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Multivariate Statistical Analysis To Assess Groundwater Quality In Ankleshwar Taluka, Bharuch District, Gujarat, India

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Abstract: Groundwater quality must be assessed since it determines whether or not it may be used for drinking. Water for drinking, cooking, land farming and other purposes should be free of physical and chemical impurities. Groundwater is the primary source of drinking water. The physicochemical and biological examination of groundwater was used to determine the appropriateness of the water for consumption. The groundwater is polluted as a result of human and industrial activity. This is a significant issue nowadays. As a result, water quality analysis is critical for maintaining and improving the natural ecosystem. The factor analysis approaches are used to analyze groundwater quality data sets acquired from the CGWB, Gandhinagar in India in this study. The data were normalized and submitted to factor extraction in order to make it easier to comprehend and identify the characteristics that cause the most variability in water quality. The goal is to determine the reciprocal connections among the various water quality metrics in order to identify the key variables that influence reservoir water quality as well as the variations between them. The water quality index (WQI) is a useful and unique rating that depicts the total state of water quality in a single term and aids in the selection of appropriate treatment techniques to address the concerns.

Index Terms **- groundwater, water parameters, water quality standards, multivariate analysis, India**

I. INTRODUCTION:

The most significant factor in sculpting the terrain and controlling the climate is water. It is amongst the most essential molecules that has a significant impact on human existence. It is critical to ensure that the water being used drinking and irrigation is of good quality. Drinking water of poor quality has a negative impact on human health. Because they do not have access to excellent quality water, most people in underdeveloped nations like India utilise untreated groundwater for numerous uses. Calcium, Magnesium, Nitrate, and other chemical risks exist. Groundwater must be free of physical and chemical risks as a matter of public health. In past years, the environmental issues that have an influence on groundwater quality are perhaps the most apparent. According to the World Health Organization, water is responsible for around 80% of all human ailments. Once groundwater has been contaminated, it is difficult to restore its quality and devise strategies to safeguard it. One of the most successful methods for communicating information about water quality to concerned individuals and policymakers is the water quality index. As a result, it becomes a key criterion for groundwater evaluation and management. Removable minerals in soils and sedimentary rocks provide the majority of the soluble ingredients in ground water. The decline in water quality and pollution, both surface and groundwater, is known to be caused by a variety of causes and processes.

Factor analysis is important for evaluating groundwater quality datasets and connecting it to particular hydro-geologic and anthropogenic activities in this respect. Many instances of multivariate analysis being used to sets of data gathered for ground and surface waters may be found. Cluster analysis (CA) a multivariate statistical approach, are excellent for manipulating, analysing, and expressing data about groundwater pollutants and geochemistry. The use of multi component approaches in surface water, groundwater quality assessment, and environmental research is widely documented in the literature. Multivariate statistical methodologies allow for the extraction of hidden information regarding probable environmental impacts on water quality from a data collection.

II. STUDY AREA AND DATA COLLECTION:

The study area of Ankleshwar is situated in Gujarat's Bharuch district. It is located within 21.6264° N (latitude) and 73.0152° E (longitude) (longitude). The taluka of Akleshwar is around 14 kilometres from the district of Bharuch. The attractive Bharuch district is located on the Narmada, which is also regarded as Gujarat's lifeblood. The Bharuch district's river banks are lush with vegetation.

In ancient times, Ankleshwar village and Bharuch both have unique characteristics. Ankleshwar taluka is home to a number of pharmaceutical industries. In this region, there seem to be around 2000 industries.

Ankleshwar Industrial Association is Gujarat Industrial Development Corporation's largest industry association (GIDC). In 2011, the population of Ankleshwar was estimated to be approximately 140839. Deccan Trap, Sandstone, and Alluvium are the most common geological formations found in the study region.

