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ASSESSMENT OF GROUND WATER AT VARIOUS PLACES OF SURAT DISTRICT USING MULTIVARIATE STATISTICAL TECHNIQUES

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Abstract - *Ground water is most important natural resources. It is major source of water for agriculture and industrial sector. Ground water usage is about 50% of total water used. So it is important to maintain ground water quality detoriation due to anthropogenesis activities. Objective of study was access the spatial and temporal variation in ground water quality and identify the sources of irrigation project of Surat district by multivariate statistical techniques. Surat city is located at southernmost tip of Gujarat. In this area ground water is available in confined and unconfined zone. The area at irrigation project were water contamination due to use of fertilizer, insecticides and pesticides. Furthermore, this quality assessment study carried out by collecting sample of ground water. Samples were collected from pre monsoon and post monsoon seasons. This samples were analysed for 11 quality parameter including ph, TDS, conductivity, alkalinity, sulphate, chloride, bicarbonate, magnesium, calcium, sodium, potassium Result of this study demonstrate the usefulness of multivariate statistical analysis in terms of hierarchical cluster analysis and factor analysis in geochemistry which provides the hidden relationship between ions and change in water quality for both the seasons due to agriculture uses another human activity. The fundamental idea behind using this technique was to utilize all available hydro chemical variables in the quality assessment.*

Key Words: Multivariate statistical analysis, Pre monsoon, Post monsoon, Ground water quality, Quality assessment, unconfined zone

1. INTRODUCTION

Ground water is most important natural resources. The water that exists in the voids between the particles of the subsurface soil and in the cracks is groundwater. In aquifers, vast amounts of groundwater are contained. Ground water usage is about 50% of total water used. It is the primary source of water for human activities such as agriculture, industry and domestic drinking water especially in regions with limited annual precipitation (Todd, 1980). So it is important to maintain ground water quality detoriation due to anthropogenesis activities. This is a major concern now, a few days ago. The water quality research is therefore very critical for maintaining and prefecting the natural eco system. These issues restrict the use of groundwater and generate additional difficulties in meeting the rising demand for water. There are various forms of Contaminants Such as nitrate, Heavy metals and saltwater, that can be present in groundwater.

In this study access the spatial and temporal variation in ground water quality of Surat city. Surat city is located at southernmost tip of Gujarat. In this area ground water is available in confined and unconfined zone. The area at irrigation project where water contamination due to use of fertilizer, insecticides and pesticides.

1.1 Need of this Study

Identify the main source responsible for hydrochemistry of groundwater aquifer so that corrective and preventive methods can be implemented. In view of limitation of conventional techniques like stiff and piper and also increasing number of chemical parameters now being measured in ground water study have shown that multivariate statistical technique can be very useful tool. Ground water Quality parameters have been examined to assess temporal variation. This method is very effective tool for classifying huge number of samples with many hydro chemical variables. With water classification, water re-use at study area can be investigate.

1.2 Objective of this Study

- To calculate the water quality index for analysis of ground water.
- To study the spatial and temporal variation in ground water quality due to non-point source of pollution using multivariate statistical analysis.
- Analysis of ground water quality in the different groups obtained from cluster analysis.
- Variation of ground water quality during pre-monsoon and post monsoon periods in the similar groups.
- To study the major type of contaminants present in water, identifying the source of contaminants and remedial measures.

1.3 Scope of the Study

- To collect the physical and chemical parameter of ground water of different places of Surat district.
- To calculate the water quality index for analysis of ground water.
- To analyze the groundwater quality for drinking purpose and for agriculture purpose by using multivariate statistical analysis.

2. STUDY AREA

2.1 General Features and Topography

The city lies at a bend of the river tapi. Surat is located at southern side of Gujarat, India. Area of the city is 4,549 sq. km. Study area is located at $21^0 10'12''$ N and $72^0 49'51''$ E. The district is bound by Bharuch district, in the south by Valsad district, in east by the dang district and Maharashtra state and in a west by Arabian Sea. The coastal part is made of marshy area and consolidated dunes. Prominent rivers include the Kim, the tapi and purna flowing towards the west of the Arabian Sea.

