TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

Evaluation of Water Quality Trends in the River Hindon, Ghaziabad, From 2010 to 2016 by WQI and Multivariate Analysis

Prerna Raghava[1] and S.K.Singh[2]
Inderprastha Engineering College, Ghaziabad[1;]
Delhi Technological University, Delhi[2]
Prerna.raghava@gmail.com[1]
sksinghdce@gmail.com[2]

Article Info
Volume 83
Page Number: 5608 - 5622
Publication Issue:
May - June 2020

Abstract

River Hindon is a tributary of Yamuna River caters to the need of densely populated agricultural and manufacturing cluster of Ghaziabad, Uttar Pradesh, India. The quality of water in River Hindon is declining breakneck rate due to various metropolitan, municipal and agricultural activities. The data covers 6 years (2010-2016) this data has been used to assess namely pH, DO, BOD, COD, and Fecal Coliform & Total Coliform. The analysis is conducted using MS Excel and SPSS 25 software. This paper uses the multivariate analysis of the Hindon River in three locations Mohan Nagar, Karheda&Chijrashi in the Ghaziabad region. It uses analytical techniques such as WQI, CA, PCA, and DA to assess temporal and spatial changes and to interpret enormous and complex water quality data. A dendrogram created from the cluster analysis shows two significant clusters separating the pre-monsoon from the post-monsoon on the temporal scale in the study areas. The data were investigated using multivariate techniques for analysis that reduced the input dimensions for better interpretation, recognizable pieces of proof of contamination sources or factors, and getting temporal or spatial changes in water quality for adequate stream water quality administration. The major pollutants are organic pollutants. Studies show water quality become worst during the 2012-13 year. The Temperature parameter during 2012-13 was quite high; this leads to higher evaporation and concentration of contaminants. This Study also found factor analysis latent variables are interpretable for portraying the stream water quality in the River Hindon. The wellsprings of these pollutants were released from fabric, tannery, paper, sugar industries, and distilleries. The consequence of this investigation demonstrates the utility of multivariate analytical techniques in the examination of river water quality.

Keywords: *Hindon River; PCA; FA; DA; WQI.*

Article History
Article Received: *19 November 2019*
Revised: *27 January 2020*
Accepted: *24 February 2020*
Publication: *17 May 2020*

1.0 Background

Rivers form the focal inland water asset for private, assembling and watering utilizes in numerous regions and assumes a fundamental job in hydrologic and biogeochemical cycles. Even though a couple of streams kept up in their flawless condition because of escalated anthropological exercises, and outside water contamination is today of incredible ecological concern worldwide. Surface water is exceedingly inclined to point and non-point contaminations because of its simple receptiveness for the transfer of wastewaters, the issue with its insurance, opened, and its high stream speed. Regular procedures on surface water are because of precipitation, disintegration, enduring of crustal materials and anthropogenic impacts are influenced by private, mechanical, and farming exercises, and expanding utilization of water assets. (Giridharan et.al 2009; Alkarkhi et. al 2008; Zhang et al 2008).Regular checking programs have made for evaluating surface water quality in various nations, creating complex multidimensional data due to various constituents, distinctive testing frequencies,

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

and a couple of observing stations.Appropriate appraisal for ordinary checking information is progressively significant for water quality assessment. Moreover, restricting the potential contamination sources and significant parts that in a general sense add to the spatial and temporal changes in water quality is as often as possible the fundamental issue to assess water quality. To comprehend with the multivariate information and dissect a general estimation of the spatial and temporal changes in the River quality, the multivariate strategies including bunch investigation (grouping), Principal Component Analysis (PCA) and factor analysis (FA). Grouping means scanning for combinations (clusters) in the information dependent on the similitudes inside a gathering and dissimilarities among various groups. This framework takes into account the gathering of water quality information with important attributes having a place with an observing territory or season and in this manner clarify the investigation [Kaufman and Rousseeuw, 1990; Legendre and Legendre, 1998].The same study was conducted to evaluate the water quality in Dal Lake(S. K. Singh et al 2017). Due to complex characteristics in the stream water significant data from an enormous database was removed by utilizing multivariate statistical methods, i.e., (DA) discriminant analysis (ZalinaMohd Ali et al 2013). The DA method utilized in this investigation to give better information on the River water quality, especially concerning the improvement of the elements in perceiving the spatial districts in the Hindon River.To know the Water Quality Index (WQI) of Hindon River utilizing six water quality parameters pH, Dissolved Oxygen, biochemical oxygen demand, chemical oxygen demand, fecal coliform, and total coliform estimated at three unique stations from the year 2010 to 2016. To discover WQI along the stretch of the River bowl Weighted Arithmetic method utilized.

2.0 Material &Methods

2.1. Study Area:-

The Yamuna River is the sub-basin of Ganga River basin significant tributary named Hindon is a waterway in India that begins from the Saharanpur District from Upper Shivalik in Lower Himalayan Range.The stream is rained and has a catchment region of 7,083 square kilometers (2,735 sq. mi). It streams among Ganges and Yamuna waterways for 400 kilometers (250 mi) through Muzaffarnagar District, Meerut District, Baghpat District, Ghaziabad, Noida, Greater Noida before it joins Yamuna stream simply outside Delhi. The primary land use in the basin is farming, with little forest cover-The basin area densely populated because of the rapid industrialization and farming growth amid the most recent couple of decades. The present examination incorporates the stretch of the Hindon River. It lies on its bank of the Ghaziabad area on the outer parts of Delhi.Hindon River estimated a 30 km stretch along National Highway-24 in Ghaziabad. Water samples collected from three different sites ((Kharheda, Mohan Nagar &Chijrashi) as shown in Figure1.

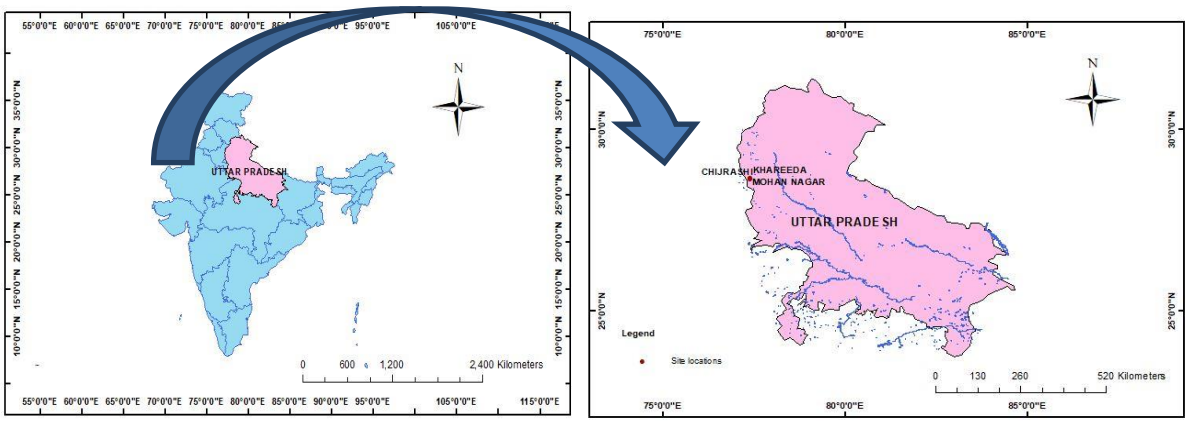


Figure 1:-Geographic location of the study area along with the monitoring stations at Hindon River, Ghaziabad in India

