Original Research Paper
Volume-8 | Issue-5 | May-2018 | PRINT ISSN No 2249-555X
Earth Science

SEASONAL VARIATIONS AND SPATIAL ANALYSIS OF DRINKING WATER SUITABILITY OF DINDI RESERVOIR CATCHMENT AREA USING GIS, MAHBUBNAGAR AND NALGONDA DISTRICTS, TELANGANA STATE, INDIA

Dr. K. Krishna Kumar Senior Hydro geologist, Hyderabad

ABSTRACT 91 samples were collected for pre monsoon and post monsoon for the analysis. In pre monsoon Total Hardness in the study area varies from 125 to 1328; pH varies from 7.0 to 8.1; Total Dissolved Solids (TDS) varies from 142 mg/l to 2705 mg/l and Electric Conductivity varies from 211.9 mg/l to 4037.3 mg/l. In post monsoon Total hardness of groundwater varies from 132 to 1320; pH varies from 6.5 to 8.1; Total Dissolved Solids (TDS) varies from 332 mg/l to 4404 mg/l and Electric Conductivity varies from 495.5 mg/l to 6573.1 mg/l. In pre monsoon constituents such as Sodium (Na^{+}) varies from 152.8 mg/l to 23 mg/l; Potassium (K^{+}) varies from 57.8 mg/l to 2.1 mg/l; Calcium (Ca^{+}) varies from 82 mg/l to 12 mg/l; Magnesium (Mg^{+}) varies from 362 mg/l to 12 mg/l; Carbonates (CO^{3-}) varies from 96.6 mg/l to 0.2 mg/l); Bi-Carbonates (HCO^{3+}) varies from 1352.4 mg/l to 217.4 mg/l; Nitrates (NO^{3-}) varies from 102 mg/l to 0.4 mg/l; Sulfates (SO^{4+}) varies from 246 mg/l to 4 mg/l; Chlorides (Cl^{-}) varies from 816 mg/l to 36 mg/l; Fluoride (F^{+}) varies from 2.8 mg/l to 0.1 mg/l; iron varies from 2 mg/l to 0.0 mg/l and Alkalinity varies from 680 mg/l to 109 mg/l. In post monsoon constituents such as Sodium (Na+) varies from 296 mg/l to 11 mg/l; Potassium (K+) varies from 250 mg/l to 0.7 mg/l; Calcium (Ca+) varies from 756 mg/l to 16 mg/l; Magnesium (Mg+) varies from 362 mg/l to 5 mg/l; Carbonates (CO3-) varies from 241.5 mg/l to 0.1 mg/l); Bi-Carbonates (HCO3+) varies from 1342.8 mg/l to 237.5 mg/l; Nitrates (NO3-) varies from 42.4 mg/l to 0.9 mg/l; Sulfates (SO4+) varies from 186 mg/l to 1.4 mg/l; Chlorides (Cl-) varies from 201 mg/l to 10.4 mg/l; Fluoride (F+) varies from 5.9 mg/l to 0.1 mg/l; Iron varies from 10 mg/l to 0.0 mg/l and Alkalinity varies from 724 mg/l to 104 mg/l. Piper classification in the pre monsoon revealed 75 % of samples are Magnesium type, 22 % are Calcium, Bi-Carbonate type are 1% and remaining 2 % area Chloride type. There are two types of groundwater facies which exists with 97 % of Calcium and Magnesium facies and 3 % Calcium+Magnesium+ Sodium+ Potasiumfacies. In the post monsoon, 74 % of samples are Magnesium type, 17 % are Calcium, Sodium type are 4%, 2 % area Chloride type and remaining 2% are Potassium type. There are two types of groundwater facies of which 91 % are of Calcium and Magnesium facies and 9 % Calcium+Magnesium+ Sodium+ Potasium facies.

KEYWORDS : Seasonal variations, BIS standards, Spatial distributions, WHO standards

Introduction

Chemistry of groundwater could reveal important information on the suitability of groundwater for domestic, agriculture and industrial purposes (R. Ramesh et. al.). Clean water is the best form of medicine available to mankind, animals and plants. Gradually, exponential rise in population size led to pollution and depletion of river water. People took recourse in groundwater believing that it is safe in all respects. This indispensable resource is a victim of over-exploitation, pollution and exhaustion. Rate of groundwater development and management is not at par with rate of utilization. Presently India is the biggest user of groundwater for agriculture in the world (Nag SK et.al, M. J. Islam et.al). The chemical alteration of the rain water depends on several factors such as soil-water interaction, dissolution of mineral species and anthropogenic activities (N. Janardhana Raju et.al). The chemical composition of water is an important factor to be considered before it is used for domestic or irrigation purpose. Chemical composition of water may be rendered unfit for human consumption, and thus may lead to health problems. The importance of groundwater quality in human health has recently attracted a great deal of interest. In the developing world, 80% of all diseases are directly related to poor drinking water and unsanitary conditions (J.M. Ishaku et. al, Shreya Das et.al.)

Study area:

Geographically the study area is located longitude between 78°19'31.2"E and 78°54'35.8"E to latitude between 16°50'40.6"N and 16°11'24.9"N; covering survey of India toposheet numbers 56L/5, 56L/6, 56L/7, 56L/10, 56L/11, 56L/14, 56L/15. Figure 1 shows the location map of study area. The study area lies at the north and south of Dindi reservoir covering part of Dindi River catchment which is tributary of Krishna River. Geographical area of the study area is 14, 840 sq.m. Administratively it could be found in Mahabubnagar district of Telangana state, India which is about 115 kilometers by the road from the Hyderabad to Kalvakurthy at Dindi Village, boarder of Nalgonda district on east.

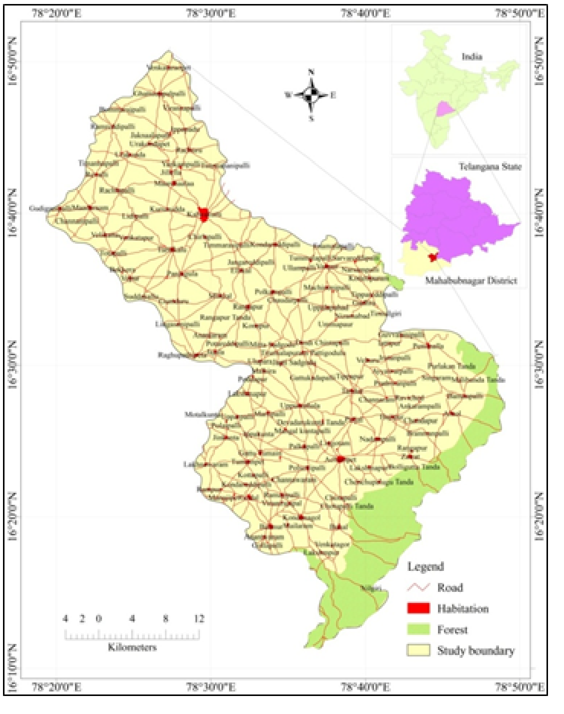

Figure 1: Location map of the study area

Methodology

For the present study 91 groundwater samples data were collected from the different sources. pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sodium, Potassium, Magnesium, Calcium, Chloride, Sulphites, Carbonates, Bi-Carbonates, Nitrates, Iron and Fluoride constituents in the samples were analysed. Suitability of groundwater for drinking purpose Bureau of Indian Standards (BIS) of

1993 is used for analysis. In the present study Survey of India toposheet of 1: 50,000 scale was geo referenced and geometrically rectified to WGS-84 world geometrical coordinate system using geo reference tool by using Arc GIS 10.2. Polygon shape files of study area boundary, point shape file of geographic location of each sample source was prepared. By using this point shape file as input file and boundary shape file spatial analysis maps were prepared by using spline interpolation tool. In all spatial maps classes has been divided based on the BIS permissible range as well as acceptable range.

