0.690	0.030	0.720	*Cymbella aspera*		2
0.690	0.030	0.720	*Cymbella tumida*		2
0.577	0.001	0.578	*Gomphonema gracile*		6
0.533	0.001	0.533	*Nitzschia obtusa*		8
0.056	0.137	0.193	*Cos. moniliforme*		20
0.001	0.000	0.002	*Cymbella cistula*		27
0.267	**0.489**	0.755	*Fragilaria capucina*		1
0.388	0.027	0.414	*Cymboplura haukii*		11
0.276	0.008	0.284	*Cos. punctatum*		15
0.064	0.325	0.389	*Pediastrum simplex*		12
0.109	0.048	0.157	*Rhopolidia gibba*		22
0.097	0.012	0.110	*Chroococcus minor*		24

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Vol. 2, Issue 5, May, 2013

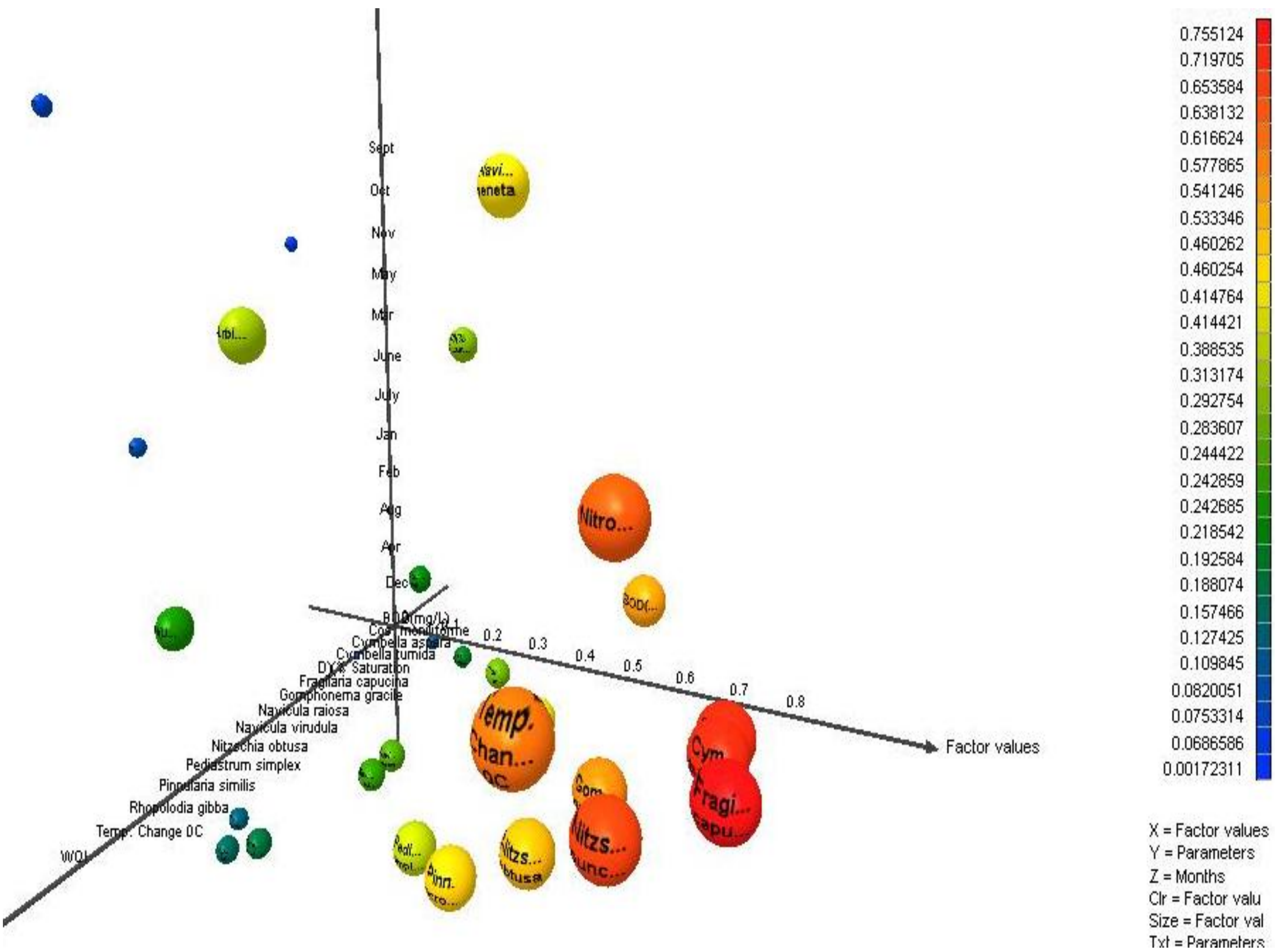
The squared sums of the Cosines of Factors1 and Factors 2 are represented in Table 4 .

The factor loadings of the PCA are shown in Table 4 and the 3D structure is plotted in Fig.2.The impact analysis can be determined by the ranking of the parameters after arrangement in the PCA plot. *Fragilaria capucina*(0.755) has the highest weightage securing the top position. *Cymbella aspera* and *Cymbella tumida* stand next while *Nitzschia punctate* in the third rank are the most significant plankton species that are expressed in the lake. Associated with these are the physico-chemical parameters such as Total nitrogen and change in the water temperature. *Gomphonema gracile*, Biochemical Oxygen Demand, *Nitzschia obtusa*, *Pinnularia acrosphearia* and *Navicula veneta* from the second cluster of importance. The intensity of the colour and the size of the spheres in the 3D plot (Fig.2) represent the interrelationships of these factors. Total phosphorous has no major role in the distribution of species in the lake. A very low distant relationship exists between these organisms and the Water Quality Index. The factor loading is very low and the ranking position is 26, almost at the far end of the factor loadings. The hypothesis that the WQI has an impact on the diversity of plankton or vice versa cannot be completely accepted. The WQI may be completely dependent on the physico-chemical parameters. Based on the physico-chemical parameters the WQI was categorized as good only three times during the period of study and was ranked as medium for rest of the months.

IV. CONCLUSION

Water Quality Index is a critical tool in the evaluation of the quality of lake waters. Lakes often support abundant growth of microalgae which have the capability to change the quality of water. A total of 21 species of algae were recorded during a 12 month study period in Alagudu Lake of T. Narasipura. Among these 4 species had very high factor loadings and were the prominent species of the lake. The water quality was ranked good for only three months and was medium for rest of the months. The distribution of algae was not abnormal. *E.coli* recorded was below the permissible limits. None of the plankton species resulted in a bloom. Diversity of plankton species did not have a major impact on the Water Quality Index in the present study. The online WQI calculator and the 3D PCA plot serve as important tools in the study of lake ecology.

FIG.2.PCA 3-D SCATTER PLOT



The 3D plot is represented for the data of eight physico-chemical parameters and 21 algal species that occurred in the lake over a period of 12 months. The figures on the right of the plot are the squared sum of factors 1 and 2. The importance of principal component is represented by the intensity of the colour and the size of the spheres.

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BIOGRAPHY

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