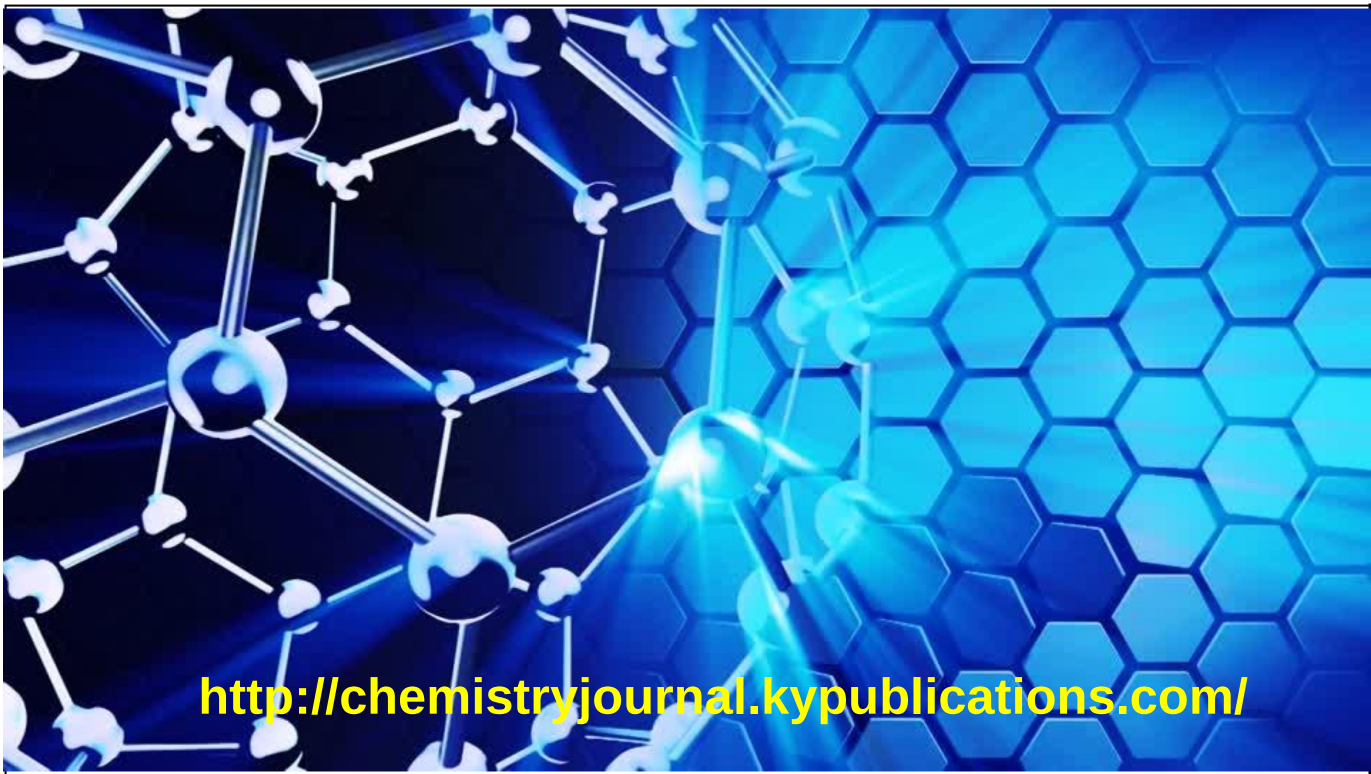

INTERNATIONAL JOURNAL OF CHEMISTRY AND AQUATIC SCIENCES (IJCA)

WWW.CHEMISTRYJOURNAL.KYPUBLICATIONS.COM
ISSN:2455-040X

Volume 2 Issue.2:2016

©KY PUBLICATIONS 2013
www.kypublications.com
Editor-in-Chief
Dr.Y.H.Rao
Email:submitijca@gmail.com

INTERNATIONAL JOURNAL OF CHEMISTRY AND AQUATIC SCIENCES (IJCA) *Volume.2 Issue.2. 2016*

SEASONAL VARIATIONS IN PHYSICO-CHEMICAL CHARACTERISTICS OF NAGARAM MANDAL GROUND WATER-A 'GIS' APPROACH

RESEARCH ARTICLE

Medikondu Kishore *PhD.,*
Department of Chemistry, SVRM College (Autonomous), Nagaram, A.P., India
Email:medikissi@gmail.com

©KY Publications.

ABSTRACT

The quality of groundwater was assessed by determining the physicochemical parameters (pH, EC, Turbidity, TDS and TH) and major ions concentration (CO3, HCO3, F, Nitrates, Cl, SO4, Ca, Mg, Na and K) biological Parametesr (BOD, DO and COD) around Nagaram Mandal in Guntur District of Andhra Pradesh State, India. It is located 57 KM towards East from District head quarters Guntur. The groundwater samples were collected from 92 locations in 2013 Pre-monsoon (Jun-July),Post monsoon(Sep-Oct) and Summer (Apr-may) seasons. As per water quality index (WQI) values, the groundwater in the study area during monsoon ranging from “Good” to “Unfit for drinking” in Summer season. The statistical analysis indicates that the presence of major ions and physicochemical parameters are chiefly controlled by rock–water interaction of the groundwater. The GIS mapping technique were adopted to highlight the spatial distribution pattern of physicochemical parameters and major ion concentration in the groundwater. The results were compared with WHO and ISI guidelines desirable limits for drinking water and found that EC, total hardness, concentration of Cl, Sulphates Bi carbonates etc., were not within the acceptable rage. Finally, the potential zones were identified and assessed as suitable, moderately suitable and unsuitable for domestic purpose. Based on groundwater quality and geospatial analysis, measures were suggested to protect groundwater resources.

Keywords: GIS, Groundwater quality parameters, Ordinary Kriging, Groundwater quality index.