2.2 Temperature and Rainfall

The study area comprises semiarid climate in nature. The summers are hot with temperature ranging from 37.7°C to 44.4°C. The climate is temperate during autumn while monsoon is pleasant .the winters are not very cold but the temperature in January range from 10°C to 15.5°C.the average annual rainfall of the city has been 1143 mm.

2.3 Geology and Soil Type

In Surat city soils are very deep, fine and medium textured and well drained. They are slight to strong saline and slightly alkaline. The soil drainage in this area is well to moderately drain.

3. DATA COLLECTION

The data needed for the project is ground water quality parameters from pre-monsoon and post-monsoon seasons. For this project sample will for 11 quality parameter including ph, TDS, conductivity, alkalinity, sulphate, chloride, bicarbonate, magnesium, calcium, sodium, potassium of total 34 wells at surat district. Collected data shows that most of the well are dug well or bore well type. Following data were collected from ground water resources department of Surat.

- Groundwater location and other detailed of Surat district.
- Groundwater Quality Data of Pre-monsoon season and Post-monsoon Season.

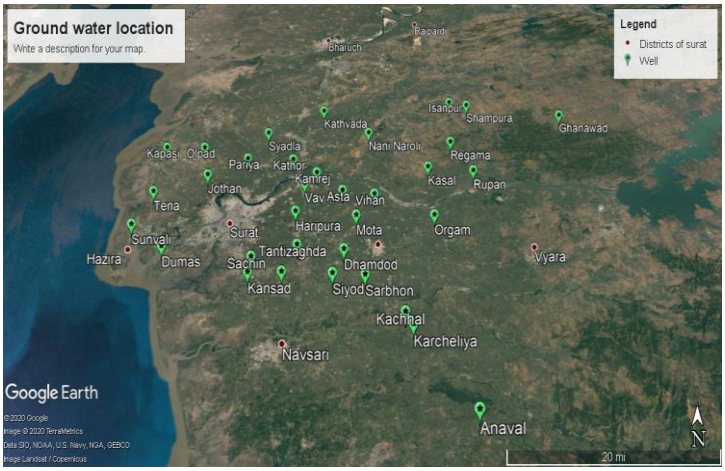

Fig -1: Ground Water Location from Google Earth

4. METHODOLOGY

4.1 Different Chemical parameters in groundwater

Common cations: Na^+, K^+, Mg^{2+}, Ca^{2+}

Common anions: CO_3^{2-}, Cl^-, HCO^{3-}, So_4^{2-}

Some other parameters like Fe^{2+}, B, NO_3, F^-, PO_4^{3-}, Sio_2 etc also bear spatial importance in ground water studies.

4.2 Calculation of ground water quality index

The calculation of WQI made using weighed Arithmetic index method in the following steps,

Step 1. Assign a weight/ weightage factor (Wi):

Assigning of weightage factor (Wi) to groundwater quality parameter as per its relative significance and determine relative weight (Wr). The range of such weightage factors may be framed out accordingly, its scope is set between 1 to 4 where 1 weightage factor can be assigned to least important parameter and 4 weightage factor assigned to most contributive parameters to overall groundwater quality. Computed relative weights of various parameters.

Relative Weight (Wr) = Wi / (Wi + Wi+1 ….Wn)

Step 2. Determine Quality Rating (qi) for each parameter:

Quality Rating (qi) = (Ci / DSi) x 100

Where,

qi = quality rating

Ci = concentration of each chemical parameter in each water sample in mg/L,

DSi = Indian drinking water standard for each chemical parameter according to the BIS-10500, 1991.

