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INTERPRETATION OF WETLAND ECOLOGY OF VELI LAKE USING MULTIVARIATE STATISTICAL TECHNIQUES

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Abstract: The study has been undertaken to illustrate the impact of ecological and anthropogenic stresses acting up on the Lake Veli. The Lake Veli is the smallest eustuarine wetland in the southwest coast of Kerala (08° 31 and 08° 31 ′ NL and 76° 522 30′ to 76° 532 30′ EL) situated at Thiruvananthapuram district. Wetland is a general term applied to the land areas that are seasonally or permanently water logged including lakes, rivers eustuaries and fresh water marshes. General physicochemical parameters of the lake were carried out for a period of two year from June 2009 to may 2011. The assays of parameters are performed by the use of standard analytical techniques followed by AOAC and APHA. General physico chemical parameters such as temperature, TDS, pH salinity, electrical conductivity, nutrients and minerals such as nitrite, nitrate, phosphate, ammonia, silica, copper were analyzed. Dissolved oxygen, biological oxygen demand organic matter, chemical oxygen demand and hardness were also conducted. The data prepared and processed in SPSS and STASTISTICA software. Multivariate statistical technique such as principal component analysis, cluster analysis, factor analysis, descriptive statistics, dendrogram were applied to evaluate the similarities and variations of ecological parameters. Principal component analysis developed five components which together account for 66.88% of total variance. The statistically dominant first component mainly characterized by the positive loading of ammonia, nitrite and temperature explains 25.10% of variance. The second factor is contributed mainly by copper and third component concerned with electrical conductivity. Higher factor loading shown by DO and BOD on fourth component indicates oxygen debt. Strong positive loading of pH is noted in the fifth component. Significant negative loadings are exhibited by salinity and TDS in second and fifth component respectively. The first component reveals the eutrophication in relation with temperature. The second component specifies industrial pollution. Fifth component indicates the alkaline nature of lake. The dependence of the electrical conductivity with the climatic factor rain is established by the third component. The second principal component governed by the bio accumulation of copper and enrichment of phosphate is mainly contributed from the nearby clay factory and Travancore Titanium Products. Hence, it is essential to safe guard the pristine purity of the lake.

Key wods: Lake Veli, Principal component analysis, Eutrophication, Physicochemical parameters, Industrial pollution, Dendrogram, Biological conservation

INTRODUCTION

The study has been aimed to assess the precise factors causing degradation of the lake. The study also focuses on the strategies for the sustainable utilization and conservation of the resources of the lake. The Lake Veli is the smallest estuarine wetland in the southwest coast of Kerala (08° 31 and 08° 31 ′ NL and 76° 522 30′ to 76° 532 30′ EL) situated at Thiruvananthapuram. Wetland is a general term applied to the land areas that are seasonally or permanently water logged including lakes, rivers estuaries and fresh water marshes. Estuaries function as important sinks and transformers of toxic colloidal nutrients and minerals. Ramsar convention (1971) provided the framework for the conservation and wise use of resources of wetland. Wetlands act as natural filters and help to remove a wide range of pollutants from water. The wetlands across the world suffering from an ecological 'coma' and the recovery from which is virtually impossible (Liamas, 1999) wetlands are among the most productive and biologically rich ecosystems on earth (Richardson, 1995). The lake receives fresh water inputs from Aakkulam and Kadinamkulam Lake with small tributaries. The Travancore Titanium Products and English Indian clay factory situated at the close vicinity of the lake. Multivariate statistical techniques were applied to evaluate key variables of eco system. The lake remains separated from the Arabian Sea by a sand bar. During monsoon a

temporary connection 'pozhi' established between the sea and the lake due to the sand bar break which reformed after the cessation of the rain. The lake is a shallow one with a mean depth of 2.4meter and has a length of 1.25 km and width 0.44 km. Health and distribution of aquatic life depends upon the climatic and physico chemical parameters of the lake. Nowadays the rate of wetland reduction is becoming accelerated which adversely affect the quantity and quality of lake. The data was prepared and processed in SPSS and STASTISTICA software. Multivariate Statistical technique such as principal component analysis, cluster analysis, factor analysis, and descriptive statistics were applied to evaluate the similarities and variations of ecological parameters. The study helps to assess the changes in physico chemical properties of the lake. Cluster analysis joins the most similar observations to construct dendrogram up to the levels of similarities.

MATERIALS AND METHODS

General physicochemical parameters of the lake were carried out for a period of two year from June 2009 to may 2011. The assay of parameters was performed by the use of standard analytical techniques followed by AOAC (1995), APHA (1995). General physico chemical parameters such as Temperature (atmospheric, water, Sediment-celsius thermometer), total dissolved solid (TDS Tester), pH (pH Meter), electrical conductivity (Electrical conductivity Tester), salinity (salinity meter) nutrients and minerals such as nitrite, nitrate, phosphate, ammonia, silica, copper (multi parameter bench photometer, Hanna 200) were analyzed. Dissolved oxygen, biological oxygen demand (Winkler's method), alkalinity (Grasshoff's Method), chemical oxygen demand, hardness (AOAC 1995) and organic matter (Welch PS) were also conducted. Rainfall data obtained from Indian meteorological department Thiruvananthapuram. Data analysis was carried out with the help of commercially available software SPSS and Statistical in windows XP.