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

2.2 The River water quality Data Analysis:-

The three chose to observe stations (Figure 1) are at Karheda Village, Mohan Nagar Road Village, Chijrashi Village of Ghaziabad area Uttar Pradesh. All things considered, there are many water quality parameters in the waterway water quality investigation, but only six sampled parameters that were available consistently available selected for this study analysis...The data obtained from the Central Water Commission and Jal Nigam for 2010-2016. The data for 12 months for each parameter such as (pH, BOD, COD, Fecal Coliforms, Total Coliforms and DO) of each year converted into the normalized data set, while non-numerical factors changed into numerical factors for helpful investigation Shows in table 1, 2 and

Table 1: Mean value of Pre and Post monsoon of Mohan Nagar Station

Mohan Nagar

Year	Water quality parameter (Pre Monsoon) mean value					
	pH	BOD	COD	Fecal coliform	Total coliform	DO
2010	7.033	29.616	105	95833.33	162333.33	0.9166
2011	6.983	25	93.5	130500	211666.67	0.9166
2012	7.3667	57.667	215.1667	151666.67	200000	0.7667
2013	7.166	102	380	140000	160000	0
2014	7.331	86.2	236.5	180000	306666.67	0
2015	7.25	38.67	98.6	151666.7	276666.67	0.95
2016	7.15	59.3	181.483	156666.7	195333.33	0

Year	Water quality parameter (Post Monsoon) mean value					
	pH	BOD	COD	FECAL COLIFORM	TOTAL COLIFORM	DO
2010	7.067	26.067	86	75833.33	126666.67	1.2
2011	7.333	24.9	80	135000	210000	0.63
2012	7.2167	62.16	219.83	128333.33	160000	0.54
2013	7.65	34.833	221.23	129166.66	185000	0
2014	6.945	59.266	195.567	166666.67	288333.33	0.63
2015	7.1167	36.25	113.13	145000	231666.66	0.69
2016	7.4	31.65	108.5	190000	260000	0

Table 2: Mean value of Pre Monsoon and Post Monsoon of Karehda Station

Karehda

Year	Water quality parameter (Pre-Monsoon) mean value					
	pH	BOD	COD	FECAL COLIFORM	TOTAL COLIFORM	DO
2010	7.3	12.967	47	72500	112666.7	2.4167
2011	7.083	16	65.667	54833.33	111833.3	1.45
2012	7.1	44.83	178.33	86500	1533.33	0
2013	6.983	89.167	381	109666.7	141666.7	0.1667
2014	7.353	55.467	162.9	14333.33	25833.33	0
2015	6.95	23.816	75.433	110000	21666.67	1.6583
2016	6.85	35.5	102.4	78457	151333.3	1.1083

Year	Water quality parameter (Post-Monsoon) mean value

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

	pH	BOD	COD	FECAL COLIFORM	TOTAL COLIFORM	DO
2010	7.266	12.667	50.333	54500	98500	2.3
2011	6.95	16.7833	64.333	24500	42166.67	1.1083
2012	7.366	59.5	299.167	89666.67	148666.7	0.5833
2013	7.25	35.033	183.5	111000	166666.7	0
2014	7.081	35.633	155	126666.7	246666.7	1.31
2015	6.8167	21.7	73.167	83333.33	156666.7	1.233
2016	6.7	20.4	40	6000	110000	2.5

Table 3: Mean value of PreMonsoon andPost Monsoon of Chijrashi Station

Chijrashi

Year	Water quality parameter (PreMonsoon) mean value					
	pH	BOD	COD	FECAL COLIFORM	TOTAL COLIFORM	DO
2010	7.2	15.27	50	78000	120000	2.083
2011	7.267	18.5	73.833	75333.33	122333.33	1.2
2012	7.167	47	188.67	100333.33	160000	0
2013	7.1	92.167	380.33	117333.33	142333.33	0.1667
2014	7.36	61.233	177.3	156666.667	265000	0
2015	7.067	29.083	83.4	121666.67	265000	0
2016	7.05	35.25	106.7	97666.67	169833.33	0.99

Year	Water quality parameter (PostMonsoon) mean value					
	pH	BOD	COD	FECAL COLIFORM	TOTAL COLIFORM	DO
2010	7.167	14.067	56	59500	106000	2
2011	7.5	18.0833	66.5	32333.33	61500	0.7916
2012	7.33	62.033	246	98000	14900	0.5567
2013	7.55	35.5833	193.833	110666.67	163333.33	0
2014	7.128	43.4	170.6	145000	270000	0.9433
2015	6.93	22.216	76.633	103333.33	186666.67	1.093
2016	7	22.2	48.4	5000	5000	2.32

2.3 Data Treatment:-

The water quality information was translated by a multivariate investigation by utilizing factual examinations device were performed utilizing Microsoft Excel 2007 and SPSS 25 adaptation. By incorporating multivariate measurable examination instruments, for example, Cluster Analysis (CA), important segment analysis (PCA), Factor analysis (FA), and Discriminant Analysis (DA).

*2.3.1Water Quality Index (WQI):-*Exact data on the general nature of water is unavoidable to frame open strategy and to incorporate the water quality enhancement applications.Water quality record (WQI) gives information about water quality in lone regard.It is depicted as a rating mirroring the composite impact of various water quality parameters was pondered for the count of Water Quality Index (WQI). .WQI is the decision to know the nature of water quality parameters. Effect on the nature of water parameters on pollution depends upon the acceptable measurements as proposed by the Indian Council of Medical Research (ICMR, 1975). Parameters having low allowable cutoff centers will be given high weightage as they are hazardous to the idea of water, allegorically, on the slight expansion in respect (ICMR, 1975). Thusly we give high weightage to these parameters having higher admissible cutoff centers are less hurtful and subsequently, we give less weightage. In this assessment, Horton's (1965) system was used to

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

learn WQI. Count of WQI worked done by Horton's strategy. The WQI is determined by utilizing articulation given in Equation (1)

$WQI = \sum QnWn / \sum Wn$ (1)

Where, Qn = Quality Rating of nth Water Quality Parameter

Wn = Unit Weight of nth Water Quality Parameter.

Quality rating (Q_n)

The Quality Rating (Qn) is determined to utilize the articulation given in Eq. 2.

