JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

ASSESSMENT OF GROUNDWATER QUALITY AND DRINKING AND IRRIGATION PURPOSES IN PARTS OF MALLAMPALLY AREA OF TELANGANA STATE

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Abstract

A of total-thirty three samples were collected and analyzed for major ion chemistry of the groundwater quality and its suitability for drinking as well as irrigation purposes. The pH ranges from 6.3-8.1 and 6.1-7.9 indicating the water is slightly acidic to alkaline. TDS ranges from 262-2780 mg/l and 188-2065 mg/l during pre and post monsoon season. Total Hardness (TH) ranges from 107-1065 mg/l and 113-699 mg/l; Chloride ranges from 7-699 mg/l and 8-944 mg/l; sulphate ranges from 0.4-420 mg/l and 1-170 mg/l during pre and post season respectively. The majority of the samples are suitable for domestic purposes due to low to medium hardness, however few samples are described as very hard and unsuitable for domestic, drinking and irrigation purposes. Various indices like Salinity Index, Sodium Absorption ratio (SAR), Kelly's ratio (KR), Permeability Index (PI) and Water Quality Index (WQI) are used to classify groundwater and surface water for drinking as well as irrigation purposes. Besides this, Piper, Wilcox, and Gibb's plots were studied for geochemical controls and Hydrogeochemistry of groundwater.

Keywords: Water quality Index, Piper Trilinear, Gibbs plot, Drinking and irrigation.

1.0 Introduction

Water scarcity in many areas worldwide is due to population growth and fast growing big cities often located in unfavorable places is a major concern now-a-days [1]. The drastic increases in population, modern land use applications (agricultural and industrial), and ever increasing demands for water supply resulted in deterioration of water quality and quantity. Even though urban aquifers are the only natural resource for drinking water supply, they are often perceived as of lesser relevance for the drinking water supply, leading toward crisis in terms of drinking water scarcity, becoming increasingly polluted thereby decreasing their portability [2]. Once contamination of groundwaterin aquifers occurs by means of agricultural and industrial activities and urban development, it persists for several of years because due to slow movement in the aquifer regime [3] and prompts investigations on their quality [4]. The groundwater quality is of major concern in densely populated and thickly industrialized areas which depend on shallow groundwater tube wells [5].

Groundwater occurs in fracture zones and weathering formations of granitic terrain. The maximum depth of the weathered formationis about 10-30 m, but the majority of the wells that are encountered fall in the depth range of 20-30 m. The topography characteristics are found to have extensive influence on the groundwater regime. It is found that the deeper wells are capable of sustaining daily pumping for about 7-8 hrs. The position of water tables is not only influenced by the rainfall, but also controlled by topography, geology, structures and hydrogeological conditions. The groundwater resources can be replenished and improve water quality through drainage pattern, construction of percolation tanks, judicious land management and crop pattern [6]. Desirable results of water/soil analysis may further indicate the quality of water.

The objective of the study is to assess the groundwater and surface water quality from parts of Mallampally area of Mulugu mandal, Warangal district of Telangana State for safe drinking and irrigation purposes. A better understanding of water chemistry in the study area is important for evaluating the contamination process more precisely. This study uses a multifarious approach to understand the mechanism responsible for the spatial and temporal distribution of groundwater and surface water throughout the watershed composed of different geological units (granitic/gneiss and sedimentary rock).

2. Study area

The study area covered in parts of Mallampally area of Mulugu mandal, Warangal district. The present study area falls under toposheet No. 56 N/16 of Survey of India covering an extent of 100 km^2 (**Fig. 1**). The area under investigation falls in the semi-arid zone. The temperature gradually rises from the month of February and reaches a maximum in the month of May. It gradually decreases form June to December. May is the hottest month with a temperature range from 28°C to 40°C, and it varies from 10 to 12°C during winter. Rainfall occurs between June and October during the onset of the southwest monsoon. The normal annual average rainfall of the district is 668 mm**.**