INTRODUCTION

According to WHO, about 1.1 billion people lack access to improve drinking water supply. In most cities, towns and villages in India, valuable man-hours are spent on seeking and fetching water, often of doubt quality from distant sources. Groundwater quality assessment is important in order to ensure sustainable safe use of water. The quality of water is of vital importance to mankind since it is directly linked with human health. Variation in groundwater chemistry with time provides information on the impact of land use land cover changes on the water quality. The quality of groundwater is equally important to its quantity due to the suitability of water for various purposes ranging from drinking, domestic, industrial and agricultural purposes all over the world. Water quality index, based on some very important water quality parameters, can provide a simple indicator of water quality at a certain location and time. Water Quality Index (WQI) is a unit-less number that expresses overall water quality at a certain location and time based on several water quality parameters. Kavitha *et al*. (2010)[1] aimed at minimizing the adverse impacts likely to occur due to water pollution as a consequence of rapid industrialization and population growth in Erode District of Tamilnadu. Ramakrishnaiah *et al*. (2009)[2] calculated the water quality index (WQI) for the groundwater of Tumkur taluk.

In India, numerous technical and non-technical reports concerning water conservation strategies are available. For example, Survey of India (SoI) topo sheets, Geological survey of India (GSI) surface geological maps, Central Ground

Water Board (CGWB) hydro-geologic, water quality, and depth to water maps, all are available only at a scale of 1:25,000 or smaller. These technical maps can best act as primary data sources for decision making at global to regional (district) scale. However, in practice most of the water conservation strategies are to be implemented at regional to local scale. GIS has been useful in establishing the spatial relationship between pollution level and its source in this study. It was suggested that the use of GIS techniques is vital in testing and improving the groundwater contamination risk assessment methods. Considering the above aspects of groundwater contamination and use of GIS in groundwater quality mapping, the present study was undertaken to map the groundwater quality in Nagram Mandal, Andhra Pradesh, India. This study aims to visualize the spatial variation of certain physico-chemical parameters through GIS.

Study Area: The study area is the part of the Guntur district, Nagaram mandal consist of 73 Villages and 25 Panchayats. Thotapalle is the smallest Village and Allaparru is the biggest Village. It is in the 10 m elevation(altitude) . It is located 53 KM towards South from District head quarters Guntur. 331 KM from State capital Hyderabad towards west. Telugu is the Local Language here. Also People Speaks Urdu . Total population of Nagaram Mandal is 51,388 living in 14,546 Houses, Spread across total 73 villages and 25 panchayats . Males are 25,864 and Females are 25,524. This area is also located in Coastal line of the state and 20 KM far way from bay of bengal.

OBJECTIVE OF THE STUDY

The objective of this study is carrying out water quality analysis on waler samples obtained from randomly selected hand dug wells and boreholes in iyo metropolis in order to ascertain;

i) The level of some physical, chemical parameters present in the sample,

ii) The level of suitability of the different sources to WHO standards for drinking water quality.

iii) evaluation of water quality by statistical approach

iv) Mapping of Water quality by Geographic information system (GIS)

SIGNIFICANCE OF THE STUDY

The importance of this study is to identify the groundwater quality conditions from various sources in Nagaram mandal. The major activity is the necessity to provide data and information on the level of physical, Chemical properties and statistical approach of 92 different water samples. It also gives a summary of the level of these properties investigated in the randomly selected sites within the study area. This work bridge the gap between scientific and scale issues by analyzing topographical, hydro-geological, and quality parameters at village scale in a scientific manner. The objective of this user guide is to aid water conservation strategies at village scale through geo-physical and water quality investigations.

METHODOLOGY

Chemicals

All chemicals used in the present study purchased from Sd.Fine chemical, Merk India Ltd in Analytical grade

GIS-Spatial prediction methods

Geographic information system (GIS) is most effective tool to provide better information for the consumers, policy makers and this helps for taking quick decision. For representing the spatial distribution of sampling locations, the coordinates have been found using the Google Earth satellite view. The interpolation of the water sample values has been done by ordinary kriging interpolation technique in the ArcGIS9.2 software.

ORDINARY KRIGING[3]

Kriging is a linear predictor, meaning that a prediction at any location is obtained as a weighted average of the neighbouring data. The weights used in the kriging estimation are computed so that the variance between the estimated value and the unknown value is minimized**.** Ordinary kriging assumes a constant, but unknown mean, and estimates the mean value as a constant in the searching neighbourhood. Ordinary kriging is mathematically defined as:

$Z(s)=\mu+\varepsilon(s)$

where Z(s) is the value at that location; s is a sampled location; μ is the constant mean and ε(s) are random errors with spatial dependence. The predictor is generated as a weighted sum of the data mathematically defined by the following equation

$\widehat{Z}(s_0)=\sum_{i=1}^{N}\lambda_i Z(s_i)$

where so is the prediction location; N is equal to the number of measured values that will be used to predict the value at the unknown location; λ_i is an unknown weight for the measured value at the i^{th} location, and Z(s*i*) is the measured value at the i^{th} location.

Water quality index[4]

In this study, for the calculation of water quality index, thirteen important parameters were chosen. The WQI has been calculated by using the standards of drinking water quality recommended by the World Health Organization (WHO), Indian council of Medical Research (ICMR) and Bureau of Indian Standards (BIS) has been used for the calculation of WQI of the water body.

The Water Quality Index (WQI) was computed using 10 water quality parameters viz. pH, Total Dissolved Solids, Turbidity, Total Hardness, Fluoride, Chloride, Nitrate, Iron, Sulphate and Dissolved Oxygen of groundwater samples in three years on average. WQI indicates a single number like a grade that expresses the overall water quality at a certain area and time based on several water quality parameters.

$W_i = 1/ S_i$

Where, Wi is weightage factor and Si is the highest permitted value of parameter as given by WHO.

$Q_i= \{[(V_{actual}- V_{ideal})/ (V_{standard}- V_{ideal})]*100\}$

Where, Qi is quality rating of parameter, V_{actual} is the mean value of a parameter as obtained from analysis of field samples, $V_{standard}$ is value of water quality parameter as proposed by WHO, V_{ideal} is zero for all parameters except pH where $V_{ideal} = 7$.