$Qn = [(Vn – Vid)/(Sn-Vid)] X 100$ (2)

Where, Vn = Estimated estimation of nth water quality parameter at a given sample location.

Vid = Ideal incentive for an nth parameter in unadulterated water. (Vid for ph = 7 and 0 for every single other parameter)

Sn = Standard allowable estimation of nth water quality parameter.

Unit weight

The unit weight (Wn) is determined by utilizing the articulation given in Eq. 3.

$Wn = k/Sn$ (3)

Where Sn = Standard reasonable estimation of nth water quality parameter.

k = Constant of proportionality and it is determined by utilizing the articulation given in Eq. 4.

$k = [1/(\sum 1/Sn=1,2,..n)]$ (4)

The scopes of WQI, the relating status of River quality and its conceivable use is abridged in Table 4 and standard estimations of water quality parameters and their qualities and loads in Table 5

Table 4: WQI & Corresponding water quality status according to Mishra and Patel 2001

WQI and Corresponding Water Quality Status			
S.No	WQI	Status	Possible usage
1	0-25	Excellent	Drinking, Irrigation & Industrial
2	26-50	Good	Drinking, Irrigation & Industrial
3	51-75	Fair	Irrigation & Industrial
4	76-100	Poor	Irrigation
5	101-150	Very Poor	Restricted use for Irrigation
6	151 & above	Unfit for Drinking	Proper Treatment Required Before Use

Table 5: Permissible values of River quality parameters and their corresponding ideal values and unit weights

Parameters	Sn	Recommendation Agency	Vid	k	Wn
pH	8.5	IS	7	3.09744	0.364404
DO	6	IS	0	3.09744	0.51624
TC	5000	WHO	0	3.09744	0.00061948
FC	1000	WHO	0	3.09744	0.0030974
BOD	30	Envir. Protection 1986	0	3.09744	0.103248
COD	250	Envir. Protection 1987	0	3.09744	0.012397

2.3.2 Cluster Analysis: -The objectives of bunch investigation are to dole out perceptions to gatherings (\clusters") so perceptions inside each gathering are like each other concerning factors or traits of premium and the gatherings themselves stand separated from each other. Bunch examination is additionally used to aggregate factors into homogeneous and unmistakable gatherings. CA is connected to decide the gathering of checking locations for the investigation area In this examination, progressive (hierarchical) CA utilized Ward's strategy with squared Euclidean separations as a proportion of closeness (Zhaoa Y et al 2012).

2.3.2.1 Ward's Method: - Ward's strategy is a rule connected in hierarchical cluster investigation. Ward's is a minimum variance method an uncommon instance of the target work approach initially introduced by Joe H. Ward, Jr.Wardproposed a general agglomerative hierarchical grouping methodology.

The minimum variance criterion: - Ward's base difference standard limits the aggregate inside group change. The underlying bunch separates in Ward's base fluctuation strategy are along these lines characterized to be the squared Euclidean distance between focuses in equation (5)

$$d_{ij} = d(\{X_i\}, \{X_j\}) = ||X_i - X_j||^2 . \quad (5)$$

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

2.3.3 Principal Component Analysis: - It is utilized to evaluate the essentialness of factors that clarify the watched groupings and examples of the inalienable characteristics of the checking locations. The latest symmetrical factors clarified by a decreased arrangement of determining components are called PCs (Osei J et al. 2010)parts (components), which are not direct conspicuous (Yu et al., 2003). There are three stages in the constituent investigation (Gupta et al., 2005): 1) For all of the elements an association structure is made 2) Variables are extricated from the connection network dependent on the connection coefficients of the elements 3) To expand the connection between a portion of the components and factors, the elements are pivoted.

2.3.4 Discriminant analysis: - The DA was performed to affirm the gatherings recognized by methods for the CA. The DA system develops a discriminant function (DF) for each gathering to predict the group enrollment of new cases by methods for the bunch centroids.

3.0Results & Discussions*:* - Figures 2, 3 & 4 shows Pre & Post monsoon season at threestations. In figure 2 in 2013 variation is high in pre as compared to post-monsoon whereas

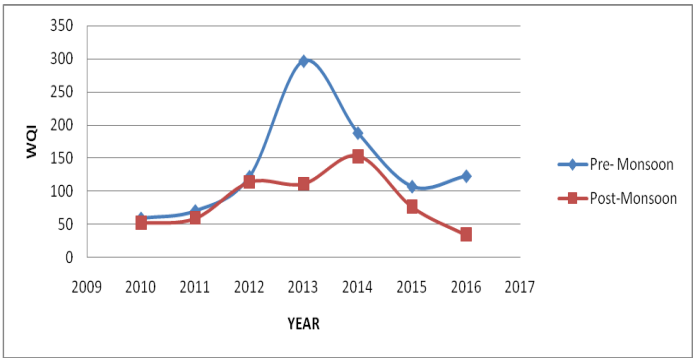


Fig. 2: Pre-Monsoon and Post-Monsoon Conditions in Mohan Nagar Region

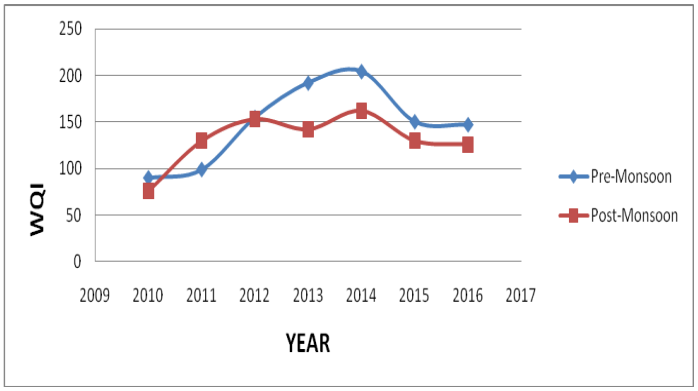


Fig. 3: Pre-Monsoon and Post-Monsoon Conditions in Chijrashi Region

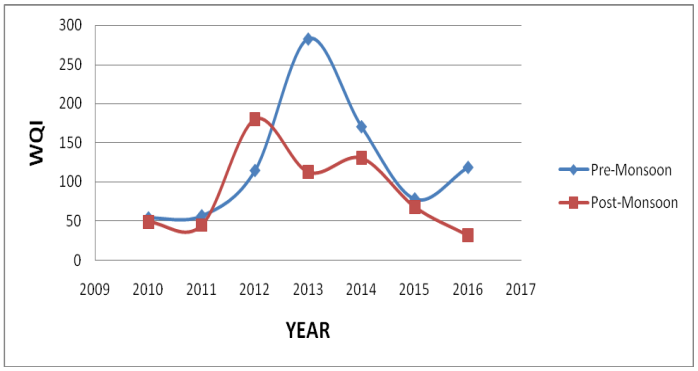


Fig. 4: Pre-Monsoon and Post-Monsoon Conditions in Karehda Region

3.1WQI:- WQI Value obtained after Calculations using Ms. Excel is further reduced to two groups Pre-monsoon & Post-monsoon by considering the mean value in Figs. 5 and 6.