Step 3. Compute the WQI:

SIi =Wr x qi

WQI = Σ SIi

Where,

SIi = sub-index of i^{th} parameter

WQI of Ground Water	Rating of Water Quality
0-50	Excellent
50.1-100	Good
100.1-200	Poor
200.1-300	Very Poor
>300	Unfit

Table -1: Quality of Water based on WQI Range

4.3 Hierarchical cluster analysis

Hierarchical clustering is a cluster analysis method, which produce a tree-based representation of a data which is called Dendrograms. Objects in the Dendrograms are linked together based on their similarity.

Hierarchical clustering is where you build a cluster tree to represent data, where each group links to two or more successor groups. The groups organized as a tree, which ideally ends up as a meaningful classification scheme.

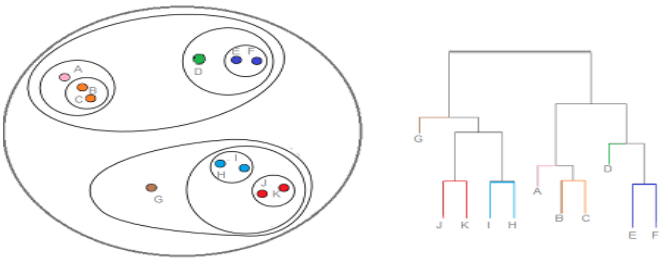

Fig -2: Dendrogram representing clusters

4.4 Methodology for Generation of Dendrogram for Cluster Analysis

In data mining and statistics, hierarchical clustering is a method of cluster analysis which seeks to build a hierarchy of clusters. Strategies of hierarchical clustering generally fall in to two types.

All hierarchical clustering algorithms are monotonic they either increase or decrease. The Cluster can be bottom up or top down.

Agglomerative: this is a "bottom-up" method. Each observation starts in its own cluster, and pairs of cluster are merged as one moves up the hierarchy.

- Treat each text at the beginning of the algorithm as a single cluster
- Merged two items at a time into a new cluster. How the Pairs merge involve measuring a difference between and pair that has been merged and the pair other samples. There are many ways to do this.

