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ASSESSMENT OF WATER QUALITY OF HINDON RIVER

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ABSTRACT:
The Hindon River is an important River of western Uttar Pradesh. The river is highly polluted due to industrial, municipal and agricultural activities. In the present study, water quality of river Hindon is assessed by using Multivariate statistical methods. The present study has helped to recognize the major components contributing to water quality and has further illustrated the significance of multivariate techniques for analysis and elucidation of water quality data.
Key words- Assessment, Water Quality

INTRODUCTION:

Rivers are an important resource for human civilizations as they meet water demand for various uses apart from supporting flora and fauna, improving aesthetic and landscape quality, moderating climate and providing resources for hydropower. Rivers also plays a significant role in the assimilation and transportation of domestic and industrial waste waters, which form invariable pollution sources and agricultural runoff, which is temporal and commonly affected by climate. Rivers are highly prone to pollution; therefore it becomes necessary to keep check on surface water quality and interpret the temporal and spatial variations. Regular monitoring of the quality of water is essential because clean water is obligatory for human health and the integrity of aquatic ecosystems. The particular complexity in the case of water quality monitoring is
the complication associated with analyzing the huge number of measured variables and high variability due to anthropogenic and natural influences.

Conventional techniques of surface water quality evaluation such as descriptive statistics lacks in determining long term correlations between variables and do not quantify pollution sources. The use of multivariate techniques and water quality index has several advantages to overcome these limitations.

The multivariate treatment of data is widely used to characterize and evaluate surface and freshwater quality, and it is useful for revealing temporal and spatial variations caused by natural and anthropogenic factors linked to seasonality. These techniques are the useful tool which facilitates the identification and extraction of the probable sources that influence the water systems. Various studies on the application of multivariate techniques to assess the water quality of rivers have been carried out worldwide.

River Hindon originates from the lower Himalayas in Saharanpur district, Uttar Pradesh and flows 260 km through six districts, including Muzaffarnagar, Meerut, Baghpat, Ghaziabad and Gautambudh Nagar until its confluence with the Yamuna. It is a major source of water to the highly populated and predominantly rural population of western Uttar Pradesh. Water quality of Hindon is deteriorating at an alarming rate attributable to rapid urbanization, untreated industrial effluents into the river stream.

Some previous studies on River Hindon revealed that industrial and municipal effluents pose great stress on the health of river. Work of revealed that the seasonal variations in the intensity of rainfall cause both the quality and quantity of flow of the rivers to vary widely. He further suggested that there is a need of proper enforcement of water pollution control laws and regulations. Assessed the metal pollution on River Hindon and concluded that elevated metal concentrations normally

attributed to anthropogenic sources carried out the study on the quantification of organochlorine pesticides in Hindon River and it is found to be contaminated with pesticides. A study on water quality analysis of different stretches of river Hindon in different cities has been reported.

All previous studies concluded that various anthropogenic factors such as urbanization, industrialization, agricultural practices, constructional activities, etc are responsible for deterioration of Water quality of River Hindon but the degree to which these factors are responsible is still unclear. Thus, it is necessary to decrease this uncertainty by extracting latent pollution sources. The information extracted facilitates water quality managers to prioritize and take coherent decisions for implementation of the best action plan for water quality improvements.

After comprehensive literature review it has been found that no work has been reported on the application of multivariate techniques on water quality parameters of river Hindon. It is against this background that this study is conducted which can facilitate the withdrawal of possible sources of water quality variations and pollution. In this study principal component analysis and cluster analysis is applied to find out the sources of the water quality inputs and to group monitoring stations using surface water quality data collected from different sampling stations located along the selected stretch of river Hindon.

MATERIALS AND METHODS:

Study area-

The river originates from the upper Siwalik and lies between the latitude $28^0$4' to 35^0 5'N and longitude $77^0$8' to 77^0 4'E. The climate of this region is tropical to temperate with extreme temperature conditions in summer (up to 43^0C) and winter (up to 3^0C). The mean annual rainfall in this region is 702 mm varying spatially in different sub regions of the districts. The river is characterized by sluggish flow throughout the year, except during monsoon when rainfall causes a manifold increase in the runoff.

Sampling and Analysis-

Total 16 water samples are collected from the selected study sites during November 16 to May 17. Samples are collected in sterile capped containers, following the methods prescribed in. Sampling bottles are kept in ice box at 4^0C and transported to the laboratory within 6 hours for analysis. Samples are analyzed for 12 water quality parameters as per standard methods. These parameters include pH, Temperature, Electrical conductivity, Total hardness, Biological oxygen demand, Chemical Oxygen Demand, Chloride, Nitrate, Sulphate, Total dissolved solids, Total Alkalinity and Calcium.

Table-1

Water quality parameters, units and analytical methods for analysis of water quality

S. No.	Parameter	Unit	Method	Instrument
1-	pH	-	Instrument	pH meter
2-	Temperature	^{0}C	Instrument	Thermometer
3-	Electrical Conductivity	µ S	Instrument	Conductivity meter
4-	Total dissolved solids	Mg/l	Filtration and gravimetric	Oven
5-	Total hardness	Mg/l	EDTA Titration	Titration assembly
6-	Calcium	Mg/l	EDTA Titration	Titration assembly
7-	Total alkalinity	Mg/l	Titration	Titration assembly
8-	Biological oxygen demand	Mg/l	5 days incubation at 20^0C	BOD incubator
9-	Chemical oxygen demand	Mg/l	Open reflux method	Reflux assembly
10-	Chloride	Mg/l	Argentometric titration	Titration assembly
11-	Nitrate	Mg/l	spectrophotometry	Spectrophotometer
12-	Sulphate	Mg/l	spectrophotometry	Spectrophotometer

Reagents and Standards:
Analytical grade chemicals and deionised water are used for the preparation of reagents and standards. The glass wares are washed with dilute nitric acid followed by several portions of distilled water.