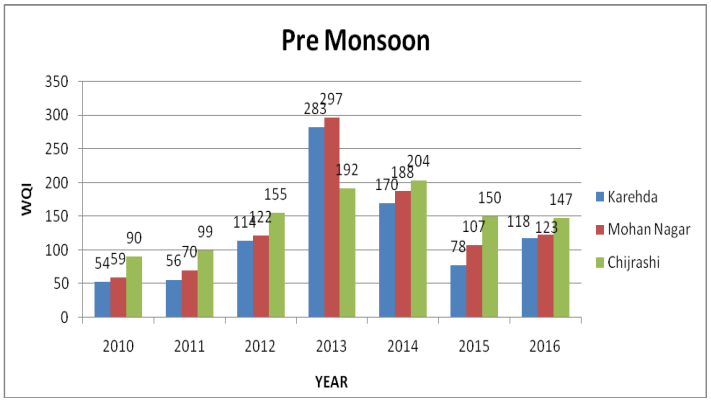


Fig. 5: WQI (Pre-monsoon) for Hindon River, Ghaziabad

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

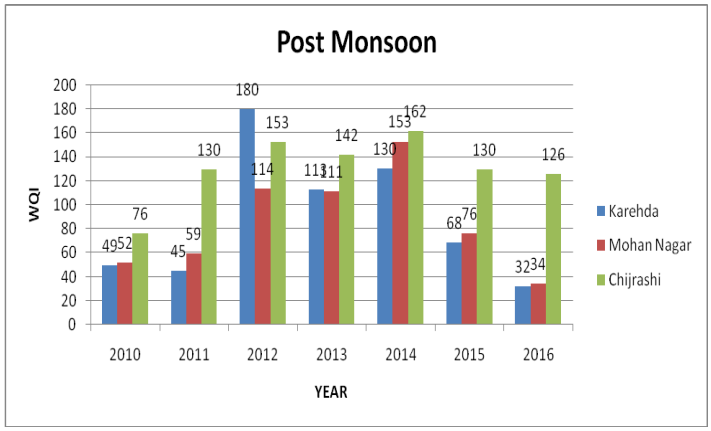


Fig. 6: WQI (Post monsoon) for Hindon River, Ghaziabad

The above results obtained show that amid the post-rainstorm season the Water Quality Index of the various destinations is low. Moreover, in pre-monsoon season the Water Quality Index is high as high esteem speaks to progressively corrupted water quality (from the above table).Subsequently, the water quality amid post-monsoon is low. It additionally means the high contamination status of water. From 2010-2012 the debasement in waterway quality watched is uniform yet there is a lofty ascent in the corruption bend. From 2012-2013 which demonstrates that the water nature of the waterway amid this period is in the most pitiable condition. From 2014-2016 water nature of Hindon River improves as the WQI esteem got begins diminishing step by step at each site.

*3.2Cluster analysis: In*Figures 7, 8 & 9 there are three dendrograms represents the grouping of this yearly pre-monsoon & post-monsoon data based onlikeliness intheir River quality by using Ward's method for Mohan Nagar, Chijrashi and Karheda sampling sites. Ward's method for Mohan Nagar, Chijrashi, and Karheda sampling sites.

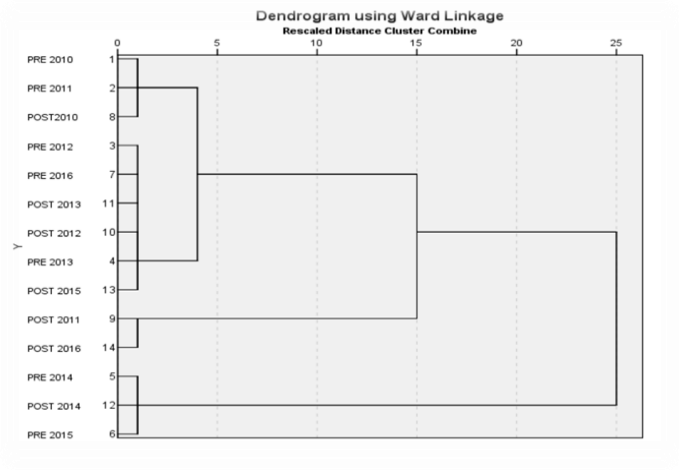


Fig. 7: Mohan Nagar sampling site dendrogram

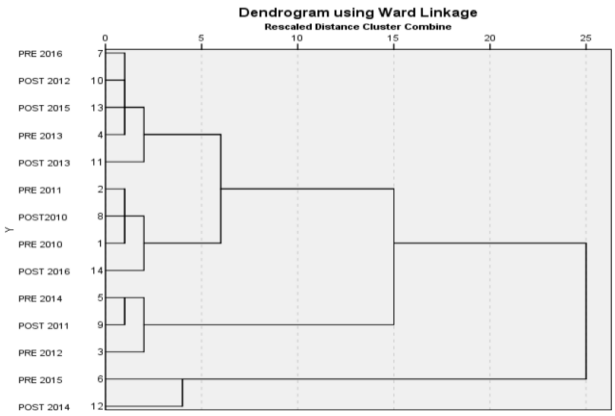


Fig. 8: Karheda sampling site dendogram

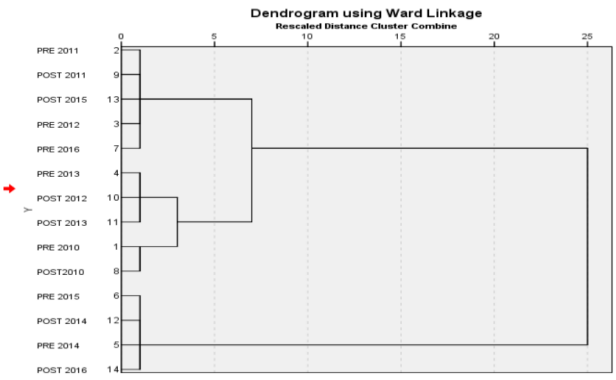


Fig. 9: Chijrashi sampling site dendogram

CA was completed on water quality informational collection to estimate the spatial and temporal changeability among the water nature of the Hindon stream at three testing sites in Ghaziabad district. Data on which CA is done was categorized in pre-monsoon (PRE) and post-monsoon (POST) from

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

2010 to 2016.The analysis resulting in the grouping of two major clustersbased on their squared Euclidian distance on which following were observed from three sampling sites: Mohan Nagar: water quality data of PRE-2014, POST-2014 & PRE-2015 are most dissimilar in comparison to other groups Karheda: water quality data of PRE-2015, & POST-2014 are most dissimilar in comparison to other groups. Chijrashi: water quality data of PRE-2014, POST-2014, and PRE-2015 & POST-2016 are most dissimilar in comparison to other groups.

