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# LOGARITHMIC METHOD OF GROUNDWATER QUALITY INDEX IN PALAR BASIN AT CHITTOOR DISTRICT, ANDHRA PRADESH

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***Abstract***— ***Logarithmic method of Water Quality Index (WQI) was applied in Palar basin, chittoor district, Andhra Pradesh for calculating WQI and assesses the groundwater quality, total 50 groundwater samples were collected. Using eleven water quality parameters (pH, Total hardness, chlorides, Dissolved solids, calcium, Magnesium, sulphate, Nitrate, Flouride, Alkalinity, and sodium).Groundwater Quality Index (GWQI) a congregate parameter representing the quality and suitability of groundwater for drinking purpose is computed using logarithmic method. The WQI value 63.83 is maximum and the value 14.28 is minimum in the study area. The computed WQI shows that 94% of water sample fall in the 'good' to 'excellent' water category. On the other hand, 16% of water samples fall in the 'fair' to 'poor' category indicating that the water is not suitable for direct consumption and require treatment. After treatment, the water can be used for drinking purpose.***

***Keywords—: Physico-chemical analysis, Logarithmic method Water Quality Index (WQI), Palar basin.***

## I. INTRODUCTION

Ground water occurs almost everywhere beneath the earth surface not in single widespread aquifer but in thousands of local aquifer systems and compartments that have similar characters. Knowledge of the occurrence, replenishment and recovery of groundwater has special significance in arid and semiarid regions due to discrepancy in monsoon rainfall, insufficient surface waters and over drafting of groundwater resources. Groundwater, of late, has become an important source of water to reckon with to meet different needs of an individual and also of society. Ascertaining the quality is crucial before its use for various purpose such as drinking, agricultural, recreational and industrial use. Till recently, ground water assessment has been based on laboratory investigation, but the advent of satellite Technology and Geographical Information system (GIS) can be a powerful tool for developing solutions for water resources problems assessing water quality[1-3].

Water Quality Index (WQI) is an important tool to find the groundwater quality and its suitability for drinking purpose. WQI is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption [4-6]. WQI is a mathematical equation used to transform large number of water quality data into a single number. The standards for drinking purposes as recommended by WHO [7] has been considered for the calculation of WQI. Water quality index is one of the most effective tools to communicate information on the quality of any water body [8-10]. It is simple and easy to understanding of water quality issues by integrating complex data and generating a score that describes water quality status.

### *A. Study Area:*

Chittoor District is one of the chronically drought affected rayalaseema district of Andhra Pradesh. Administratively the district is divided into 3 revenue divisions which are further subdivided in to 66 mandals. The important drainage basins are Bahuda, Pincha, swarnamuki, palar , ponnai and araniyar. Palar basin lies between north Latitude 13052' to 13038' and East Longitude 79054' to 790 45' with a total drainage 703 km2(Figure 1). It cover five mandals that is Chandragiri, somala, Puthalapattu.Irala and Pakala.This region is influenced by semi arid climate. The mean temperature lies between to 30 ºC to 42 ºC . The Normal annual rainfall over the study area is about 860 mm. The district is underlain by rocks of Archaean, proterozoic, jurassiic- caraceous and Tertiary-Quaternary ages. The oldest rock in the area belongs to Migmatite Complex, representing by migmatised quartzo-feldspar gneiss and are exposed in the northeastern part of the district. Older metamorphic comprise amphibolites, hornblende-talc-mica-schist, fuchsite quartzite, calcium sillicate rock, marble and banded ferruginous quartzite. The older matamorphics occur as enclaves with peninsular Gneissic Complex (PGC). The study area majorly covers granite gneiss rock type and dolerite dykes and quartz vanes are present. There are mainly two types of soils present in the basin they are Red loamy soils and Stream courses are covered by black clay soils.

