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FLUORIDE AND NITRATE CONTAMINATIONS IN GROUNDWATER OF CHEVELA MANDAL, RR DISTRICT, TELANGANA STATE, INDIA

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Abstract

Groundwater samples were collected in Chevela mandal, Ranga Reddy district, Telangana State, India for two seasons (pre-monsoon and post-monsoon) and analyzed for chemical parameters with respect to fluoride and nitrate. Spatial distribution of nitrate and fluoride high values is observed from the northern, southern, central and south-western parts of the region. In terms of NO_3^- about 43% and 42% and F^- 29% and 26% of the groundwater samples are non-acceptable limits of nitrate is 45 mg/l and fluoride is 1.5 mg/l during pre and post-monsoon seasons respectively. Hydrogeochemical facies distribution indicates water-rock interaction resulted in occurrence of high fluoride concentration in groundwater. An analytical result plotted on Gibb's diagram indicates rock and evaporation dominance. Principal component analysis indicates hydro-geochemical processes like weathering, ion exchange, and anthropogenic activities contribute to groundwater chemistry.

Keywords: Fluoride, Groundwater, Hydrogeochemical facies, Gibb's plot

Introduction

Fluoride contamination in drinking water due to natural and anthropogenic activities has been recognized as one of the major problems worldwide imposing a serious threat to human health. Fluorine has the highest electro-negativity and most reactive among all known elements. Fluoride ion (F^-) occurs in natural waters commonly in concentrations less than 1.0 mg/l and seldom outside the range from 0.01 to 10.0 mg/l. The amount of F^- occurring naturally in groundwater is governed principally by climate, composition of the host rock, and hydrogeology. Some anthropogenic activities such as use of phosphatic fertilizers, pesticides and sewage and sludge, depletion of groundwater table, etc., for agriculture have also been indicated to cause an increase in F^- concentration in groundwater (Ramanaiah et al. 2006). Due to excessive F^- in take dental and skeletal fluorosis occur besides the muscle fiber degeneration low hemoglobin levels, excessive thirst, headache, skin rashes, nervousness and depression, etc. (Meenakshi 2006). In natural conditions the concentration of F^- in water is generally <1 mg/l (Hem 1991). The (WHO, 2004) suggests that the highest desirable limit of F^- is 1.5 mg/l in water for drinking purpose. In India, the Bureau of Indian Standards (BIS 2003) prescribed the F^- limits 0.6 to 1.2 mg/l.

Around 200 million people from 25 nations suffer from ill-health because of a higher F concentration in drinking water (Ayoob and Gupta 2006). It is worth to note that inadequate amount of F^- is also equally harmful (Susheela et al.1999). In India, its concentration up to 38.5 mg/l is found (Susheela et al. 1999). The dreaded fluorosis prevalent in some parts of central and western China is a result of drinking of F^- bearing groundwater. In India, about 60 million people (including 6 million children), especially in the states of Andhra Pradesh, Assam, Bihar, Delhi, Gujarat, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Talangana, Tamilnadu, and Uttar Pradesh, have no option except to drink F^- contaminated drinking water (Subba Rao 2011).

The chosen area for this study, Chevela mandal of Ranga Reddy district is marked as one of the prevalent fluoride zones in Telangana State, India; this has prompted the authors to take up the present study to delineated fluoride vulnerable zones and to identify the geochemical process controlling the incidence of fluoride in groundwater.

Study Area

The study area covering about 240 sq. km falls in Chevela mandal, Ranga Reddy district of Telangana State. It is located 30 km from Hyderabad, India. Study area lies in between North Latitudes 17° 25' to 17° 38' and East Longitudes 78° 03' to 78° 25' (**Fig. 1**) and falls in the Survey of India toposheet No. 56 K/3 and 56 K/4. The Study area receives rainfall (860 mm) both by northeast and southwest monsoons. The climate of the study area is generally hot. Average temperature in summer is 43^0C, in winter is 12^0C.

