

## **Statistical study on physicochemical characteristics of groundwater in and around panjapur area near korai river, Tamil Nadu, India**

J. SIRAJUDEEN\*, V. MANIVEL AND S. ARUL MANIKANDAN

PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous),  
Tiruchirappalli District, Tamil Nadu, India

### **ABSTRACT**

Groundwater is the most precious gift of nature to living beings, particularly to the mankind and is essential for life. In recent years, rapid development has created an increased demand for drinking water, which is increasingly being fulfilled by groundwater abstraction. The groundwater samples collected from a panjapur area near korai river Tiruchirappalli district Tamil Nadu India. Groundwater samples collected seasonal variation Pre monsoon (May), Monsoon(August), and Post monsoon (November) during the Year 2014. Ten groundwater samples analyzed for major physicochemical parameters such as pH, Electrical Conductivity, Total DissolvedSolids, Total Hardness, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Bicarbonate, Calcium,Magnesium, Sodium,Potassium, Sulphate,Chloride and Nitrate, in order to understand the different geochemical processes affecting the groundwater quality. The analytical data were interpreted using WQI. The Calculated WQI value is (101.6). The analytical results indicate the majority of the groundwater samples are unsuitable for drinking purposes. The typical sewage comprising of domestic and other waste is discharged directly into the open land without any proper treatment will cause contamination. This contamination poses serious health impacts in the local residents.The correlation and regression provide an excellent tool for the prediction of parameter values within a reasonable degree of accuracy.

**Keywords:**Groundwater, hydrogeochemistry, water quality assessment, correlation analysis.

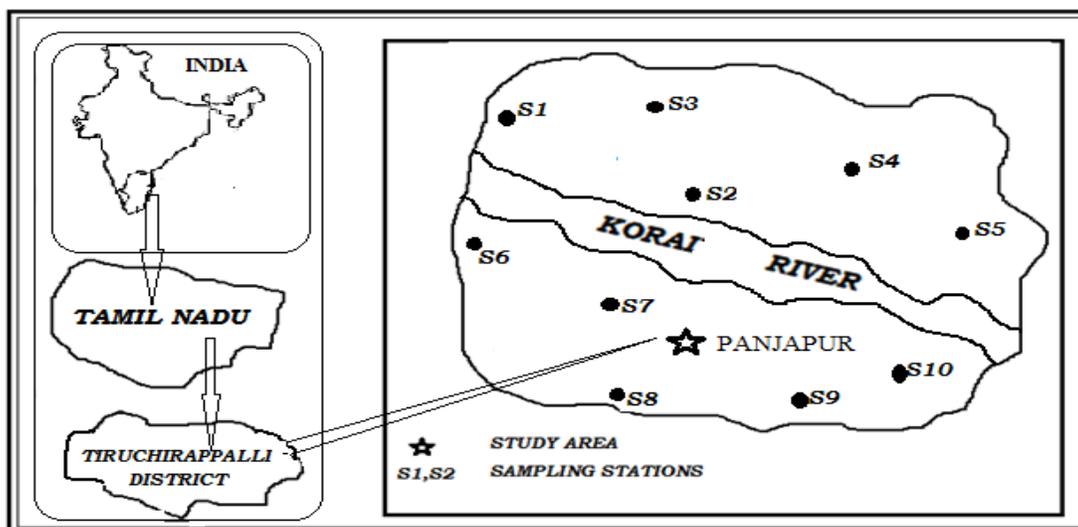
## **INTRODUCTION**

Groundwater is used for domestic, agriculture and industrial purpose in most parts of the world. Rural population living in India depends on groundwater for domestic and agriculture purpose. The major sources of water or rainfall, surface water involving rivers, lakes and groundwater involving wells and bore wells, etc. Also normally the groundwater is the only water sources for the different locations, where the municipal water supply facilities are not made available. Nowadays, the groundwater potential and its quality level in major cities and urban centers is getting deteriorated due to the population explosion, urbanization, industrialization and the failure of monsoon and improper management of rainwater. The groundwater quality is normally characterized by different physicochemical characteristics. These parameters change widely due to the various types of pollution, seasonal fluctuation, groundwater extraction, *etc.*. The chemical character of any groundwater determines its quality and utilization. The drastic increase in population, urbanization and modern land use applications and demands for water supply has limited the globally essential groundwater resources in terms of both its quality and quantity. Because, quality is a function of the physical, chemical and biological parameters, and can be subjective, since it depends on a specific intended use and is influenced by natural and anthropogenic effects including local climate, geology and irrigation practices. Naturally, ground water contains mineral ions [1]. These ions slowly dissolve from soil particles, sediments, and rocks as the water travels along with mineral surfaces in the pores or fractures of the unsaturated zone and the aquifer; they are referred to as dissolved solids. Some dissolved solids may have originated in the precipitation water or river water that recharges the aquifer. The quality of ground water depends on various chemical constituents and their concentration, which are mostly derived from the geological data of the particular region (Aher K.R.,2012). Water quality may be related to the suitability of water for a particular use or purpose. The quality of water is characterized by a range of physical, chemical parameters, which arise from a variety of natural and human influences. Considering this aspect the present study assesses the quality of groundwater, which is the main source of drinking water. Hence a continuous monitoring of groundwater becomes mandatory in order to minimize the groundwater pollution and have control of the pollution causing agents.

## STUDY AREA

The study area panjapur is located in near Korai River at heart part of the Tiruchirappalli city. The population of the panjapur area is around 8000. Many industries, small scale industries are located in and around this area (Fig: 1). They are discharging the waste water, untreated effluent directly into the open lands without any proper treatment will cause contamination by polluting ground water through percolation. Most of the people residing along depend upon this water for bathing, domestic irrigation and other purposes. This contamination poses serious health impacts in the local residents.

Fig: 1 LOCATION MAP OF THE STUDY AREA



## MATERIALS AND METHODS

The groundwater samples were collected panjapur area near korai river Tiruchirappalli district Tamil Nadu India. The current study was designed to investigate the conditions of groundwater contamination in the panjapur area. Groundwater samples were collected seasonal variation Premonsoon (May), Monsoon (August) and Post monsoon (November) during the Year 2014. The ten groundwater samples collected two litter plastic polyethylene bottles and were analyzed for major physicochemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Bicarbonate, Calcium, Magnesium, Sodium, Potassium, Sulphate, Chloride and Nitrate.