3.3PRINCIPAL COMPONENT ANALYSIS: - This is a technique for information decrease. Principal component analysis, similar to factor analysis, can be performed on crude information.If raw data utilized, the method makes the essential correlation matrix or covariance matrix, as determined by the user. On the off chance that the correlation matrix utilized, the factors are standardized, and the total variance rises to the number of factors utilized in the examination (because each standardized variable has a distinction equivalent to 1.Additionally, Principal Component analysis expects that every essential measure gathered without measurement error. Principal Component analysis is a method that requires an expansive example measure. Principal components analysis dependent onthe correlation framework (matrix) of the factors involved and similarities, for the most part, needs an extensive example estimate before they settle. As a standard guideline, a flat out least of 10 observationseach factor is imperative to keep up a vital good way from computational difficulties.Tabachnick and Fidell (2001) allude to Comrey, and Lee's (1992) brief as for test measure: 50 cases are poor, 100 reduced, 200 is sensible, 300 is great, 500 is awesome, and at least 1000 is uncommon.

Table 6: Correlation analysis in Karheda region

Correlation Matrix							
		pH	BOD	COD	Fecal Coliform	Total Coliform	DO
Correlation	pH	1	0.186	0.291	0.109	-0.186	-0.283
	BOD	0.186	1	0.953	0.32	-0.015	-0.736
	COD	0.291	0.953	1	0.464	0.083	-0.725
	Fecal Coliform	0.109	0.32	0.464	1	0.682	-0.285
	Total Coliform	-0.186	-0.015	0.083	0.682	1	0.225
	DO	-0.283	-0.736	-0.725	-0.285	0.225	1

Table 7: Correlation analysis at Chijrashi region

Correlation Matrix							
		pH	BOD	COD	Fecal Coliform	Total Coliform	DO
Correlation	pH	1	0.013	0.2	0.291	0.083	-0.601
	BOD	0.013	1	0.907	0.391	0.131	-0.576
	COD	0.2	0.907	1	0.247	-0.091	-0.663
	Fecal Coliform	0.291	0.391	0.247	1	0.814	-0.645
	Total Coliform	0.083	0.131	-0.091	0.814	1	-0.187
	DO	-0.601	-0.576	-0.663	-0.645	-0.187	1

Table 8: Correlation matrix Mohan Nagar region

Correlation Matrix						
	pH	BOD	COD	Fecal Coliform	Total Coliform	DO

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

Correlation	pH	1	0.045	0.155	0.027	-0.049	-0.459
	BOD	0.045	1	0.956	0.573	0.365	-0.696
	COD	0.155	0.956	1	0.534	0.297	-0.734
	Fecal Coliform	0.027	0.573	0.534	1	0.953	-0.633
	Total Coliform	-0.049	0.365	0.297	0.953	1	-0.487
	DO	-0.459	-0.696	-0.734	-0.633	-0.487	1

There is a high correlation that is high in BOD & COD and high in also between total coliform and fecal coliform in Tables 6, 7 & 8. Also the negative correlation between DO with all water parameters. This shows that all the river quality of water.

3.4Factor Analysis: -Factor examination is successful by utilizing Bartlett's test of sphericity and the Kaiser Meyer Olkin (KMO) Measure of test adequacy. After that, we calculate the factors and commonalities. The judgment based onseveral factors to hold is a compromise between maximizing the described initial dataset variability and the decrease of the underlying number of factors.To show the common changeability between the first factors and factors - Rotation performed and the varifactors gotKaiser-Meyer-Olkin Measure of Sampling Adequacy – This measure moves someplace in the scope of 0 and 1 and characteristics progressively like 1 is better. An estimation of 0.6 is a proposed least. Bartlett's Test of Sphericity is the testing correlation matrix has an identity matrix. Generally, it is used to test the equal variances which are equal to all the samples. All the scientific investigation introduced is gotten utilizing the IBM SPSS Version 25.The KMO measurement is for Karehda, Mohan Nagar and Chijrashi is 0.552, 0.616 &0.486, therefore, since $0.7 < 0.756 < 0.8$, we reason that there is typical adequacy of the FA. For Bartlett's Test of Sphericity, the $\chi 2$ measurement is for Karehda, Mohan Nagar and Chijrashi is 51.662, 82.267 and 64.312 and the p-value is under 0.005 that implies the outcome is high; the likenesses between the included factors are adequately high. In this way, it is sufficient to run a FA.

Table 9: Eigenvalues of the correlation matrix of Karehda

Total Variance Explained

		Initial Eigenvalues		Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	0.2935	48.923	48.923	2.935	48.923	48.923	2.814	46.898	46.898
2	1.658	27.629	76.552	1.658	27.629	76.552	1.779	29.653	76.552
3	0.878	14.635	91.186						
4	0.355	5.922	97.108						
5	0.145	2.423	99.531						
6	0.028	0.469	100						

Extraction method:Principal Component Analysis

This reason for PCA systems expects to change over the perceived factors to another arrangement of factors of principal components (PC) which are uncorrelated and orchestrated in the declining request of centrality so that to rearrange the issue. Table 9 spoke the measured initial value of PC, and

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

its Eigenvalues and percent of change gave in each PC in Karheda area, Fig. 10 shows the screen plot of the Eigenvalues for every segment. Eigenvalues records and screen plot demonstrated that the initial four PC is the most significant parts which present 97.108% of the change in water nature of Hindon River in Karheda region 48.92% by PC1, 27.63 % by PC2, 14.63 by PC3, 5.922 by PC4; likewise, it has Eigenvalues of multiple. In the Karehda region, the highest loading of the PC component is mainly due to pH and BOD. It implies that BOD direct influences the measure of broke down oxygen in conduits and streams. The pace of oxygen consumption is impacted by a couple of components: temperature, pH, the closeness of particular sorts of microorganisms, and the common and inorganic material in the water. A higher or low pH would affect the microorganisms that consume the organic matter, which would then affect the BOD.

Table 10: Eigenvalues of the correlation matrix of Chijrashi

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	3.024	50.394	50.394	3.024	50.394	50.394	2.309	38.491	38.491
2	1.576	26.262	76.656	1.576	26.262	76.656	1.881	31.358	69.849
3	1.095	18.246	94.901	1.095	18.246	94.901	1.503	25.052	94.901
4	0.227	3.786	98.687						
5	0.046	0.764	99.45						
6	0.033	0.55	100						

Extraction method:Principal Component Analysis

Table 10 represented the measured first PC, and it's Eigenvalues and the percent of changes contributed to each PC in the Chijrashi region, Fig. 11 Show the screen plot of the Eigenvalues for every component. Eigenvalues records and screen plot indicated that the initial four PC is the most noteworthy portions which address to 98.697% of the change in water nature of Hindon stream in Chijrashi locale 50.39% by PC1, 26.26% PC2, 18.25% by PC3 and 3.79% by PC4,what's more, it has Eigenvalues of multiple. In Chijrashi region highest loading of the PC component is mainly due to pH, BOD & COD. That shows that pH is related to the presence of free carbon dioxide and not with DO. Textile wastewater, by and large, has high BOD, COD. Probably, high chemicals and/or some organic pollutants result in a consumption of oxygen from water biologically & chemically. Besides, this outcome in low DO values in the wastewater.