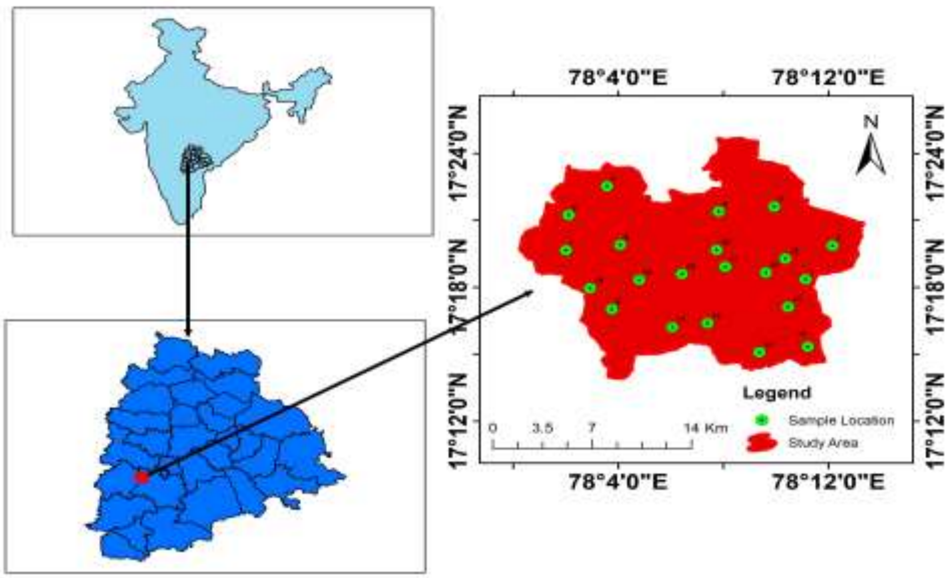

Fig. 1 Location map of the study area showing sampling points

Geology and Hydrogeology

The major exposure of the study area is peninsular gneiss, and calc gneiss which have been marked for widespread fluoride-bearing minerals indicating their accessibility to water by weathering along with leaching process. Mica content is significantly noted in peninsular gneiss and apatite is noted which are the sources of fluoride into the groundwater (Laxman Kumar et al. 2019).

Materials and Methods

In order to assess the groundwater quality, forty-two groundwater samples have been collected in pre-cleaned polyethylene containers for pre and post-monsoon seasons. They were analyzed for pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^+), Potassium (K^+), Carbonate (CO_3^{2-}), Bicarbonate (HCO_3^-), Chloride (Cl^-), Sulphate (SO_4^{2-}), Nitrate (NO_3^-) and Fluoride (F^-) for all physico-chemical parameter using standard methods (APHA, 2012).

Results and Discussion

The statistical summary of the chemical analysis of groundwater from the area of in Chevela mandal is presented in (**Table 1**). Groundwater is slightly acidic to alkaline in nature, with pH varying between 6.68-8.88 and 6.75-8.10 during pre- and post-monsoon. Total dissolved salts in the groundwater is between 465-1275 mg/l and 500-1100 mg/l in pre and post-monsoon periods, high TDS is due to the influence of anthropogenic source, such as domestic sewage, septic tanks and agricultural activities. The concentration HCO_3^- varies from 126-410 mg/l and 88-380 mg/l in pre and post-monsoon periods. The Cl^- range varies from 126-345 mg/l and 60-280 mg/l in pre and post-monsoon. The Chloride in groundwater may be from diverse sources such as weathering, leaching of rocks and soil, domestic and municipal effluents (Sarath Prasanth et al. 2012). The SO_4^{2-} values varied from 28-198 mg/l and 32-186 mg/l in pre and post-monsoon. The high sulphate indicating breaking of organic substances from topsoil/water, leachable sulfate preset in fertilizer, and other human influences (Craig and Anderson, 1979). The Ca^{2+} values ranges from 30-120 mg/l and mg/l and Mg^{2+} values varying from 12-66 mg/l and 18-56 mg/l in pre and post-monsoon periods, respectively. The TH values range from 124-572 mg/l and 193-470 mg/l in pre and post-monsoon periods. The hardness of the water is due to the presence of alkaline earths such as calcium and magnesium. The Na^+ values range from 54-240 mg/l and 28-188 mg/l and K^+ values range from 2-22 mg/l and 1-14 mg/l in pre and post-monsoon periods, respectively.