RESULTS AND DISCUSSION

Principal component analysis

PCA provides detailed information about the quality deterioration of the Lake Veli. Principal component analysis of the data set developed five principal components explaining 66.88% of the total variability. The factors have Eigen values greater than 1 taken for interpretation of the data according to Kaiser and Mazlum Criterions. Factor analysis done by varimax and Kaiser Normalization rotation method was used to obtain new variabilities. The statistically dominant first component accounts for 25.10% of variance. The maximum number of variables has been characterized by the first component. Strong positive loadings of ammonia (0.87), nitrite (0.85), alkalinity (0.77), temperature (water (0.77) atmospheric (0.76) sediment (0.75), organic matter (0.52) together grouped into the first component. The first component reveals the eutrophication pattern of the lake in relation with temperature. Temperature showed profound influence on the coagulation and precipitation of dissolved solids in the lake. Oxidation of organic matter which is controlled by the influx of land runoff and mixing up of sea water gets enhanced by high temperature. The first component has the largest acceptable value which taken as principal icon factor. The second component accounts for 11.29% of variance. The second component mainly contributed by the positive loadings of copper (0.77) and phosphate (0.75). Salinity varies with the solubility of minerals and showed an inverse relationship with hardness which clearly picturized in the second component. The second component explains industrial pollution and bio accumulation. The second principal component governed by the bio accumulation of heavy metal copper and phosphate enrichment mainly contributed by the effluent discharges from nearby factories agreed with the views of (Chandran *et al.*, 1984) and (Bijumon *et al.*, 2000). Photochemical and biological oxidation of ammonia yields nitrite firstly and nitrate secondly. Significant negative loadings exhibited by salinity (-0.59) and TDS (-0.53) in the second and fifth component respectively.

Heavy metal copper is an anthropogenic contaminant which accumulates as non biodegradable complex compounds originated from sewage and industrial effluents leads to bio accumulation. The third component mainly contributed from electrical conductivity (0.73) and rain (0.68) which explains 10.34% of variance. Impact of the climatic factor rain on the electrical conductivity and nutrients such as nitrite and silicate is established by the third component.

Electrical conductivity which in turn is dependent upon the concentration of dissolved ions in water. Approximately similar pattern of variance has been explained by the fourth (10.10%) and fifth (10.03%) components. Higher factor loadings of DO (0.85), BOD (0.70) and COD (0.54) shown by the fourth component. Oxygen debt and the indication of organic pollution are established by the fourth component. The fifth component establishes the alkaline nature of lake. The fifth component is characterized by the highest positive loadings of water pH (0.9) and sediment pH (0.88). In addition to the alkaline nature, the fifth component also explains the inverse relationship between TDS and pH.

The resultant damage of eutrophication of the lake manifested by the rampant infestation of African weed especially 'Eichhornia' species. Fertilizers and pesticides from agricultural and surface runoff, non bio degradable industrial effluents and heavy metals were responsible for the quality degradation of the lake, similar observations were reported by (Saraladevi *et al*., 1979) and (Nandan, 2004). In high temperature organic matter decomposes, which accumulates ammonia, nitrite, nitrate and phosphate thereby increases pollution. pH varies according to the dissolution of colloids. Some of Eigen values equals to the total number of variables. The Eigen values are easily interpretable by the varimax rotation. Diagonalization of correlation matrix provides Eigen values and variance is explained by these values.

The study was selected to characterize the water quality and present a statistically meaningful hydrological data based on Lake Veli. Data was exposed to statistical treatment based on multivariate analysis, descriptive statistics was employed to obtain minimum, maximum and mean values of physico-chemical parameters. DO, BOD and COD followed an increasing trend indicates higher organic and chemical load in the lake.

Table 1. The Principal Component Analysis

	Component				
	1	2	3	4	5
Ammonia	.870	5.993E-02	3.863E-02	-9.087E-02	-2.696E-02
Nitrite	.847	-6.571E-02	.286	7.498E-02	-3.212E-02
Alkalinity	.773	-.153	-.135	-.201	8.648E-02
Water	.768	.171	-.326	.206	-.150
Atmospheric	.761	4.627E-02	-.213	.311	-.105
Sediment	.751	.252	-.292	.315	-1.050E-02
Organic Matter	.523	.149	-.181	6.927E-02	.164
Copper	.284	.773	5.430E-02	-3.017E-02	-4.306E-02
Phosphate	.381	.749	-.121	2.923E-02	8.818E-02
Hardness	-.187	.647	.137	7.262E-02	-.147
Salinity	.352	-.591	.157	-.444	.134
Electrical	-8.929E-02	-3.911E-02	.727	1.224E-02	-.178
Rain	-.145	.123	.678	.279	-5.866E-02
Nitrate	.478	-.265	.546	.120	.102
Silicate	-.387	.245	.532	-.184	.207
Dissolved	-2.346E-02	-.117	.118	.845	-9.585E-02
BOD	.251	.172	.128	.700	.123
COD	.507	.288	-2.569E-02	.537	6.127E-02
Water	-2.760E-02	-.113	-4.844E-02	-1.235E-03	.904
Sediment	-.134	-8.165E-02	6.512E-02	8.272E-03	.877
TDS	-.249	-5.768E-02	.366	1.200E-02	-.534