## **RESULT AND DISCUSSIONS**

### **pH**

The pH of a water sample measures its hydrogen ion concentration and indicates whether the sample is acidic, neutral or basic. The pH values of groundwater ranged from 7.1 to 8.2, 7.2 to 8.2 and 7.0 to 8.2. All the three seasons, accepted permissible limit prescribed by WHO (7 to 8.5). This shows that the groundwater of the study area is mainly alkaline in nature.

### **Electrical conductivity**

The EC is a measure of a material's ability to conduct an electric current so that the higher EC indicates the enrichment of salts in the groundwater. Electrical conductivity in groundwater varies from 1122.5 to 8622.4 micro mho/cm<sup>-1</sup>, 1083.1 to 6541.3 micro mho/cm<sup>-1</sup>, and 1122.6 to 8210.0 micro mho /cm<sup>-1</sup>. The all the values are high permissible limit prescribed by WHO (500).

### **Total Dissolved Solids**

The total dissolved solids (TDS) are the concentrations of all dissolved minerals in water. Indicate the general nature of salinity of water. The TDS values of groundwater ranged from 783.3 to 6001.1 micro mho/cm<sup>-1</sup>, 753.3 to 4552.7 micro mho/cm<sup>-1</sup> and 781.3 to 5714.1 micro mho/cm<sup>-1</sup>. All the values above the permissible limit prescribed by WHO (500). Due to contamination of domestic wastewater, garbage, fertilizer, etc., in the natural groundwater water body the value of TDS was reported to be high.

### **Total Hardness**

Hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. In water, the principle hardness causing ions are calcium and magnesium. The total hardness recorded in the water ranges between 175 to 900 ppm, 205 to 465 and 125 to 540 ppm. The most of the groundwater samples above the permissible limit prescribed by WHO (500). The high value of hardness may be due to evaporation of water and the addition of calcium and magnesium salts by mean of plants and living organisms. High values of hardness are probably due to regular addition of large quantities of sewage and detergent into water.

### **Dissolved oxygen**

Measurement of dissolved oxygen is a primary parameter in all pollution studies. Dissolve oxygen value is higher where there was good aquatic life. The amount of dissolved

oxygen recorded in the water ranges between 6.0 to 11.0 ppm, 7.0 to 11.0 ppm and 7.0 to 10.0 ppm. Dissolved oxygen in water is often attributed to the fact that the oxygen is dissolved more during the period of active photosynthesis. In the current study the value of dissolved oxygen was found to be low which might be due to the high temperature and the addition of sewage and other waste.

### **Biochemical Oxygen Demand**

Biochemical oxygen demand depends on aquatic life; variation in BOD indicates dynamism in aquatic life. BOD refers the oxygen used by the microorganism in the aerobic oxidation of organic matter. Therefore, with the increase in the amount of organic matter in the water the BOD increases. The BOD value ranges between 18.4 to 35.3 ppm to 12.0 to 267.6 ppm and 11.4 to 24.0 ppm. The higher value of the BOD was due to input of organic wastes and enhanced bacterial activity.

### **Chemical Oxygen Demand**

COD is another measure of organic material contamination in water specified in ppm. COD is the amount of dissolved oxygen required for causes chemical oxidation of the organic material in water. COD values varied from 51.7 to 82.2 ppm, 33.7 to 58.2 ppm and 35.0 to 60.5 ppm. In the present study all the water samples are found above the permissible limit set by WHO (10 ppm). High COD may caused affected the aqua vatic life.

### **Bicarbonate**

This electrolyte is an important component of the equation that keeps the acid-base status of the body in balance. The electrolyte helps buffer the acids that build up in the body as normal byproducts of metabolism. It is in the ranges of 207.0 to 1065 ppm, 195.0 to 950 ppm and 356.0 to 650 ppm. The present study most of the water samples above the permissible limit set by WHO (500). The high values of bicarbonate lungs regulate the amount of carbon dioxide, and the kidneys regulate bicarbonate.

### **Calcium**

Calcium is most abundant ions in fresh water. The amount of calcium in the water ranges between 160.3 to 785.3 ppm, 70.5 to 160.3 ppm and 365 to 1650 ppm. The amount of calcium increases due to rapid oxidation decomposition of organic matter. Calcium is present in the water naturally,

but the addition of sewage waste might also be responsible for the increase in amount of calcium. The decrease may be due to calcium being absorbed by living organisms.

### **Nitrate**

Nitrates are contributing to fresh water through the discharge of sewage and industrial wastes and runoff from agricultural fields. The amount of nitrate recorded in the water ranges between 18.2 to 36.8 ppm, 11.6 to 51.0 ppm and 16.8 to 74.2 ppm. The high nitrate concentration might be due to influx nitrogen rich flood water that brings about the large amount of contaminated sewage water. The three seasons were the period with the highest nitrate-nitrogen concentration which is known to support the formation of blooms.

### **Magnesium**

The considerable amount of magnesium influence water quality. The amount of magnesium recorded in the water ranges between 73.3 to 178.3 ppm, 26.0 to 114.2 ppm and 24.0 to 124.3 ppm. Most of the sample above permissible limit set by WHO (500 ppm). Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Magnesium is essential for chlorophyll growth and it also acts as a limiting factor for the growth of phytoplankton. In present study higher level of magnesium may be due to the addition of sewage waste and pollutant disposal into water.

### **Chloride**

The greatest source of chlorides in water is the disposal of sewage and industrial waste. The amount of chloride recorded in the water ranges between 142.0 to 454.4 ppm, 175.2 to 257.6 ppm and 128.4 to 440.8 ppm. Most of the sample above permissible limit set by WHO (250 ppm). The high chloride concentration of the water may be due to high rate of evaporation or due to organic waste of animal origin.

### **Sodium**

Sodium is a natural constituent of raw water, but its concentration is increased by pollution sources such as rock salt, precipitation runoff, soapy solution and detergent. The amount of sodium recorded in the water ranges between 88 to 164 ppm, 175.2 to 257.6 ppm and 89.2 to 203.0 ppm. Most of the sample above permissible limit set by WHO (200 ppm). The

addition of waste water containing soap solution and detergent from the surrounding area is also responsible for the increase in sodium level in the water. The addition of sewage waste and organic pollutant were also responsible for the increase in the value of sodium in the water.

