International Conference on Recent Trends in Mechanical Engineering
International Journal of Scientific Research inScience,
Engineering and Technology
Print ISSN: 2395-1990 | Online ISSN : 2394-4099 (www.ijsrset.com)

Statistical Assessment of Water Quality Parameters for Bellandur Lake Water, Bangalore Urban Area

Ramesh. N
Department of Civil Engineering, Government Engineering College, K R Pet -571426, Karnataka, India

ABSTRACT

Statistical techniques such as Karl Pearson's coefficient of correlation and Principal Component Analysis (PCA) were used to analyze the data. Fifteen variables for twelve sampling locations used to evaluate the status of the water quality. The correlation co-efficient of pH, calcium, magnesium, alkalinity, sulphate, DO, BOD and COD were significantly correlated with a large set of variables and the BOD and COD are significantly negative correlation with other physico-chemical parameters. There is a high positive correlation of 0.99 between BOD and COD. The Principal Component Analysis (PCA) showed that the eigenvalues of the first 2 components accounts for 55% in the total varience whereas first four components accounted for almost 79% of the total variations. The PCA biplot axis 1 and 2 together 96.81% of variation in the physico - chemical parameters of the 12 sampling sites are consistently different in their characteristics.

Keywords: Water quality, Correlation, Principal Component, Biplot, Lake Water

I. INTRODUCTION

Statistical techniques such as Karl Pearson's coefficient of correlation and Principal Component Analysis (PCA) interpret the data. They help to better understand the behaviour of the water body [1]. Karl Pearson's correlation analysis will indicates the relationship between various physico-chemical parameters. The correlation coefficient indicates positive and negative correlation with each other. Positive correlation mean, one parameter increase with increase in other parameters and negative correlation mean one parameter increase with other parameters decrease [2]. The PCA was developed to summarize and it reduces a multidimensional complex data set into two or three dimensions by computing principal component. In study PCA was used to produce an ordination of independent descriptors based on water quality parameters [3]. The Bellandur lake water is an important source for the activities of drinking, fishing, recreation, cultural etc., in Bangalore urban area. There are different factors including sewage and industrial wastes which are posing threat on water quality of the lake water. The purpose of this study to assess the relationship between the various analyzed physico-chemical parameters applies statistical techniques such as pearson's correlation coefficient and PCA.

II. MATERIALS, METHODS AND DATA ANALYSIS

Investigations involving a large number of observed variables can often the simplified by considering a smaller number of linear combinations of the original values, with a Standardized Linear Combination (SLC), it is possible to make meaningful comparisons between various choices of linear combinations. PCA finds a set of SLC called the Principal Components (PSs), which taken together can explain all the variables obtained by multiplying the original correlated variables with a list of coefficients (loadings or weightings). There are generally as many PCs as variables. However, because of the way they are calculated, it is usually possible to consider only a few of them which together explain most of the original variation. PCA therefore imparts information on the most important parameters, explaining the whole data set while permitting data reduction with the least amount of loss of original information it is a potent method for pattern detection that attempts to explain the variance of a huge set of inter-correlated variables and convert them into a smaller set of independent (uncorrelated) variables(PCs). The correlation coefficient matrix determines how well the variance of each element can be explained by each relationship with each of the others (4). A rotation of principal components can achieve a simpler and more meaningful representation of the under laying factors by decreasing the contribution to PCs of variables with minor significance and increasing the more significance ones (5).

PCA is one of the best statistical techniques for extracting the linear relationships between sets of variables. PCA are linear combinations of original variables and are the eigen vectors (6). The analysis was applied to assess the significance of parameters that explain the patterns of the monitoring stations on the basis of water quality parameters. The correlation matrix consists of 15 water quality parameters.

Data Analysis

A statistical technique such as pearson's correlation and PCA were used to evaluate the water quality of Bellandur lake. SAS 9.3 software was used to carry out the analysis. Proc princomp and proc prinqual procedure are used to get correlation matrix, eigenvalues, scree plot and biplot.

III. RESULTS AND DISCUSSION

In this study, statistical methods including correlation matrix (pearson's correlation) and principal component nalysis were applied to a data set obtained from the analytical data.

Correlation matrix

The spatial correlation matrix of the water quality parameters obtained using the spearman coefficient is shown in table No.1. There exits good and strong correlation between the parameters if r more or equal to The 15 variables generated 121 correlation coefficients when analyzes in pairs and 31 were statistically significant [9].

