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ANALYSIS OF WATER QUALITY OF DCM INDUSTRIAL AREA KOTA AND THEIR STATSTICAL DETAILS

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ABSTRACT

Contamination of groundwater due to total coli and TDS is an area of concern for local, regional and global levels. Keeping in view industrial significance of Kota, present study is designed to assess groundwater quality for physicochemical and microbiological pollution and its impact on human health. For this purpose, water samples were collected from 15 localities during March-December 2014 period for investigating 24 physiochemical and other parameters including pH, Electric Conductivity (EC), Total Dissolved Solids (TDS), salinity, temperature, turbidity, sulfate, chloride, Total Hardness, fluoride, nitrate, alkalinity, iron (Fe), Total Coli etc. The results were compared with standard guidelines of World Health Organization (WHO) and BIS for groundwater quality. Cluster Analysis (CA) grouped all sites into four zones based on similarities and dissimilarities of physiochemical properties. The results revealed that the value of electrical conductivity, Total dissolve solids and Total coli are high as compared to other parameters in the study area in all seasons as they form a separate group of cluster. So, prior treatment of water should be done before use.

KEY WORDS: Groundwater, public health, Kota, Cluster analysis, TDS.

INTRODUCTION

Water contained in an aquifer matrix located below the surface in the saturated zone, acts as primary buffer against drought for human requirements and plant production [1]. Exploitation of groundwater for irrigation purposes in India has increased in the recent years. Obviously groundwater contains mineral ions dissolved from soil particles, sediments and rocks as water flows along mineral surfaces of the aquifer. Factors like slope, climate and drainage conditions contribute to the groundwater quality. [2]

Kota has been known as educational hub in addition to industries of varying nature ranging from plastics, cement, metals, food production to textile and metallurgical streams. With the advent of time, surface and groundwater of Kota DCM industrial area has been degraded due to rapid industrialization, urbanization and agricultural activities in its surroundings areas.[3] The present study thus has relevance to analyze the groundwater chemistry of the area. In order to have a close look pre-monsoon, monsoon and post-monsoon seasons of year 2014 were chosen. [4] Important physico chemical parameters were analyzed by standard methods. Out of the various parameters studied, with regards to earlier ones like concentration of Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH) and Total Coli were found very high in study area. Statistical analysis, particularly, cluster analysis method has been used for highlighting concern of polluted study area.

MATERIALS AND METHODS

Study Area

Kota is located along eastern bank of the Chambal River. The cartographic coordinates are 25°11′N 75°50′E/ 25.18°N 75.83°E. It covers an area of 318 km^2 (3.63 per cent of the Rajasthan State). It has an average elevation of 271 meters (889 ft). The district is bound on the North and North West by Sawai Madhopur, Tonk and Bundi districts. The Chambal river separates these districts from Kota district, forming the natural boundary.DCM industrial area and its adjoining areas in western part of Kota have been chosen as area of study. Total covered area under study is 10 sq. Kms. The details of various spots selected for study are given in Figure 1.