### **Potassium**

The amount of potassium in the water ranges between 19.0 to 57 ppm, 15.0 to 39 ppm and 15.0 to 22.0 ppm. All the three seasons above the permissible limit prescribed by WHO (12 ppm). Potassium is an essential element for humans, plants and animals, and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rainwater, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. Higher values of potassium in groundwater may be due to the disposal of sewage and agricultural

### **Sulphate**

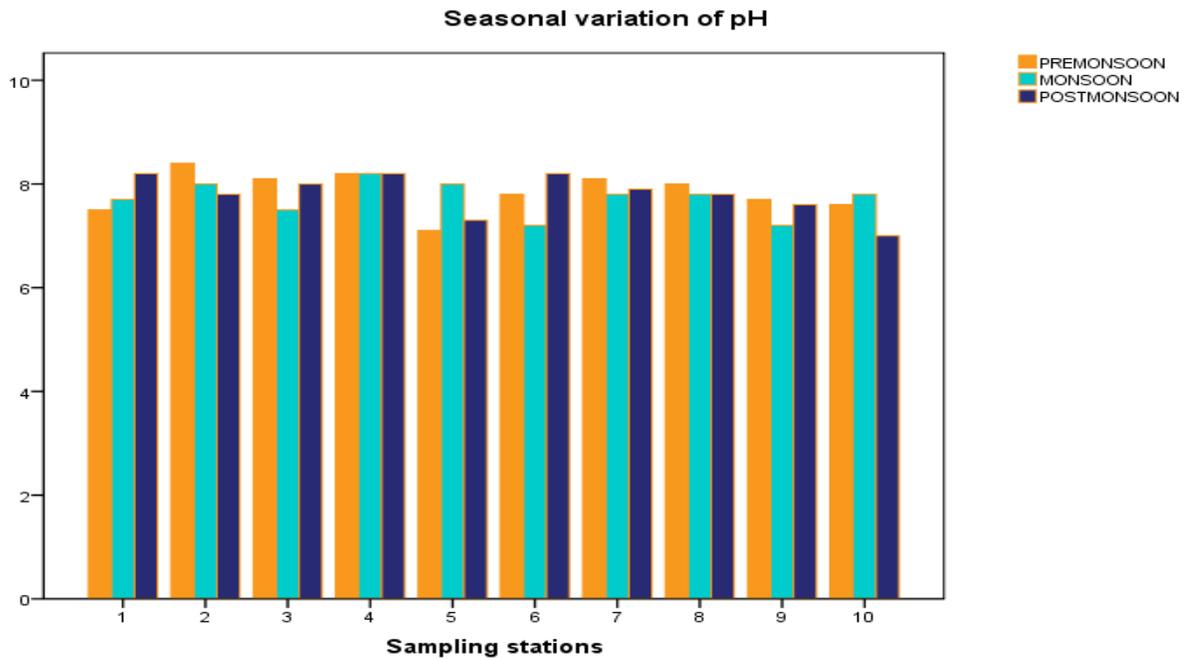
Sulphate content in groundwater is made possible through oxidation, precipitation, solution and concentration, as the water traverses through rocks. The sulphate values of groundwater ranged from 56 to 98 ppm, 68 to 97 ppm and 145 to 376 ppm. In the present investigation the sulphate values are found below the limit of WHO (500 ppm).

**Table: 1 The mean values of physico-chemical parameters analyzed groundwater samples collected from the panjapur area during the year 2014.**

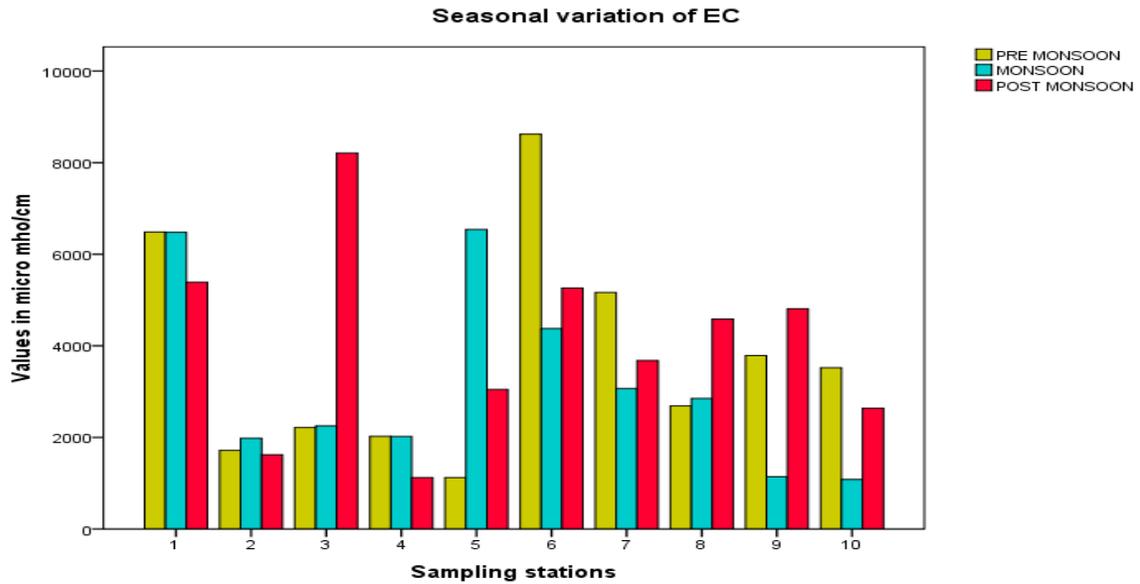
<b>Sampling stations</b>	<b>pH</b>	<b>EC</b>	<b>TDS</b>	<b>TH</b>	<b>DO</b>	<b>BOD</b>	<b>COD</b>	<b>HCO<sub>3</sub></b>	<b>Ca</b>	<b>NO<sub>3</sub></b>	<b>Mg</b>	<b>SO<sub>4</sub></b>	<b>Cl</b>	<b>Na</b>	<b>K</b>
<b>S1</b>	7.8	6117.9	4258.0	283	8.0	23.5	52.8	961	128.2	24.0	87.1	161	345.9	180.1	30
<b>S2</b>	8.0	1775.0	1235.5	363	8.0	24.5	59.0	730	221.0	22.1	78.2	146	668.6	150.3	19
<b>S3</b>	7.8	4226.8	2941.8	323	9.0	18.9	55.2	560	200.4	20.4	103.4	176	156.3	183.5	22
<b>S4</b>	8.2	1723.2	1199.3	325	10.0	19.1	64.1	866	201	18.9	97.5	166	249.4	171.1	25
<b>S5</b>	7.4	3571.2	2486.0	295	8.0	21.4	51.5	490	97.6	19.1	103.5	140	218.1	158.2	18
<b>S6</b>	7.7	6087.0	4236.5	345	8.0	17.70	56.4	848	281.7	17.5	92.3	165	209.2	157.9	20
<b>S7</b>	7.9	3970.2	2763.2	408	7.0	20.2	50.8	463	225.3	23.0	98.6	120	195.4	119.1	25
<b>S8</b>	7.8	3374.9	2348.9	390	8.0	19.50	55.7	443	285.9	45.6	78.7	98	216.8	168.8	30
<b>S9</b>	7.5	3246.1	2259.2	438	8.0	18.70	51.1	493	223.5	43.1	84.5	111	256.9	169.0	17
<b>S10</b>	7.4	2413.1	1679.3	525	8.0	18.60	46.6	470	317.2	41.1	105.8	108	247.1	154.7	38