Results and Discussions

Potential Hydrogenise (pH)

The symbol pH is used to express the acidity or alkalinity in the water. It influences the chemical and biological process within the water body (Hem, 1985). It is expressed as the negative logarithm the hydrogen-ion concentration in water. The measure of pH is on a scale of 0-14 where in pH less than 7 are acidic and greater than 7 is alkaline (basic) and exact 7 is neutral. The permissible limit is between 6.5-8.5 (WHO). In the study area regarding to pH all samples has below permissible limit for drinking purpose in pre and post monsoon seasonsElectrical Conductivity (EC)

Electrical conductivity is the ability of a substance to conduct an

Table 1: Groundwater Suitability for drinking purpose in pre and post monsoon

Sl. No	Parameter	Standard limits		% of samples					
				Pre monsoon			Post monsoon		
		Permissible	Maximum Accepted	Permissible	Maximum Accepted	Not suitable	Permissible	Maximum Accepted	Not suitable
1	TH	300	600	20	69	11	14	69	15
2	pH	6.5-8.5	9.2	100	0	0	100	0	0
3	TDS	500	2000	8	88	4	9	84	7
4	EC	-	-	-	-	-	-	-	-
5	Na	50	-	20	0	80	17	0	83
6	K	10	-	11	0	89	23		76
7	Mg	30	100	8	8	84	12	17	71
8	Ca	75	200	3	51	46	17	47	36
9	Fe	0.3	1	82	15	3	78	21	1
10	F	1	1.5	34	51	15	36	62	2
11	Cl	250	1000	70	23	7	60	40	0
12	SO4	200	400	98	2	0	100	0	0
13	HCO3	30	-	0	0	100	0	0	100
14	CO3	75	200	0	0	100	89	9	1
15	NO3	45	-	98	0	2	0	100	0

Spatial variation of pH (Figure 2) shows that more than maximum acceptable limits (> 9.2) noticed at central north and south east edges of the study area.

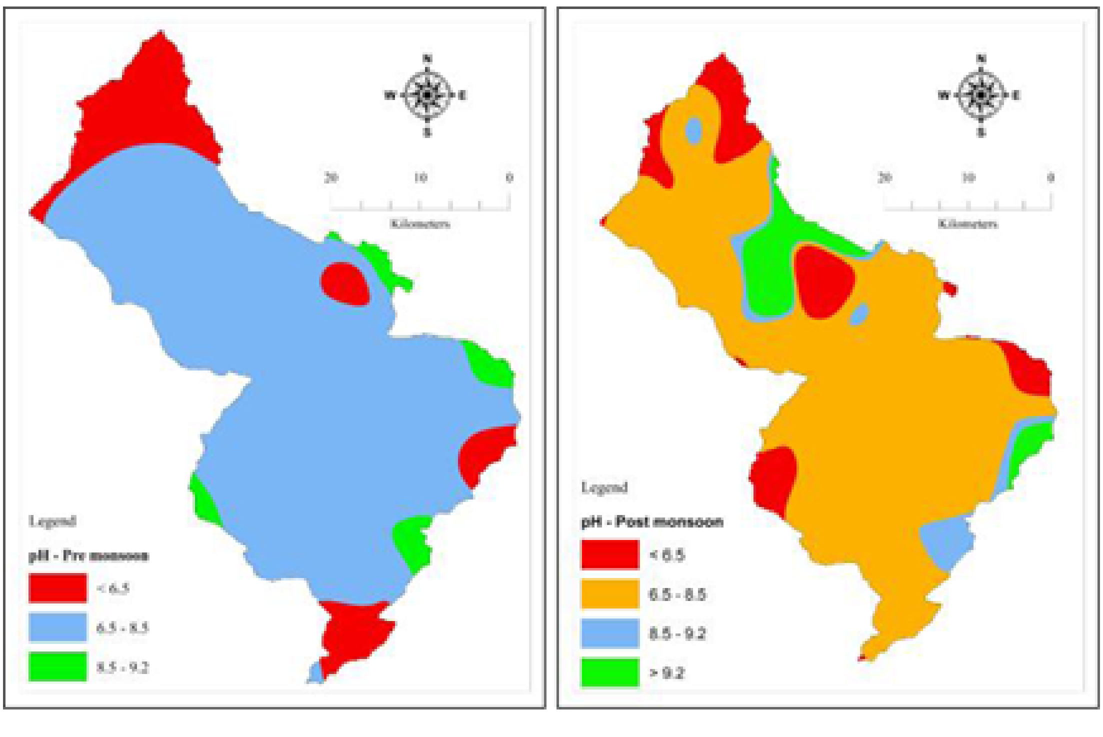

Figure 2: Spatial map of pH in Pre and post monsoon

Electrical Conductivity (EC)

electric current and is measured before carrying out the actual analysis of any water sample. The salt concentration of water is generally measured with the help of Electrical Conductivity. (Sisir Kanti Nag et. al, 2012). The electrical conductivity of water is directly proportional to the salt concentration and vice versa. Hence, the conductivity measurement provides an indication of ionic concentrations. It depends upon temperature, concentration and types of ion present (Hem, 1985).

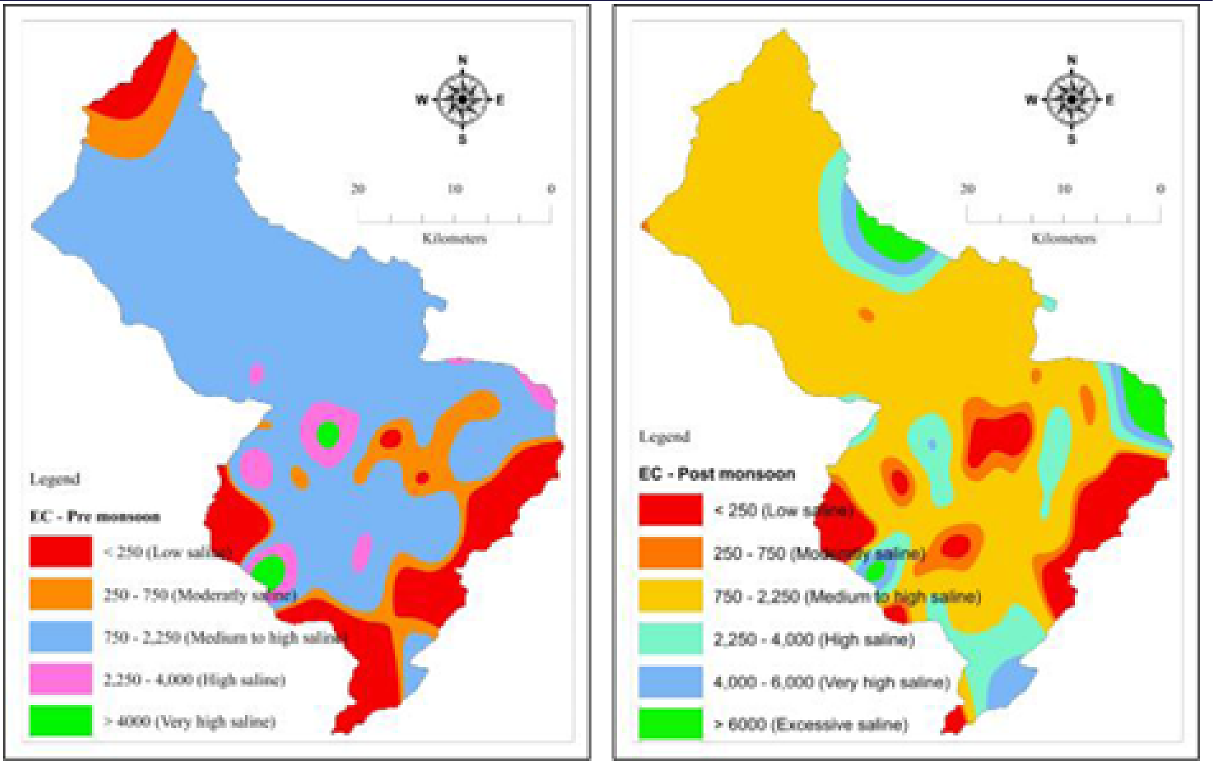

Figure 3: Spatial map of Electric Conductivity in Pre and post monsoon

Figure 3 shows that in pre monsoon very high saline groundwater spread at central and south west portion whereas in post monsoon it is located at south, south west, north east of the study area. Majority of the portion has medium to high saline in pre and post monsoon.

Total Dissolved Solids (TDS)

The mineral constituents dissolved in water constitute dissolved solids. The concentration of dissolved solids in natural water is usually less than 500 mg/l, while maximum acceptable limit for drinking is 2000 mg/l (Sultan Singh et al, 2012). Ground water in the study area 8 % of the samples have within the permissible limits while 88 % have maximum acceptable limits and remaining 4 % is not suitable for drinking in pre monsoon and whereas in post monsoon 9% of samples has permissible limit, 84% has maximum acceptable limit and remaining 7% has not suitable for drinking.