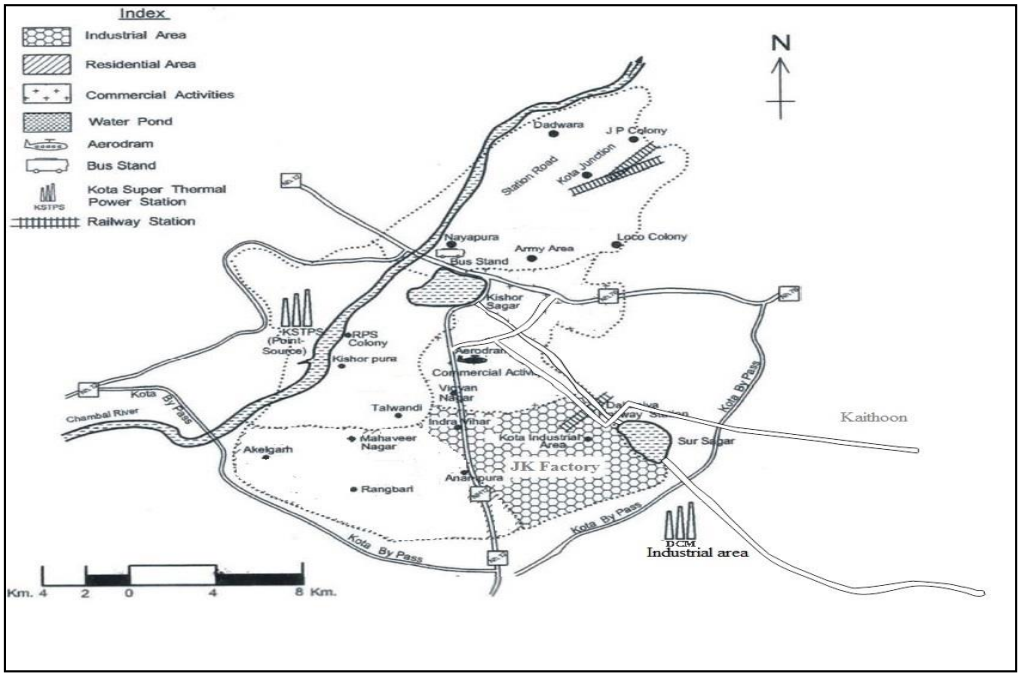

Figure-1: Map of Study area

Data used and Methodology

SPSS (Statistical Product and Service Solutions) 16.0 was used for the preparation of the cluster analysis (CA) map and analyze the data for the evaluation of groundwater quality. CA grouped the sampling sites into clusters on the basis of similarities within a zone and dissimilarities between different zones. The results of CA helped in interpreting the data and indicating patterns of similar objects. [5] Ward's method was used as a clustering technique to identify the zones in the data and Euclidean distance was used as a distance matrix.

For analyzing the chemical aspects of groundwater in the study area, total 15 samples of groundwater used for drinking purpose were collected from different sources like hand pumps or open wells at different spots spread over DCM Industrial area during Pre-monsoon, Monsoon & Post-monsoon season in 2014.These spots were specifically identified on the basis of frequent use and probability of contamination and were mapped (Figure-2). The season was selected because contamination often increases due to starting of rain and tends to the accumulation of ions and decreases in the ending of rain. (Table-1)

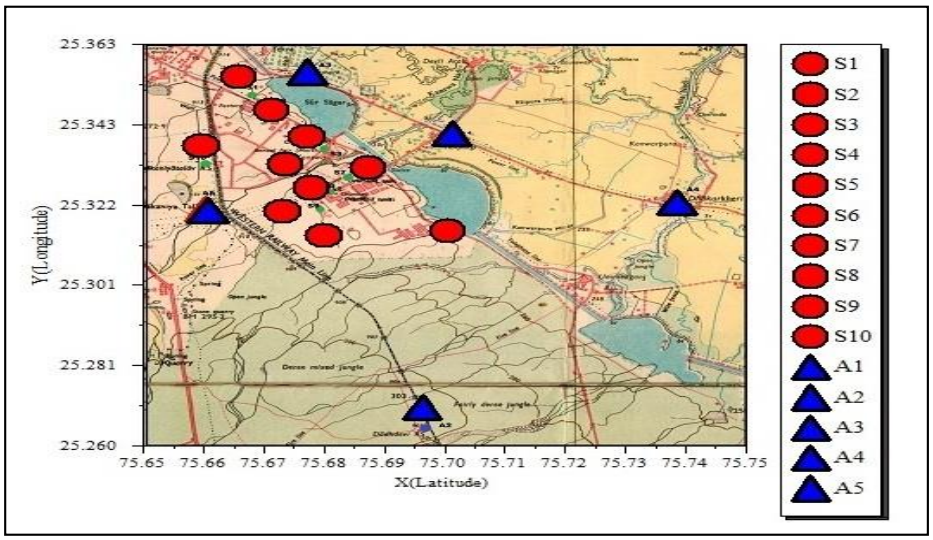

Figure-2: Map of location with different sampling spots of study area with adjoining areas

The samples were analyzed using standard methods of analyses to assess various physicochemical parameters according to APHA & WHO norms. [6-8]Some parameters like temperature, color, and pH were measured on site. Water samples were analyzed by standard methods [9] for physicochemical parameters like water temperature(^{0}C), TDS, conductivity, turbidity, odor, nitrate, sulphate, phosphate, Dissolved Oxygen, hardness, chlorides, fluorides, nitrate, sodium, potassium and Chemical Oxygen Demand(COD),Biological Oxygen Demand (BOD), alkalinity, Iron.

Table 1: Description of spots and source type

Sampling Station	Spot No.	Name of the spot	Source type
1.	S1	Near Govt. Girls Senior Secondary School, Bombay Yogena, Kansua	Tube Well
2.	S2	Near Bombay Yogena Colony, Kansua	Hand Pump
3.	S3	Near Samudayik Bhawan, Near Maszid, Kansua	Hand Pump
4.	S4	Near Shiv Mandir, Kansua	Hand Pump
5.	S5	Near Govt. Senior Secondary , Ram Nagar	Hand Pump
6.	S6	Near Govt. Senior Secondary School, Indra Colony , DCM	Hand Pump
7.	S7	Shri Ram Fertilizer Gate , Near Fly Over, Prem Nagar	Hand Pump
8.	S8	Samudayik Bhawan Ke Paas Prem Nagar III	Tube Well
9.	S9	Papaji Ke Bhatte Ke Paas, Rayans Industry Boundary,Prem Nagar III	Tube Well
10.	S10	Industrial Area, Near Dakaniya Station, Sanjay Nagar	Hand Pump
11.	A1	Raipura	Dug Well
12.	A2	Daddevi	Dug Well
13.	A3	Soorsagar	Pizometer
14.	A4	Dhakerkhari	Dug Well
15.	A5	Dakniya talav	Hand pump