Table 11: Eigenvalues of the correlation matrix of Mohan Nagar

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	3.5	59	59	3.54	59	59	2.492	41.54	41.54

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

	4								
2	1.278	21.296	80.296	1.278	21.296	80.296	2.325	38.756	80.296
3	0.963	16.044	96.34						
4	0.171	2.846	99.186						
5	0.038	0.633	99.819						
6	0.011	0.181	100						

Extraction method:Principal Component Analysis

Table 11 represented the set first PC, and its Eigenvalues and percent of changes provided in individual PC in Mohan Nagar region, Fig. 12 Show the screen plot of the Eigenvalues for the individual segments.Eigenvalues records and screen plot demonstrated that the underlying four PC is the most significant parts which speak to 99.16% of the variety in water nature of Hindon stream in Mohan Nagar locale 59.00% by PC1, 21.29% PC2, 16.044% by PC3 and 2.846% by PC4, also, it has Eigenvalues of multiple. The highest loading factor in this region is due to pH and BOD. There is the same number of parts extracted amid a principal component analysis as there are factors that are put into it has appeared in Table 9, 10, and 11.Primary Eigenvalues –Eigenvalues are the changes in the principal components. Since we conveyed our vital Principal Component Analysis on the Correlation matrix, the factors are standardized, which implies that every factor has variations of 1, and the all-out difference is equivalent to the number of factors utilized in the investigation. All out – This section contains the eigenvalues. The principal segment dependably represents the most difference (and subsequently has the most elevated eigenvalue), and the following part represents a great part of the remaining variety as it can, etc. Appropriately, each ceaseless segment represents less and less distinction. % of Variance – This section incorporates the percent of change represented by every key segment. Cumulative % – This section contains the total percentage of variation represented by the present and all principal components.Extraction Sums of Squared Loadings – The three sections of this half of the table precisely recreate the qualities given on a similar line on the left half of the table. The number of lines pursued on the correct side of the table dictated by the number of vital segments whose eigenvalues are 1 or higher.

Fig. 10: Screen plot of Eigenvalues of Karehda

Fig. 11: Screen plot of Eigenvalues of Chijrashi

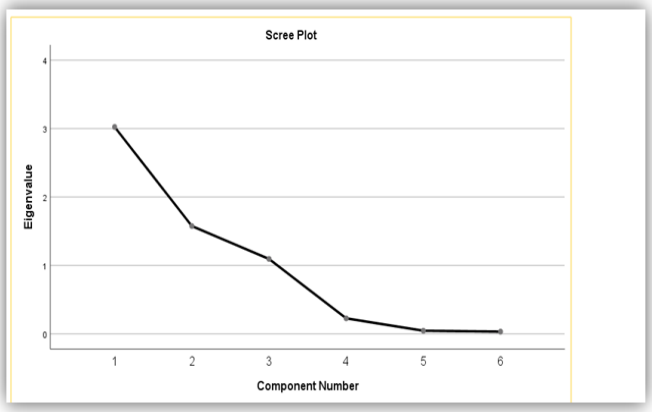
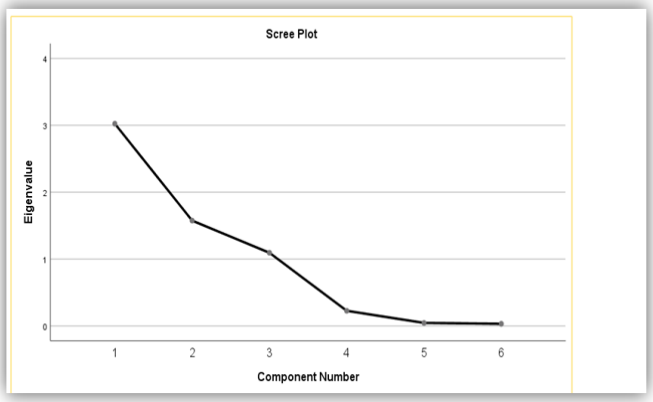


Fig. 12: Screen plot of Eigenvalues of Mohan Nagar



The first four PC components i.e. pH, BOD, COD, and fecal coliform contribute the most in the analysis of the three chosen sites. The eigenvalues screen plot against component number shows that the slope is changing considerably more for the first four components then the other two indicating the effect of these factors is high in the river at all the sites.

In general, the summary of the four Principal Components serving different processing are:

- Seasonal effects
- Exposure of low pH and high pH levels leads tothe bigger problem due to which metals get into the water and lead to health problems and consumption of these metals neurological and reproductive issues can occur.
- Too much organic matter either from chemical and biological source effects like kills fish occur or extreme algal blooms occur.
- High loading of Organic matter and inorganic matter indicate the effect of drainage of farming and stormwater from the river that washing out topsoil with its many impurities.
- Garbage water pollution from residential, municipal, and manufactured and its organic loading.

3.5Discriminant Analysis (DA):-The listed the distinctive variables/indicators, in the factors subcommand. In this investigation chose six indicators: pH, COD, BOD, TC, FC, and DO. We are involved in comparing the original groupings in status (good or bad) to the anticipated groupings created by the discriminate investigation. A divided the data from WQI and formed two groups excellent and bad based on water quality status. DA showed that these were the DO, BOC, FC, TC parameters which have a significant difference in mean and standard deviation between the groups excellent and bad. Consequently, these parameters impact the water nature of the Hindon River. So the significant poisons in Hindon River are organic toxins.

4.0 Conclusion

From the above examination, found that the water quality was most exceedingly awful during the time of 2012 and 2013. The major pollutants were organic pollutants released from fabric, tannery, paper, sugar industries, and distilleries. According to the Indian Meteorological Department, the rainfall during the year of 2012 -2013 was nearly 65% than the average rainfall (880mm) which led to a higher concentration of the pollutants. These were the year when many industries were set up on the Hindon River. The average temperature of the year 2012 and 2013 which was quite high, led to higher evaporation and increased in the concentration of pollutants. But in late 2013 to 2014 the water quality was found better due to 104 % of rainfall and quite a low average temperature.

According to Times of India's reports (Feb 15, 2016), there was a total of 265 industries which were responsible for polluting Hindon. From which 42 were approached to close down and 218 others were requested to introduce effluent treatment plant to check contamination .this promoted improvement of water quality. There are two STPs operational on Hindon and the government is arranging 2 more in Ghaziabad area which will additionally improve the nature of Hindon water. In this investigation, scientific examination shows that multivariate strategies are helpful apparatuses for assessing contaminations. These outcomes give different data to growing better water contamination control systems for the Hindon River.