According to table-1, all the variables are correlated with each other. The variables that showed only one significant correlation were EC with calcium (0.43). Some variables had a moderate number of significant correlations. Turbidity is positive correlation with alkalinity. The TDS showed significant positive correlation

with pH (0.51), total hardness (0.97) and magnesium (0.77).The pH showed significant positive correlation with TDS (0.51), total hardness (0.48), magnesium(0.57), alkalinity (0.41), DO (0.43) and negative correlation with BOD (-0.42) and COD (- 0.40). The total hardness showed significant positive correlation with TDS (0.97), pH (0.48) and magnesium (0.67). The calcium showed significant positive correlation with EC (0.43), BOD (0.41), COD (0.42) and negative correlation with sulphate (-0.46). The magnesium showed significant positive correlation with TDS (0.77), pH (0.57), TH (0.67), alkalinity (0.46), DO (0.61) and negative correlation with BOD (-0.56) and COD (-0.56). The alkalinity showed significant positive correlation with turbidity (0.48), pH (0.41), magnesium (0.46), chloride (0.59), phosphate (0.54) and negative correlation with nitrate (-0.43). The sulphate is positive correlation with DO (0.47) and significant negative correlation with calcium (-0.46), BOD (-0.42) and COD (-0.45). The nitrate is significant negative correlation with alkalinity (-0.43), chloride (-0.60) and phosphate (- 0.62). The chloride is significant positive correlation with alkalinity (0.59) and DO (0.42) and negative correlation with nitrate (-0.60). The phosphate is positive correlation with alkalinity (0.54) and negative correlation with nitrate (-0.62). The DO is significant positive correlation with pH (0.43), magnesium (0.61), sulphate (0.47), chloride (0.42) and negative correlation with BOD (-0.92) and COD (-0.94). The BOD is positive correlation with calcium (0.41) and COD (0.99) and significant negative correlation with pH (-0.42), magnesium (-0.56), sulphate (-0.42) and DO (-0.92). The COD is positive correlation with calcium (0.42) and BOD (0.99) and significant negative correlation with pH (-0.40), magnesium (-0.56), sulphate (-0.45) and DO (-0.94). Examples of the above mentioned pattern were compared with the pH, calcium, magnesium, alkalinity, sulphate, DO, BOD and COD were significantly correlated with a large set of variables.

The correlation co-efficient that of BOD and COD are negative correlation with other water quality (physico-chemical) parameters namely turbidity, total dissolved solids, pH, total hardness, magnesium, sulphate, nitrate, chloride and dissolved oxygen might be due to different pollution loads from different origin.

The physico-chemical properties showed significant correlations except few with the sulphate, nitrate, BOD and COD. There is a high positive correlation of 0.99 between BOD and COD. This implies that BOD is derived from COD.

Principal Component Analysis

The principal component analysis biplot graph executed on 15 variables for 12 sampling locations in order to identify quality of lake water were performed measured on physico-chemical parameters of Bellandur lake. Each observed variable contributes one unit of variable to the total variance in the data set. Any component that displays an eigenvalue greater than 1.0 is accounting for a greater amount of variance and is retained; the remaining factors have eigenvalues of less than unity [8]. Eigenvalues greater than one was taken as criterion for extraction of the principal components required to explain the variance in the data. The obtained factor loading values and variance calculated by the PCA are tabulated in table 2 and the figure 1 shows the scree plot of the eigenvalues of principal component. The first component accounted for one third of all the variance in the data (32%). Second component accounted for one fourth of all the variance in the data (23%). First two components (with eigenvalues of 4.86 and 3.39) accounted for 55% in the total varience where as first four components accounted for almost 79% and rest of the components accounted for 21%. The scree plot is a graph

of eigenvalues in decreasing order. The y-axis has shows the eigenvalue and the x- axis show their principal component in order is as shown in figure 1.

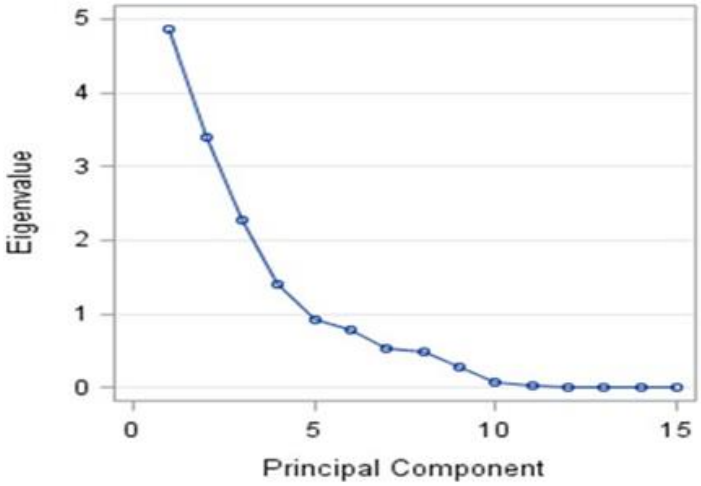
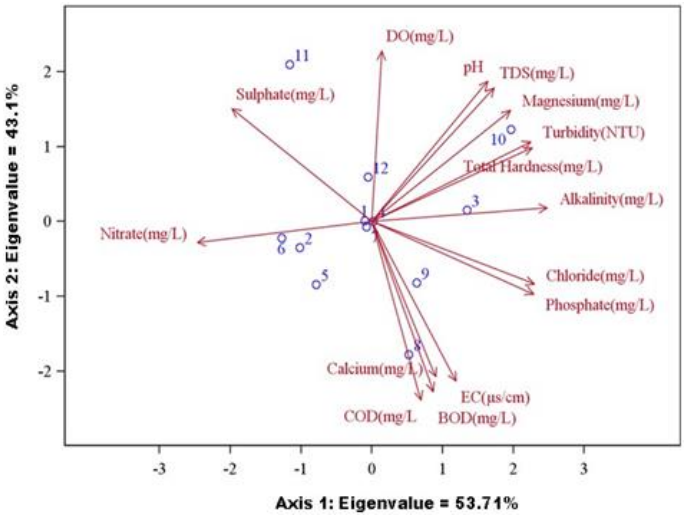