RESULTS AND DISCUSSION

Cluster analysis (CA) is a multivariate technique. Its primary purpose is to classify the objects of the system into categories or clusters based on their similarities and dissimilarities in the group. CA was applied to water quality data using a single linkage method, wherein the distances or similarities between two clusters A and B are defined as the minimum distance between a point in A and a point in B:

$$D(A, B) = \min \{d(xi, xj), \text{ for } xi \text{ in } A \text{ and } xj \text{ in } B\}$$

where d (xi, xj) is the Euclidean distance in Equation. At each step the distance is found for every pair of clusters and the two clusters with smallest distance (largest similarity) are merged. After two clusters are merged the procedure is repeated for the next step: the distances between all pairs of clusters are calculated again, and the pair with minimum distance is merged into a single cluster. As similarity decreases, all subgroups are merge into a single cluster[10].The Euclidean distance usually gives the similarity between two samples, and a distance can be represented by the difference between transformed values of the samples [11].The result of a hierarchical clustering procedure can be displayed graphically using a tree diagram, also known as a dendrogram [12].

In the present study, hierarchical CA was performed on the standardized data using single linkage method (linkage between groups) with Euclidean distances as a measure of similarity and was amalgamated into dendrogram plot. All the physico-chemical characteristics were used as variables to show the spatial heterogeneity among the stations as a result of sequence in their relationship and the degree of contamination. Accordingly, dendrogram classified 15 monitoring sites in the DCM Industrial Area into four groups (Group A, Group B, Group C, and Group D) based on similarities of water quality characteristics.

The group classifications varied significantly, because the sites in these groups had similar features and natural backgrounds that were affected by similar sources. It is evident from the figures that sampling stations in Group A were free from major point and non-point pollution sources, could be categorized as less polluted and less noticeable spatial variation. The sampling stations in Groups B even though appear to have less noticeable spatial variation, they formed different cluster. The sampling stations in Groups C even though appear to have noticeable spatial variation, they formed different cluster. Group D alone formed a group with highest Euclidian distance compared to

other cluster groups reflecting noticeable spatial variation in the physicochemical parameters and appears to be highly polluted but marginally free from major point and nonpoint pollution sources .[13]

Pre monsoon:

Table 2 Group of clustered stations during Pre monsoon season

Group	Sampling stations	Variables
A	5,6,7,8,9	Odor , Color, BOD, F^-, Phosphate, Potassium, DO, Fe, NH_4^+,Turbidity,pH, Na^+, COD, Temperature, Mg^{2+}, Nitrate, Ca^{2+}, Sulphate, MgH, Cl^-,HCO_3^-
B	10,12,13,14,15	Alkalinity, Carbonate, CaH, Hardness
C	1,2,3,4,11	Conductivity, TDS
D	-	Total Coli

It is evident from the Figure 3 that pre-monsoon stations in Group A (S5, S6, S7, S8, S9) , maximum variables were free from major point and non-point pollution sources, could be categorized as less polluted and less noticeable spatial variation. The sampling stations in Groups B (S10, A2, A3, A4, A5) even though appear to have less noticeable spatial variation, they formed different cluster and was characterized by large amount of alkalinity (193.42-310.13mg/L), carbonate (118-305.08 mg/L), CaH (79.33-279 mg/L), hardness (118-492 mg/L).