*B. Map View:*

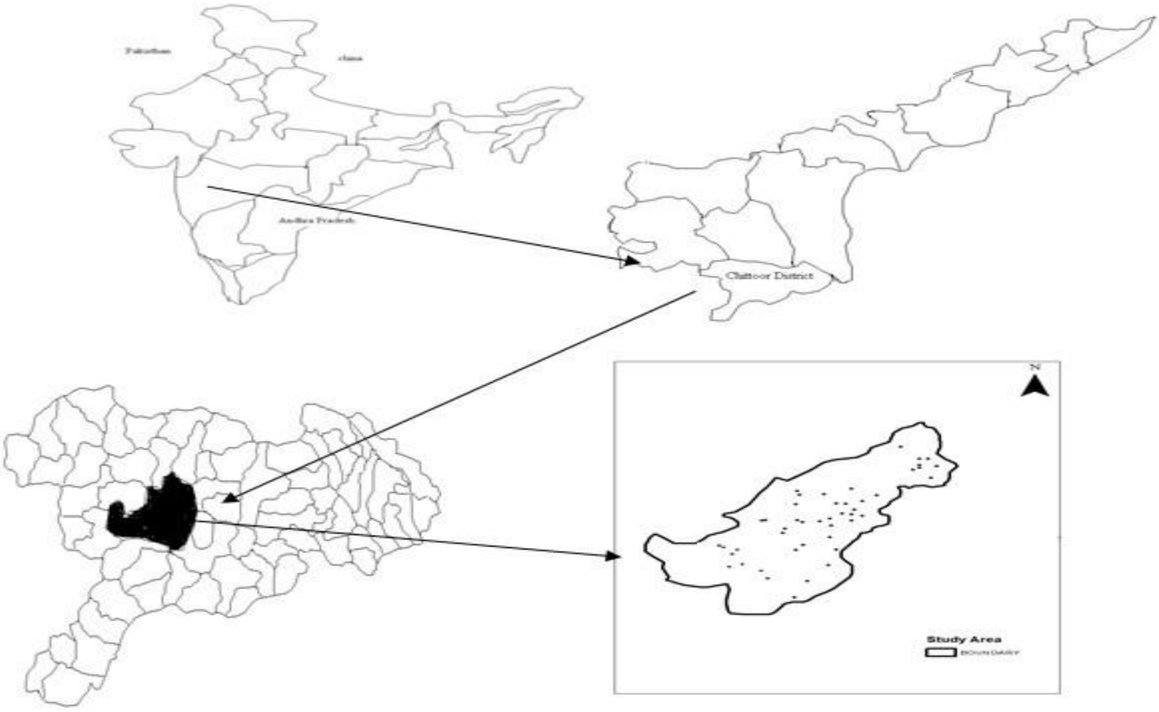


**Figure 1**. Location map of the area

## II MATERIALS AND METHODS

Chemical Analysis: Water samples were collected in July 2017 from 50 boreholes capturing the deep aquifer of Palar basin. The water samples were collected in clean polythene bottles. At the time of sampling, the bottles were thoroughly three times rinsed with the groundwater to be sampled. In the case of bore wells and hand pumps, the water samples were collected after pumping for 10 min. This was done in order to remove to groundwater stored in the well. Each of the groundwater sample was analyzed for 11parameters such as pH, TDS, Total hardness, Magnesium, Sulphate, Nitrate, Fluoride, Alkalinity, Sodium, Chlorides, Calcium. Using standard procedure recommended by APHA [6].pH is determined by using pH meter. Total solids are determined by using evaporation method. Total hardness, calcium, magnesium, alkalinity and chlorides are determined by titration method. Nitrate is determined by Brusin Sulphonic acid method and sulphates are determined by Turbedometeric method. Flouride is determined by SPANDS method. Sodium is determined by Flame photometer method All the water quality parameters was expressed in mg/l, except pH . Each parameter was compared to the desirable standard limit of that parameter stipulated for drinking water as prescribed by the WHO for drinking and public health purposes. Parameters as well as applied math measures, like minimum, maximum, mean and standard deviation, are presented.

## III LOGARITEMIC METHOD OF WATER QUALITY INDEX

Logarithmic method of Water Quality Index (WQI) is a very useful and efficient method for assessing the quality of water. WQI is a very useful tool for communicating the information on overall quality of water. Logarithmic method, developed by Tiwari and Mishra(1985) from the concept of WQI introduced by Brown et al.,(1972) and supported by Simha and Saxena (2006) and several researchers Landwehr and Deineinger (1976), Subba Rao et al..(1997), Swarnalatha and Nageswara Rao (2010), Shanthilal et al.,(2011) is used in the present studyto compute WQI. To determine the suitability of the groundwater for drinking purposes, WQI is computed adopting the following steps

$$GWQI = \text{Antilog}\{\sum[W_i \times \log(q_i)]\} \quad (1)$$

Where,

$W_i$ is the weightage factor computed using Eq. (2),

$q_i$ is the quality rating for the $i^{th}$ water quality parameter

$$W_i = K / P_i \quad (2)$$

Where, Pi is the permissible limit of ith parameter
K is the Proportionality constant, computing using Eq. (3),

$$K = 1/ \sum (1/Pi) \quad (3)$$

Quality rating for the ith water quality parameter (qi) is calculated using Eq.(4)

$$qi = 100 \times [(Ci\ Vi) /(Pi\ Vi)] \quad (4)$$

Ci = Observed concentration of i$^{th}$ parameter
Vi = Ideal value of the i$^{th}$ parameter