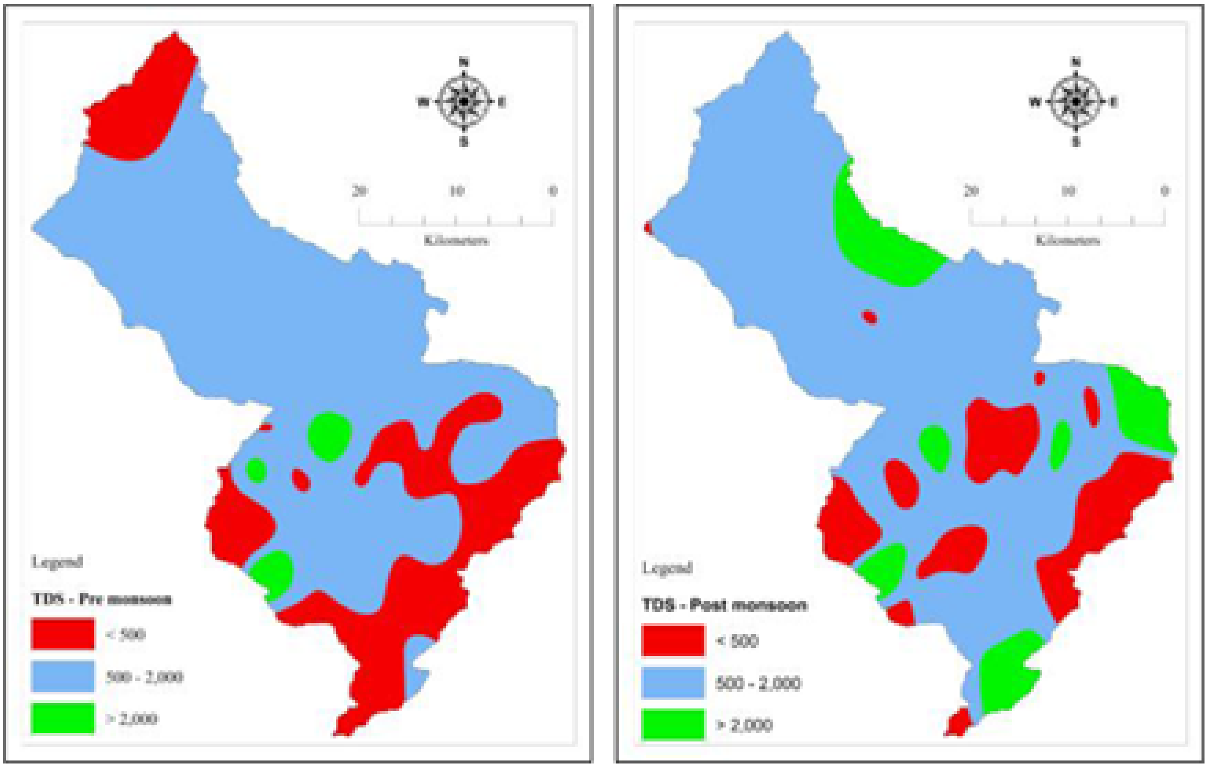

Figure 4: Spatial map of TDS in Pre and post monsoon

Figure 4 shows that area of more than acceptable limits (> 2000) increased in post monsoon where as permissible limits decreased. Majority of the area has within the maximum acceptable range.

Total Hardness (TH)

Calcium and magnesium mostly cause the hardness of water. The total hardness of water may be divided in to 2 types, carbonate or temporary and bi-carbonate or permanent hardness. Hardness produced by the bi-carbonates of calcium and magnesium can be virtually removed by boiling the water and is called temporary hardness. The hardness caused mainly by the sulphates and chlorates of calcium and magnesium cannot be removed by boiling and is called permanent hardness. Total hardness is the sum of the temporary and permanent hardness (Ch. Venkateswara Rao, et. al.). The maximum allowable limit of TH for drinking purpose is 300 mg/l and the maximum acceptable limit is 600 mg/l as per the BIS standard (Raihan F. et al, 2008). In pre monsoon season 20 % has permissible limit, 69 % has maximum acceptable limit and remaining 11% are not suitable for drinking. In post monsoon 14 % has permissible limit, 69 % has maximum acceptable limit and remaining 15% are not suitable for drinking. Figure 5 shows that area of more than maximum acceptable limits (> 600) are increased in post monsoon especially southern part of the study area.

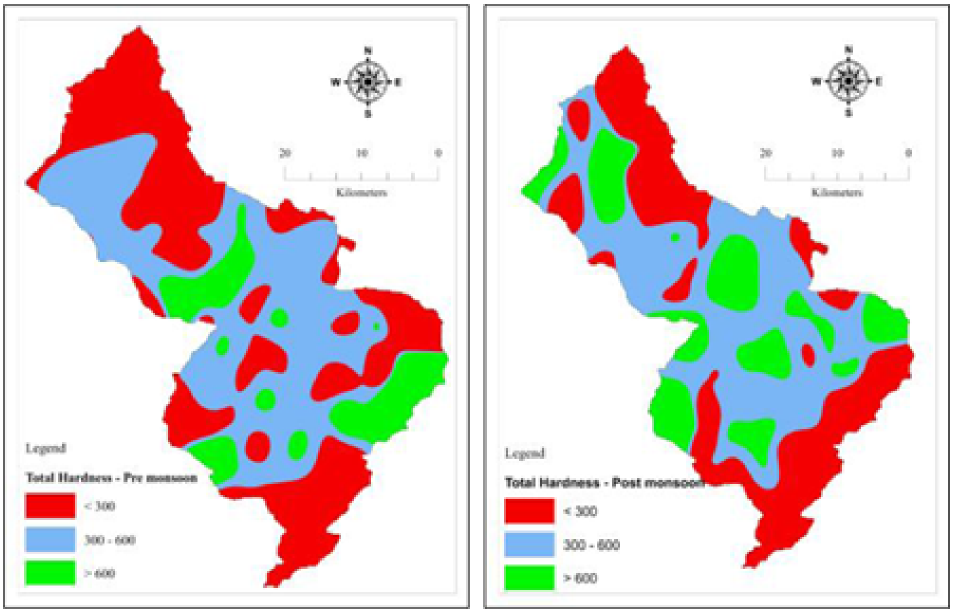

Figure 5: Spatial map of Total Hardness in Pre and post monsoon

Calcium (Ca)

Calcium is a principal cation and it is widely distributed in earth's crust and is important elements in all waters. It is mainly derived from weathering of Silicate mineral groups of Plagioclase, Pyroxene, and Amphiboles which are present in rocks. (T. Subramani et al 2005). As per the BIS standards permissible limit of Calcium in the groundwater is 75 mg/l where as maximum acceptable limit is 200 mg/l. (Tripathi C.N. et al, 2013). In the present study area in pre monsoon season 3 % of samples has acceptable limits where as in post monsoon it increases to 17 %. In pre monsoon season 51 % of samples as well as 47 % of samples in post monsoon has maximum acceptable limits. 46 % in pre monsoon as well as 36 % in post monsoon are not suitable for drinking purpose. Figure 6 shows that in post monsoon maximum acceptable limit (< 200) and permeable limits (<75) increased at all portions of the study area.

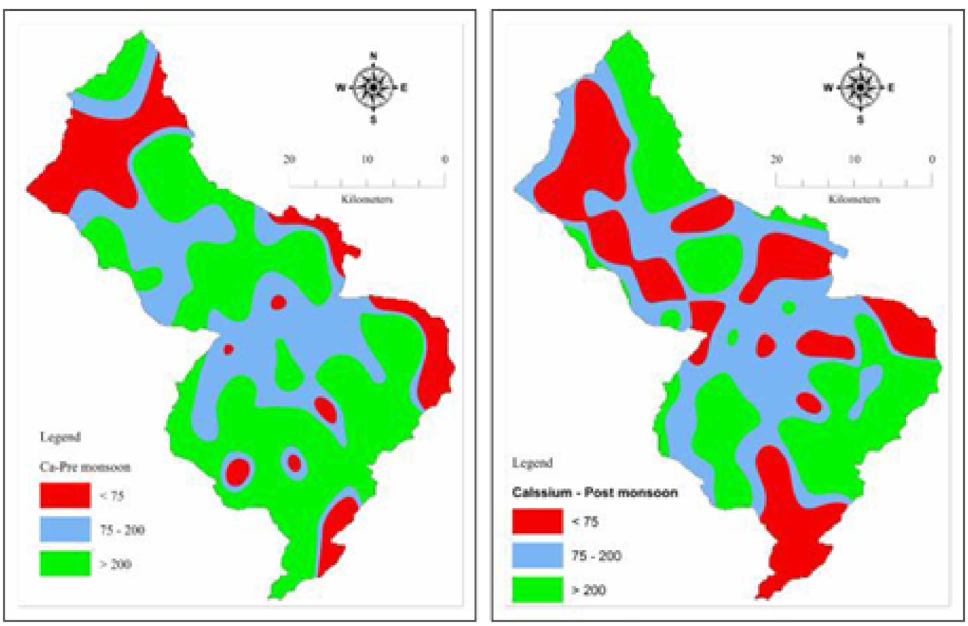

Figure 6: Spatial map of Calcium in Pre and post monsoon

Magnesium (Mg)