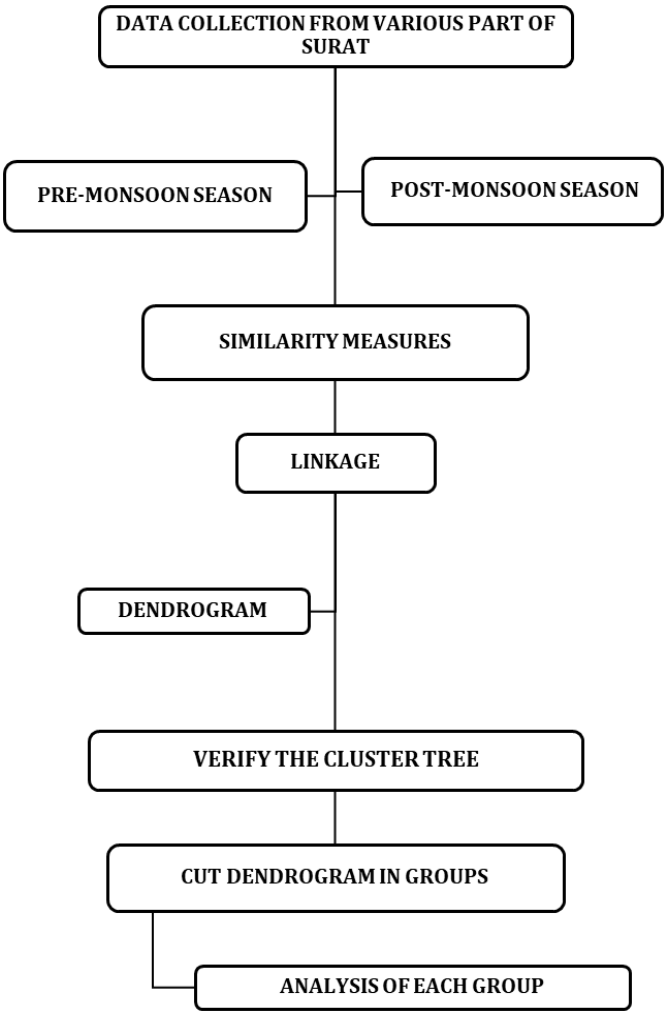

Fig-3: Methodology chart for cluster analysis

4.5 Methodology adopted

- The following methodology is adopted in the present study
- Data obtained from GWRDC office for pre-monsoon, post-monsoon season.
- To find quality of ground water, GWQI is used which help in classify the type of water or identify the place where water can reuse or unfit for use.

- To find distance of wells from the sea "Google Earth" was used to finding the exact location of the wells through which coordinates of wells based on latitude and longitude.
- Find the affected area result from cluster analysis of every parameter plot on Google earth this gives virtual picture of groups of similar parameter of pre monsoon and post monsoon. It helps to find change in position of area.
- Plot the Dendrogram of various parameter T.D.S, sodium, calcium, bicarbonate, magnesium, potassium, chloride, electrical conductivity using SPSS Softwere.to check temporal variation.