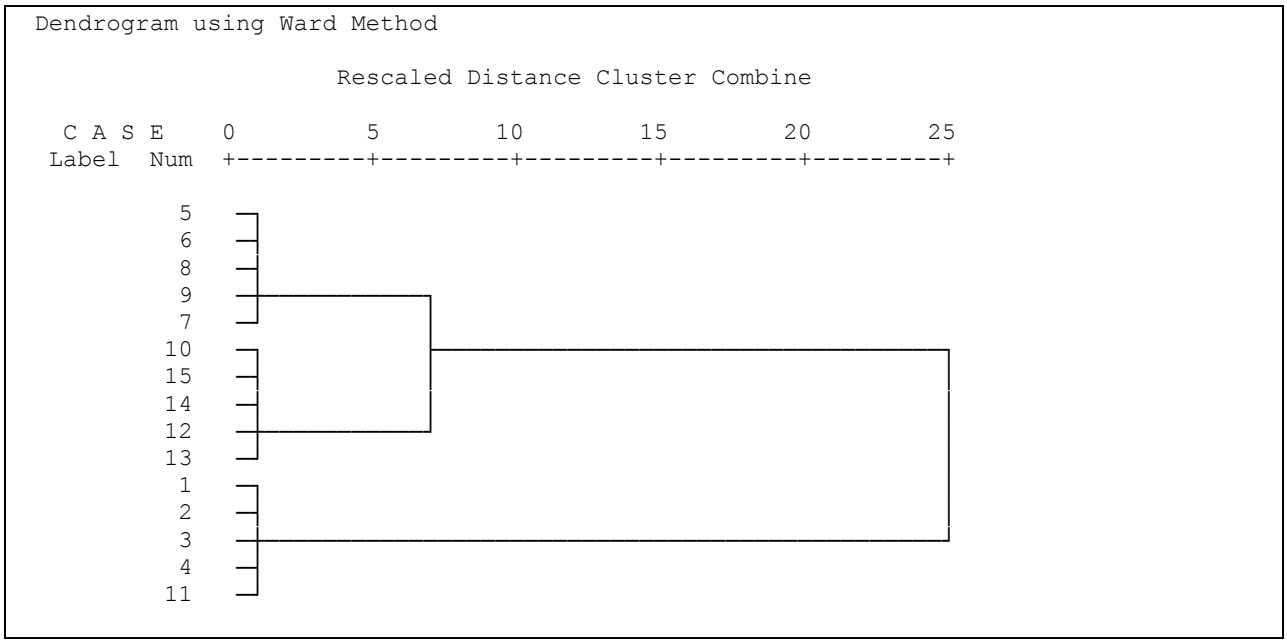

Figure 3 (a) Dendrogram by Hierarchical cluster analysis in pre-monsoon (Spots)

The sampling stations in Groups C (S1, S2, S3, S4, A1) even though appear to have noticeable spatial variation, they formed different cluster with variables conductivity (307.47-794.62 µmhos/cm) & TDS (327.63-905.82). Total Coli (14.67-2313.33 MPN/100ml) in Group D alone formed a group with highest Euclidian distance compared to other cluster groups reflecting noticeable spatial variation in the physicochemical parameters and appears to be highly polluted. Sampling stations S1, S2, S3, S4, A1 in group C was restricted to those places which were very close to stagnant ponds and seasonal nullahs receiving large volume of effluents and sewage waste throughout the year. **[Table 2, Figure 3 (a) & (b)]**

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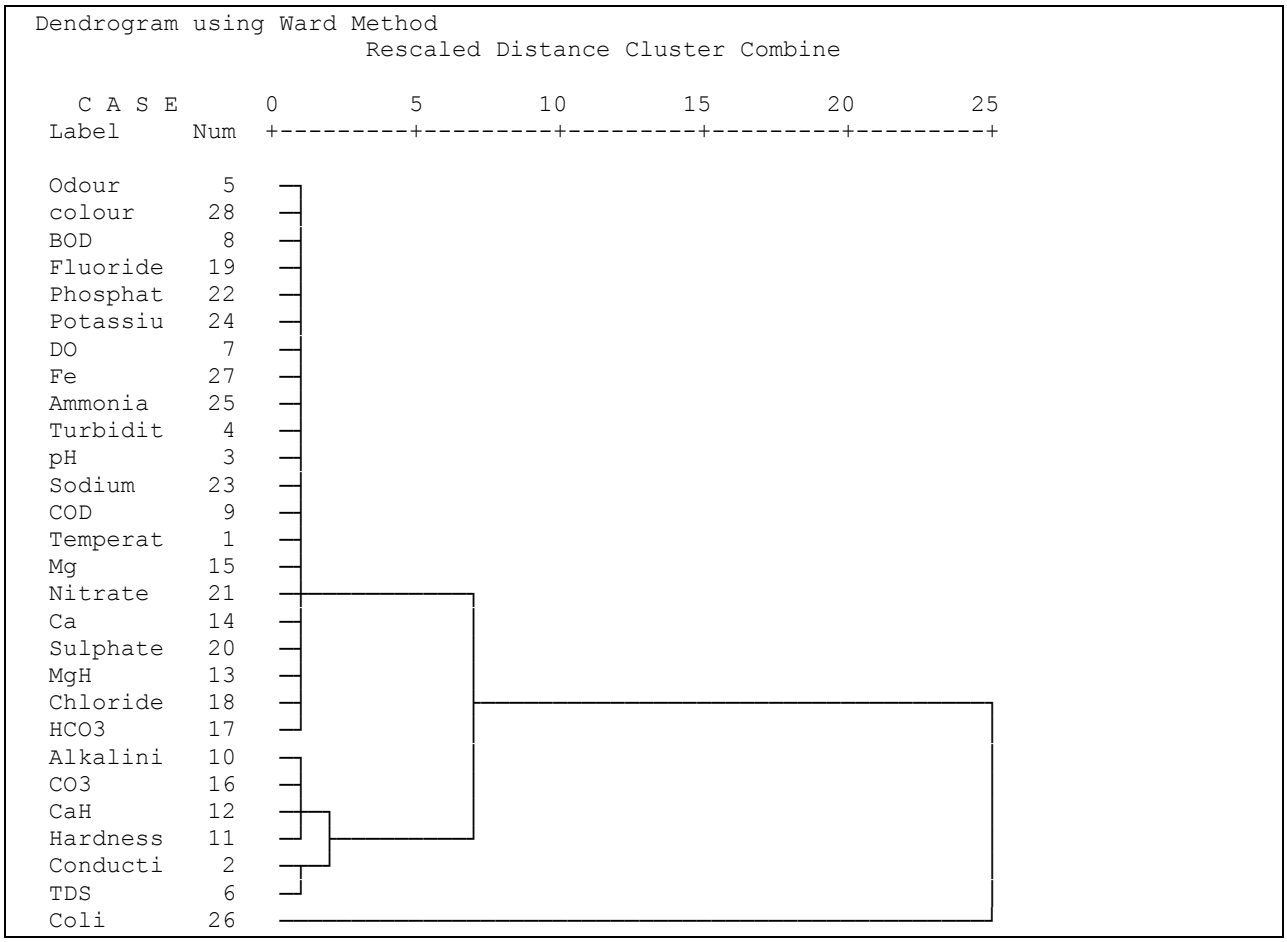