Magnesium is also one of the abundant elements in rocks. It causes hardness in water. The concentration of Magnesium in the groundwater is due to the weathering of the pyroxenes present in the granites of the study area. The main source for available of magnesium in ground water is chlorite, serpentine, biotite, hornblende, olivine, and augite like minerals. (Priya Kanwar et al, 2014; K. Balathandayutham et. al). As per the BIS standards permissible limit of Magnisium in the groundwater is 30 mg/l where as maximum acceptable limit is 100 mg/l. In the present study area in pre monsoon season 8 % of samples has acceptable limits where as in post monsoon it increases to 12 %. In pre monsoon season 8 % of samples as well as 17 % of samples in post monsoon has maximum acceptable limits. 84 % in pre monsoon as well as 71 % in post monsoon are not suitable for drinking purpose. Figure 7 reveals that permeable and maximum acceptable limits are increased in post monsoon at north and east of the study area.

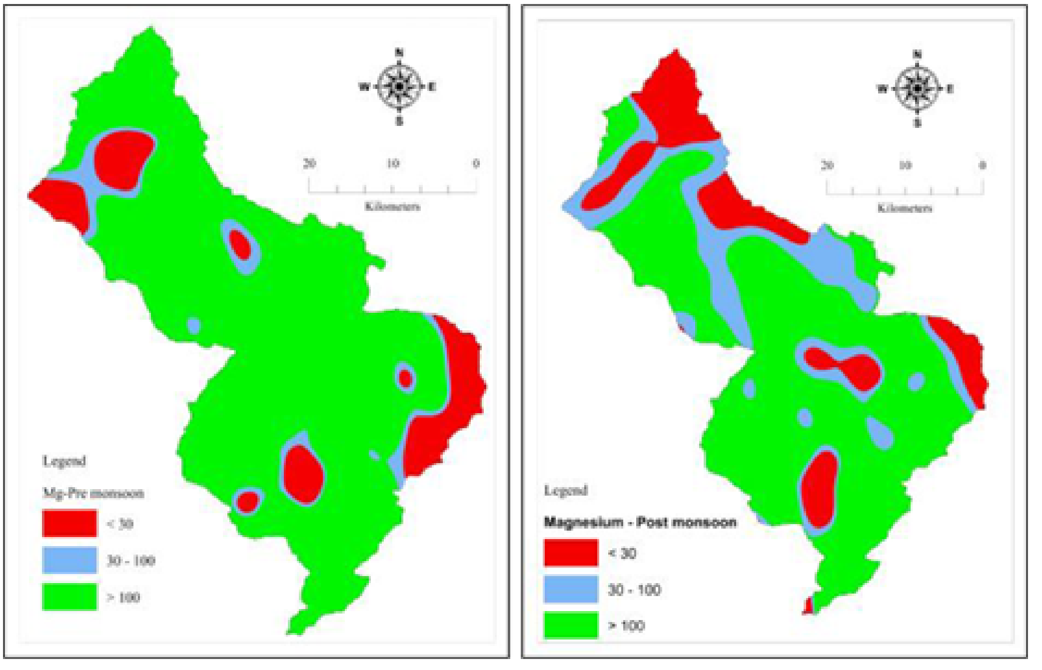

Figure 7: Spatial map of Magnesium in Pre and post monsoon

Sodium (Na)

Sodium salts (e.g., sodium chloride) are found in virtually all food (the main source of daily exposure) and drinking-water. Sodium is one of the important constituents in the determination of suitability of water for drinking purpose. The primary source of sodium in natural water is from the release of the soluble products during the weathering of plagioclase feldspars. (R. Sundaraiah et al, 2014). As per the BIS standards permissible limit of Sodium in the groundwater is 50 mg/l where as no maximum acceptable limit. In the present study area in pre monsoon season 20 % of samples has acceptable limits where as in post monsoon it decreases to 17%. 80 % in pre monsoon as well as 83 % in post monsoon are not suitable for drinking purpose. Figure 8 shows that permissible limit (<50) increased at south and decreased at north in the study area.

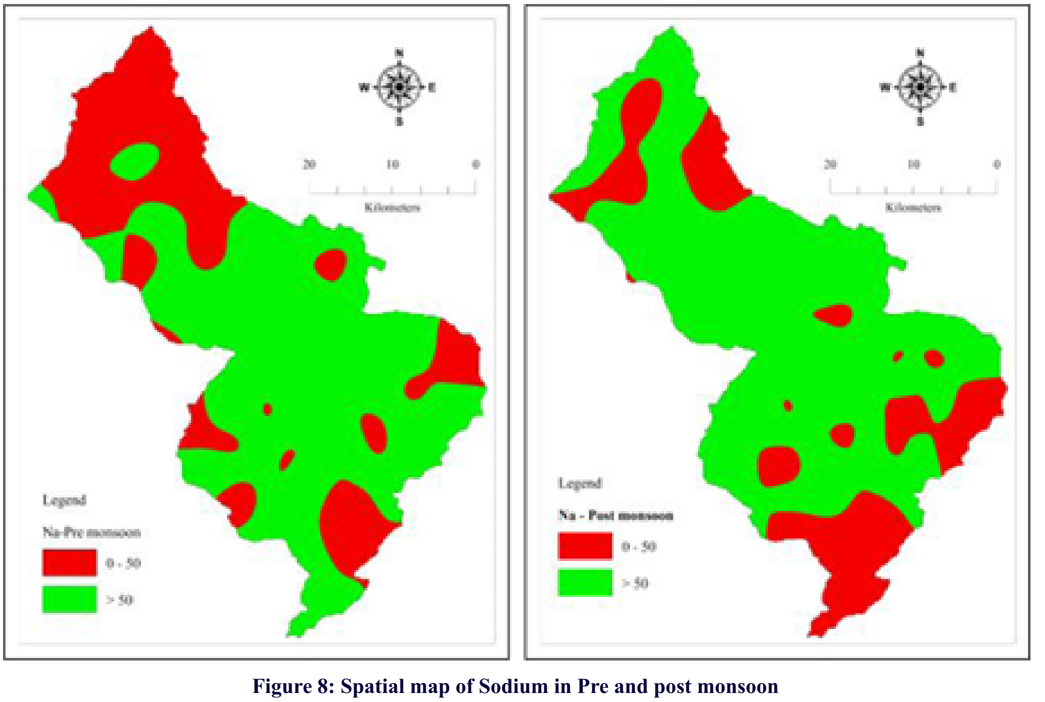

Figure 8: Spatial map of Sodium in Pre and post monsoon

Potassium (K)

Potassium occurs at fairly low concentrations in groundwater. However, excessive fertilizer usage can increase the Potassium concentration in surface as well as groundwater. The WHO limit for Potassium is 10 mg/l. Source of potassium in the groundwater is due to weathering of orthoclase, microcline feldspars and biotite minerals present in granites and the important factor of potassium is its involvement in the biosphere especially in soil and vegetation. (R. Sundaraiah et al, 2013). As per the BIS standards permissible limit of potassium in the groundwater is 10 mg/l where as no maximum acceptable limit. In the present study area in pre monsoon season 11 % of samples has acceptable limits where as in post monsoon it increases to 23%. 89 % in pre monsoon as well as 76 % in post monsoon are not suitable for drinking purpose.

Iron (Fe)

As per the BIS standards permissible limit of potassium in the groundwater is 0.3 mg/l where as maximum acceptable limit is 1 mg/l. In the present study area in pre monsoon season 82 % of samples has acceptable limits where as in post monsoon it decreases to 78%. In pre monsoon 15 % and in post monsoon 21 % samples have maximum acceptable limits. 3 % in pre monsoon as well as 1 % in post monsoon are not suitable for drinking purpose.