**All the values are expressed in ppm except pH and EC (micro mho cm)**

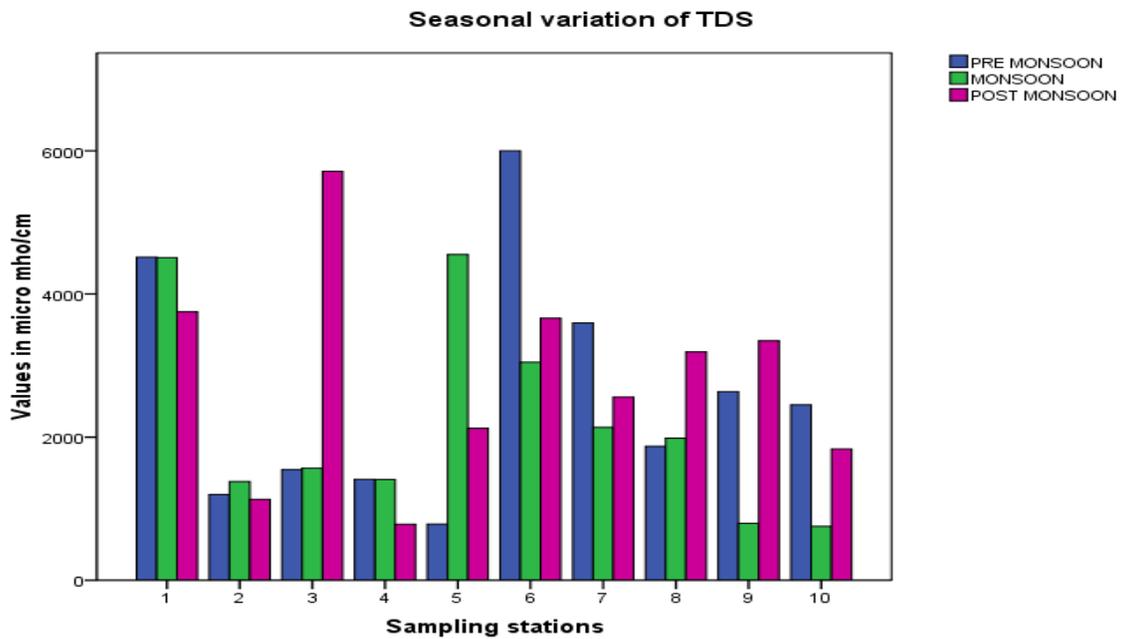
**Fig: 2** Variation of pH values collected from different sampling from Panjapur area.



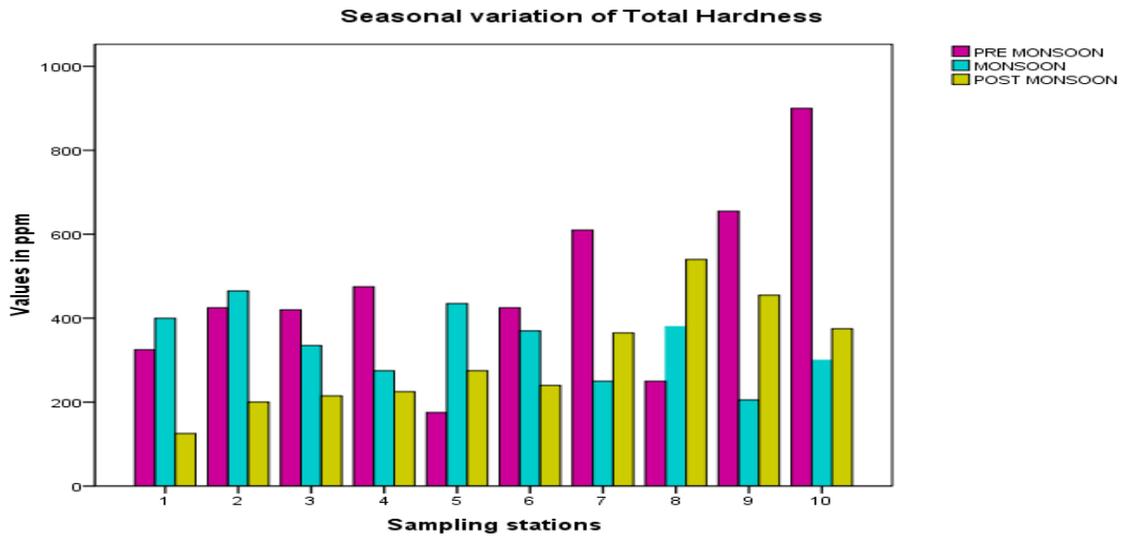
**Fig: 3** Variation of Electrical conductivity values collected from different sampling from Panjapur area.