Table 1: Method adopted for estimating groundwater quality parameters

| S.NO | Parameters | Method |
|---|---|---|
| 1 | pH | Digital pH Meter |
| 2 | Total Hardness (TH) | EDTA titration method |
| 3 | Sulphate ($SO_4$) | Spectrophotometric method |
| 4 | Fluorides (F) | Spectrophotometric method |
| 5 | Chlorides (Cl) | Titrimetry |
| 6 | Total Dissolved Solids (TDS) | Elico Meter |
| 7 | Calcium (Ca) | Titrimetry |
| 8 | Magnesium (Mg) | ICP Mass Spectrometry |
| 9 | Sodium(Na) | Titrimetry |
| 10 | Nitrate ($NO_3$) | Spectrophotometric method |
| 11 | Alkalinity (Al) | Titrimetry |

Table 2: Water Quality parameters Values for collected Groundwater samples at various locations

| | | | TH | $SO_4^{2-}$ | Fluoride | $CL^-$ | TDS | $Ca^{2+}$ | $Mg^{2+}$ | $Na^{2+}$ | $NO_3^-$ | Alkalinity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample | T(°C) | pH | ----- mg/l ----- | | | | | | | | | |
| 1 | 33.5 | 6.54 | 380 | 17.7 | 0.2 | 166 | 550 | 231 | 125 | 100 | 1.2 | 221 |
| 2 | 30 | 7.32 | 160 | 15.2 | 0.1 | 157 | 890 | 65 | 72 | 258.5 | 0.1 | 65 |
| 3 | 33 | 6.76 | 220 | 9.65 | 0.3 | 59 | 950 | 105 | 92 | 90 | 0.1 | 95 |
| 4 | 33 | 6.60 | 450 | 20.75 | 0.2 | 279 | 970 | 265 | 232 | 91.8 | 0.25 | 256 |
| 5 | 31 | 6.84 | 270 | 14.45 | 0.3 | 124 | 450 | 158 | 89 | 104.9 | 1.1 | 148 |
| 6 | 30 | 6.65 | 240 | 12.5 | 0.2 | 54 | 650 | 91 | 125 | 85.6 | 0 | 98 |
| 7 | 32 | 6.75 | 280 | 16.75 | 0.3 | 89 | 550 | 138 | 119 | 68 | 0 | 128 |
| 8 | 30 | 6.36 | 280 | 10.3 | 0.2 | 32 | 550 | 165 | 92 | 50.6 | 0.1 | 155 |
| 9 | 31 | 6.76 | 390 | 20.3 | 0.2 | 121 | 850 | 145 | 222 | 108.2 | 0.1 | 138 |
| 10 | 31 | 6.71 | 250 | 13.65 | 0.3 | 69 | 450 | 78 | 149 | 97.2 | 0.45 | 68 |
| 11 | 31 | 6.52 | 340 | 18.55 | 0.3 | 179 | 850 | 265 | 52 | 96.7 | 0.4 | 255 |
| 12 | 34 | 7.02 | 440 | 13.8 | 0.2 | 149 | 850 | 198 | 219 | 110.1 | 0 | 188 |
| 13 | 30 | 7.48 | 420 | 24 | 0.2 | 114 | 850 | 231 | 165 | 106.9 | 0 | 227 |
| 14 | 30 | 6.61 | 460 | 25.5 | 0.2 | 214 | 950 | 231 | 205 | 111.3 | 0.75 | 221 |
| 15 | 32 | 6.89 | 460 | 25.05 | 0.2 | 224 | 1050 | 298 | 139 | 106.1 | 0.8 | 258 |
| 16 | 29 | 6.87 | 470 | 25.2 | 0.1 | 214 | 950 | 231 | 215 | 137.8 | 1 | 221 |
| 17 | 31 | 6.85 | 460 | 19.65 | 0.2 | 164 | 950 | 248 | 189 | 53.4 | 0.25 | 238 |
| 18 | 33 | 6.55 | 260 | 12.25 | 0.2 | 49 | 550 | 165 | 72 | 39 | 0.6 | 155 |
| 19 | 31 | 6.77 | 260 | 11.95 | 0.2 | 54 | 550 | 148 | 89 | 45 | 0.6 | 138 |
| 20 | 31 | 6.28 | 280 | 10.95 | 0.2 | 124 | 550 | 165 | 92 | 42 | 0.45 | 155 |
| 21 | 32 | 6.43 | 210 | 12.05 | 0.3 | 29 | 350 | 98 | 89 | 41.4 | 1.2 | 88 |
| 22 | 32 | 6.84 | 450 | 22.95 | 0.2 | 109 | 950 | 198 | 229 | 105.7 | 0 | 188 |