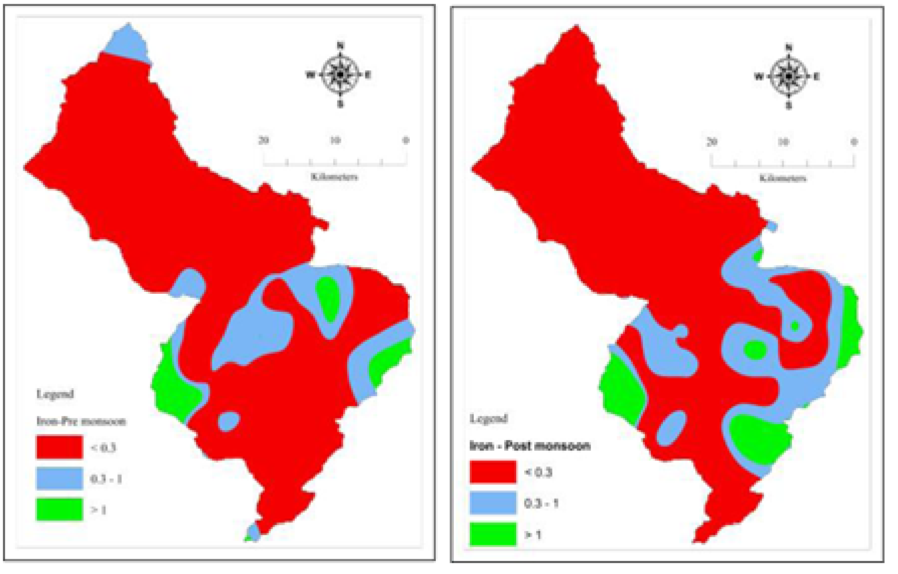

Figure 9: Spatial map of Iron in Pre and post monsoon

Figure 9 reveals that more than maximum acceptable limits (>1) increased in southern part of the study area.

Carbonates (CO3) and Bicarbonates (HCO3)

These two anions are predominant in groundwater and contribute to all the alkalinity or acid neutralizing power of water. The primary source of Carbonates and bicarbonates in groundwater is the dissolved carbon dioxide in rain (snow). (Umamaheswara Rao B et al, 2015). Bicarbonate usually the primary anion in groundwater is derived from the carbon dioxide released by the organic decomposition in the soil (Todd, 1980). It is also well known fact that nature and concentration of dissolved constituents in natural water are affected generally by Climate of the area, nature of the soil, nature of the rocks, topographical slope. Based on climatic factor, Handa (1968) has classified water as Bicarbonate, Sulphate, Chloride types. The main source of CO3, HCO3 ions is the dissolved carbon dioxide in rain water and dissolved CO2 passes through the soil and rocks and it dissolves the carbonate minerals to bicarbonates. Carbonate and bicarbonate ions have the power of neutralization of alkalinity. As per the BIS standards permissible limit of Carbonates in the groundwater is 75 mg/l where as maximum acceptable limit is 200 mg/l. In the present study area 100 % of samples have more than maximum acceptable limits where as in post monsoon 89 % of samples has permissible limits and 9 % of samples has maximum acceptable limits and remaining 1 % has beyond limits. Regarding Bi-Carbonates in pre and post monsoon seasons all samples are beyond limits. Figure 10 reveals that in post monsoon maximum acceptable limits identified at central north of the study area.

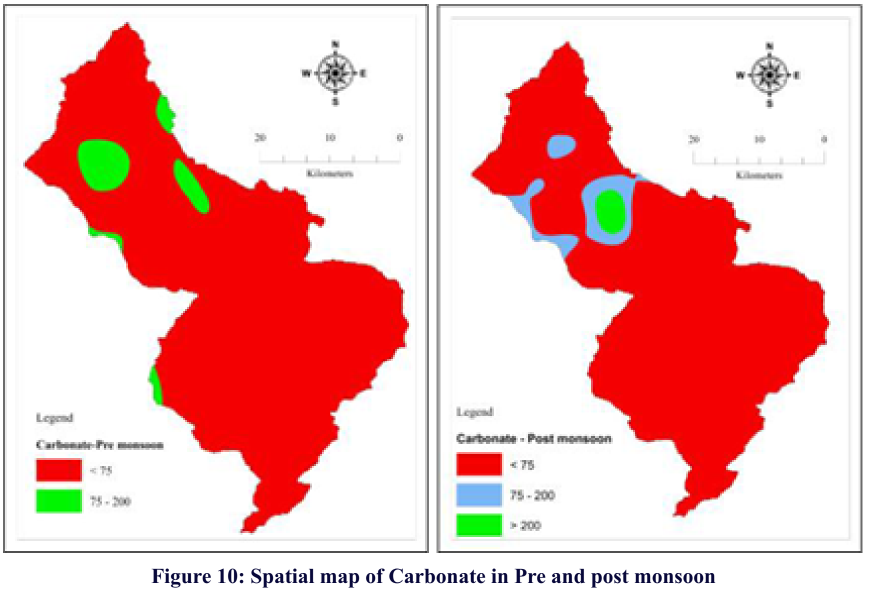

Figure 10: Spatial map of Carbonate in Pre and post monsoon

Figure 11 reveals that in the study area in pre monsoon permissible limits concentrated at extreme north, extreme east, south east and south tip where as in post monsoon it has been concentrated at extreme south east and central south.

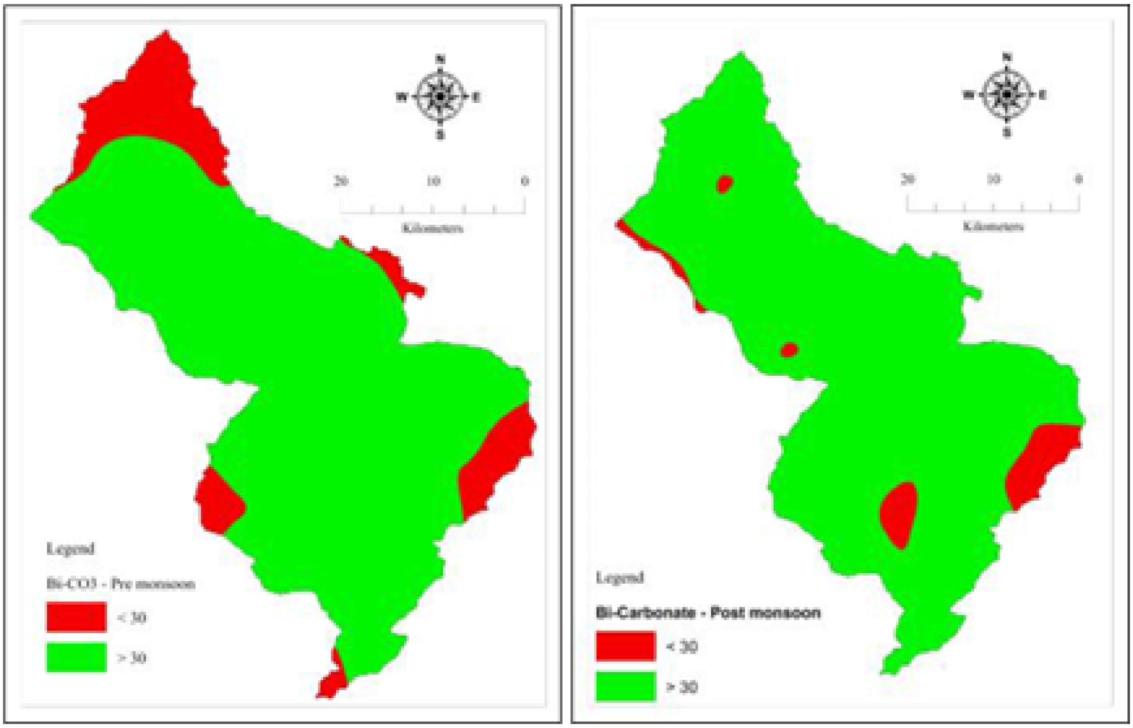

Figure 11: Spatial map of Bi-Carbonate in Pre and post monsoon

Chlorides (Cl)

Chloride is minor constituent of the earth's crust. Rain water contains less than 1 ppm Chloride. Chloride in drinking water originates from natural sources, sewage and industrial effluents, urban runoff containing de-icing salt, and saline intrusion (WHO, 1993). Its concentration in natural water is commonly less than 100mg/L unless the water is brackish or saline (Fetter, 1999). High concentration of chloride gives a salty taste to water and beverages and may cause physiological damages. Water with high chloride content usually has an unpleasant taste and may be objectionable for some agricultural purposes. (S.M. Shah et al 2013). As per the BIS standards permissible limit of Chloride in the groundwater is 250 mg/l where as maximum acceptable limit is 1000 mg/l. In the present study area in pre monsoon season 70 % of samples has acceptable limits where as in post monsoon it decreases to 60%. In pre monsoon season 23 % and 40 % has maximum acceptable limits. 7 % in pre monsoon are not beyond the limits. Figure 12 shows that maximum permissible area increased in post monsoon at all parts of the study area.