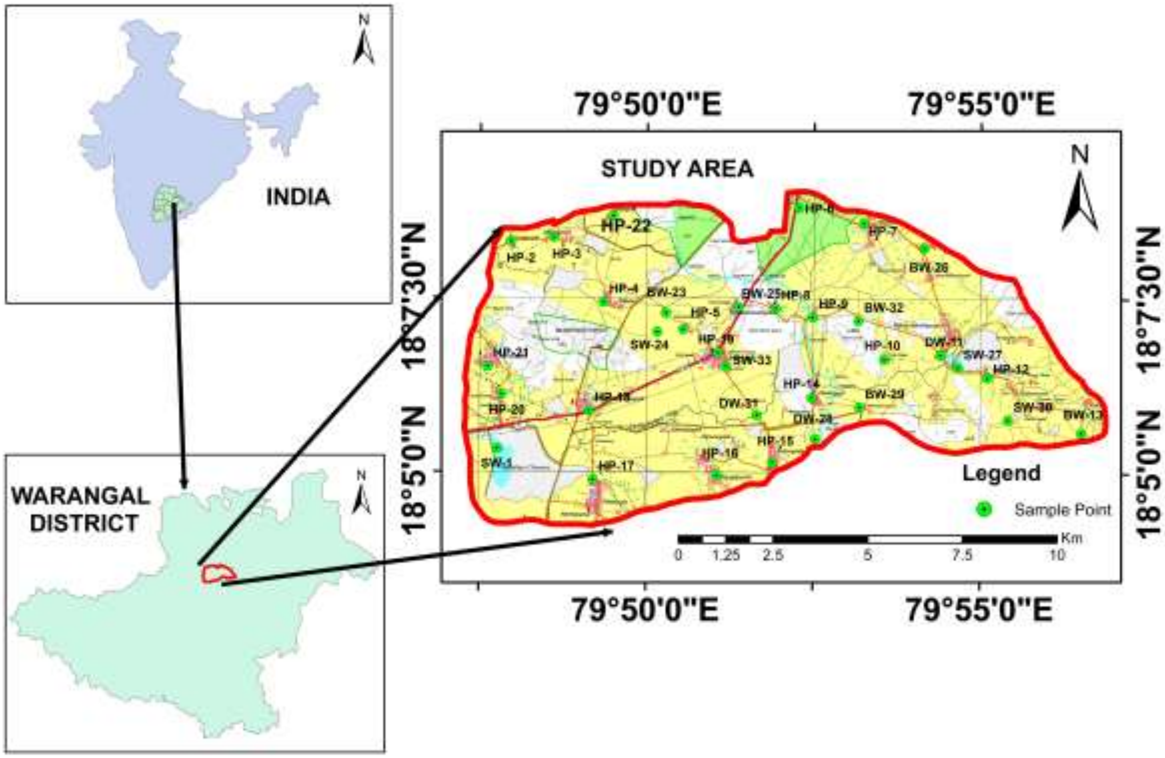

Fig. 1: Study area with water sample locations

3. Geology and hydrology of the study area

The drainage of the study area is of dendritic pattern controlled by undulatory topography. The investigated area falls under part of the stable Southern Indian shield consisting of Peninsular Gneissic Complex (PGC), Pakal group, Mulugu subgroup. Mulugu subgroup occupies a major part of the study area and comprises of Arkose, shale with dolomite quartzite, shale, quartzite, Limestone, sandstone, gneisses, granite and dolorite dykes. In the study area Archaean peninsular gneissic complex are unconformably overlain by sedimentary rocks of Middle Proterozoic age, consisting the Pakal group of rocks [7] (**Fig. 2**).