| 23 | 31 | 6.44 | 460 | 29.35 | 0.2 | 114 | 950 | 215 | 222 | 83.5 | 0 | 205 |
| 24 | 32 | 6.95 | 440 | 23.85 | 0.2 | 119 | 1050 | 331 | 85 | 108.7 | 0.45 | 335 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | 31 | 6.60 | 320 | 19.45 | 0.3 | 119 | 650 | 165 | 132 | 71.3 | 0 | 155 |
| 26 | 31 | 7.25 | 500 | 16.9 | 0.1 | 214 | 950 | 198 | 279 | 86.6 | 1.4 | 188 |
| 27 | 32 | 7.16 | 260 | 24.3 | 0.4 | 314 | 1050 | 315 | 72 | 191.1 | 1.6 | 305 |
| 28 | 30 | 6.39 | 450 | 33.2 | 0.1 | 184 | 950 | 181 | 245 | 105.3 | 0.9 | 171 |
| 29 | 30 | 7.23 | 260 | 12.7 | 0.2 | 41 | 450 | 148 | 89 | 39.4 | 1.1 | 138 |
| 30 | 30 | 7.02 | 380 | 15.85 | 0.2 | 132 | 850 | 198 | 159 | 97 | 0.25 | 188 |
| 31 | 32 | 6.75 | 280 | 7.2 | 0.2 | 49 | 750 | 131 | 125 | 47.6 | 0.6 | 121 |
| 32 | 30 | 6.78 | 440 | 19.7 | 0.2 | 114 | 950 | 181 | 235 | 83.6 | 0 | 171 |
| 33 | 32 | 6.83 | 460 | 20.15 | 0.1 | 116 | 950 | 198 | 239 | 110.9 | 1 | 188 |
| 34 | 31 | 7.18 | 250 | 10.85 | 0.1 | 47 | 550 | 148 | 79 | 42.6 | 0.5 | 138 |
| 35 | 31 | 6.85 | 380 | 13.7 | 0.2 | 121 | 750 | 181 | 175 | 69.6 | 1.2 | 171 |
| 36 | 31 | 6.68 | 440 | 25.35 | 0.2 | 134 | 850 | 198 | 219 | 94 | 1.1 | 188 |
| 37 | 32 | 6.85 | 280 | 10.45 | 0.1 | 119 | 550 | 131 | 125 | 125.9 | 0.7 | 121 |
| 38 | 30 | 7.20 | 280 | 6.75 | 0.1 | 39 | 550 | 131 | 125 | 50.9 | 1.6 | 121 |
| 39 | 30 | 6.79 | 260 | 6.3 | 0.1 | 39 | 550 | 265 | 12 | 58.1 | 1.7 | 255 |
| 40 | 30 | 6.78 | 280 | 2.7 | 0.1 | 44 | 550 | 98 | 159 | 48.2 | 0 | 88 |
| 41 | 30 | 7.10 | 420 | 11.1 | 0.1 | 131 | 750 | 165 | 232 | 69.2 | 0 | 155 |
| 42 | 30 | 7.20 | 340 | 36.75 | 0.1 | 199 | 850 | 231 | 85 | 113.3 | 0.7 | 221 |
| 43 | 32 | 7.26 | 490 | 36 | 0.2 | 204 | 1020 | 265 | 252 | 98.4 | 0 | 255 |
| 44 | 31 | 7.18 | 280 | 7 | 0.2 | 41 | 450 | 98 | 159 | 49.9 | 1.4 | 88 |
| 45 | 31 | 7.08 | 380 | 17.35 | 0.2 | 87 | 650 | 131 | 225 | 73.8 | 0.45 | 121 |
| 46 | 31 | 7.11 | 360 | 17.8 | 0.2 | 89 | 750 | 181 | 155 | 82.7 | 0.1 | 171 |
| 47 | 31 | 7.26 | 470 | 16.35 | 0.3 | 161 | 950 | 231 | 215 | 58.1 | 1.6 | 221 |
| 48 | 30 | 7.44 | 610 | 26.5 | 0.3 | 399 | 1300 | 165 | 422 | 166.9 | 1.4 | 155 |
| 49 | 30 | 7.42 | 560 | 26.45 | 0.1 | 399 | 1150 | 265 | 272 | 176.5 | 1.6 | 255 |
| 50 | 30 | 6.84 | 500 | 16.7 | 0.1 | 224 | 1050 | 231 | 245 | 120.5 | 1.6 | 221 |
| MIN | 29 | 6.28 | 160 | 2.7 | 0.1 | 29 | 350 | 65 | 12 | 39 | 0 | 65 |
| MAX | 34 | 7.48 | 610 | 36.75 | 0.4 | 399 | 1300 | 331 | 422 | 258.5 | 1.7 | 335 |
| MEAN | 31.07 | 6.88 | 365.96 | 17.76 | 0.20 | 138.35 | 783.27 | 186.33 | 164.31 | 93.68 | 0.66 | 177.19 |
| SD | 1.09 | 0.30 | 103.36 | 7.65 | 0.07 | 86.36 | 221.93 | 62.30 | 77.05 | 42.46 | 0.57 | 61.26 |