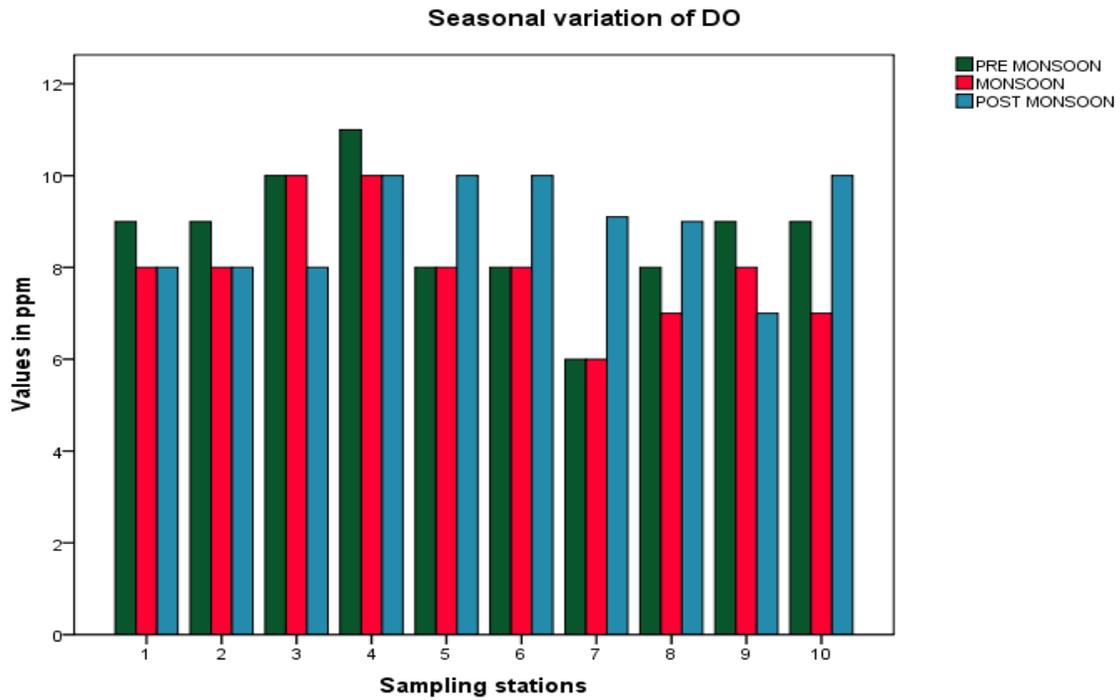
**Fig: 4** Variation of Total dissolved solids values collected from different sampling from Panjapur area.



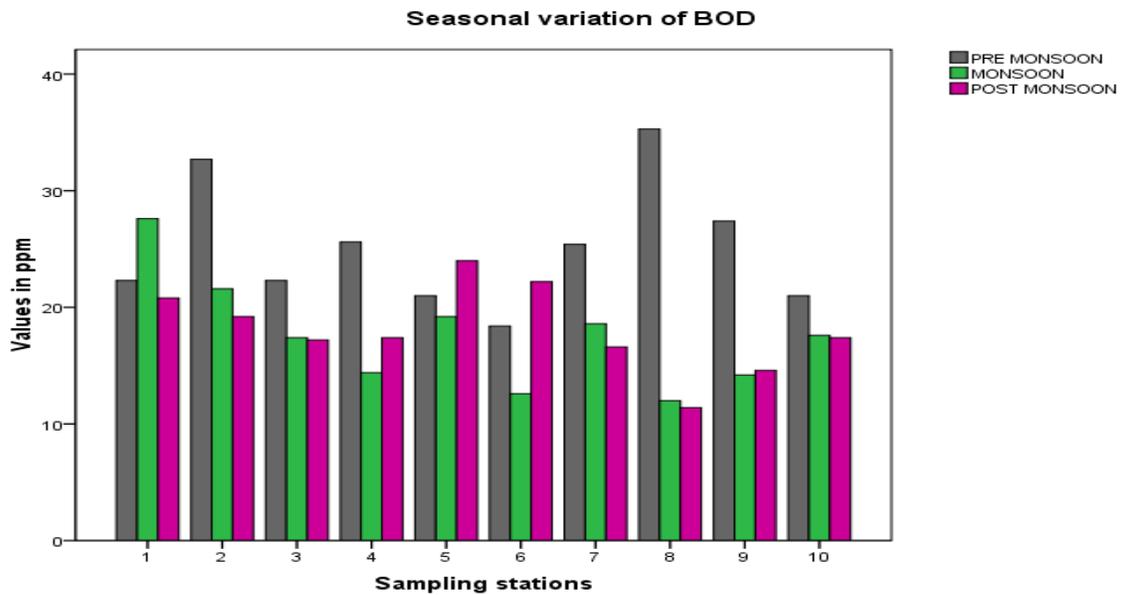
**Fig: 5** Variation of Total Hardness values collected from different sampling from Panjapur area.



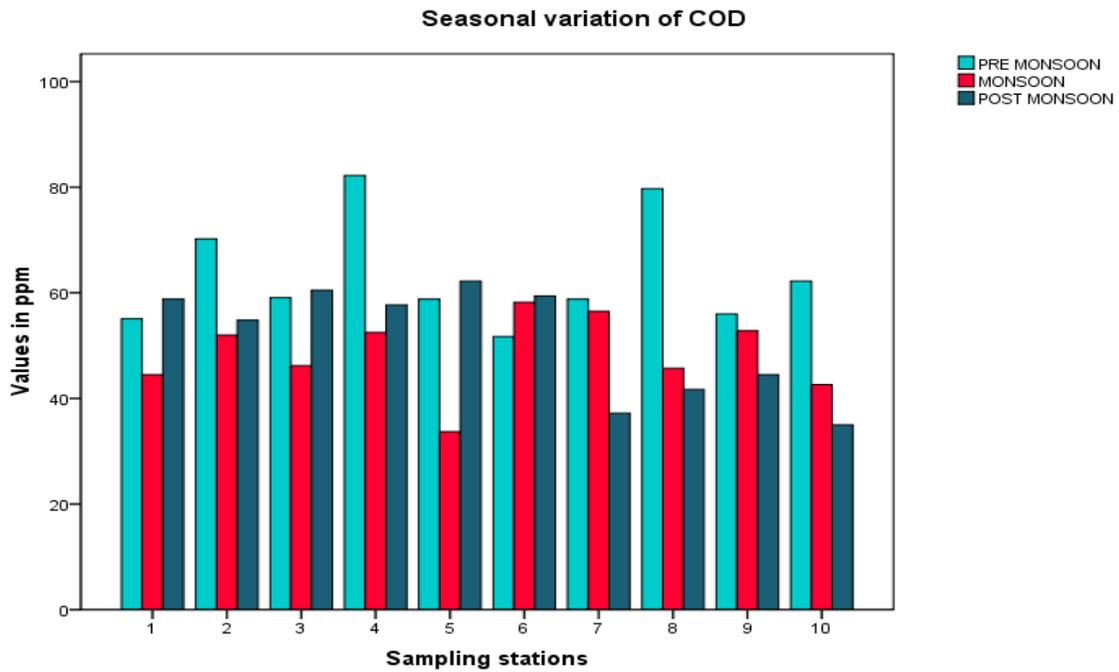
**Fig: 6** Variation of Dissolved oxygen values collected from different sampling from Panjapur area.