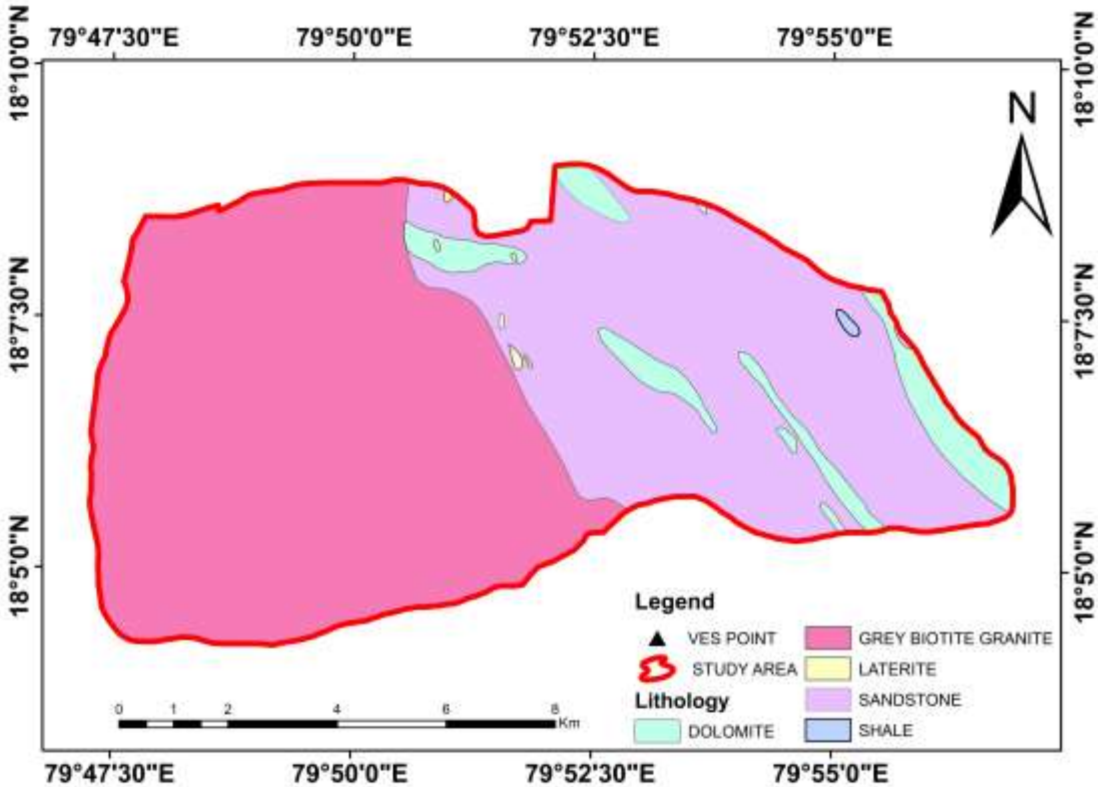

Fig. 2.1 Geological map of the study area

4. Materials and Methods

The methods of collection of samples play an important role in maintaining a high degree of accuracy of analytical data and its application to hydrochemical studies. Groundwater samples were collected in pre-cleaned polyethylene bottles from the tanks (surface water), dug wells, hand pump and bore wells in the pre and post-monsoon periods as per the standard procedures [8]. The water samples were analyzed at Centre for Materials for Electronics Technology (C-MET) Laboratory, Hyderabad. The pre and post-monsoon were studied for various physic-chemical parameters which include pH, EC, TDS, TH, cations such as Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and anions Cl^{-} , SO_4^{2-}, F^{-} , NO_3^{-} , CO_3^{-} and HCO_3^{-}. The analytical data of groundwater samples are presented in **Table 1**.

Table 1 Chemical parameters of groundwater samples in pre and post-monsoon

Variables	Pre-monsoon season					Post-monsoon season				WHO, 2011
	Minimum	Maximum	Mean	% of samples exceeded the limits		Minimum	Maximum	Mean	% of samples exceeded the limits	
pH	6.30	8.10	7.08	-		6.10	7.90	6.90	-	**6.5 - 8.5**
EC (µS/cm)	409	4344	1449	33		294	3227	1128	27	**1500**
TDS (mg/l)	262	2780	927	85		188	2065	722	58	**500**

Ca^{2+} (mg/l)	24	268	81	33		19	129	54	15	**75**
Mg^{2+} (mg/l)	11	96	40	24		13	118	43	24	**50**
TH as CaCO3	107	1065	367	15		113	699	314	6	**500**
Na^{+} (mg/l)	8	358	109	24		10	437	111	21	**200**
K^{+} (mg/l)	4	22	5	6		1	37	6	15	**12**
HCO_3^{-} (mg/l)	156	551	367	9		98	388	219	-	**500**
Cl^{-} (mg/l)	7	669	175	30		8	944	201	27	**250**
NO_3^{-} (mg/l)	0.20	332	79	48		0.25	188	58	45	**45**
SO_4^{2-} (mg/l)	0.40	420	65	6		1	170	28	-	**250**
F^{-} (mg/l)	0.10	3.10	1.01	24		0.14	2.12	0.61	6	**1.5**
SAR (meq/l)	0.49	6.52	2.24	-		1.30	8.64	4.16	-	**-**
KR (meq/l)	0.06	2.21	0.66	-		0.08	2.84	0.71	-	**-**
PI (meq/l)	33	87	61	-		31	94	59	-	**-**
Gibbs I (meq/l)	0.03	0.87	0.61	-		0.05	0.93	0.44	-	**-**
Gibbs II (meq/l)	0.10	0.85	0.47	-		0.13	0.89	0.50	-	**-**

NOTE: Min-Minimum, Max-Maximum, Mean

5. Results and Discussion

Drinking water purposes the quality of groundwater of the study area was assessed as per standard specification given by BIS [9] and World Health Organization [10].

5.1 Hydrogen ion concentration (pH)

The pH of the water samples in the study area varies from 6.30 to 8.10 and 6.10 to 7.90 with a mean value of 7.08 and 6.90 during pre and post-monsoon seasons respectively (**Table 1**). The pH is acidic to alkaline. The desirable range of pH in drinking water is 6.5-8.5 [9]. The spatial distribution of pH of water samples in the area does not show any significant variation during pre and post-monsoon seasons.

5.2 Total Dissolved Solids (TDS)

The groundwater of pre-monsoon season has high TDS values (from 262 to 2780 versus 188 to 2065 mg/l) than in post-monsoon season. The average TDS of pre-monsoon samples is 927 mg/l, while it is 722 mg/l for post-monsoon samples (**Table 1**). The temporal variation of TDS of groundwater samples is displayed in concentration maps for the pre and post-monsoon seasons.