Acknowledgment

TEST Engineering & Management

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

This exploration was supported by Ar. Nancy Gupta, All India Institute of Local Self Government, India. We thank our associates from Inderprastha Engineering College, Ghaziabad who gave understanding and skill that significantly helped the exploration, even though they may not concur with the entirety of the translations/finishes of this paper. We express gratitude toward Prof. S.K. Singh, Delhi Technological University, and New Delhi for help with the examination of Water Quality Data and for remarks that significantly improved the composition. The creators are appreciative of Central Water Commission, India for its help.

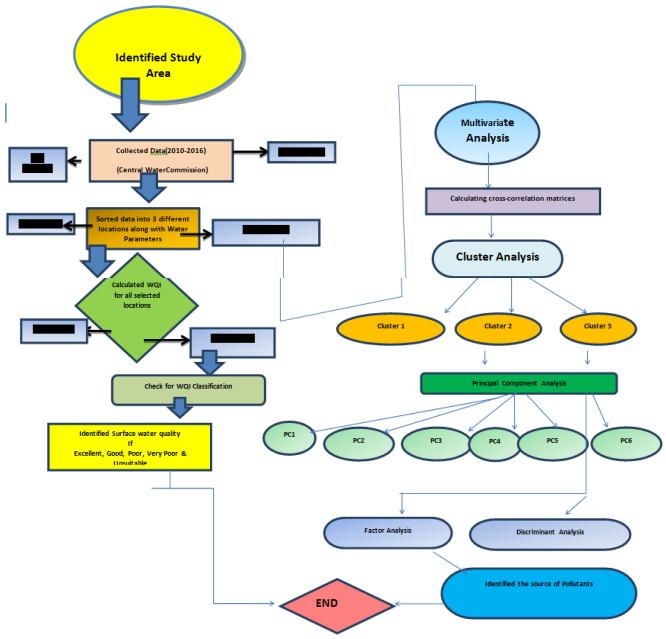
Conflict Of Interest

The author pronounces that there is no irreconcilable situation regarding the distribution of this original copy. What's more, the moral issues, including counterfeiting, educated assent, wrongdoing, information creation or potentially adulteration, twofold production and additionally accommodation, and excess has been seen by the author.

Abbreviations

%	Percentage
BOD	Biological Oxygen Demand
CA	Cluster Analysis
COD	Chemical Oxygen Demand
DA	Discriminant Analysis
DO	Dissolved Oxygen
FA	Factor Analysis
FC	Fecal Coliform
TC	Total Coliform
ICMR	Indian Council of Medical & Research
IS	Indian Standard
PRE	Pre-monsoon
POST	Post monsoon
PCA	Principal Component Analysis
Qn	Quality Rating of nth Water Quality Parameter
Sn	Standard allowable estimation of nth water quality parameter
SPSS	Statistical Package for the Social Sciences
Vid	An ideal incentive for an nth parameter in unadulterated water. (Vid for pH = 7 and 0 for every single other parameter)
Vn	Estimated estimation of nth water quality parameter at a given sample location
Wn	Unit Weight
WHO	World Health Organization
WQI	Water Quality Index
STP	Sewage Treatment Plant

GRAPHICAL ABSTRACT



HIGHLIGHTS

- Water Quality Analysis using multivariate tools to assess temporal and spatial changes and to interpret colossal and complex water quality data.
- The Temperature parameter during 2012-13 was quite high; this leads to higher evaporation and concentration of contaminants.
- High loading of Organic matter and inorganic matter indicate the effect of drainage of farming and stormwater from the river that washing out topsoil with its many impurities.
- The major pollutants in the Hindon River are biological.

References

[1] Alkarkhi, A.F.; Ahmad, A.; Easa, A.M., (2009). Assessment of surface water quality of selected estuaries of Malaysia: multivariate statistical techniques. The Environmentalist, 29(3): 255-262 **(8 pages).**

[2] https://link.springer.com/article/10.1007/s10669-008-9190-4

[3] Ali, Z.M.; Ibrahim, N.A.; Mengersen, K.; Shitan, M.; Juahir, H., (2014).Discriminant analysis of water quality data in Langat River.

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

From sources to the solution.Springer, Singapore.597-601 **(5 pages).**

[4] https://link.springer.com/chapter/10.1007%2F978-981-4560-70-2_106

[5] Azhar, S. C.; Aris, A. Z.; Yusoff; M. K.; Ramli, M. F.; Juahir, H. (2015). Classification of river water quality using multivariate analysis. Procedia Environmental Sciences, 30, 79-84**(5 pages)**.

[6] https://www.sciencedirect.com/science/article/pii/S1878029615006088

[7] Comrey, A.L.; Lee, H.B., (2013). A first course in factor analysis.Psychology Press.

[8] https://www.amazon.com/First-Course-Factor-Analysis/dp/1138965456

[9] Giridharan, L.; Venugopal, T.; Jayaprakash, M., 2009. Assessment of water quality using chemometric tools: a case study of river Cooum, South India. Arch. Environ. Contam.Toxicol., 56(4): 654-669 **(16 pages).**

[10] https://www.ncbi.nlm.nih.gov/pubmed/19301065

[11] Gupta, A.K; Gupta, S.K.; Patil, R.S;(2005). Statistical analyses of coastal water quality for a port and harbor region in India: Environmental Monitoring and Assessment: 179-200**(3 Pages)**.

[12] https://www.ncbi.nlm.nih.gov/pubmed/15869186

[13] Horton, R.K ;(1965).An index number system for rating water quality. Journal of Water Pollution Control Federation, 37(3), pp.300-306 **(6 pages).**

[14] https://www.researchgate.net/publication/309074458_An_index_number_system_for_rating_water_quality

[15] Kaufman, L. and Rousseeuw, P.J;(2009). Finding groups in data: an introduction to cluster analysis: John Wiley & Sons (Vol. 344).

[16] https://onlinelibrary.wiley.com/doi/book/10.1002/9780470316801

[17] Kumar, M.; Ramanathan, A. L.; Tripathi, R.; Farswan, S.; Kumar, D.; Bhattacharya, P. (2017). A study of trace element contamination using multivariate statistical techniques and health risk assessment in groundwater of Chhaprola Industrial Area, Gautam Buddha Nagar, Uttar Pradesh, India. Chemosphere, 166, 135-145**(10 pages)**.

[18] https://www.sciencedirect.com/science/article/pii/S0045653516312875

[19] ICMR; (1975).Manual of standards of quality for drinking water supplies.Indian Council of Medical Research, Spe. Rep. No. 44: 27.

[20] http://www.sciepub.com/reference/34835

[21] Legendre, P; Legendre, L. (1998).Numerical ecology. Second English edition. Elsevier, Amsterdam.