It may at this stage, be noted that based on GWQI values, the Groundwater quality is rated as excellent, good, moderately polluted, very poor, and unfit for drinking as listed table below

Table 3: Water quality based on GWQI values

| GWQI Range | Type of Water |
|---|---|
| <25 | Excellent water |
| 26-50 | Good water |
| 57-75 | Moderately polluted water |
| 76-100 | Very Poor water |
| >100 | Unfit for Drinking |

## IV RESULTS AND DISCUSSIONS

Groundwater samples collected from 50 wells were tested for eleven quality parameters as listed in the table 2. A glance at these parameters indicates the following:

*pH:*

The negative logarithm of hydrogen ion concentration of a solution is the pH . In the study area . The values of pH in the groundwater samples collected varied from 6.28 to 7.48 with an average value of 6.88. This shows that the quality of groundwater of the study area is within the enticing limit.

*Total Hardness (TH):*

Hardness in water is caused primarily by the presence of carbonates and bicarbonates ofcalcium and magnesium, sulphates, chlorides and nitrates. Total hardness could be a live of calcium (Ca2+) and magnesium (Mg2+) content in water and is expressed as equivalent of CaCo3. Water with a hardness of but less than 75 mg/l is considered as soft. Hardness of 75-150 mg/l isn't objectionable for many functions.. Minimum total hardness of 160 mg/l and maximum value of 610 mg/l.

Table 4**.** Water Quality Index Values for different samples

| Sample | WQI | Status |
|---|---|---|
| 1 | 34.59 | Good Water |
| 2 | 61.94 | Moderately polluted Water |
| 3 | 44.36 | Good Water |
| 4 | 46.56 | Good Water |
| 5 | 44.54 | Good Water |
| 6 | 14.45 | Excellent Water |
| 7 | 44.15 | Good Water |
| 8 | 53.08 | Moderately polluted Water |
| 9 | 45.49 | Good Water |
| 10 | 34.47 | Good Water |
| 11 | 63.83 | Moderately polluted Water |
| 12 | 46.24 | Excellent Water |
| 13 | 25.53 | Excellent Water |
| 14 | 25.35 | Excellent Water |
| 15 | 25.06 | Excellent Water |
| 16 | 14.28 | Excellent Water |
| 17 | 26.24 | Good Water |
| 18 | 25.70 | Excellent Water |
| 19 | 26.18 | Good Water |
| 20 | 25.28 | Excellent Water |
| 21 | 37.15 | Good Water |
| 22 | 26.36 | Good Water |
| 23 | 26.00 | Good Water |
| 24 | 26.30 | Good Water |
| 25 | 26.29 | Good Water |
| 26 | 14.39 | Excellent Water |
| 27 | 47.97 | Good Water |
| 28 | 14.42 | Excellent Water |
| 29 | 26.18 | Good Water |
| 30 | 26.60 | Good Water |
| 31 | 26.67 | Good Water |
| 32 | 25.35 | Excellent Water |
| 33 | 15.13 | Excellent Water |
| 34 | 15.13 | Excellent Water |
| 35 | 24.26 | Excellent Water |
| 36 | 26.42 | Good Water |
| 37 | 14.42 | Excellent Water |
| 38 | 14.58 | Excellent Water |
| 39 | 14.48 | Excellent Water |
| 40 | 14.33 | Excellent Water |
| 41 | 14.32 | Excellent Water |
| 42 | 14.52 | Excellent Water |
| 43 | 26.00 | Good Water |
| 44 | 25.88 | Excellent Water |
| 45 | 26.42 | Good Water |
| 46 | 26.18 | Good Water |
| 47 | 14.96 | Excellent Water |
| 48 | 15.00 | Excellent Water |
| 49 | 14.86 | Excellent Water |
| 50 | 15.08 | Excellent Water |