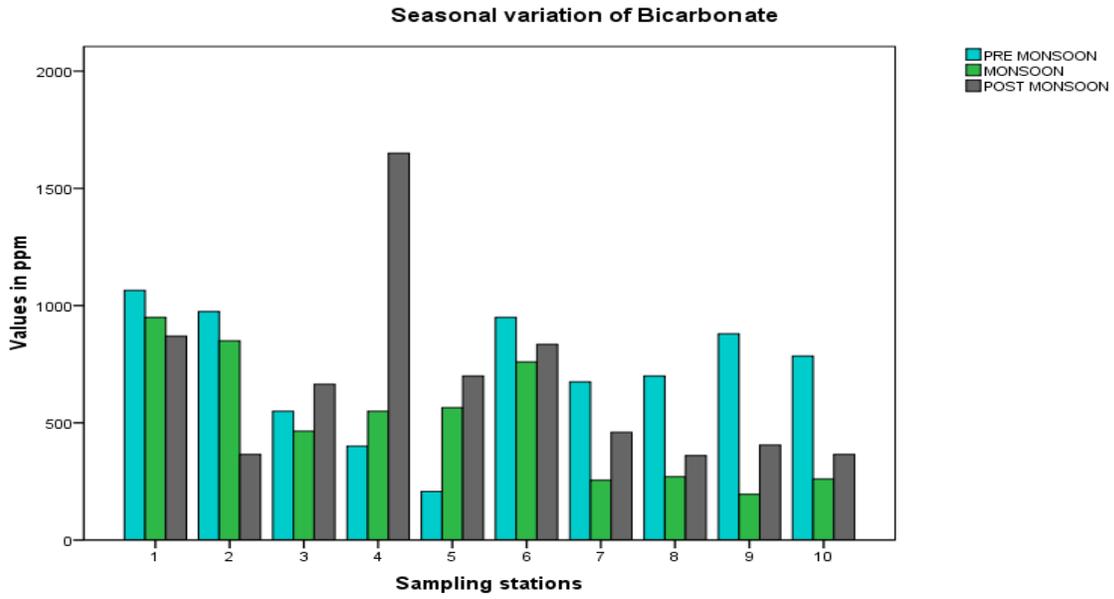
**Fig: 7** Variation of Biological Oxygen Demand values collected from different sampling from Panjapur area.



**Fig: 8** Variation of Chemical Oxygen Demand values collected from different sampling from Panjapur area.



**Fig: 9** Variation of Bicarbonate values collected from different sampling from Panjapur area.



**Fig: 10** Variation of Calcium values collected from different sampling from Panjapur area.

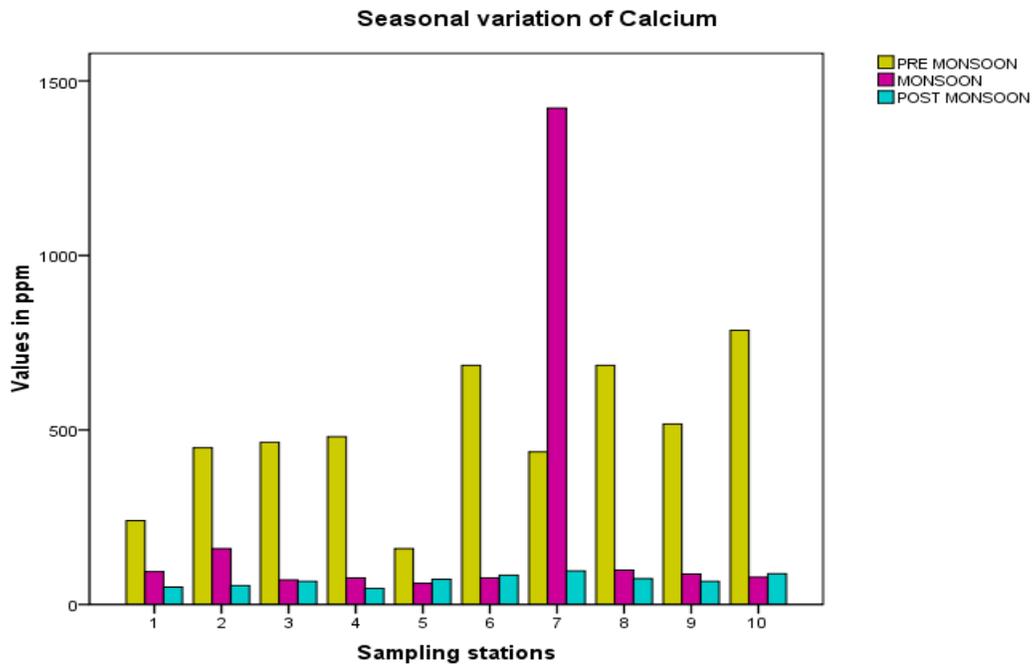


Fig: 11 Variation of Nitrate values collected from different sampling from Panjapur area.