Figure 3 (b) Dendrogram by Hierarchical cluster analysis in pre-monsoon (Variables)

During Monsoon season:

Table 3: Group of clustered stations during monsoon season

Group	Sampling stations	Variables
A	3,4,9,10,15	Odor , Color, BOD, F^-, Phosphate, Potassium, DO,Fe,NH_4^+,Turbidity,pH,Na^+,COD,Temperature, Mg^{2+}, Nitrate, , Sulphate,
B	1,2	Ca^{2+} , Cl^-, Na^+, MgH, ,HCO_3^-
C	11,12,13,14	Alkalinity, Carbonate, CaH, Hardness, Total Coli
D	5,6,7,8	Conductivity, TDS

During monsoon season cluster analysis result shows that sampling station S3, S4, S9, S10 and A5 in Group A. It indicates that most of the variables form similar group meaning thereby that the values of these parameters are under permissible limits according to WHO. Group B formed by station S1 & S2 and variables are Ca^{2+} , Cl^-, Na^+, MgH, HCO^{3-} exist in this group which have less noticeable pollutants . Group C formed by A1, A2, A3, A4 these are adjoining areas of study area, which are mostly agricultural areas and less populated. Due to fertilizers and pesticides being used there amount of alkalinity, carbonate, CaH, Hardness, Total Coli in the area was found high.

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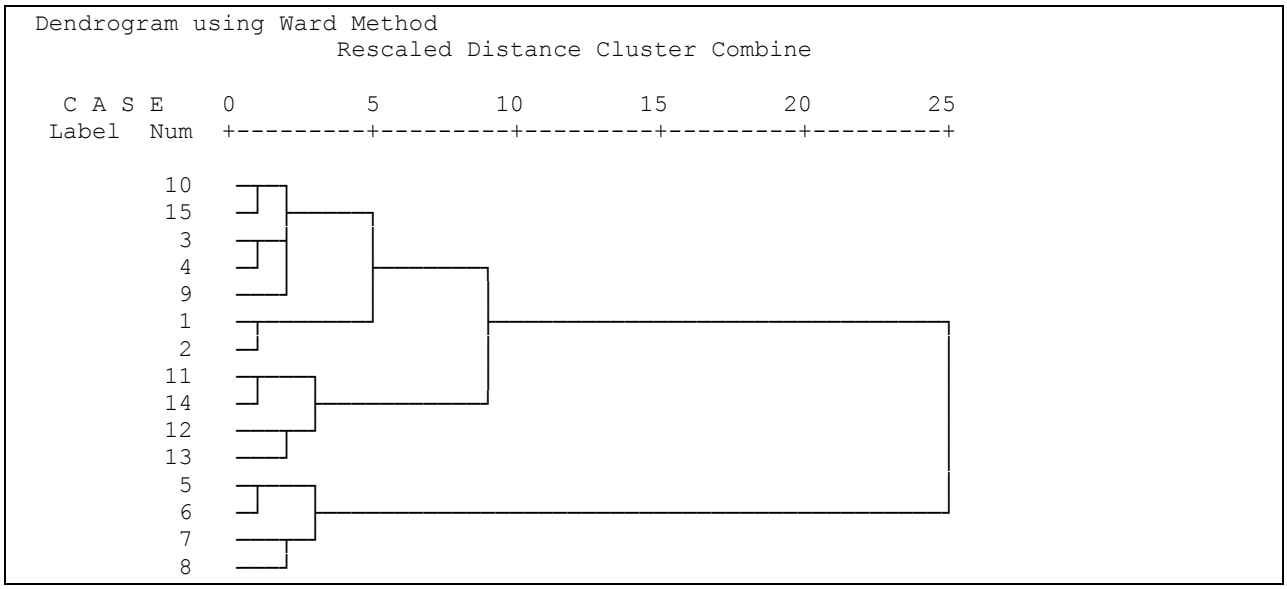