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. a Rotation converged in 9 iterations.

Table 2. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Atmospheric	96	28.00	38.00	32.3344	2.1882
Water	96	27.00	37.00	31.3292	2.1465
Sediment	96	27.00	38.50	31.6885	2.2488
Water	96	7.10	9.50	8.5646	.4847
Sediment	96	7.00	9.50	8.3115	.4526
TDS	96	410.00	2000.00	980.9375	285.6243
Electrical	96	840.00	1900.00	1197.2917	201.6223
Salinity	96	4.00	7.90	5.8885	.9843
Phosphate	96	.20	.94	.6471	.1769
Nitrite	96	.06	3.90	1.1299	.5793
Nitrate	96	17.27	100.00	66.3666	19.2454
Ammonia	96	1.45	8.40	4.3868	1.3026
Copper	96	60.00	198.00	127.0000	33.1589
Silicate	96	.15	2.00	.7727	.4109
Hardness	96	105.00	186.00	148.7708	17.5592
Alkalinity	96	60.00	115.00	81.2552	10.0279
Dissolved	96	3.45	9.00	5.1639	1.2087
Organic Matter	96	.65	7.80	5.4485	.9698
BOD	95	.90	4.40	2.4752	.6713
COD	96	1.50	14.00	8.5338	2.5462
Rain	96	.00	424.60	160.0042	113.1840
Valid N (listwise)	95				

Descriptive statistics

According to descriptive statistics the maximum values for temperature is 38°C, pH 9, ammonia 8.4mg/l, nitrite 3.9mg/l and copper 198µ/l and as per the mean values of temperature obtained for atmospheric, water and sediment were 32.3° C, 31.3° C, 31.6° C respectively with standard deviation of 2.1 to 2.2. The mean values obtained for ammonia is 4.3 mg/l, nitrite 1.1 mg/l, nitrate 66.36 mg/l and phosphate 0.64 mg/l which exceeds the permissible limit. Values of mean pH of water and sediments obtained as 8.5 and 8.3 with standard deviation 0.48 and 0.45 respectively

Cluster analysis

In cluster analysis homogenous group of data set identified with variable similarities grouped into Hierarchial clusters. The findings of cluster analysis in the form of dendrogram support the findings. The Hiearchial cluster analysis according to Ward with squared Euclidiean distances was applied to detect multivariate distances. Hiearchial clustering groups the data into five structured and relatively stable clusters over a wide range of similarities. Any alternation in the fresh water flow and saline water intrusion affects the qualitative and quantitative parameters of the lake. Water storage space and carrying capacity were reduced by the sediment accumulation and sand mining which in turn alters the natural self purifying capacity of the lake. Both the qualitative and quantitative parameters show the declining pattern of the lake. The lake deserves immense and immediate conservation measures to overcome the environmental degradation. Dynamic estuarine environment owned by the wetland ecosystem of Lake Veli. Extensive use of urea and diammonium phosphate fertilizers in the nearby

paddy fields contributes pollution loads to the lake, which may be the reason for the ammonium and phosphate enrichment resulting eutrophication and industrial pollution in the lake. Previous studies conducted by Nedwell (1975), Olansson (1980), Ramanathan *et al.* (1993) and Singh *et al.* (2004) supports the present findings.

CONCLUSIONS

The study highlights the precise assessment of the extent of degradation caused to the lake. Human interferences such as sand mining, ecotourism, urbanization, wetland reclamation practices, industrial and organic pollution taken heavy toll on Veli wetland. Multivariate analysis reduced the set of 21 parameters into five reliable groups. The values obtained picturizes the fluctuating pattern of estuarine dynamics. Principal role in the shaping of bio geochemical process of the lake is owned by the statistically dominant, first component which explains 25.10% variance. Temperature dependent eutrophication, industrial pollution and electrical conductivity are related with climatic factor, oxygen debt and alkaline nature of the lake which has been established by the five components which together contributes 66.88% variance. The lake is facing an acute environmental crisis due to the ever increasing rate of pollution. The study formulates a baseline for future impact studies. Even though wetlands are biological hotspots; presently they are under serious threat and the Lake Veli is not an exception. It is essential to safe guard the pristine purity of lake.

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