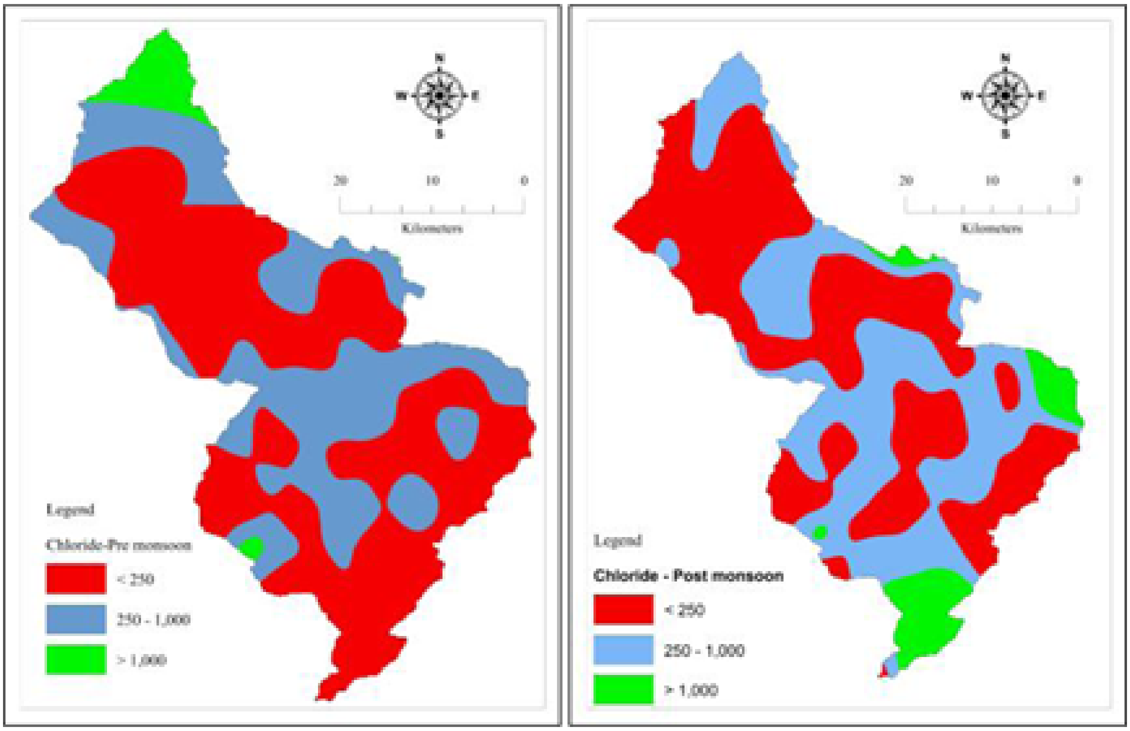

Figure 12: Spatial map of Chloride in Pre and post monsoon

Sulphates (So4)

Sulphates occur naturally in numerous minerals and are used commercially, principally in the chemical industry. They are discharged into water in industrial wastes and through atmospheric deposition; however, the highest levels usually occur in groundwater and are from natural sources. Sulphates occur naturally in water as a result of leaching from surrounding rock. The main source of Sulphates in rocks is as Sulfur minerals which are common in igneous and metamorphic rocks. (S.K.Nag et al, 2014). As per the BIS standards permissible limit of sulphates in the groundwater is 200 mg/l where as maximum acceptable limit is 400 mg/l. In the present study area in pre monsoon season 98 % of samples has acceptable limits where as in post monsoon it increases to 100%. In pre monsoon season 2 % samples has maximum acceptable limits. Figure 5.13 reveals that more than acceptable limits observed at south east and north east of the study area in post monsoon.

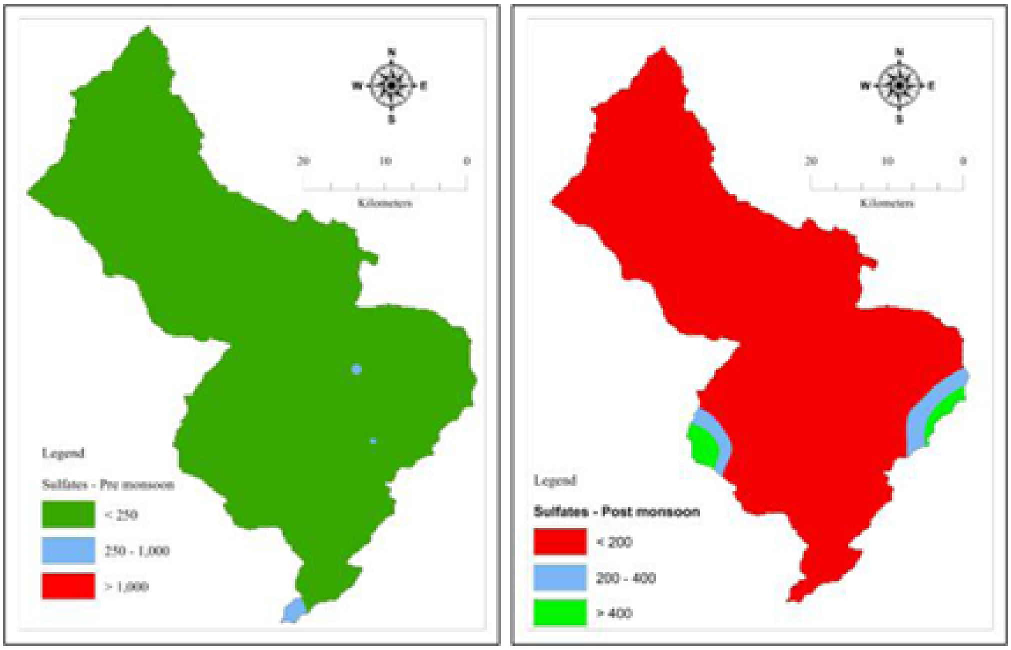

Figure 13: Spatial map of Sulpahtes in Pre and post monsoona

Nitrate (No3)

The main source of nitrate in water is from atmosphere, legumes, plant debris and animal excreta (WHO, 1993). During recent years, the problem of groundwater contamination by nitrates has been studied thoroughly all over the world (Hudak, 1999, 2000; Vinten; Levallois et al., 1998; Nas and Berktay, 2006; Fytianos and Christophoridis, 2004). The concentration in natural water is less than 10 mg/L. Water containing more than 100 mg/L is bitter to taste and causes physiological distress. Evaporation and eventually reaches the groundwater. Nitrate in groundwater generally originates from sewage effluents, septic tanks and natural drains carrying municipal wastes. As per BIS (ISI, 1993) stands permissible limit of Nitrate concentration in drinking water is specified as 45mg/l. In the present study area in pre monsoon season 98 % of samples has acceptable limits where as in post monsoon it increases to 100%. In pre monsoon season 2 % samples has beyond acceptable limits. Figure 5.14 shows that in pre monsoon maximum acceptable limits noticed at central part where as in post monsoon entire study area has maximum acceptable limits except south east of the study area.