5.3 Calcium (Ca^{2+})

Ca^{2+} in groundwater for pre and post-monsoon seasons varies from 24 to 268 mg/l and 19 to 129 mg/l, respectively. The average amount of calcium present in water samples of the pre-monsoon season is 81 mg/l and in post-monsoon season 54 mg/l (**Table 1**). It seems that the average values of Ca^{2+} are within the permissible limits as per WHO [10] standard value of 200 mg/l. The high concentration of calcium is predominance of gneissic rock containing feldspars, pyroxene and amphiboles, accessory minerals such as apatite, hornblende and fluorite.

5.4 Magnesium (Mg^{2+})

The concentration of Mg^{2+} in groundwater ranges from 11 to 96 mg/l with a mean of 40 mg/l during the pre-monsoon season and post-monsoon season varies from 13 to 118 mg/l with a mean of 43 mg/l respectively (**Table 1**). All the analyzed water samples are suitable for drinking purposes, since the values of Mg^{2+} are above the permissible limits (<150 mg/l) as per the standards [10]. Sources of Magnesium in the groundwater are mainly derived from the process of ion exchange of minerals in rocks and soils by water [6].

5.5 Chloride (Cl^-)

Chloride concentrations in the study area have a wide range from 7 to 669 mg/l and 8 to 944 mg/l in the groundwater samples during the pre and post-monsoon periods (**Table 1**). The Cl^- ions are compatible with Na^+ cation in most of the groundwater samples collected from wells due to geochemical coherence between Cl^- and Na^+. Both ions are controlled by extensive and intensive weathering of granite and gneisses that contain a lot of plagioclase, alkali amphiboles, micas apatite and fluorite minerals. Few wells have Cl^- concentration exceeding the desirable limits (250 mg/l) as per WHO [10] rendering unsuitable for drinking, but can be used for irrigation and domestic purposes.

5.6 Sulfate (SO_4^{2-})

SO_4^{2-} concentration is possibly contributed by the type of precipitation and excess use of fertilizers in paddy cultivation. The sulfate in the groundwater during the pre- monsoon season varies from 0.4 to 420 mg/l with a mean of 79 mg/l and in the post-monsoon season from 0.25 to 188 mg/l with a mean of 58 mg/l (**Table 1**). The maximum permissible limit SO_4^{2-} was 250 mg/l.

5.7 Water quality criteria for irrigation

Water quality for irrigation refers to its suitability for agricultural use. The estimation of concentration and composition of dissolved constituents in water plays important role in ascertaining its quality for irrigation. Quality of water is an important consideration in any appraisal of salinity or alkalinity conditions in an irrigated area. The suitability of groundwater for irrigation is evaluated by Salinity index (EC), Sodium Absorption Ratio (SAR), Kelly's Ratio (KR), Permeability Index (PI) and Water Quality Index (WQI) (**Table 2**).

Table 2 Classification of drinking water quality and % of samples falling in various categories

Category	Range	Pre-monsoon (%)	Post-monsoon (%)
Based on TDS (mg/L)			
Fresh water	0 – 1,000	70	76
Brackish water	1,000 – 10,000	30	24
Saline water	10,000 – 1,00,000	00	00
Brine	>1,00,000	00	00
Sodium Adsorption Ratio (Wilcox, 1955)	Range	Pre-monsoon (%)	Post-monsoon (%)
Excellent	<10	100	100
Good	10-18	Nil	Nil
Doubtful	18-26	Nil	Nil
Unsuitable	>26	Nil	Nil
Kelley's Ratio (Kelley 1951)	Range	Pre-monsoon (%)	Post-monsoon (%)
Suitable	<1	82	76
Marginal	1-2	12	18
Unsuitable	>2	6	6

5.7.1 Classification of salinity (EC) in groundwater:

The electrical conductivity (EC) of the groundwater in the study area varies from 409 to 4344 µS/cm and 294-3227 µS/cm in pre and post-monsoon, respectively (**Table 1**). Based on the EC, the groundwater of study area has been classified into four classes [11]. Accordingly these classes C2S1 15% and 46%, C3S2 9% and 12%, C4S2 12% and 6% C3S1 64% and 36% in pre- and post-monsoon seasons respectively based on the classes medium, high, very high salinity hazards to low, medium sodium hazards in the study area (**Fig. 3**).