Data Treatment and Multivariate:
Statistical Methods:
Before multivariate analysis, all skewed data sets were normalized by log normal transformation. Kolmogorove Smirnov statistics were used to test the goodness of- fit of the data to log-normal distribution. The Kolmogorove Smirnov test shows that all variable follows the log normal distribution. To test the suitability of data for principal component analysis, Kaiser- Mayer-Olkin and Barlett's test of sphericity were performed. Kaiser- Mayer-Olkin measures the sampling adequacy which points out the fraction of variables that are having common variance. Kaiser-Mayer-Olkin Values greater than 0.5 are considered as satisfactory for principal component analysis. In the present study, this value is 0.637 (Table 2) which indicates that the data set is fit for principal component analysis. Barlett's test of sphericity test whether variables are significantly related and correlation matrix is an identity matrix.

Significance level which is 0.00 for this study clearly indicates that the correlation matrix is not identity matrix and variables are significantly related. River water quality data have been subject to two multivariate techniques namely, principal component analysis and cluster analysis. All statistical calculations are made with the use of SPSS 16.0 software.

Table-2
Kaiser-Meyer-Olkin measures and Barlett's test of Sphericity

Kaiser-Meyer-Olkin measure of sampling adequacy		0.64
Bartlett's test of sphericity	Approx. chi-square	189.15
	df	64.00
	sig	0.00

Principal component analysis (PCA):
Principal component analysis is a statistical technique of data reduction, which explains the variance within the data while lessening the number of variables to a few unrelated components. A principal component provides information on the most meaningful parameters, which describes a whole data set, facilitates data reduction with a minimum loss of the original information. Principal component analysis of the normalized variables is performed to extract significant principal components and to further reduce the contribution of variables with minor significance; these Principal components are subjected to varimax rotation (raw) generating Varifactors. Principal components are defined according to the norm that merely factors that account for variance greater than 1 (Eigen value-one criterion) ought to be incorporated. The underlying principle for this is that any component must account for more variance than any single variable in the standardized test score space. Hence, Principal component analysis is applied using varimax rotation with Kaiser Normalization. By extracting the Eigen values from the correlation matrix, the number of significant factors and the percent of variance explained by each of them are calculated.

Results and Discussion:
Descriptive statistical summary of the dataset is the pH values vary which shows a slightly alkaline nature of river water. High pH values are indicative of bicarbonates and carbonates of calcium and magnesium in river water. The probable source of such chemicals could be industrial and urban runoff.

Electrical conductivity in water is due to ionization of dissolved inorganic solids and become a measure of Total Dissolved Solids. It is the basic index to check the suitability of water for agricultural purposes. EC values in this study vary from 295 to 1133μ S/cm. Higher conductivity of water corresponds to mixing of sewerage in river water. Total Dissolved Solids is the measure of the solids dissolved in the water. This includes salts, some organic materials ranging from nutrients to toxic materials. High Total Dissolved Solids in water adversely affects the dissolved oxygen and increases the biological and chemical oxygen demand.

Total Dissolved Solids values in the present study range from minimum of 120 mg/l to maximum 863 mg/l. High values of Total Dissolved Solids indicate the mixing of sewerage, cloth washing and garbage dumping. The main sources of Total Dissolved Solids in river water are natural sources, sewage, urban runoff, industrial waste water and chemicals used in water treatment process. Alkalinity values lies between 200- 505 mg/l. The high value of alkalinity indicates the sewerage mixing in the river. Total hardness is caused due to cations of calcium, magnesium, iron and strontium. In present study TH values ranges from 120 to 340 mg/l. Calcium hardness varies from 32.06 to 123.4 mg/l among different study sites. Higher calcium content in the river water is the indicative of sewerage and urban runoff.

CONCLUSION:

Descriptive statistics reveal that all measured variables of water quality are exceeding permissible limits and indicates that the water is unfit for any recreational activity and propagation of any aquatic organisms. The high value of the BOD at almost sites is indicative of serious organic pollution load which needs to be checked by management authorities.

Multivariate techniques are successfully applied to assess the water quality status of river Hindon. Three factors determined in the Principal component analysis are responsible for 36.85% of total variance. Component 2 can be termed as nutrient pollution explains 28.34% of total variance and Component 3 that can be attributed to organic pollution is accountable for 19.71% of total variance respectively. Principal component analysis results in identification of sources of pollution and the water quality of river Hindon is highly influenced by mineral, nutrient and organic pollution. Cluster analysis grouped all sampling stations into two clusters based on the similarity of water quality characteristics. Cluster 1 consists of site 4,5,6,7 and 8 which are located on the downstream of river have a higher concentration of almost all variables, whereas Cluster 2 consists of all upstream sites i.e. 1, 2 and 3 have comparatively low concentration of all studied variables.

Results of cluster analysis can be used to construct an optimal sampling strategy which could reduce the number of sampling sites. The Present study clearly indicates the efficacy of multivariate techniques to assess the surface water quality and facilitates decision makers to determine priorities for any pollution management program. Moreover Principal parameters responsible for significant variations identified by the Principal component analysis can further be used to incorporate into the water quality index calculation which would give a more precise picture of water quality at the monitoring stations.

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