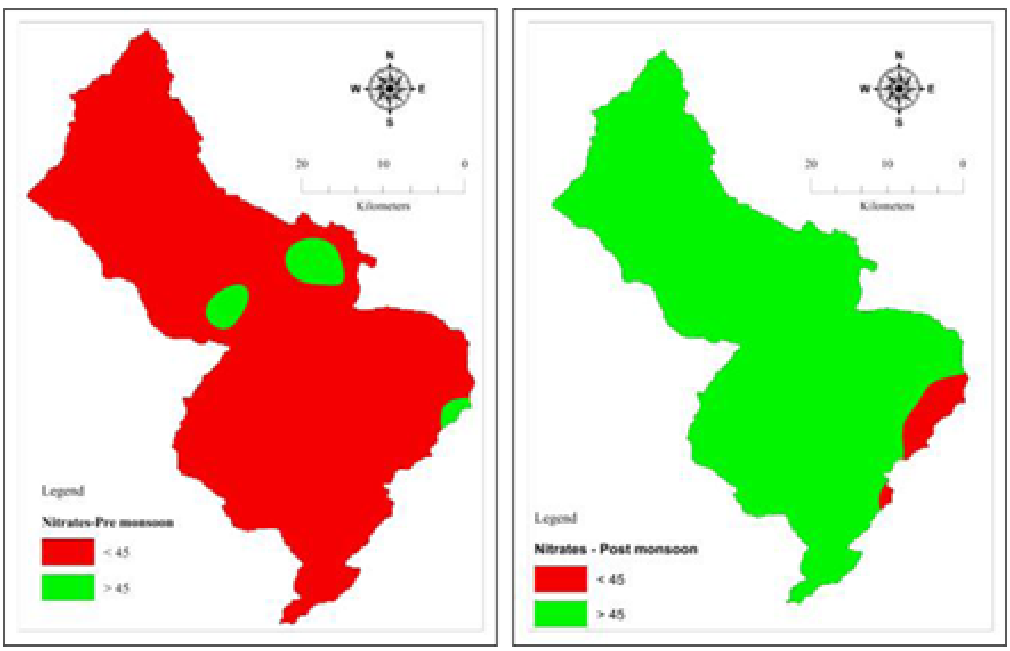

Figure14: Spatial map of Nitrates in Pre and post monsoon

Fluoride (F)

Fluoride is a common element in the earth's crust and is present in groundwater naturally from trace concentrations to 5 mg/l. Fluoride belongs to halogen group, but is quite different from other elements in its geochemistry. This compound has a low solubility, and is mainly derived from dissolution of fluorine bearing minerals in rocks (Handa, 1975 and Rama Rao, 1982). The concentration of Fluoride in groundwater is limited due to the low solubility of fluorite minerals. According to UNESCO specifications, water containing more than 1.5 mg/l of Fluoride can cause mottled tooth enamel in children and also the excess of Fluoride may give rise to skeletal damages resulting in fluorosis. A recent study by the Fluorosis vimochana vedika (FVV) a non government organization (NGO) revealed that severe stages of fluorosis resulting in skeletal deformities could be delayed for decades if people's diet is rich in Calcium, Magnesium and Vitamin C (The Hindu, 2006). The main contribution of fluorine in igneous rock is from fluorite and fluoroapatite apart from topaz, amphibole and micas. In sedimentary rocks, it is related to fluoroapatite while some amount is absorbed by the clay minerals (Udas and Krishna Murthy, 1967). In Andhra Pradesh the occurrence of fluorosis was reported in 1937 in some areas of Podili, Darsi, Kanigiri and Markapur taluks of Prakasam district (Pandit et al, 1940), and Nalgonda district of Telangana State. As per the BIS standards permissible limit of fluorides in the groundwater is 1 mg/l where as maximum acceptable limit is 1.5 mg/l. In the present study area in pre monsoon season 34 % of samples has acceptable limits where as in post monsoon it increases to 36%. In pre monsoon 51 % of samples has maximum accepted limit where as in post monsoon it has increased to 62 %. 15 % and 2 % in pre and post monsoon seasons respectively has beyond these limits.

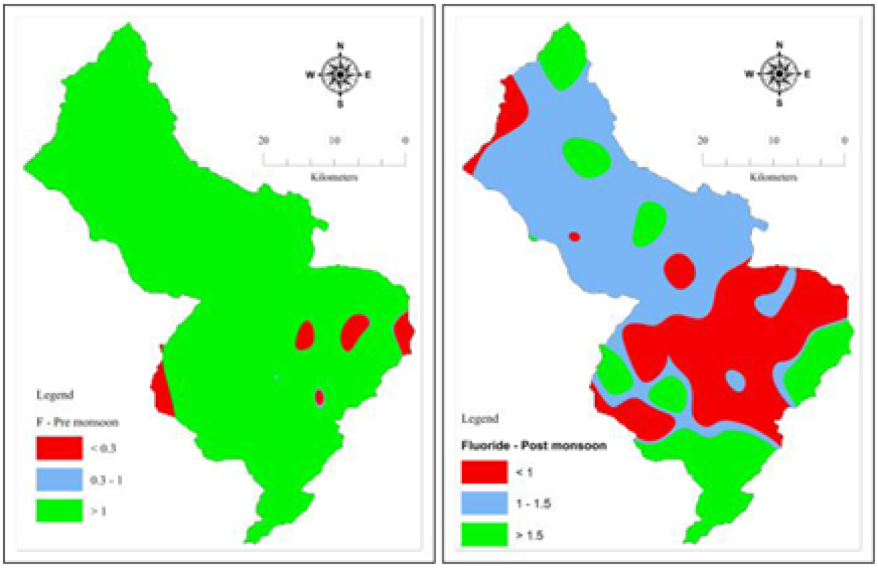

Figure 15: Spatial map of Fluoride in Pre and post monsoon

Figure 15 reveals that in pre monsoon groundwater in the study area has more than maximum acceptable limit (> 1) except some parts at central south. In the post monsoon area of permissible (<1) and maximum accepted limits (>1) increased entire area study area.

Chemical classification of groundwater

The tri-linear plotting method proposed by Piper (1944) is the most extensively used technique for analyzing the geochemical facies of groundwater. The Piper diagram plots the major ions as percentages of milli-equivalents in two base triangles. The total cations and the total anions are set equal to 100% and the data points in the two triangles are projected onto an adjacent grid. This plot reveals useful properties and relationships for large sample groups. The main purpose of the Piper diagram is to show clustering of data points to indicate samples that have similar compositions. (Godbole Mahendra T et al, 2010).

The Trilinear diagrams are very useful in bringing out chemical relationships among groundwater in more definite terms than the other possible plotting methods (Walton, 1970). Piper Trilinear diagrams (Piper, 1953) is one of the most useful graphs used to know the origin and source of dissolved salts for specifying the hydro geological processes that is responsible for modifying groundwater quality and help in classification of different water types. The Piper Trilinear diagram consists of three distinct fields i.e. two lower triangular fields and central diamond shaped fields. In the lower left side triangle the major cations Ca, Mg, Na, and K in epm % values are plotted. Whereas, the major anions like CO_3 + HCO_3, Cl and SO_4 in epm % are plotted on the lower right side triangle. Then the positions of the plots in two triangular fields are projected on to a quadrilateral or central diamond shaped field which is used in the determination of the groundwater types. Based on the positions of the plots in sub areas of the diamond shaped field different types of groundwater can be find out. (Vineesha Singh et al 2008).

Figures 16 give the Piper classification of groundwater for pre monsoon and figure 17 shows the post monsoon seasons. Distribution of groundwater samples in different sub divisions of the diamond shaped field of the piper diagram reveals the analogies and dissim ilarities.

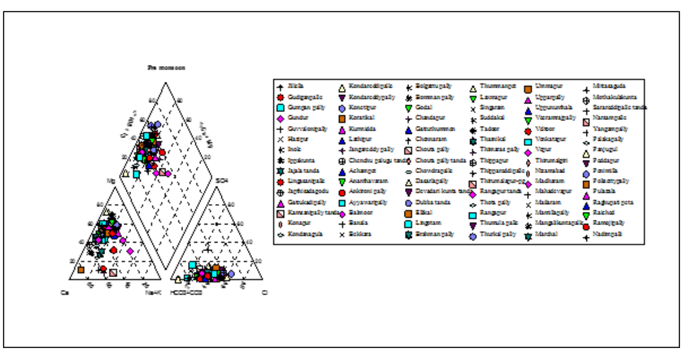

Figure 16: Piper diagram of Pre monsoon season

In the pre monsoon there is 75 % of samples are Magnesium type, 22 % are Calcium, Bi-Carbonate type are 1% and remaining 2 % area Chloride type. There are two types of groundwater facies are exits as 97 % of Calcium and Magnesium facies and 3 % Calcium + Magnesium+ Sodium+ Potassium. In the post monsoon there is 74 % of samples are Magnesium type, 17 % are Calcium, Sodium type are 4%, 2 % area Chloride type and remaining 2% are Potassium type.. There are two types of groundwater facies are exits as 91 % of Calcium and Magnesium facies and 9 % Calcium + Magnesium + Sodium+ Potassium.