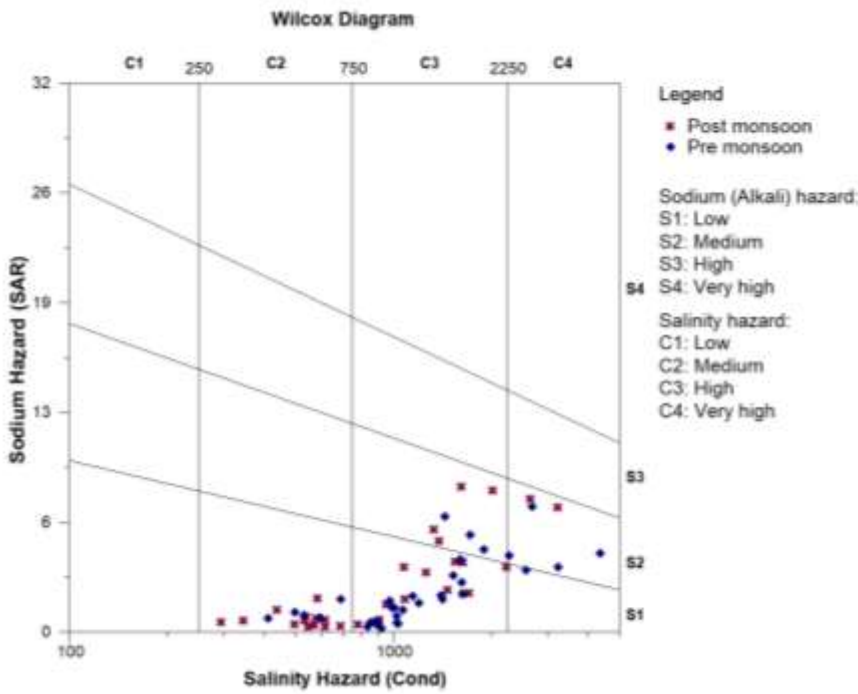

Fig. 3: USSL classification of groundwater in pre-monsoon and post-monsoon

5.7.2 Sodium Adsorption Ratio (SAR)

Sodium adsorption ratio which depends on calcium and magnesium is in the proper proportion with sodium, it is the suitable yield of soil condition.

$$SAR = \frac{Na^{+}}{\sqrt{\frac{Ca^{+2} + Mg^{+2}}{2}}}$$

Within the study region, sodium adsorption ratio ranges from 0.49 to 6.52 meq/L with a mean of 2.24 mg/L and 1.30 to 8.64 meq/L with a mean of 4.16 mg/L in both monsoon seasons (**Table 1**). As per the sodium adsorption ratio of the study region all groundwater samples are excellent categories, which accumulates that no risk of the soluble base is expected to the irrigation [12] (**Table 2**).

5.7.3 Kelley's Ratio (KR)

The Na^{+} estimated Ca^{+2} and Mg^{+2} is known as Kelly's proportion, because of which the supply of water to land can be evaluated [13]. The concentration of Na^{+} in the supply of water to land water is viewed as one of the major reasons that make roles in making water unsatisfactory. In Kelly's proportion is <1 suitable, negligible is 1-2 and unacceptable is >2.

$$KR = \frac{Na^{+}}{Ca^{+2} + Mg^{+2}}$$

The Kelly ratio esteem extends from 0.06 to 2.21 meq/L and 0.08 to 2.84 meq/L with averages of 0.66 meq/L and 0.71 meq/L (**Table 1**), around 82% and 76%, 12% and 18%, 6% samples are suitable, moderate and unacceptable categories in both seasons for irrigation purposes (**Table 2**).

5.7.4 Permeability Index (PI)

The PI esteems additionally delineate the reasonableness of groundwater for the supply of water to land purposes, subsequently; long-standing utilization of water system can influence the dirt penetrability. The Permeability Index communicated in an accompanying manner:

$$PI = \frac{(Na^{+} + K^{+})}{(Ca^{+2} + Mg^{+2} + Na^{+} + K^{+})} x100$$

The absorptions are accounted in meq/l. The standard for surveying the reasonableness of water for the supply of water to land depends on PI, where irrigation purposes which are denoted classes I, II, and III [14]. The PI levels ranges from 33 to 87 meq/L and 31 to 94 meq/L with a mean of 61 meq/L and 59 meq/L (**Table 1**). As per the arrangement, PI regards for both monsoons are almost 2%, 83%, 15%, and 21%, 64%, 15% groundwater samples drop in the period I, II and III classes (**Fig. 4**).