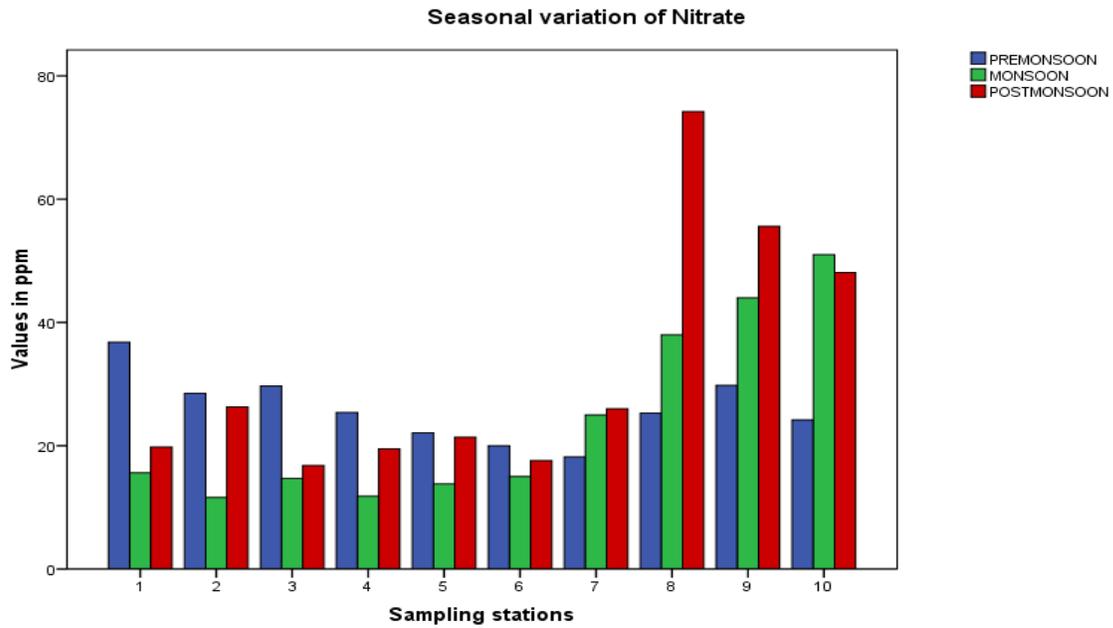


Fig: 12 Variation of Magnesium values collected from different sampling from Panjapur area.

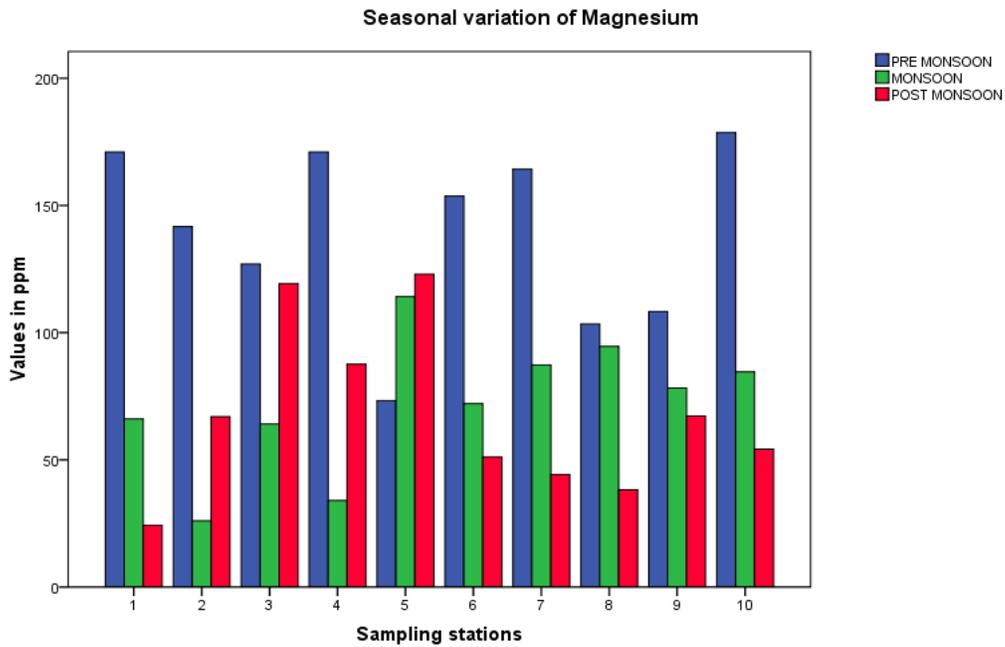
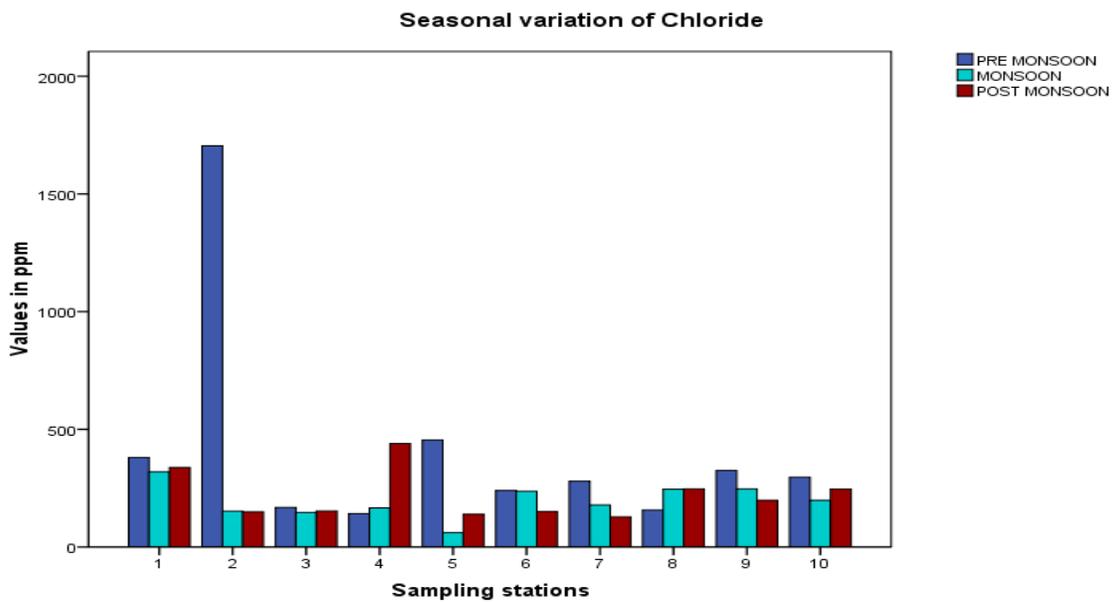


Fig: 13 Variation of Chloride values collected from different sampling from Panjapur area.



## WATER QUALITY INDEX

Water Quality index (WQI) is defined as a technique of rating that provides the composite influence of individual water quality parameter on the overall quality of water. It is calculated from the point of view of human consumption.

### The Calculation Involves the Following Steps:

First, the calculation of weight age of  $i^{\text{th}}$  parameter.

Second, the calculation of the quality rating for each of the water quality parameters.

Third, the summation of these sub-indices in the overall index.

The Weight age of  $i^{\text{th}}$  Parameter

$$W_i = k/S_i \quad (1)$$

Where  $W_i$  is the unit of weight age and  $S_i$  the recommended standard for  $i^{\text{th}}$  parameter ( $I = 1-10$ ),  $k$  is the constant of proportionality

The individual quality rating is given by the expression

$$Q_i = 100V_i / S_i \quad (2)$$

Where  $Q_i$  is the sub index of  $i^{\text{th}}$  parameter,  $V_i$  is the monitored value of the  $i^{\text{th}}$  parameter in mg/l and  $S_i$  the standard or permissible limit for the  $i^{\text{th}}$  parameter.