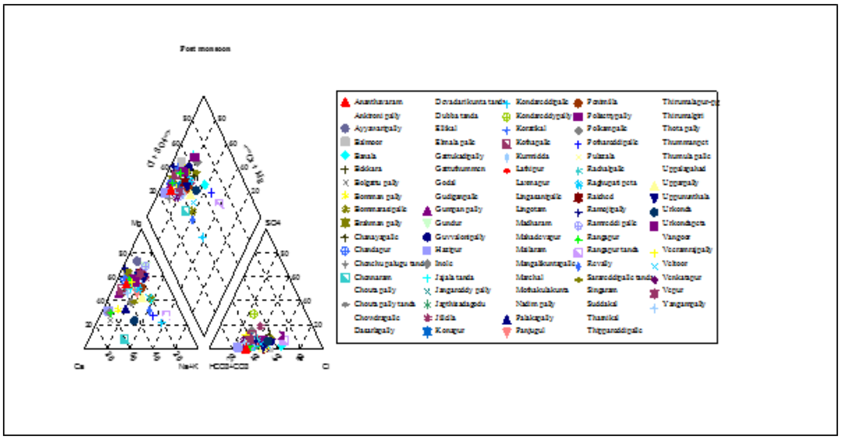

Figure 17: Piper diagram of Post monsoon season

Conclusions

In the study area in pre monsoon water samples have more than permissible limits of fluoride content which could be happened due to lowering of water levels in pre monsoon season in this area. In post monsoon some isolated portions of the northern part as well as southern part of the study area still has more than acceptable limits; therefore it can be conclude that more concentration need for construction of groundwater recharge structures at this part of the study area. Piper diagram reveals that in post monsoon increase of area of concentration of sodium and potassium due to weathering of orthoclase, microcline feldspars and biotite minerals present in granites.

REFERENCES

1. K. Balathandayutham, et al., 2016. Appraisal of irrigation water quality study in coastal aquifers of Turicorin city, Tamilnadu, India, Indian journal of Geo Marine Sciences, Vol.45 (11), pp 1522-1530.
2. Nag SK et. al., 2016. Groundwater Quality and its Suitability for Irrigation and Domestic Purposes: A Study in Rajnagar Block, Birbhum District, West Bengal, India, Journal of Earth Science & Climatic Change, Volume 7, Issue 2.
3. M.J. Islam, et, al., 2014. Hydrogeochemical quality and suitability studies of groundwater in northern Bangladesh, Journal of Environmental Biology, Vol.35, pp 765-779.
4. N. Janardhana Raju, et. al., 2009. Groundwater quality in the lower Varuna river basin, Varanasi district, Uttar pradesh, Journal Geological Society of India, vol.73, February 2009, pp.178-192.
5. J.M. Ishaku, et. al., 2011. Assessment of groundwater quality using chemical indices and GIS mapping in Jada area, Northeastern Nigeria, Journal of Earth Sciences and Geotechnical Engineering, vol. 1, no. 1, pp. 35-60
6. Shreya Das et. al., 2015. Deciphering groundwater quality for irrigation and domestic purposes – a case study in Suri I and II blocks, Birbhum District, West Bengal, India, Journal of Earth System Science, Indian Academy of Sciences124, No. 5, pp. 965–992.
7. Hem, J.D., 1985. Study and interpretations of the chemical characteristics of natural water. U.S. Geological Survey Water Supply Paper 2254, p. 263 p., U.S. Geological Survey, Alexandria, Virginia, USA. [Comprehensive review of the chemical characteristics of natural waters, including groundwater].
8. Sisir Kanti Nag et. al., 2012. Hydro chemical characteristics of groundwater for domestic and irrigation purposes in Dwarakeswar sub basin area, India. American Journal of Climate change, 1, pp. 217- 230
9. Sultan Singh et. al., 2012. Groundwater Quality Analysis of Safidon and Julana Blocks of District Jind, Haryana, India, Journal of Water Resource and Protection, 4, pp. 39-47.
10. Ch. Venkateswara Rao et. al., 2009. Spatial distribution of ground water quality information at Rajahmundry and its surrounding areas – GIS approach, seminar on spatial information retrieval, analysis, reasoning and modelling.
11. Raihan F et. al., 2008. Assessment of groundwater quality in Sunamganj of Bangladesh. J.Environ. Health. Sci. Eng., 5(3), pp. 155-166
12. T. Subramani, et. al., 2005. Groundwater quality and its suitability for drinking and agricultural use in Chithar River Basin, Tamil Nadu, India, Environ Geol (2005) 47: 1099–1110.
13. Tripathi C.N. et. al., 2013. Ground Water Quality Assessment for Agricultural and Domestic Purposes in Hindustan College of Science and Technology Campus Farah Mathura, India. International Journal of Engineering Research & Technology (IJERT), 2(4).
14. Priya Kanwar et.al., 2014. Appraisal of ground water quality for irrigation in outer plains of kathua district, J&K, India. International Journal of Geology, Earth & Environmental Sciences, 4(3) pp. 74-80
15. K. Balathandayutham et. al., 2015. Assessment of Groundwater Quality using GIS: a case study of Walayar Watershed, Parambikulam-Aliyar-Palar Basin, Tamilnadu, India, Current World Environment, vol. 10(2), 602-609.
16. R. Sundaraiah et al, 2014. Groundwater Quality and Its Suitability for Drinking and Agricultural Use in Kalwakurthy Area, Mahabubnagar District, Andhra Pradesh, India, International journal of advanced scientific and technical research Issue 4 volume 1.
17. R. Sundaraiah et al, 2013. Geochemistry of groundwater in Kalwakurthy area, Mahabubnagar District of Andhra Pradesh with special reference to Fluoride distribution, Journal of applied geochemistry, vol 15, No (2), pp 238 - 249.
18. Umamaheswara Rao B et. al., 2015. Spatial and Temporal Analysis of Rainfall Variation in Yadalavagu Hydrogeological unit using GIS, Prakasam District, Andhra Pradesh, India. International Research Journal of Environment Sciences, Vol. 4(4), pp 30-35
19. Todd, D.K., 1980. Groundwater Hydrology, Second Edition, Wiley, New York. Van der Meer, P. (1978). "Calculation methods for two-dimensional ground water," Report No. 28, Rijkswaterstaat, Holland.
20. Fetter, C.W., 1999, Contaminant hydrogeology (2d ed.): Upper Saddle River, N.J., Prentice-Hall, 500 p.
21. S. M. Shah and N. J. Mistry, 2013. Groundwater Quality Assessment for Irrigation Use in Vadodara District, Gujarat, India, World Academy of Science, Engineering and Technology International Journal of Biological, Bio molecular, Agricultural, Food and Biotechnological Engineering Vol:7, No:7.
22. S.K. Nag and Shreya Das, 2014. Groundwater quality for irrigation and domestic purposes – a GIS based case study of Suri I and II blocks, Birbhum district, West Bengal, India. International Journal of Advancement in Earth and Environmental Sciences, 2(1), 25-38
23. Hudak, P. F., 1999. Chloride and nitrate distributions in the Hickory Aquifer, Central Texas, USA. Environment International, 25(4), 393–401.
24. Hudak, P. F., 2000. Regional trends in nitrate con-tent of Texas groundwater. Journal of Hydrology
25. Levallois, et al., 1998. Groundwater contamination by nitrates associated with intensive potato culture in Québec. The Science of the Total Environment, 217, 91–101.
26. Nas B., and Berktay, A., 2006. Groundwater contamination by nitrates in the City of Konya, (Turkey): A GIS perspective. Journal of Environmental Management, 79, 30–37.
27. Fytianos, K. et.al, 2004. Nitrate, arsenic and chloride pollution of drinking water in Northern Greece: Elaboration by applying GIS. Environmental Monitoring and Assessment, 93, pp. 55–67.
28. Handa B.K., 1975. Geochemistry and genesis of fluoride containing groundwater in India. Ground Water 13:275–281
29. Rama Rao N.V., 1982. Geochemical factors influencing the distribution of fluoride in rocks, soil and water sources of Nalgonda district. AP Thesis, Osmania University, Hyderabad
30. Udas. G. R. et.al., 1967. An account of a rich fluorite deposit at Hingoria, Broach District, Gujarat State. Curro Sci., v. 37, pp. 77-78.
31. Pandit C.G, et. al., 1940. Endemic fluorosis in South India. Indian J. Med. Res, 28, P. 533.
32. Godbole Mahendra T. et.al., 2015. Evaluation of Groundwater Quality and its Suitability for Drinking and Agricultural use in and around Hingoli Region, Maharashtra, India." American International Journal of Research in Humanities, Arts and Social Sciences.
33. Vineesha Singh and M.C. Khare, 2008, Groundwater quality evaluation for Irrigation purpose in some areas of Bhind, Madhya Pradesh (India), Journal of Environmental Research and Development, vol. 2 no. 3.