$WQI = W_i*Q_i$

Sampling location

Sampling is the first essential step in accessing the quality of water. The present investigation is carried out during the Summer, pre-monsoon and Post Monsoon season of the year 2013. Water samples were collected in plastic bottles. After collection, the sample has been handled and preserved carefully to prevent any alternation in physical and chemical properties. The data required for water quality analysis in the present study has been obtained from 12 villages and 92 locations in the study area. The data pertaining to the test results of the water samples analyzed from the groundwater sources of various villages in Nagaram mandal (Figure 1) in 2013 (Table 1.). The analytical data of the samples (92) collected from all the villages of Nagaram mandal have been used to assess the groundwater quality of the area through the determination of WQI, comparison with WHO & BIS:10500-1991 for drinking water and statistical analysis.

Differential Global Positioning System (DGPS - Trimble) was used to determine the geo-coordinate points of the sampling locations (Table 1). The samples are collected after pumping the well or bore hole for at least an hour. After collection of the samples, the samples are preserved and shifted to the laboratory analysis. Chemical analysis was carried out to determine PH, EC, TDS, TH, Ca, Mg, Na, K, CO_3, HCO_3, Cl-, NO_3, SO_4, Fluoride etc., (Table2) parameters by following standard procedure (APHA-1995)[7] compared with standard values recommended by WHO[6].

The pH, electrical conductivity (EC) and total dissolved solids (TDS) values in samples were recorded in the field itself using Elico Model portable pH-EC-TDS meter instrument. Samples were analyzed in the laboratory for the major ionic concentrations employing standard methods[7]. Concentrations of major cations like Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+) and Potassium (K^+) were determined by flame atomic absorption spectrophotometer and the concentration of major anions chloride (Cl^-) , sulphate (SO_4^{2-}) have been determined by ion chromatography. Bicarbonate (HCO_3^-) was determined by acid titration with HCl.

Irrigation water quality[5]

The overall irrigational water quality of the samples collected, certain parameters have been derived. These include – (i) Sodium Adsorption Ratio (SAR), (ii) Soluble Sodium Percentage (SSP), (iii) Permeability Index (PI), (iv) Residual Sodium Carbonate (RSC), (v) Magnesium Adsorption Ratio (MAR) and (vi) Kelly's Ratio/Index (KR/KI). The derived parameters have been shown in Table 3. These parameters help to evaluate the irrigational as well as domestic suitability of ground water in the study area.

Sodium adsorption ratio (SAR): The sodium adsorption ratio (SAR) was calculated using the following equation:

$SAR^* = (Na^+)/ \{[(Ca^{2+}) + (Mg^{2+})]/2\}^{1/2}$

Soluble sodium percentage (SSP): It is calculated by the following equation:

$SSP^* = [(Na^+ + K^+)] / [Ca^{2+} + Mg^{2+} + Na^+ + K^+]\times100$

Permeability index (PI): The permeability of soil is affected by sodium, calcium, magnesium and bicarbonate contents of irrigation water. Doneen calculated the permeability index based on the formula

PI*= {[Na + (HCO_3)1/2)]*100}/ (Ca+ Mg+ Na)

Residual sodium carbonate (RSC): The Residual Sodium carbonate (RSC) is calculated according to: RSC* = (CO_3 + HCO_3) – (Ca + Mg)

Kelly's index (KI): Kelly devised an equation for the sodium problem in water.

KI*= Na/ (Ca + Mg)

*All concentrations are in meq/L.

Table 1: Locations and Number/Type of water Samples collection

S.No	Villages Name	Sample GPS Coordinates (Long/Lati)	No of Samples Collected*		
			Summer	Pre-Monsoon	Post-Monsoon
1	Allaparru	15° 59' 7.1484'' N/80° 46' 34.2084'' E	3	5	3
2	Dhulipudi	16° 2' 10.7808'' N/80° 45' 41.85'' E	2	4	1
3	Edupalle	15° 58' 27.2712'' N/80° 42' 17.3088'' E	3	2	2
4	Eletipalem	15° 59' 57.9336'' N/80° 44' 56.9616'' E	3	4	3
5	Nagaram	16° 0' 20.448'' N/80° 43' 32.16'' E	2	5	2
6	Pamidimarru	16° 1' 19.7724'' N/80° 47' 14.0928'' E	1	3	2
7	Pedamatlapudi	16° 24' 55.3248'' N/80° 36' 27.7668'' E	2	3	2
8	Pedapalle	16° 35' 24.144'' N/80° 6' 3.528'' E	2	4	2
9	Peddavaram	16° 0' 25.02'' N/79° 38' 40.5492'' E	1	2	2
1(	Pudiwada	15° 59' 49.2972'' N/80° 41' 37.3848'' E	2	3	3
1	Siripudi	15° 59' 40.8084'' N/80° 40' 22.5048'' E	1	4	3
1	Thotapalle	18° 15' 58.3596'' N/ 80° 40' 27.8112'' E	2	2	2
Total samples collected (Hand Pump/Bore Well/Panchayati supplied water)			24	41	27
Grand Total			92		

Figure 1: Location of Investigation

RESULTS AND DISCUSSIONS

The groundwater quality of Summer and pre/Post monsoon is presented in Table 2 based on physico-chemical and biological analysis. Individual parameter is presented based on the average and standard deviation of the samples in particular specific areas. Due to averaging, individual values were within Indian/WHO drinking water standards in Table 2, although some of the samples were found above permissible limits.

The pH value is ranges from 7.26 to 8.51 in post monsoon, 7.39 to 8.44 in pre monsoon and 7.5 to 8.56 in summer season (Table 2). Most of the samples are alkaline in nature except only one station in post monsoon as acidic in nature. 90% of water samples are within the permissible limit at all the three seasons. Acceptable range of pH for drinking water is 6.5-8.5.