Figure 4 (a) Dendrogram by Hierarchical cluster analysis in monsoon (Spots)

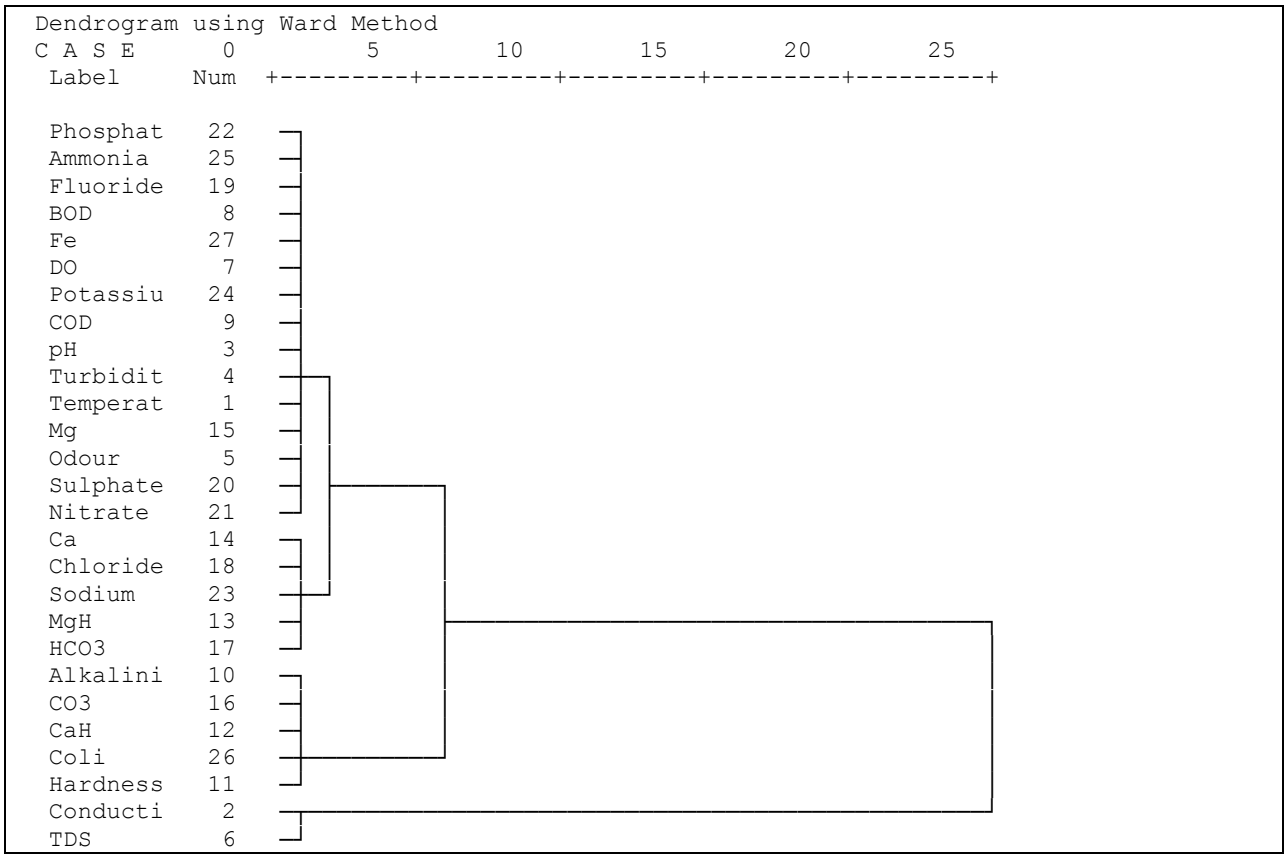

Figure 4 (b) Dendrogram by Hierarchical cluster analysis in monsoon (Variables)