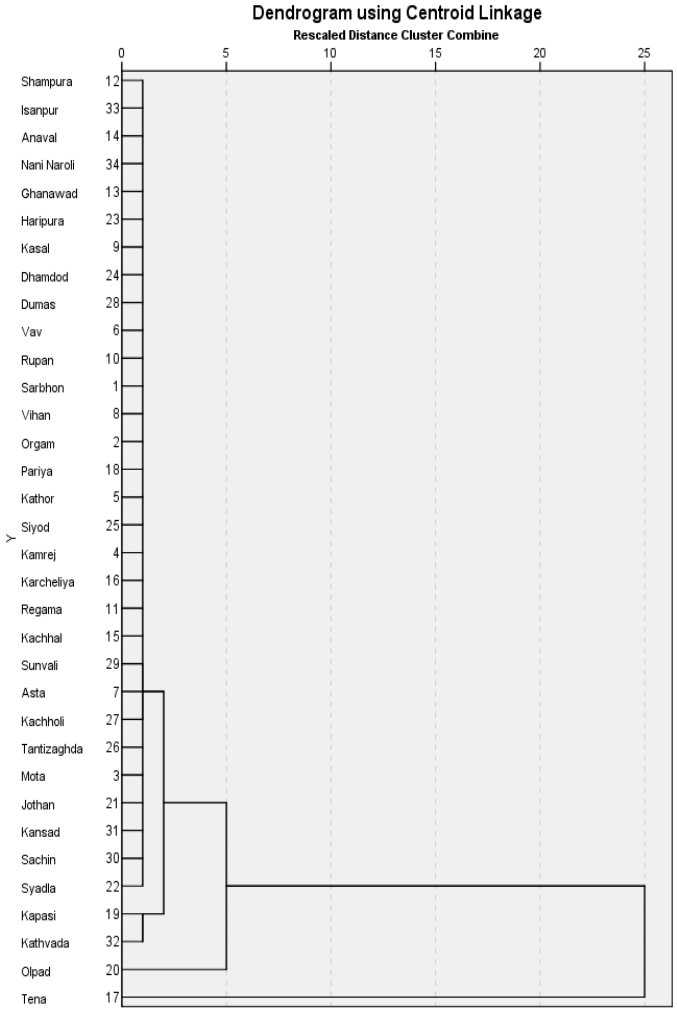

Fig-4: Dendrograms Sodium of Pre-Monsoon Season

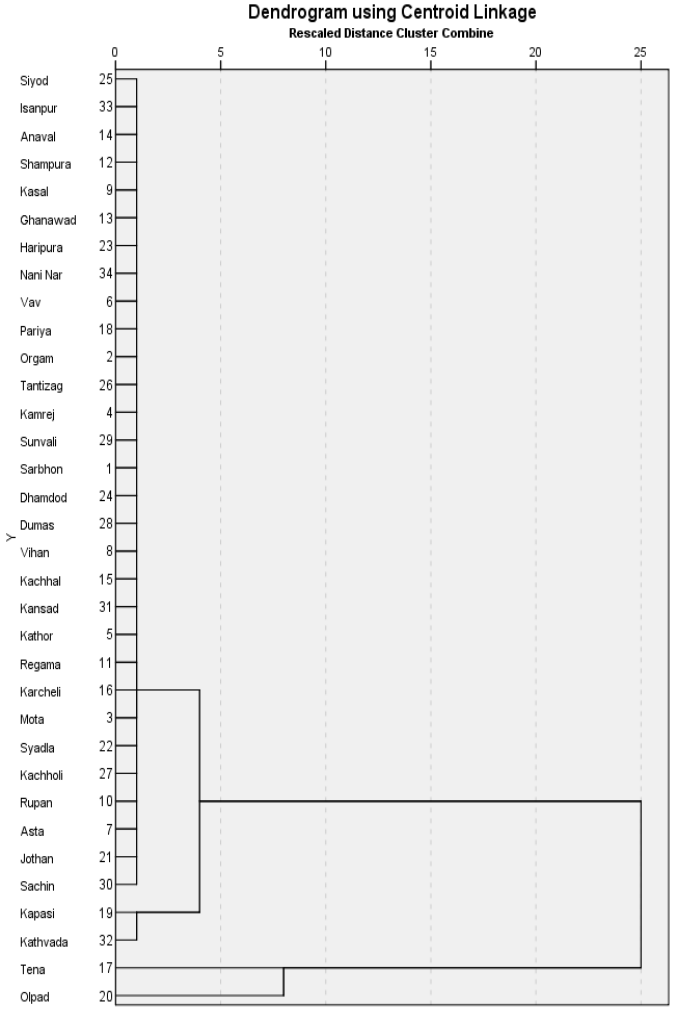

Fig-5: Dendrograms Sodium of Post-Monsoon Season

5. RESULT ANALYSIS ON PARAMETERS OF WATER

The Dendrograms obtained from pre monsoon and post monsoon season data .which is divide in different cluster. Analysis of each cluster from both the season. The cluster having variation in quality of water from pre monsoon to post monsoon.

The clusters having change in water quality derive from pre monsoon and post monsoon data were studied and the cause of variation is analyses.

Comparison of all parameter between pre monsoon and post monsoon data of year 2019.

Sr. No	Water Quality Parameters (mg/l)	Bureau of Indian Standard (IS-10500: 2009)	Pre-Monsoon 2019 (Parameter Range)	Post-Monsoon 2019 (Parameter Range)
1	pH value	6.5-8.5	7.5-9.1	6.8-9.4
2	Total Dissolved solids	500-2000	170-15040	180-13060
3	Chloride	250-1000	18-6425	18-5400
4	Magnesium	30-100	9-300	3-342
5	Bicarbonate	100-300	41-1612	52-1210
6	Potassium	0.4-11.1	0.4-73.2	0.2-70.3

Table -2: Seasonal wise concentrations of water quality parameters in groundwater Samples of year 2019

5.1 Water Quality Index (WQI)

The Water Quality Index is Depends on Various Types of Parameters like pH, TDS, Calcium, Magnesium, Sodium, Carbonate, Bicarbonate, Potassium, Sulphate and other parameters. Water Quality Index Values are slightly higher in post monsoon Season than Pre monsoon Season and improvement in type of water. In Surat District Tena, Olpad and Kathvada are same type of water in pre monsoon and post monsoon. Other village Kamrej, Vav, Vihan, Shampura, Kapasi, Syadla, Tantizaghda, Kansnd and Nani Naroli are Better Improvement in Water.