Figure 1. Scree-plot for the principal component analysis

The PCA biplot analysis performed on the entire set of measured physico- chemical parameters [3,7] of Bellandur lake showed in figure 2. Biplot showed a projection of the initial variables in the factor space. Variables on right side showed positive correlation among themselves but negative correlation with the factors on left side [1]. The PCA axis 1 and 2 together 96.81% of variation in the physico- chemical parameters of the 12 sampling sites are consistently different in their characteristics. The parameters DO, pH, TDS, magnesium, turbidity, total hardness, alkalinity, chloride, phosphate, electrical conductivity, BOD, COD and calcium which is positively associated with physico- chemical parameters. The gradient was negatively associated with sulphate and nitrate.



Arrows represent variables

◦ Symbols represent sampling sites

Figure 2. Biplot of standardized PCA-analysis performed on entire set of physico- chemical parameters of Bellandur lake

TABLE 1. CORRELATION MATRIX OF THE 15 PHYSICO- CHEMICAL PARAMETERS OF BELLANDUR LAKE.

	TU	EC	TDS	pH	TH	Ca	Mg	ALK	SO4	NO3	Cl	PO4	DO	BOD	COD
TU	1														
EC	0.27	1.00													
TDS	0.24	0.31	1.00												
pH	0.32	0.31	**0.51**	1.00											
TH	0.15	0.29	**0.97**	**0.48**	1.00										
Ca	0.30	**0.43**	0.13	-0.14	-0.04	1.00									
Mg	0.27	-0.02	**0.77**	**0.57**	**0.67**	-0.08	1.00								
ALK	**0.48**	0.16	0.37	**0.41**	0.28	0.16	**0.46**	1.00							
SO4	-0.33	-0.29	-0.27	-0.07	-0.21	**-0.46**	-0.07	-0.18	1.00						
NO3	0.33	0.17	0.05	-0.27	0.02	0.27	-0.08	**-0.43**	-0.08	1.00					
Cl	0.32	0.17	0.30	0.33	0.27	0.05	0.30	**0.59**	-0.05	**-0.60**	1.00				
PO4	-0.26	-0.10	0.29	-0.04	0.20	0.27	0.32	**0.54**	-0.27	**-0.62**	0.35	1.00			
DO	0.16	-0.04	0.38	**0.43**	0.37	-0.36	**0.61**	0.02	**0.47**	-0.06	**0.42**	-0.22	1.00		
BOD	-0.24	0.02	-0.24	**-0.42**	-0.23	**0.41**	**-0.56**	0.06	**-0.42**	-0.04	-0.27	0.33	**-0.92**	1.00	
COD	-0.14	-0.02	-0.29	**-0.40**	-0.29	**0.42**	**-0.56**	0.12	**-0.45**	-0.05	-0.23	0.32	**-0.94**	**0.99**	1.00

TU = Turbidity; EC = Electrical Conductivity; TDS = Total Dissolved Solids; TH= Total Hardness; Ca = Calcium; Mg = Magnesium; ALK = Alkalinity; SO4 = Sulphate; NO3 = Nitrate; Cl = Chloride; PO4 = Phosphate; DO = Dissolved Oxygen; BOD = Biological Oxygen Demand; COD = Chemical Oxygen Demand

TABLE 2. FACTOR LOADING VALUES AND VARIANCE.