Conductivity (418.70-819.33 µmhos/cm) and TDS (356-841.70 mg/L) in Group D alone formed a group with highest Euclidian distance compared to other cluster groups reflecting noticeable spatial variation in the physicochemical parameters and appears to be highly polluted area. Sampling stations S5, S6, S7and S8 are near to

industries and in highly populated areas and surface water channels (seasonal nallahs) pass nearby, receiving pollutants from untreated urban sewage and industrial waste. **[Table 3, Figure 4(a) & (b)]**

Post Monsoon season:

Table 4 Group of clustered stations during Post monsoon season

Group	Sampling stations	Variables
A	5,6,7,8,9	Odor , Color, BOD, F^-, Phosphate, Potassium, DO,Fe,NH_4^+,Turbidity,pH, Na^+, COD, Temperature, Mg^{2+}, Nitrate, Ca^{2+}, Sulphate, MgH, Cl^-,HCO_3^-
B	10,12,13,14,15	Alkalinity, Carbonate, CaH, Hardness
C	1,2,3,4,11	Conductivity, TDS
D	-	Total Coli

During post-monsoon season results were similar to the Pre-monsoon season such as conductivity and TDS in Group C even though appears to have noticeable spatial variation, they formed different cluster. Total Coli in Group D alone formed a group with highest Euclidian distance compared to other cluster groups reflecting noticeable spatial variation in the physicochemical parameters and appears to be highly polluted. In this season, cluster analysis shows that variables have same cluster analysis result during pre and post monsoon season. **[Table 4, Figure 5(a) & (b)]**

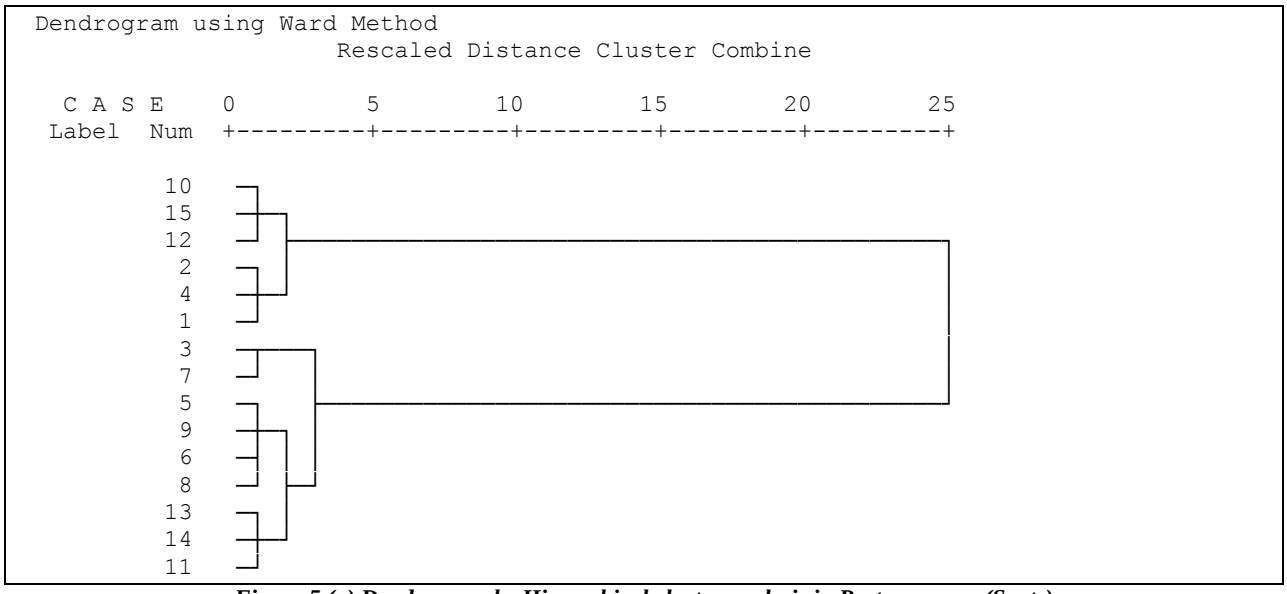

Figure 5 (a) Dendrogram by Hierarchical cluster analysis in Post monsoon (Spots)

The results of cluster analysis indicate that the variables conductivity, TDS, Total Coli are highest in all sampling stations which form different clusters in all seasons. Most of the stations in study area are near industries and highly populated areas and untreated waste directly is disposed into the open drains. Various types of small ponds which are polluted by industrial waste or urban waste are near spots. These ponds affect the quality and purity of groundwater at this site.