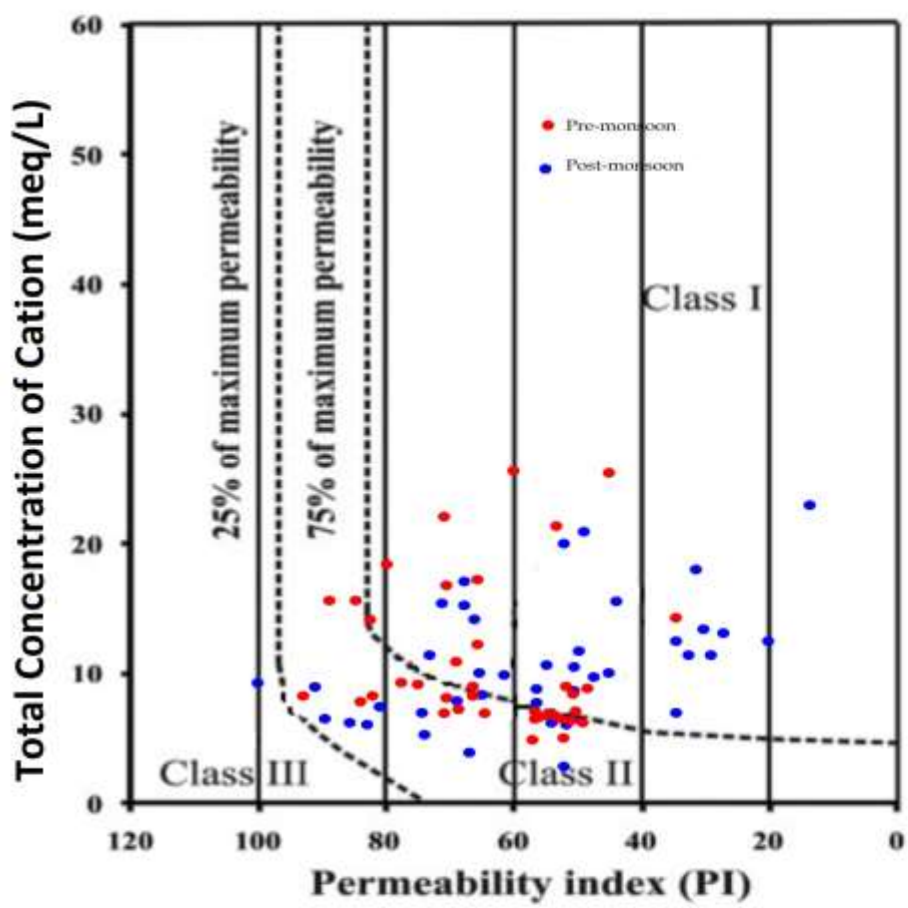

Fig. 4 Irrigation Water based on the Permeability index in pre and post-monsoon seasons

5.8 Water Quality Index (WQI)

The water quality index on groundwater suitability for drinking water specification on each variable was calculated. The major ions of groundwater of the study region such as major ions (cations and anions) pH, TDS, and F^- were given to the assigned high significance. The hydrochemical appraisal on groundwater quality is main purpose of impact on human health [15]. The study region on the WQI was estimated for each sample with below formulae.

$$W_i = \frac{w_i}{\sum_{n=1}^{n} w_i}$$

As per formulae, the relative weight is W_i; the assigned weight is w_i and rating of water quality (q_i) on variables for drinking water is Sahu and Sikdar [15].

$$q_i + \frac{C_i}{S_i} x100$$

Where, q_i is referred to as the water qualitative C_i is the attentiveness of each chemical variable in each sample mg/L, and S_i as per the recommended standard of the WHO [10]. Calculated the WQI, the SI is first determined for each chemical variable, which is then used to determine the WQI as per the following eq.

$$SI_i = q_i x W_i$$

Finally, WQI was calculated by the summation of the sub index values of all the chemical parameters using following equation.

$$WQI = \sum_{i=1}^{n} SI_i$$

In deciding the overall water quality of the region which is assigned due to weights, relative weights and respective drinking water specifications presented in **Table 3.**

In the pre-season around eighteen samples are fabulous with WQI values extending from 26 to 48; ten groundwater samples had good quality (54 to 90) ranges, five samples had poor water quality ranges from 105-157 (**Table 4**). In post-monsoon nine groundwater samples are fabulous with WQI values extending from 21 to 44; twenty two groundwater samples had good quality ranges from 53 to 97 and two samples had poor water quality ranges from 107-145 (**Table 4**).

5.9 Hydrogeochemical processes of groundwater

The Piper chart comprises cation, anion triangular areas and a central diamond-shaped field [16]. Three areas safe the joining of major practices as it were, which are cations like alkaline earth, alkalis, weak acid, and strong acid [17]. The Hydrochemical facies for groundwater of the study region are mixed CaHCO3, mixed CaMgCl and NaCl are the dominating water type in pre and post-monsoon seasons (**Fig. 5**). The piper trilinear diagram appears the groundwater samples are predominant of calcium, magnesium, sodium, bicarbonate and chloride rich minerals in the study region.