The Water Quality Index (WQI) is then calculated as follows

$$WQI = \frac{\sum_{i=1}^n (Q_i W_i)}{\sum_{i=1}^n W_i} \quad (3)$$

Where,  $Q_i$  is the sub index of  $i^{\text{th}}$  parameter.  $W_i$  is the unit weight age for  $i^{\text{th}}$  parameter,  $n$  is the number of parameters considered. Generally, the critical pollution index values is 100

**Table: 2 Calculation of WQI values for the physico-chemical parameters of ground water around Panjapur.**

Parameters	Mean value in ppm (Vi)	Highest permitted value (WHO) (Si)	Unit of weightage	Wi × Qi
pH	7.7	8.5	0.717	64.8
EC	3650	600	0.010	6.083
TDS	2540	500	0.012	6.096
TH	369	500	0.012	0.885
Cl	276	250	0.024	2.649
SO <sub>4</sub>	139	500	0.012	0.333
HCO <sub>3</sub>	632	500	0.012	1.516
NO <sub>3</sub>	27	50	0.121	6.534
Ca	218	100	0.060	13.08
Mg	92	150	0.040	2.452
Na	161	200	0.030	2.415

$$WQI = \frac{\sum_{i=1}^n (Q_i W_i)}{\sum_{i=1}^n W_i} WQI = 101.6$$

**Table 3: Status categories of WQI**

WQI	Quality of water
0 - 25	Very good
26 - 50	good
51 - 75	poor
Above 75	Very poor (unsuitable for drinking)

	pH	EC	TDS	TH	DO	BOD	COD	HCO <sub>3</sub>	Ca	NO <sub>3</sub>	Mg	SO <sub>4</sub>	Cl	Na	K
pH	1														
EC	-0.1969	1													
TDS	-0.19695	0.23476	1												
TH	-0.38347	-0.40097	-0.40105	1											
DO	<b>0.434629</b>	-0.32817	-0.32817	-0.33356	1										
BOD	<b>0.245542</b>	-0.06278	-0.06275	-0.40323	-0.22108	1									
COD	<b>0.826164</b>	-0.23765	-0.23766	-0.53692	<b>0.687048</b>	<b>0.109306</b>	1								
HCO <sub>3</sub>	<b>0.514383</b>	<b>0.336361</b>	<b>0.33632</b>	-0.57885	<b>0.400462</b>	<b>0.307777</b>	<b>0.577374</b>	1							
Ca	-0.03095	-0.19135	-0.19147	<b>0.759378</b>	-0.12254	-0.55283	-0.09122	-0.26308	1						
NO <sub>3</sub>	-0.41397	-0.25425	-0.25429	0.721206	-0.25035	-0.26285	-0.45129	-0.56305	<b>0.524455</b>	1					
Mg	-0.30296	0.009077	0.009126	0.071296	0.18882	-0.40644	-0.32569	-0.209	-0.12444	-0.32403	1				
SO <sub>4</sub>	<b>0.429663</b>	<b>0.329581</b>	<b>0.329588</b>	-0.74821	<b>0.550852</b>	0.143614	<b>0.553433</b>	<b>0.736337</b>	-0.44624	-0.85179	<b>0.224094</b>	1			
Cl	<b>0.31347</b>	-0.34657	-0.34661	-0.06212	-0.08948	<b>0.783912</b>	<b>0.289806</b>	<b>0.34329</b>	-0.08247	-0.10449	-0.58325	0.073846	1		
Na	-0.01414	0.166307	0.166312	-0.38594	0.645913	-0.07123	0.273978	0.342718	-0.22539	0.091448	-0.11521	0.391693	-0.10407	1	
K	-0.06441	-0.04323	-0.04329	0.446827	-0.03811	-0.10082	-0.32868	-0.06308	0.41587	0.431662	0.194768	-0.33511	-0.16241	0.02006	1

### Correlation Coefficients Among Water Quality Parameter

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).

The correlation coefficient values it was found that TDS on DO ( $r = 0.43$ ) are more significantly and positively correlated which reflects the direct proportionality between conductance and DO, and the dependence of TDS on DO. Similarly, different pairs of Chemical parameters with different coefficient of correlations such as DO-COD (0.82), TDS-HCO<sub>3</sub> (0.51), Na-EC (0.92), TDS-TH (0.89), CL-SO<sub>4</sub> (0.89), COD-HCO<sub>3</sub> (0.57), TDS-SO<sub>4</sub> (0.87), COD-Cl (0.78), HCO<sub>3</sub>-SO<sub>4</sub> (0.71), Mg-SO<sub>4</sub> (0.22), explains the degree of relationship between two variable. From the correlation coefficient values it was found that are positively correlated and indicates the measure of dissolved solids in the ground water. The high electrical conductivity values are due to natural concentration of ionized substances present in water and due to higher total dissolved salts. The matrix shows fairly high correlation of HCO<sub>3</sub> with SO<sub>4</sub> (0.73). The total hardness of water is mainly due to the presence of divalent cations i.e. SO<sub>4</sub> which is more abundant in the study area. When more than two

variables are considered simultaneously multiple linear regression analysis was used to evaluate their interdependency.

## **CONCLUSIONS**

Groundwater samples were collected seasonal variation Pre monsoon (May), Monsoon (August) and Post monsoon (November) during the Year 2014. The ten groundwater samples analyzed for major physicochemical parameters such as pH, Electrical Conductivity, Total Dissolved Solids, Total Hardness, Dissolved Oxygen, Biological Oxygen Demand, Chemical Oxygen Demand, Bicarbonate, Calcium, Magnesium, Sodium, Potassium, Sulphate, Chloride and Nitrate. The result obtained during the study was analyzed and it was found that maximum number of parameters EC, TDS, Cl, HCO<sub>3</sub> and Ca above desirable limit. This result shows that the water of central region receives very high amount of pollution from the surrounding. And the water is the highly contaminated study also suggests that the pollution control is very essential to prevent direct disposal of waste discharged directly into the open land without any proper treatment will cause contamination and other pollutants into the water system. This contamination poses serious health impacts in the local residents. Since the correlation coefficient gives the interrelationship between the parameters, correlation coefficients. Results of correlation analysis show that sulphate and nitrate, conductivity and chloride are having a high correlation with most of the other parameters.

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