The Electrical conductivity of surface water varies from 2438 to 3565 in post monsoon, 1714 to 3722 in pre monsoon and 1818 to 3722.48 µs/cm in summer season (Table 2). Higher electrical conductivity may be attributed to high salinity and high mineral content in the sampling points. High concentration of oxygen usually indicates good water quality. As the temperature increases amount of Dissolved oxygen decreases. There is no prescribed standard suggested by WHO. The EC value is completely depends on the TDS value if TDS is increases the EC value will increase. But the high EC value indicates the more salts in the groundwater. Distribution of EC in samples is shown in Figure 2.

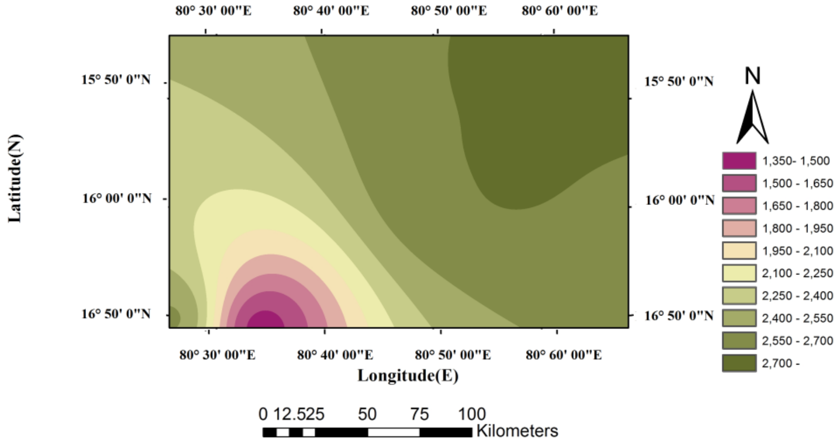

Figure 2: Special distribution maps of Electrical conductivity in Three Seasons

Turbidity is the cloudiness of water caused by a variety of particles and is another key parameter in drinking water analysis. It is also related to the content of diseases causing organisms in water, which may come from soil runoff. The standard recommended maximum turbidity limit, set by WHO for drinking water is 10 nephelometric turbidity units (NTU). In the present analysis all water samples in three seasons are within the permissible limits.

The total dissolved solids are the sum of total cations and anions. TDS are the inorganic matters and small amounts of organic matter, which are present as solution in water. It includes the total ionic species such as sodium, potassium, calcium, magnesium, chloride, bicarbonate, nitrate, sulphate and other trace elements[8]. The TDS range in post monsoon, pre monsoon and summer is 1405 to 2384 mg/L, 1125 to 2740 mg/L and 1398 to 2394 mg/L respectively. Most of the samples are above the permissible limit. It may be due to the agricultural runoff. Water with high dissolved solids generally has inferior palatability and may induce an unfavourable physiological reaction in the person who drinks it. Figure 3 shows TDS values for all drinking water samples collected from 92 sites in three seasons.

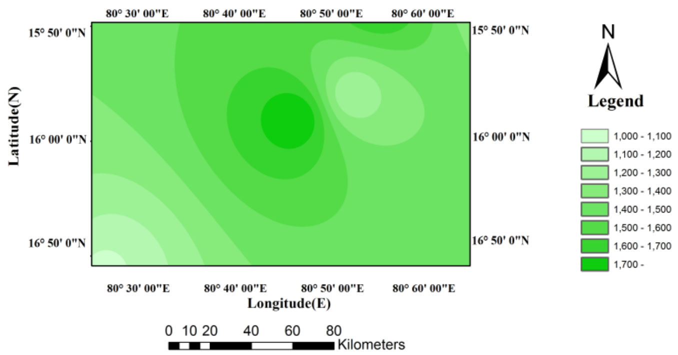

Figure 3. Special distribution maps of total dissolved solids in Three Seasons

Total hardness Water hardness is caused primarily by the presence of cations such as calcium and magnesium and anions such as carbonates and bicarbonates, chloride and sulphate in water. The value ranges is 268 to 752 mg/L in post monsoon, 268 to 939 mg/L in pre monsoon and 259 to 1711mg/L in summer season. Most of the samples are above the permissible limit in all the three seasons. Principal cations imparting hardness are calcium and magnesium. So the high value is due to the dissolved Ca and Mg from sedimentary rocks and soil leakage and overflow. Hardness is called temporary if it is caused by bicarbonate and carbonate salts of cations, since it can be removal easily by boiling the water. Permanent hardness is caused mainly by sulphates and chlorides of the metals[9]. Corresponding variations in Hardness shown by GIS in the following figure 4.

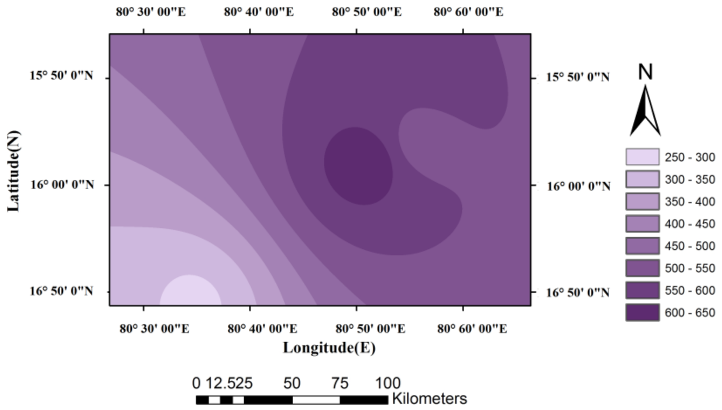

Figure 4. Special distribution maps of Total hardness in Three Seasons

The sources of calcium and magnesium in groundwater are weathering of primary minerals such as hornblende, mica, feldspar, calcite and dolomite. In general Calcium and Magnesium maintains a state of equilibrium in most groundwater. The concentration of calcium in the water samples collected vary from 45-204 mg/L with an average of 138 mg/L (post-monsoon); 48 to 226.0 mg/L with an average of 149 mg/L (pre-monsoon) and 38 to 214.0 mg/L with an average of 141 mg/L (summer). these values declares 90% of water samples are within the permissible limit (200mg/L) (Table 2). The concentration of magnesium in the water samples collected 100% within the permissible limit (<150mg/L) with an average of 84.09 mg/L (pre-monsoon) (Table 2).