5.2 Total Dissolved Solid (TDS)

In Surat district Total Dissolved Solids rang in pre monsoon is 170-15040 mg/l and post monsoon range 270-13060 mg/l. in Pre monsoon Season total 12 numbers of village is more than 1200 mg/l in TDS than post monsoon Season 6 Numbers of village is more than 1200 mg/l. we can say that concentration of TDS is very high near coastal area and also this area contain some industrial site also.

5.3 Electrical Conductivity (EC)

In Surat District, calcium Parameters range in Pre monsoon is 280 to 23490 mg/l and in Post monsoon Season range is 270 to 20440 mg/l. this Difference Analyses the post monsoon Season is well Improve to the Pre monsoon Season there are 5 area like Mota, Tena, Kapasi, Olpad, Kathwada is unsuitable for use. in post monsoon season due to decrees in Electrical conductivity and also one of the reason was site is far away from costal area and after the monsoon rain water infiltrate in to ground in decrease the amount of salt.

5.4 Sodium

In Surat District, Sodium Parameters range in Pre monsoon is 15 to 4802 mg/l and in Post monsoon Season range is 12 to 3428 mg/l. this Difference Analyses the post monsoon Season is well Improve to the Pre monsoon Season. Concentration of sodium mostly depend on leaching of salt and study area near to agriculture area to use of fertilizers.

5.5 Potassium

Potassium observed from the Study area was between 0.6 - 73.2 and 0.3 – 70.3 in Pre monsoon and Post monsoon respectively. Tena, Olpad and Sunvali village were found unacceptable value of potassium. Potassium is also available in ground water due to leaching and agriculture activity.

5.6 Magnesium

Magnesium is Observed from these area are range between 9 to 300 and 3 to 342 Respectively Pre Monsoon and Post Monsoon. Sarbhon, Rupan, Ghanawad, Tena, Olpad, Jothan, Dhamdod and Dumas were post monsoon Values are more than the pre monsoon. Quantity of magnesium in water due to natural water movement in rocky stage and also industrial waste.

5.7 Chloride

In Surat District observed the value 20-500 mg/l and 15-500 mg/l in pre monsoon and post monsoon respectively. Generally, water standards require chloride level not to exceed 250 mg/l. Tena, Kapasi, Olpad and Kathvada villages are the values more than 250 mg/l in pre monsoon and post monsoons.

5.8 Calcium

In Surat District, calcium Parameters range in Pre monsoon is 15 to 325 mg/l and in Post monsoon Season range is 15 to 445 mg/l. this Difference Analyses the post monsoon Season is well Improve to the Pre monsoon Season

6. CONCLUSIONS

- Ground water quality index shows that Quality of water in post monsoon season is better than Pre monsoon due to increasing depth of water level during monsoon. Also Ground water Quality in Study Area lie between excellent to poor but some area like mota, tena, Kapasi, Olpad, Sachin and Kathwada found unsuitable. This need special attention toward improvement of ground water quality.
- Major contaminants in study area are sodium, chloride, potassium. And observation from data analysis show

that potassium in most of the ground water, higher concentration observed post monsoon season and low in pre monsoon season. It is likely due to leaching and study area near to agriculture area to use of fertilizer.

- Hierarchical cluster analysis indicate recognizable Arial changes in water quality in different season
- Multivariate statistical analysis methods applied for the study area are found to be effective of characterization of hydro-geochemical processes and the water chemistry of the region.
- The hydro geochemical composition of groundwater in the rural part of surat district, Gujarat is affected by the geogenic process and also has impact of anthropogenic Inputs.
- Since Study area has semi-arid climate, so a higher rate of evapotranspiration, a longer residence time of water in the aquifer zone, intensive and long term irrigation, industrial water and Sea water intrusion are the supplementary factors to further enhance Quality Parameters in the ground water. Thus the results of this study clearly demonstrate the usefulness of multivariate statistical analysis in the hydro chemical.

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