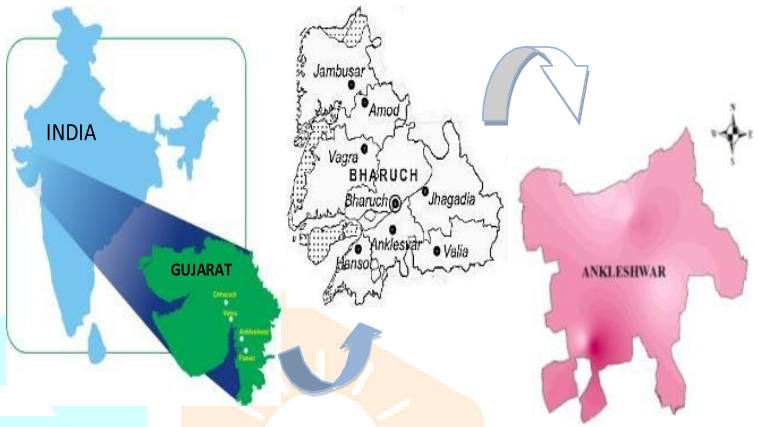

Figure: 1 Study area map of Ankleshwar

III. MATERIALS AND METHODS

Water samples were taken from 73 places throughout the district, with the exception of the structurally steep sections. During the premonsoon seasons of 2000-2020, water samples were collected in cleaned polythene bottles. Standard procedures were used to evaluate the gathered samples for main ion chemistry. Conductivity metres were used to measure hydrogen ion concentration (pH) & electrical conductivity (EC). By multiplying EC by 0.7, total dissolved solids (TDS) were calculated. Titrating with H2SO4 yielded estimates of carbonate (CO3) & bicarbonate (HCO3). Using standard EDTA, total hardness (TH) as CaCO3 and calcium (Ca) were titrimerically determined. Magnesium (Mg) being determined from TH and Ca, sodium (Na) and potassium (K) were determined using a flame photometer, chloride (Cl) was calculated using a conventional AgNO3 titration, and sulphate (SO4) and nitrate (NO3) were determined using a colorimeter. Calculating the ion-balance between anions and cations of a sample was used to verify the correctness of the lab analysis. The various list of parameters and methods of determination are being mentioned in the below table 1.

Table 1: List of Parameters and Methods of Determination

Parameters	Methods of determination
pH	pH Meter
TH (mg/l)	EDTA Method
NO3- (mg/l)	Titration Method
Mg (mg/l)	Titration Method
Na (mg/l)	Flame Photometer (Calibration Method)
K (mg/l)	Flame Photometer (Calibration Method)
TDS (mg/l)	Potentiometric Method
EC (µS/cm)	Conductometer
F (mg/l)	UV Spectrophotometric Method
SO_4 (mg/l)	Turbidimeter Method
Cl- (mg/l)	Titration Method

IV. STATISTICAL ANALYSIS:

Because the groundwater in the research region was determined to be mixed type, statistical analysis may be used to investigate the dominating hydro chemical parameter observed in groundwater samples. In this study, eleven hydro chemical data were collected from 10 different places within the study region and statistically analyzed. This results in a ten-by-eleven data set matrix. The features of a data collection may be investigated using statistical analysis techniques such as descriptive, correlation, and cluster analyses, or a singular numbered outcome out of each analysis can be obtained to evaluate the data set's wholesome nature.

V. DESCRIPTIVE ANALYSIS:

It's a type of statistical analysis that characterizes a data collection by its maximum and minimum values, mean, and standard deviation. Mean is a central tendency metric that represents the arithmetic average of a group of observations. The standard deviation is the square root of the arithmetic mean of squares of departures of given observations from the arithmetic mean. We may use the standard deviation to figure out where any number in the data set is in reference to the mean. Below table 2 indicates the statistical analysis of ground water quality parameters in ankleshwar taluka.

Table 2: Statistical Analysis of Ground Water Quality Parameters in Ankleshwar taluka, Bharuch District, Gujarat, India

Symbols	Parameters	Min	Max	Mean	Standard Deviation
pH	pH	7.38	8.86	8.072	0.287
EC	Electrical Conductivity	670	6548	2724.48	1265.94
TDS	Total Dissolved Solids	449	4752	1803.46	973.59
TH	Total Hardness	160	1650	528.871	364.561
NO3-	Nitrate	46	786	408.24	181.79
Mg	Magnesium	12.5	378.09	80.19	65.87
Na	Sodium	46	786	408.24	181.97
K	Potassium	0.5	82	12.72	15.74
SO4	Sulphate	6	534	134.48	134.04
Cl	Chloride	36	1985	570.53	415.03
F	Fluoride	0.1	3.2	1	0.64

EC has a standard deviation of 1265.94, which is the highest standard deviation number when compared to other metrics. EC has a mean value of 2724.48 (mg/L), which is higher than the ideal limit (800 mg/L) but lower than the acceptable maximum (2500 mg/L) set by IS: 1050017. The minimum and maximum concentrations of water quality indicators will provide crucial information regarding the amount of concentration fluctuations across samples obtained from a given location. Because TDS concentrations vary widely and have a greater standard deviation than other samples in the data set, it may have a role in identifying groundwater in the research region as mixed water type.

VI. CORRELATION ANALYSIS:

Water quality is influenced by a number of variables if there is a high connection between them, and thus the combination of these variables has an impact on water quality. If connections between water quality metrics are recognised, the process of monitoring water quality can be made easier. If there is a link between water quality metrics, monitoring a few and predicting others using them is a good idea.

A correlation study's findings might be valuable in establishing the water's quality. A detailed statistical study of correlation coefficients of water quality parameters not only assists in the assessment of overall water quality, but also provides important recommendations for implementing rapid water quality management programmes.. A pair of parameters having correlation coefficient r up to 0.5 do not have any significant correlation between them, $r \geq \pm 0.5$ bears significant linear correlation between them and $r \geq \pm 0.8$ indicates very strong linear correlation between them20. The positive and negative correlation among hydro chemical parameters of groundwater samples are summarized in Table 3.