The chloride range in post monsoon, pre monsoon and summer is 479 to 1002 mg/L, 409 to 1010 mg/L and 481 to 997 mg/L respectively(Table 2 & Figure 5). Most of the samples are above the permissible limit in three seasons. The high value is may be due to the discharge of domestic sewage and agricultural waste into ground. However, chloride concentrations in excess of about 250 mg/l can give rise to detectable taste in water and the observed range is 7.10 - 8.45 mg/L.

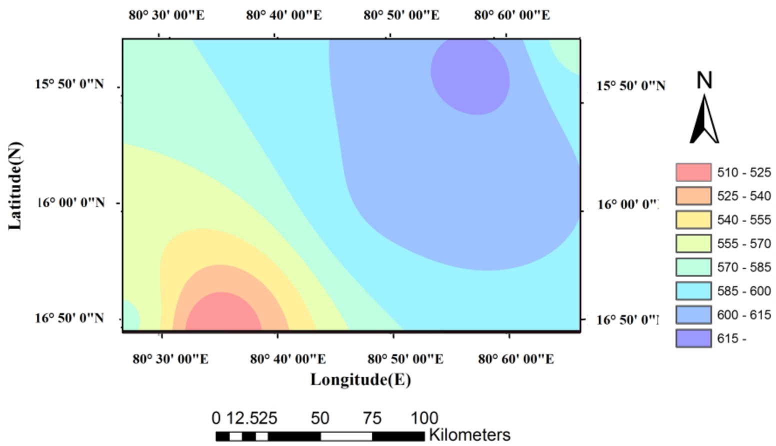

Figure 5. Special distribution maps of Chloride ion in Three Seasons

Sodium is a highly soluble chemical element which often occurs naturally in groundwater. Although it does not smell, it imparts awkward taste to the water at concentrations of 200 mg/L or more. Most compounds are highly water soluble. The concentration of sodium in the water samples collected vary from 113 to 460 mg/L with an average of 326 mg/L (post-monsoon); 124 to 457 mg/L with an average of 242mg/L (pre-monsoon) and 118 to 446 mg/L with an average of 252 mg/L (summer) (Table 1). 84% samples are above the permissible limit i.e. 200 mg/L. Figure 7a and 7b represent the spatial distribution of sodium during pre- and post- monsoon periods in the study area (Figure 6).

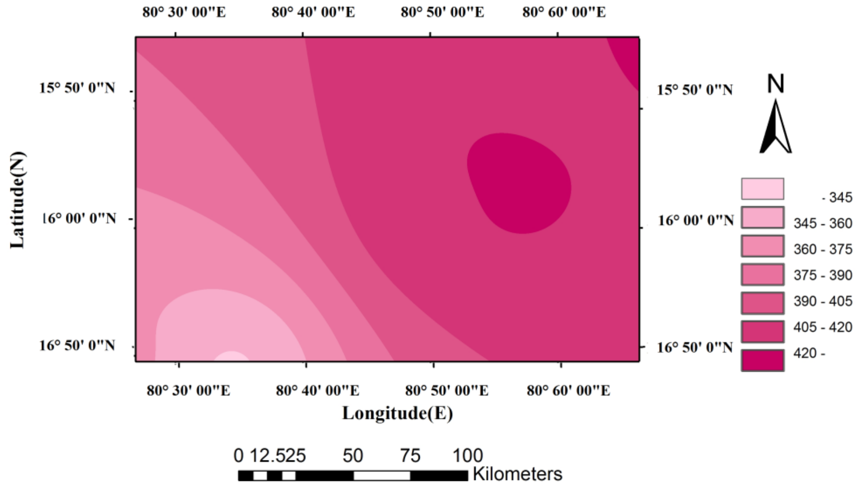

Figure 6. Special distribution maps of Sodium ion in Three Seasons

Potassium controls body balance and maintains normal growth of the human body. No standard limits have been provided by the Bureau of Indian Standards for level of potassium in drinking water.

Sulphate ions do not have any significant detrimental effect on plants and animals. It is essential nutrient for plants. Excess sulphate concentration increases salinity and hardness of water. At levels above 1000 mg/L, sulphate in drinking water can have a laxative effect. Sulphur bacteria may produce a dark slime or deposits of metal oxides that develop as a result of the corrosion of metal pipes. Sulfate ion varied from 289 to 507 mg/L during the post-monsoon with an average of 409 mg/L; from 187 to 499 mg/L in pre-monsoon seasons with an average of 351 mg/L and in summer from 252 to 473 mg/L with an average of 381 mg/L. Figure 7 shows the spatial distribution of sulphate in pre- and post-monsoon and summer period.

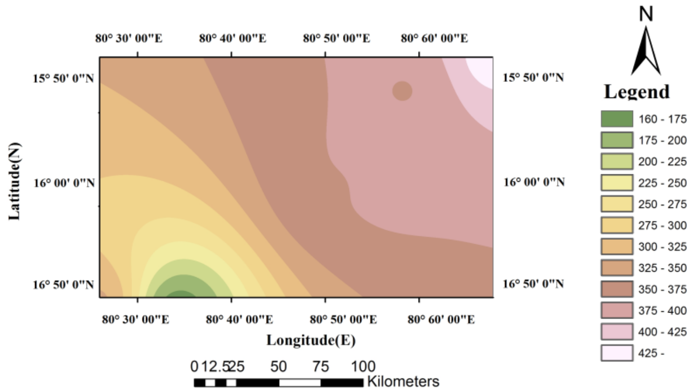

Figure 6. Special distribution maps of Sulphate ion in Three Seasons

Mean fluoride concentration of water samples in pre & post monsoon and in summer as 0.68mg/L, 0.70mg/L and 0.76 showed no significant difference between seasons. The values were within WHO guidelines for fluoride in drinking water (1.5 mg/l) and IS: 10500, 1991, desirable limit (1 mg/l). The values obtained for BOD/COD/DO in this study are within the recommended standards for all the water samples analysed. Mean nitrate concentration of well water was in the range of 36, 46, 41 mg/L in Post, Pre monsoon and in summer seasons, 82% were within WHO guidelines for nitrate in drinking water (45 mg/L) and Bureau of Indian Standards desirable limit (45 mg/l). Usually nitrate is not present in pure water. However, nitrate detected in well water samples might have originated from decaying organic matter, discharge of sewage and industrial wastes and runoff from agricultural fields containing nitrate fertilizers.