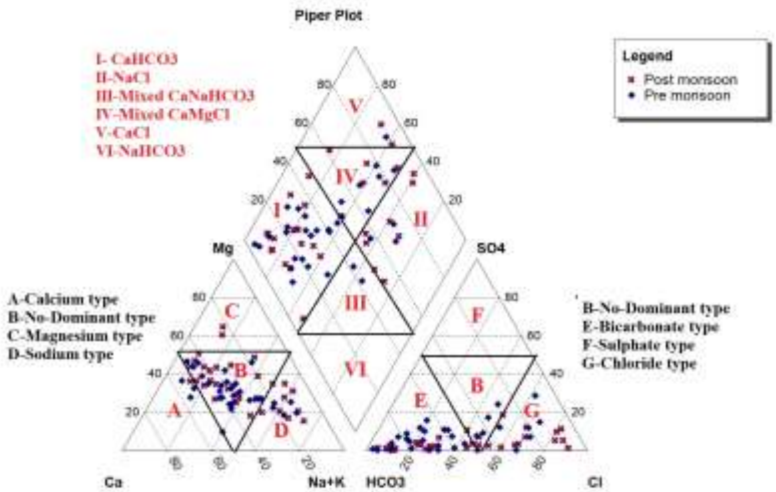

Fig. 5 Hydrochemical facies of groundwater in pre and post-monsoon seasons

5.10 Gibbs diagram

The component of water-rock collaboration controlling the groundwater chemistry can be concentrated by plotting TDS vs. $Na^+/(Na^++Cl^-)$ and TDS vs. $Cl^-/(Cl^-+HCO_3^-)$ using Gibbs diagram [18].

The gibbs classier into three categories precipitation, rock, and evaporation dominances. Gibbs chart has been broadly utilized in various investigations everywhere throughout the globe to distinguish the major systems of water chemistry [19].

Gibbs ratio I (Anion) = $Cl^-/(Cl^- +HCO_3^-)$

Gibbs ratio II (Cation) = $(Na^+ + K^+)/(Na^+ + K^+ + Ca^{+2})$

Gibbs ratio I of the region in pre and post monsoons and average ranges 0.03 to 0.87 with a mean of 0.38 meq/L and 0.05 to 0.93, with a mean of 0.44 meq/L (**Table 1**). Gibbs ratio II for the study region extend in pre & post monsoons with an average 0.10 to 0.85, 0.47 meq/L and 0.13 to 0.89, 0.50 meq/L (**Table 1**). The Gibbs chart illustrated that the examination region is rock dominance and evaporation dominance types (**Fig. 6**). The present investigation of the groundwater chemistry is significantly affected by rock dominance, which shows that the foremost mechanism of weathering of rock-forming minerals because of the entire region is involved by granitic gneisses.