Parameter	PC1	PC2	PC3	PC4
Turbidity	0.166	0.144	0.352	0.485
EC	0.083	0.200	0.340	0.158
TDS	0.334	0.229	0.140	-0.382
pH	0.326	0.083	0.027	0.093
Total Hardness	0.317	0.178	0.114	-0.428
Calcium	-0.096	0.333	0.277	0.122
Magnesium	0.387	0.088	-0.015	-0.231
Alkalinity	0.191	0.355	-0.179	0.291
Sulphate	0.048	-0.389	-0.219	0.060
Nitrate	-0.077	-0.132	0.588	-0.139
Chloride	0.251	0.181	-0.246	0.407
Phosphate	0.030	0.362	-0.399	-0.202
DO	0.375	-0.262	-0.029	0.059
BOD	-0.345	0.314	-0.043	-0.123
COD	-0.346	0.322	-0.042	-0.031
Eigenvalues	4.86	3.39	2.27	1.40
Total Variance (%)	32	23	15	9
Cumulative Variance (%)	32	55	70	79

IV. CONCLUSION

In this study correlation matrix and principal component analysis were applied to analytical water quality data of physico-chemical parameters of Bellandur lake. The correlation coefficient indicates positive and negative correlation of physico-chemical parameters with each other.

The correlation co-efficient of pH, calcium, magnesium, alkalinity, sulphate, DO, BOD and COD were significantly correlated with a large set of variables. The BOD and COD are significantly negative correlation with other physico-chemical parameters might be due to different pollution loads from different origin. There is a high positive correlation of 0.99 between BOD and COD. This implies that BOD is derived from COD.

The PCA explains the variances of a large dataset on inter-correlated variables with a smaller set of independent variables. Biplot circle is useful in interpreting the meaning of the axis. The main object of the PCA to determine the hidden factors responsible for the data structure when whole set of data set was considered. The PCA biplot axis 1 and 2 together 96.81% of variation in the physico - chemical parameters of the 12 sampling sites are consistently different in their characteristics. The parameters DO, pH, TDS, magnesium, turbidity, total hardness, alkalinity, chloride, phosphate, electrical conductivity, BOD, COD and calcium which is positively associated with physico- chemical parameters. The gradient was negatively

associated with sulphate and nitrate. The study indicated that the lake polluted which poses a great danger to aquatic life, people using it for domestic purposes and other activities. This might be due to improper disposal of sewage, surface runoff and wastewater from different activities. The water is thus not suitable for humanactivity without physico-chemical treatment. Hence, there is a urgent need for public awareness on the state of lake water and proper treatment is require before discharge of sewage and effluent into the Bellandur lake and its catchment area.

V. REFERENCES

[1]. Altaf Hussain, Abdul Qayyum Khan Sulehria, Muhammad Ejaz and Asma Maqbool; Assessment of water quality of a flood plain reservoir for the development of aquaculture in Pakistan; Biologia(Pakistan), 2014, 1-9.

[2]. Gayathri. S, Latha. N. and Ramachandra Moha. M ; Impact of climate change on water quality of Shoolkere Lake, Bangalore; JAIR; Volume 2, Issue 6, November 2013, pp-362-368.

[3]. Jacinto Elias Sedeno-Diaz and Eugenia Lopez-Lopez; Water Quality in the Lerma, Mexico; Springer; 2007, pp-1797-1812.

[4]. Ibrahim Mohamed. Faridah Othman, Adriana I. N. Ibrahim. M.E. Alaa-Eldin and Rossita M. Yunus; Assessment of water quality parameters for Klang River basin, Malaysia; Springer; 2015, 4182, pp-1-12.

[5]. Yared Kassahun Kebede and Tesfu Kebedee ; Application of principal component analysis in surface water quality monitoring, Ethiopia; 2012, pp-83-100. www.intechopen.com

[6]. Nirmal Kumar Jangala Isaiah, Basil George, Rita Nirmal Kumar, Sajish Poliyaparambil Ravi and Shailendra Viyol ; An assessment of physico-chemical characteristics of Narmada Estuary, Gujarat; Ekologia; Volume 31, 2012, pp-65-74

[7]. Ftsum Gebreyohannes, Abraha Gebrekidan, Amanual Hadera and Samuael Estifanos; Investigations of Physico-Chemical Parameters and its pollution implications of Elala River,Ethiopia; MEJS,V7(2) , 2015, pp-240-257

[8]. Salim Aijaz Bhat, Gowhar Meraj, Sayar Yaseen and Ashok K. Pandit ; Statistical assessment of water quality parameters for pollution source identification in sukhnag stream, Kashmir,Himalaya; Journal of Ecosystems, 2014, pp-1-18

[9]. Rodrigues-Filho, Gatti-Junior, Medeiros, Degani, Blanco, Faria, Campanelli, Soares, Sidagis-Galli, Teixeira-Silva, Tundisi, , Matsmura-Tundisi, and Tundisi ; Spatial patterns of water quality in Xingu River Basin, Amazonia; Braz. J. Biol, Volume 75, 2015, pp-34-46