Irrigation water quality

The overall irrigational water quality of the samples collected, certain parameters have been derived. These include – (i) Sodium Adsorption Ratio (SAR), (ii) Soluble Sodium Percentage (SSP), (iii) Permeability Index (PI), (iv) Residual Sodium Carbonate (RSC), (v) and (vi) Kelly's Ratio (KR)

Sodium adsorption ratio (SAR): This is a better measurement of sodium hazard present in water. SAR gives an idea about the adsorption of Na^+ in water by soil. It is an important parameter that is used to evaluate the suitablity of water for irrigation purpose because it is a measure of sodium hazard to crops. Based on classification by Ayers, R.S. and Westcot, D.W. (1985)[10], all the analyzed groundwater samples have SAR values less than 10 during dry and wet seasons (following table) and are thus classified as "Excellent" for irrigation.

Water class	Alkalinity hazard	SAR values	% Monsoon season	% during summer season
Excellent	S_1	<10	100	100
Good	S_2	10 - 18	-	-
Doubtful	S_3	18 - 26	-	-
Unsuitable	S_4	>26	-	-

Permeability Index (PI): The PI values also indicate the suitability of groundwater for irrigation purpose. The influencing constituents for PI values are total dissolved solid, Sodium bicarbonate and the soil type. The PI values for both seasons (Following table) fall under "Good" class for irrigation purpose.

Water class	PI values	% Monsoon season	% during summer season
Excellent	>75	-	-
Good to permissible	75 - 25	72.4	74
Doubtful to unsuitable	<25	-	-

Soluble sodium percentage (SSP): This is an important factor for studying sodium hazards. Sodium has the potential of reacting with soil thereby reducing its permeability and supports little or no plant growth. Based on SSP values, 68% of analyzed water samples belong to "Excellent" class while 32% belong to "Good to Permissible" class during dry season. In wet season, 85% of analyzed water samples fall under "Excellent" class while only 15% falls under "Good to Permissible" class (following Table).

Water class	SSP values	% during dry season	% during wet season
Excellent	<60	68	85
Good to permissible	60 - 75	32	15
Doubtful to unsuitable	>75	-	-

Kelly's Ratio: KR values of 1 or <1 is an indication of good quality water for irrigation purpose while KR of >1 is unsuitable. Based on this classification, the KR values of groundwater samples in dry season shows that 58% belong to "Good" class while 38% belong to "Unsuitable" class for irrigation purpose. During Wet season, 85% of analyzed groundwater samples belong to "Good" class while only 15% belongs to "Unsuitable" class for irrigation use.

Residual sodium carbonate (RSC): When the sum of carbonates and bi-carbonates is in excess of calcium and magnesium, there may be a possibility of complete precipitation of calcium carbonate and magnesium carbonate. The concentration of Ca and Mg decreases relative to sodium and the SAR index will be bigger. This will cause an alkalizing effect and increase the pH. RSC values less than 1.25 are considered safe for irrigation. During wet period 91 % samples have RSC values less than 1.25 and are considered to be safe. Rest 09 % samples are marginally suitable with RSC values between 1.25 to 2.5. During dry period, only 32 % samples are safe for irrigation with RSC values less than 1.25. Remaining 68 % samples have RSC values greater than 2.5, hence unsuitable for irrigation. Figure 7 shows the spatial distribution of carbonates and bi-carbonates in wet and dry period.

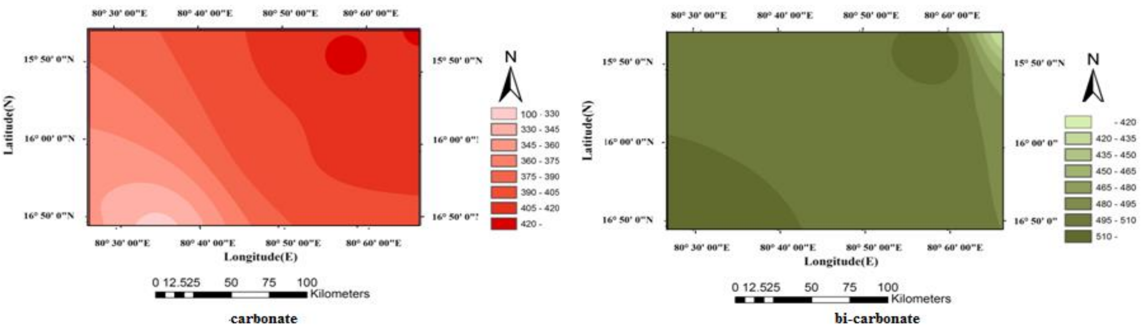

Figure 6. Special distribution maps of Sulphate ion in Three Seasons

Statistical analysis of data

The data corresponding to the basic statistics for the fluoride and other physico-chemical parameters of the groundwater samples from the study area in three different seasons listed in Table 2, in terms of minimum, maximum, median, average and S.D. Correlation coefficient is commonly used to establish the relationship between two variables. It is simply a measure to exhibit how well one variable predicts the other. In order to quantitatively analyse and confirm the relationship among major element contents in groundwater samples, correlation analysis was applied to the data. Correlations among various contents, major elements, EC and pH in groundwater samples are calculated. Significant positive correlations among various elements in groundwater samples are evident. Na, Cl, K and Mg are significantly correlated ($0.69<r<0.96$). The strong correlation between Na and Cl ($r= 0.96$), indicate a common chemical behavior. Ca and Mg are not significantly correlated (0.08) indicating that Ca and Mg are not probably related to dissolution of low magnesium carbonate, or dolomite deposits. Major elements such as Na, Cl, K, and Mg display significant correlation with EC ($0.64<r>0.95$). This reflects the fact that EC of groundwater is strongly controlled by Cl and Na content.