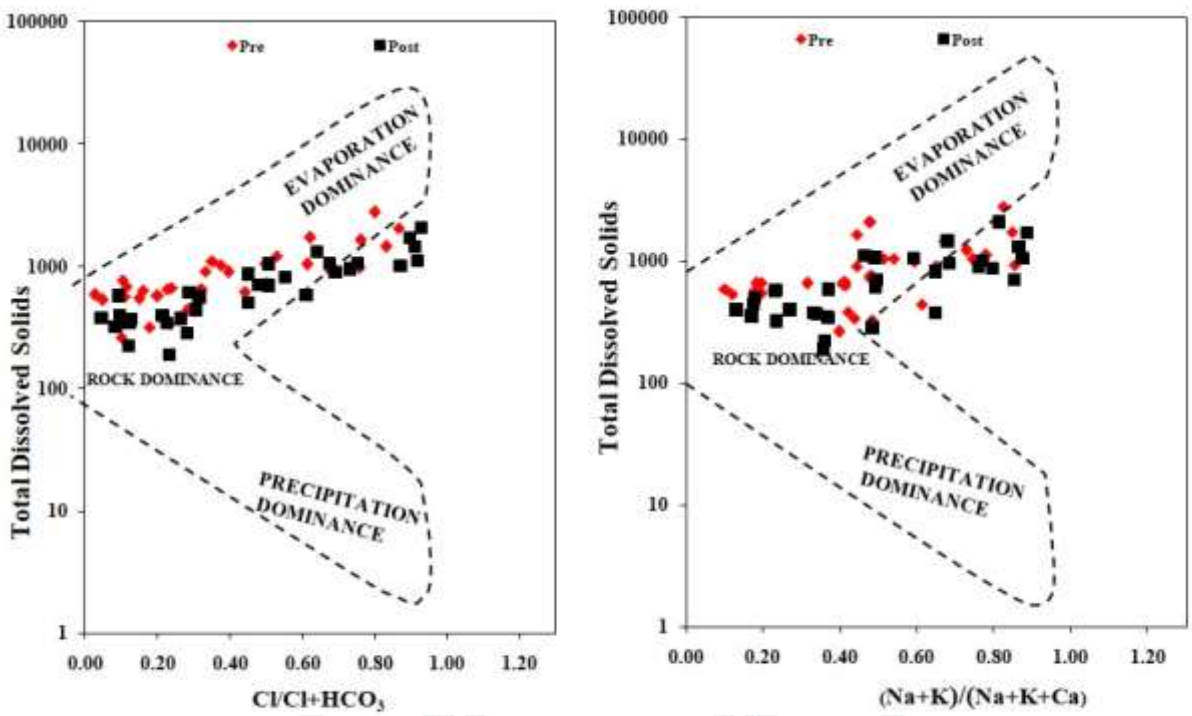

Fig. 6: Gibb's plot for the groundwater in pre and post-monsoon seasons

6. Conclusion:

The hydro chemical evaluations indicate that the groundwater pH is slightly alkaline. Hardness of water indicates that one-third of the area is unsuitable for drinking purposes. WQI for pre and post-monsoon reveals that 55%, 33%, 12% and 64%, 27%, 9% water samples are excellent to good and good to poor quality. Piper chart recognizes mixed CaHCO3, NaCl and mixed CaMgCl water type, which indicates that the alkaline earth and strong acids predominate. Gibb's plot examination uncovered that a greater part of the groundwater samples falls in weathering which indicates the groundwater association between rock chemistry and permeating water into the subsurface. Physicochemical boundaries reveal that the groundwater quality for drinking and agricultural, conflicting areas exist which are significantly brought about by anthropogenic activities, for example, industrial effluents, sewage discharge and agriculture. In regarding the utility of groundwater that proper healing measures are required to move forward the based on its quality.

Acknowledgments

We are thankful to C-MET for providing the Laboratory facilities. The authors are also thankful to the Head, Department of Geology, Osmania University, Hyderabad, Telangana State, India. The authors gratefully acknowledge the UGC, New Delhi for providing the Basic Scientific for Research Fellowship during the period of the research work.

References

1. Wolf L, Eiswirth M, Hötzl H (2006) Assessing sewer-groundwater interaction at the city scale based on individual sewer defects and marker species distributions. Environmental Geology 49: 849-857.
2. Dixit S, Gupta SK, Tiwari S (2005) Nutrient overloading of a freshwater lake in Bhopal, India. Electronic Green Journal 21: 2-6.
3. Jerry AN (1986) Basic environmental technology (water supply, waste disposal and pollution control). New York: Wiley.
4. Aksoy AO, Scheytt T (2007) Assessment of groundwater pollution around Torbali, Izmir, Turkey. Environmental Geology 53: 19-25.
5. Shivran HS, Dinesh KD, Singh RV (2006) Improvement of water quality though biological denitrification. J Environ Sci Eng 48: 57-60.
6. Machender G, Ratnakar D, Narsimha Reddy M, Panduranga Reddy I (2014) Hydrochemical characteristics of surface water (SW) and Groundwater (GW) of the Chinnaeru River basin, northern part of Nalgonda District, Andhra Pradesh, India. Environ Earth Sci 71: 2885-2910.
7. CGWB (2013) Central Ground Water Board. Ground Water Information, Warangal district, Andhra Pradesh, pp: 1-25.
8. APHA (1995) Standard methods for the examination of water and waste waters. 19th edn. American Public Health Association, Washington, DC.
9. BIS (1991) Specifications for drinking water IS: 1000:1991, Bureau of Indian Standards, New Delhi. In the soils of Tallinn (Estonia). Environ Geoche Health 22: 173-193.
10. WHO (1984) Guidelines for drinking water quality. Vol. 1. World Health Organization, Geneva.
11. Handa (1969) Description and classification of media for hydrogeochemical investigations. Symposium on groundwater studies in arid and semi-arid region. Roorkee.
12. Wilcox LV (1955) Classification and use of irrigation water. US Department of Agriculture, Circular 969, Washington, DC.
13. Kelly WP (1946) Permissible composition and concentration for irrigation waters. In: Proceedings of ASC, p: 607.
14. Doneen LD (1964) Notes on water quality in agriculture. Published as a water science and engineering paper 4001, Department of Water Science and Engineering, University of California.
15. Sahu, P., Sikdar, PK., 2008. Hydrochemical Framework of the Aquifer in and around East Kolkata Wetlands, West Bengal, India. Environmental Geology 55:823-835. doi.org/10.1007/s00254-007-1034-x
16. Piper AM (1944) A graphical procedure in the geochemical interpretation of water analysis. Trans Am Geophys Union 25: 914-923.
17. Karanth, KR., 1987. Ground Water Assessment: Development and Management. Tata McGraw-Hill Education, 720 pp.

18. Gibbs RJ (1970) Mechanism controlling water world chemistry. Science 170: 1088-1090.

19. Li, P., Feng, W., Xue, C., Tian Rui., Wang, S., 2017. Spatiotemporal variability of contaminants in Lake water and their risks to human health: a case study of the Shahu lake tourist area, northwest China. Expo Health 9:213–25.