Table 3: Correlation Matrix Indicating groundwater samples

	CHLORIDE	EC	FLUORIDE	K	MG	NA	NITRATE	PH	SULPHATE	TDS	TH
CHLORIDE	1	0.96	-0.07	-0.02	0.85	0.78	0.20	-0.16	0.33	0.84	0.89
EC	0.96	1	0.01	0.00	0.81	0.87	0.27	-0.15	0.44	0.87	0.85
FLUORIDE	-0.07	0.01	1	-0.37	-0.15	0.21	0.10	0.28	-0.11	0.16	-0.21
K	-0.02	0.00	-0.37	1	0.11	-0.13	-0.07	0.19	0.12	-0.05	0.21
MG	0.85	0.81	-0.15	0.11	1	0.51	0.22	-0.16	0.21	0.72	0.91
NA	0.78	0.87	0.21	-0.13	0.51	1	0.24	-0.01	0.50	0.73	0.51
NITRATE	0.20	0.27	0.10	-0.07	0.22	0.24	1	-0.22	0.13	0.35	0.19
PH	-0.16	-0.15	0.28	0.19	-0.16	-0.10	-0.22	1	-0.27	-0.09	-0.14
SULPHATE	0.33	0.44	-0.11	0.12	0.21	0.50	0.13	-0.27	1	0.26	0.32
TDS	0.84	0.87	0.16	-0.02	0.72	0.73	0.35	-0.09	0.26	1	0.74
TH	0.89	0.85	-0.21	0.21	0.91	0.51	0.19	-0.14	0.32	0.74	1

VII. CLUSTER ANALYSIS:

Cluster analysis (CA) is a method for breaking down vast amounts of data into smaller, more manageable chunks. In this study, hierarchical cluster analysis is used to analyze a data set containing water quality characteristics. This is the most common statistical strategy for identifying clusters of instances that are somewhat homogenous in terms of assessed parameters. It begins with every instance as a distinct cluster, then successively merges the clusters, lowering the number of clusters at each step until only one group remains. Dendogram showing the cluster analysis of ground water samples has been discussed below in figure-2.

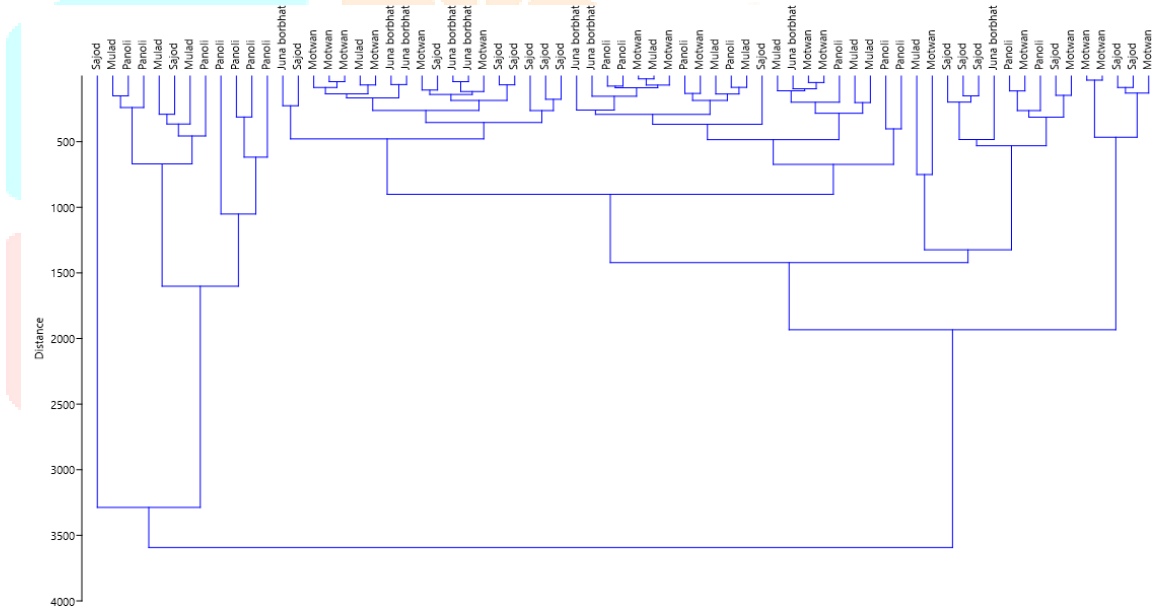

Figure-2 Dendogram showing CA of groundwater samples

VIII. Conclusions:

The findings of a multivariate statistical analysis research performed on a data set including hydrochemical characteristics of groundwater samples collected in Ankleshwar taluka in Bharuch district reveal the usefulness of statistical analysis in groundwater investigations. The kind of water is recognised according to a statistical analysis research. The amount of variances in hydrochemical parameters was determined using descriptive statistics. The parameter EC had a higher standard deviation, which might be the explanation for the mixed type water. Also discovered is that EC has a significant relationship with major cations and anions. Cluster analysis revealed that the primary cations and anions contribute to the concentration of EC through a grouping pattern. In this study, the nature of groundwater type and the primary parameter responsible for groundwater type were investigated.

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