Water Quality Index

Based on the status of water quality data, the index value ranges from 0 to 100 and is classified into five categories: heavily polluted (0-24), poor (25-49), fair (50-74), good (75-94) and excellent (95-100). If the index is low, then it indicates that some of the water quality parameters are beyond permissible ranges due to some particular reason and suitable measures are needed to improve the quality of water. Thus this index may be used as a guiding rule in management of quality of water resources. During pre-monsoon period, 5% samples are excellent, 65% are good and 30% are poor based on Water Quality Indexing. During post-monsoon period, 9% samples are excellent, 51% samples are good, 30% samples are poor and 10 samples are very poor and in summer 2% samples are excellent, 22% are good, 30% are poor 46% samples are not fit for drinking purpose based on Water Quality Indexing. Here WQI value of all stations falls in poor and very poor quality range as shown in the figure , and. This is due to all the major parameters in all the three seasons were in above the desirable limit given by WHO standards.

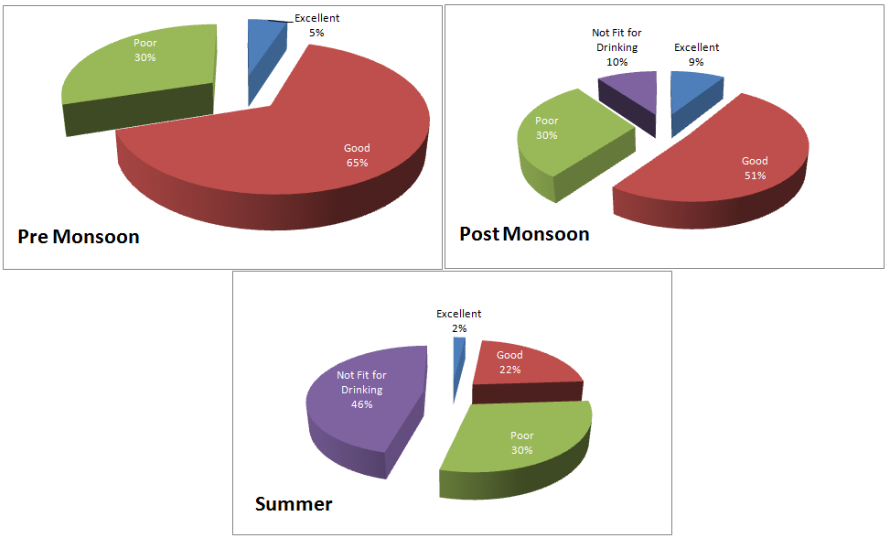

Figure 8.Water Quality Index for Pre/Post monsoon & Summer

Recommendations: Safe water and sanitation pose universal challenges for public health as:

1. Periodical monitoring of water sources for pollutants (chemical & biological).
2. Periodical testing of supplied water by government needed
3. The risk of microbial contamination in tanks can be reduced by several well-known practices. These include the installation of first flush devices, cleaning gutters, both of which are designed to reduce the build-up of potential contaminants and the use of filtration to remove potential contaminants before use
4. Enhanced funding is needed to validate newer molecular detection tools, understand the ecology of pathogens in aquatic ecosystems, better predict disease outbreaks, and improve emergency responses.
5. Encourage infrastructure planning, including technological advances, to ensure that improved treatment and environmental protection measures are not diminished by development or population growth.

6. Human activities such as the use of chemicals in agriculture, effluent from homes, and sewage disposal, industrial waste discharged are all factors that contaminate water. Programs are needed to assess the effects of aerial emissions on drinking water quality.
7. An improved understanding is needed of methods for assessment and risk analysis of the cumulative effects of agricultural, forestry and other land use activities as well as point-source inputs (e.g., municipal and industrial discharges) on surface and ground waters.
8. For on-site drinking water system, a minimum distance of 15 m shall be kept between the water system and potential source of contamination. Communities shall keep clean the protected area surrounding on-site drinking water systems.

There should be a long term sustained programme of monitoring the quality of groundwater in the community, to have a complete understanding of the ground water resources. Awareness should be created among the people on the possible danger of polluted water consumption and the diseases associated with it if not treated.

Table 2: Physicochemical characteristics of groundwater of Nagaram mandal in 2013 of Various seasons