*Sulphate ($So_4$):*

Sulphates can be found in almost all natural water. The origin of most sulphate compounds is the oxidation of sulphate ores, the presence of shales or the industrial wastes..In the present study the concentrations is varying from 2.7 to36.75

*Fluoride (F):*

It is originated in all natural type of waters at different concentrations. The concentration of fluoride in water is limited by fluorite solubility, so that in the presence of 40 mg/L calcium it should be limited to 3.1 mg/L. It is the absence of calcium in solution which allows higher concentrations to be reliable. Surplus fluoride intake causes different types of fluorosis, primarily dental and skeletal fluorosis. Bureau of Indian Standards (BIS) has prescribed 1 mg/l as the acceptable limit and 1.5 mg/l as the permissible limit for fluoride.

*Chloride (Cl):*

It is known fact that the sea water intrusion shows abnormal concentration of Chloride. In potable water , the salt taste is made by chloride concentrations.. At concentrations above 250mg/l, water acquires salty taste which is objectionable to human consumption. Bureau of Indian standards prescribes 250mg/l as desirable limit and 1000mg/l permissible limit as in the absence of alternate source. In the study area, Chloride concentration ranges between 29 to 399 mg/l.

*Total Dissolved Solids (TDS):*

Concentration of dissolved solids in groundwater decides its applicability for drinking, irrigation or industrial purposes. The concentration of dissolved matter in water is given by the load of the fabric on evaporation of water to dryness up to a temperature of 1800C. The values are expressed in mg/l. The major constituents of TDS include Bicarbonates (HCO) Sulphates (SO2+) and Chlorides (Cl-) of Calcium, Magnesium, Sodium and Silica. Groundwater consists of more than [4]1000 mg/l of total dissolved solids which is generally referred as brackish water. In this study area, the TDS amount ranges from 350 mg/l to 1300 mg/l with an average of 781 mg/l.

*Calcium ($Ca^{2+}$):*

Calcium can be observed in most of the geological material aquifers, Calcium occurs in water mainly due to the presence of limestone, gypsum, dolomite and gypsiferrous minerals. Calcium is a major factor of most igneous, metamorphic and sedimentary rocks. Permissible limit of calcium is 75 mg/l. Calcium concentration ranges from 65 mg/l to 331 mg/l.

*Magnesium ($Mg^{2+}$):*

Magnesium is existent in water because it is washed from rocks and subsequently ends up in water. Permissible limit of magnesium is 30 mg/l.Large dose of Magnesium causes muscle slackening, nerve problems, depressions and personality changes vomiting and diarrhea. Water quality analysis of the samples collected indicates that the magnesium concentration ranges from 12 mg/l to 422 mg/l.

*Sodium ($Na^+$):*

Major source of sodium content in the ground water is due to presence of salts. Desirable limit of sodium content in the ground water is 200 mg/l . Sodium in the ground water basin ranges between 39 mg/l to 258 mg/l.

*Nitrates:*

Nitrate is the most important nutrients in an ecosystem. Generally water bodies impure by organic matter exhibit higher values of nitrate. In the present study water samples from the stations (s1 to s50) showed low concentrations of nitrate (0 to 1.7 mg/l) well below permissible levels as per the standards.

*Bicarbonates ($HCO_3$):*

Carbon dioxide, bicarbonate and carbonates in dissolved state cause alkalinity to water. Alkalinity of the study area is found to vary between 65 to 335 mg/l.

## V CONCLUSIONS

GWQI values computed using logarithmic method are used to categorize the quality of groundwater from the study area Palar basin in Chittoor district. The Logarithmic method of Water Quality Index is a very useful and an efficient tool to summarize and to report on the monitoring data to the decision makers in order to be able to perceive the standing of the groundwater quality; and to have the opportunity for better use in future as well. The overall view of the logarithmic WQI (Table 4) of the present study zone shows a higher WQI. But, only three locations had a satisfactory result with a WQI below 75. This study demonstrates that the use of GIS and WQI methods could provide useful information for water quality assessment.

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