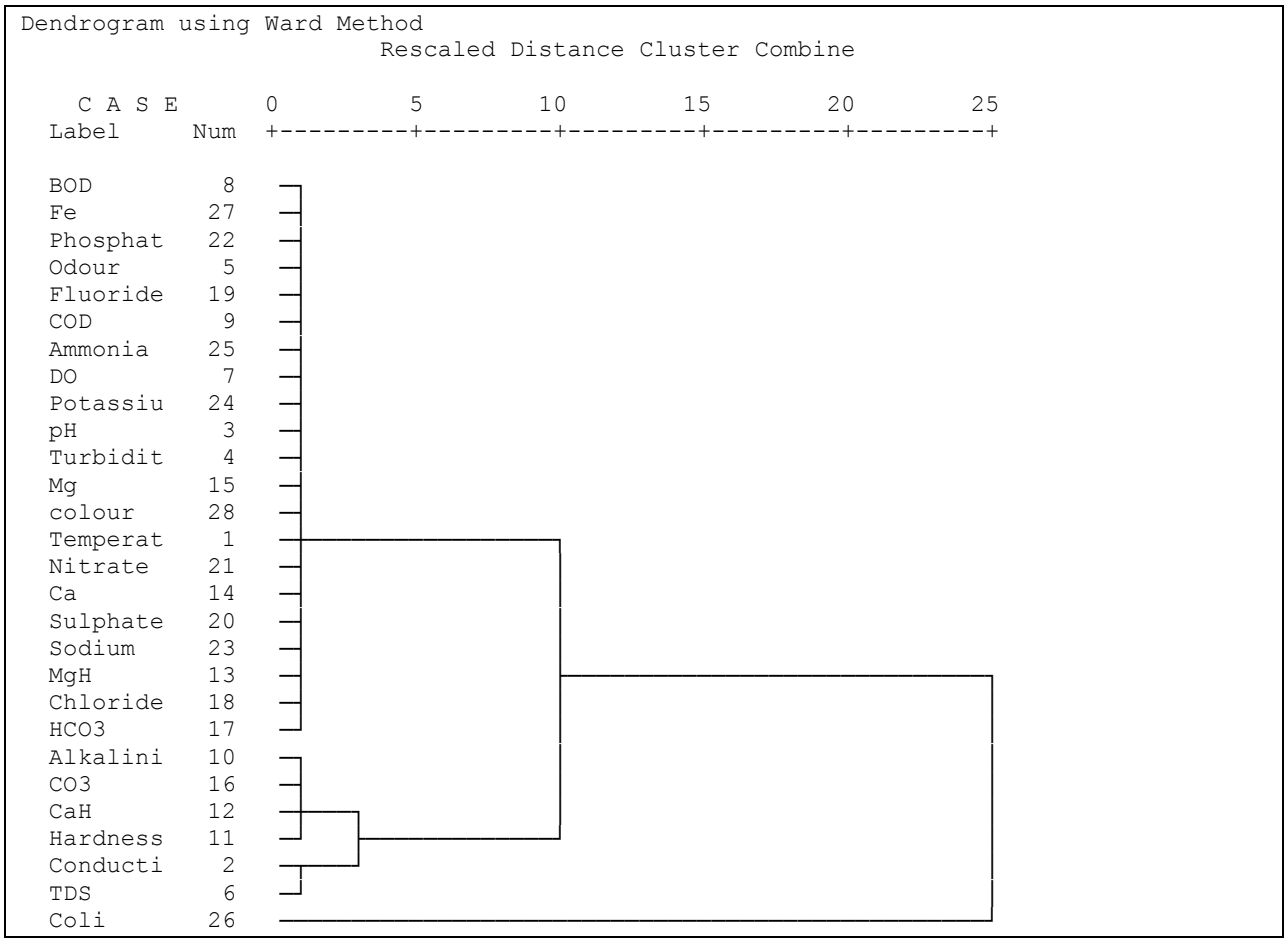

Figure 5 (b) Dendrogram by Hierarchical cluster analysis in Post monsoon (Variables)

CONCLUSION

The study focused on similarities and dissimilarities in the group by Cluster analysis of ground water parameters in the DCM industrial area, Kota. Most ground water samples had EC, TDS, Total Hardness and Total Coli concentrations exceeding the permissible limits recommended by WHO for drinking purposes. The increased concentrations of these elements pose potential sensory problem. As such, ground water in the study area was found polluted due to the influence of waste water from urban areas and untreated discharge of industrial waste and is deteriorating its quality. It can be concluded that the overall quality of water was found unsatisfactory for drinking purpose.

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