[22] https://www.elsevier.com/books/numerical-ecology/legendre/978-0-444-89249-2

[23] Li, Y.; Xu, L.; Li, S., (2009). Water quality analysis of the Songhua River Basin using multivariate techniques: Journal of water resource and protection, 1(2), p.110.

[24] https://file.scirp.org/pdf/JWARP20090200006_23557686.pdf

[25] Mishra, S.; Kumar, A.; Shukla, P. (2016).Study of water quality in Hindon River using pollution index and environmetrics, India. Desalination and Water Treatment, 57(41), 19121-19130**(9 pages)**.

[26] https://www.tandfonline.com/doi/abs/10.1080/19443994.2015.1098570

[27] Osei, J; Nyame, F.K; Armah, T.K; Osae, S.K; Dampare, S.B; Fianko, J.R; Adomako, D; Bentil, N; (2010). Application of multivariate analysis for identification of pollution sources in the Densu delta wetland in the vicinity of a landfill site in Ghana: Journal of Water Resource and Protection, 2(12), p.1020.

[28] https://www.researchgate.net/publication/228480482_Application_of_Multivariate_Analysis_for_Identification_of_Pollution_Sources_in_the_Densu_Delta_Wetland_in_the_Vicinity_of_a_Landfill_Site_in_Ghana

[29] Ouyang, Y; (2005). Evaluation of river water quality monitoring stations by principal component analysis. Water Research, 39(12), pp.2621-2635**(14 pages)**.

[30] https://www.sciencedirect.com/science/article/abs/pii/S0043135405001788

[31] Pati, S.; Dash, M. K.; Mukherjee, C. K.; Dash, B.; Pokhrel, S. (2014).Assessment of water quality using multivariate statistical techniques in the coastal region of Visakhapatnam, India. Environmental monitoring and assessment, 186(10), 6385-6402 **(17 pages)**.

[32] https://www.ncbi.nlm.nih.gov/pubmed/24880726

[33] Prerna, C; Pathak, P.K; Singh, D; Srivastava, A.K; (2012).An Analytical Study of Physicochemical Characteristics of Groundwater in Agra Region. In Emerging Trends in Science, Engineering and Technology: Springer, India: pp. 541-549 **(9 pages).**

[34] https://link.springer.com/chapter/10.1007/978-81-322-1007-8_49

[35] Raghav, P; Singh, B.P(2014) Water Quality Assessment of Hindon River at Ghaziabad by Physico-Chemical Parameters Analysis. Strategic Technologies of Complex

May – June 2020
ISSN: 0193-4120 Page No. 5608-5622

Environmental Issues–A Sustainable Approach, pp.978-93 **(15 pages)**.
[36] http://www.krishisanskriti.org/vol_image/10Sep201512092323.pdf
[37] Rizvi, N.; Katyal, D.; Joshi, V. (2015).A Multivariate Statistical Approach for Water Quality Assessment of River Hindon, India. World Academy of Science, Engineering, and Technology, International Journal of Environmental, Chemical, Ecological, Geological and Geophysical Engineering, 10(1), 6-11**(5 pages).**
[38] https://waset.org/publications/10003212/a-multivariate-statistical-approach-for-water-quality-assessment-of-river-hindon-india
[39] S. K. Singh; Shah Manaan (2017).Spatial and temporal analysis of water quality parameters of a Himalayan Lake (Dal Lake) by Multivariate statistical, International journal of advanced research Int. J. Adv. Res. 5(1), 135-143(8 pages).
[40] https://www.researchgate.net/publication/313063187_SPATIAL_AND_TEMPORAL_ANALYSIS_OF_WATER_QUALITY_PARAMETERS_OF_A_HIMALAYAN_LAKE_DAL_LAKE_BY_MULTIVARIATE_STATISTICAL_ANALYSIS
[41] Smeti, E. M.; Golfinopoulos, S. K. (2016).Characterization of the quality of a surface water resource by multivariate statistical analysis. Analytical Letters, 49(7), 1032-1039 **(7 pages).**
[42] https://www.tandfonline.com/doi/abs/10.1080/00032719.2015.1045585
[43] Singh, K.P; Malik, A; Mohan, D; Sinha, S; (2004). Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)—a case study. Water research: 38(18), pp.3980-3992 **(12 pages)**.
[44] https://www.sciencedirect.com/science/article/abs/pii/S0043135404003367
[45] Sundaray, S. K. (2010). Application of multivariate statistical techniques in hydrogeochemical studies—a case study: Brahmani–Koel River (India). *Environmental monitoring and assessment*, *164*(1-4), 297-310.
[46] https://link.springer.com/article/10.1007/s10661-009-0893-x
[47] Tabachnick, B.G; Fidell, L.S; (2001). Using multivariate statistics: Nedham Heights, MA: Allyn&Bacon(Vol. 5).
[48] https://trove.nla.gov.au/work/7185329
[49] Times of India (2015) timesofindia.indiatimes.com/city/noida/42-polluting-units-along-Hindon-shut/articleshow/50990123.cms,feb 15
[50] https://timesofindia.indiatimes.com/city/noida/42-polluting-units-along-Hindon-shut/articleshow/50990123.cms
[51] Ward Jr, J.H., 1963. Hierarchical grouping to optimize an objective function. Journal of the American statistical association, 58(301), pp.236-244 **(8 Pages).**
[52] https://www.tandfonline.com/doi/abs/10.1080/01621459.1963.10500845
[53] Xin X; Lu WX; Gong L.(2010) Discriminant analysis method application in water quality assessment: take Yinma River as an example. In2010 4th International Conference on Bioinformatics and Biomedical Engineering IEEE (pp. 1-3) **(2 Pages).**
[54] https://ieeexplore.ieee.org/document/5515023
[55] Zhang, Q; Li, Z; Zeng, G; Li, J; Fang, Y; Yuan, Q; Wang, Y; Ye, F(2009). Assessment of surface water quality using multivariate statistical techniques in red soil hilly region: a case study of Xiangjiang watershed, China: Environmental monitoring and assessment, 152(1-4), p.123 **(3 Pages).**
[56] https://link.springer.com/article/10.1007/s10661-008-0301-y
[57] Zhao, Y; Xia, X.H; Yang, Z.F; Wang, F., (2012). Assessment of water quality in Baiyangdian Lake using multivariate statistical techniques: Procedia Environmental Sciences, 13, pp.1213-1226 **(13 pages)**.
[58] https://www.sciencedirect.com/science/article/pii/S1878029612001168
[59] Yu, S; Shang, J; Zhao, J; Guo, H; (2003). Factor analysis and dynamics of water quality of the Songhua River, Northeast China. Water, Air, and Soil Pollution, 144(1-4), pp.159-169 **(10 pages).**
[60] https://link.springer.com/article/10.1023/A:1022960300693