Season		pH	EC	Turbidity (NTU)	TDS	TH	Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	CO_3^{-2}	HCO_3^{-}	NO_3^{-}	SO_4^{-2}	F^{-}	DO	BOD	COD
Summer	Min	7.5	1818.14	1.5	1398.99	259.94	38.89	40.94	118.71	3.07	481	285.53	296.43	33.77	252.78	0.52	2.17	0.23	0.98
	Max	8.56	3722.48	4.75	2394.76	711.26	214.91	83.92	446.89	8.6	997.82	628.37	999.9	59.36	473.83	1.02	2.87	0.55	1.46
	Median	8.06	2938.8	2.76	1894.83	536.26	141.23	59.36	252.44	5.53	690.8	468.21	570.1	39.86	402.71	0.74	2.52	0.45	1.31
	Average	8.01	2818.61	2.95	1883.57	501.76	129.12	59.14	257.64	5.66	717.96	455.41	580.2	41.78	381.98	0.76	2.55	0.43	1.29
	STD	0.26	568.96	0.67	252.41	143.92	53.12	11.06	80.77	1.4	152.37	69.99	180.32	7.45	69.76	0.14	0.19	0.09	0.12
Pre monsoon	Min	7.39	1714.3	2.6	1125.74	268.13	48.1	36.84	124.85	1.84	409.36	257.9	232.92	15.15	187.28	0.43	2.17	0.24	0.89
	Max	8.44	3722.48	4.76	2470.49	939.48	226.17	91.08	457.12	9.21	1010.1	600.74	900.92	61.4	499.42	1.23	2.6	0.49	1.43
	Median	7.84	2691.94	2.78	1877.94	482.02	160.67	49.12	242.88	5.53	584.36	385.82	469.54	46.05	351.03	0.63	2.4	0.36	1.25
	Average	7.8	2617.68	3.06	1723.19	531.71	149.26	54.04	255.56	5.56	662.03	401.41	499.8	46.4	331.43	0.7	2.43	0.37	1.22
	STD	0.25	707.11	0.66	465.36	142.05	43.49	12.39	83.02	1.6	201.3	90.93	164.58	10.77	97.07	0.19	0.11	0.07	0.12
Post monsoon	Min	7.26	2438.22	2.56	1405.13	268.13	45.03	35.82	133.12	2.35	479.97	289.62	296.43	15.86	289.62	0.49	2.28	0.26	1.13
	Max	8.51	3565.74	4.79	2384.52	752.2	204.68	89.04	460	8.56	1002.93	500.44	900.92	66.52	507.61	0.92	2.76	0.51	1.58
	Median	7.87	3232.68	2.8	2086.71	624.27	157.6	53.22	326.67	5.63	751.99	444.16	411.62	35.2	399.13	0.6	2.46	0.4	1.28
	Average	7.91	3120.28	3.05	1982.28	558.64	138.14	55.4	331.12	5.69	777.02	439.53	471.13	36.3	409.12	0.68	2.48	0.39	1.28
	STD	0.31	322.45	0.6	294.96	143.64	46.69	11.96	86.33	1.66	164.36	49.33	180.49	10.17	43.76	0.16	0.11	0.08	0.09
Acceptable Limits	WHO	6.5-8.5	400-2000	<10	500	100-500	75-200	50-150	200	10 to 12	200	NA	NA	45	200	0.5 to 1.5	3	6	10
	ISI	6.5-8.5	2000	<10	500	300-600	75-200	30-100	200	NA	250	NA	NA	45	250	0.6 to 1.5	3	6	10

Note: All other parameters expressed in mg/L except pH and EC (EC:µS/cm)

*source: http://www.who.int/water_sanitation_health/dwq/guidelines/en/ and

http://www.indiawaterportal.org/articles/indian-standard-drinking-water-bis-specifications-10500-1991

CONCLUSION

Water quality is dependent on the type of the pollutant added and the nature of mineral found at particular zone of bore well. Monitoring of the water quality of ground water is done by collecting representative water samples and analysis of physico-chemical characteristics of water samples at different locations of Nagaram mandal, Guntur district. In conclusion, from the results of the present study it may be said that the people in these rural areas are therefore at higher potential risk. most of the villages water is not absolutely fit for directly drinking purpose need treatments to minimize the contamination. It is recommended that water analysis should be carried out from time to time to monitor the rate and kind of contamination. it is also concluded that, the quality of groundwater in these villages is changing from season to season. Hence continuous monitoring of groundwater quality is essential in order to supply potable water to the rural people. Water Quality Index value also indicate that the groundwater is not suitable for drinking and domestic purpose. So it is advice to special care for protect the groundwater from the pollution by sewage, agricultural disposal and some human activities. In order to improve quality of groundwater and to protect people and animals from the perils of groundwater contamination, it is essential to initiate measures to check the pollution from industrial effluents through strict enforcement of legislation for industries. Regular groundwater quality monitoring network stations should be established. Replacement of damaged pipelines and lining of sewer drains is necessary to prevent the leakage of sewage in pipes and seepage through unlined channels and prevent the mixing of sewage with groundwater. Education of public on safe handling and use of drinking water is also recommended.

Acknowledgment

The author would like to thank University Grant Commission for rendering financial assistance under the scheme of minor research project No.F MRP-4681/14(SERO/UGC) March 2014 and Management of SVRM College for providing necessary facilities.

REFERENCES

[1]. Kavitha, R. and Elangovan, K. (2010). Groundwater quality characteristics at Erode district, Tamilnadu India. *International Journal of Environmental Science* **I(** 2) :145-150.

[2]. Ramakrishnaiah, C. R., Sadashivaiah, C. and Ranganna, G. (2009). Assessment of water quality index for the groundwater in Tumkur Taluk, Karnataka State. *E-Journal of Chemistry*. **6**(2) : 523-530.

[3]. Johnston, D. J. M .Ver Hoef, K. Krivoruchko, N. Lucas. 2001. Using ArcGIS Geostatistical Analyst. Environmental Systems Research Institute, Redlands.

[4]. Srinivas J., Purushotham A.V. and Murali Krishna K.V.S.G."Determination of Water Quality Index in Industrial areas of Kakinada,Andhra Pradesh, INDIA" International Research Journal of Environment Sciences, Vol. 2(5), 37-45, May (2013)

[5]. Richards LA (1954) Diagnosis and Improvement of Saline and Alkali Soils, U. S. Department of Agriculture Handbook, 60 Washington DC, USA.160

[6]. World Health Organization, Guidelines for drinking water quality, 3rd Edn., WHO, Geneva, 2000.

[7]. APHA. American public health association, Standard Method of the Examination of Water and Wastewater.18th edition, Washington D. C, 1992.

[8]. Mondal, N.C., Saxena, V.K. and Singh, V.S, , Environmental Geology, 2005, Vol. 48, pp. 149-157

[9]. Raja G. and Venkatesan P, E.Journal of Chemistry, 2010, 7(2), 473-478

[10]. Ayers, R.S. and Westcot, D.W. (1985) Water Quality for Agriculture FAO Irrigation and Drain. Paper No. 29, 1-109.