Table 1 Statistics of major ions of groundwater samples in pre and post-monsoon seasons

Variables	Pre-monsoon season				Post-monsoon season			WHO, 2011
	Minimum	Maximum	Mean		Minimum	Maximum	Mean	
pH	6.68	8.88	7.75		6.75	8.1	7.56	**6.5 - 8.5**
EC (µS/cm)	727	1992	1218		781	1719	1097	**1500**
TDS (mg/l)	465	1275	780		500	1100	702	**500**
Ca^{2+} (mg/l)	30	120	73		41	96	76	**75**
Mg^{2+} (mg/l)	12	66	36		18	56	36	**50**
TH as CaCO3	124	572	329		193	470	338	**500**
Na^+ (mg/l)	54	240	119		28	188	89	**200**
K^+ (mg/l)	2	22	8		1	14	4	**12**
HCO_3^- (mg/l)	126	410	204		88	380	162	**500**
CO_3^- (mg/l)	0	32	5		0	0	0	**-**
Cl^- (mg/l)	126	345	234		60	280	178	**250**

NO_3^- (mg/l)	30	118	51		26	95	47	**45**
SO_4^{2-} (mg/l)	28	198	90		32	186	129	**250**
F^- (mg/l)	0.22	2.1	0.99		0.18	1.88	0.7	**1.5**

Hydrochemical facies

The triangular fields are plotted separately with epm values of cations (Ca+Mg) alkaline earth, (Na+K) alkali, HCO3 weak acid, and (SO4+Cl) strong acid. Water facies can be identified by projection of plots in the central diamond-shaped field as per the classifications made by (Karanth, 1987 and Piper 1994). Aquachem 4.0 scientific software is used for the plotting of piper trilinear diagram. The piper diagram is dominated in pre and a post-monsoon period is NaCl, mixed CaMgCl and CaCl water types (**Fig. 2**). This process indicates that alkaline earth (Ca+Mg) and strong acids (Cl+SO_4) dominated over the alkalis (Na+K) and weak acids in pre and post-monsoon periods.

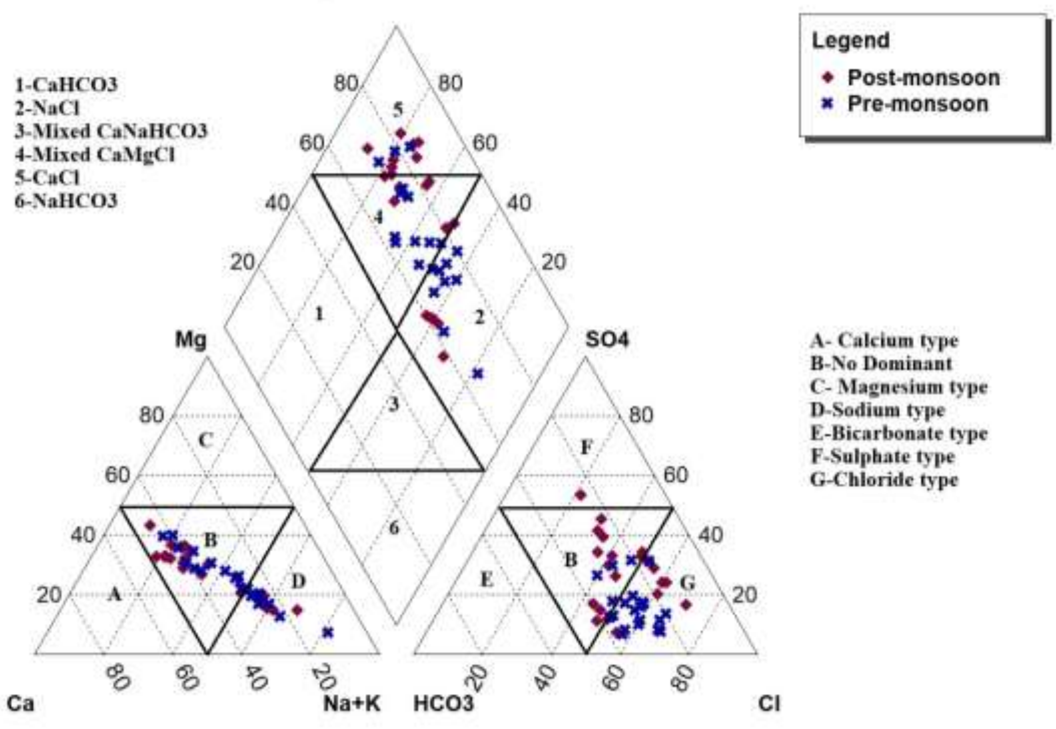

Fig. 2 Piper Trilinear diagram of the study area

Gibbs diagram

Gibbs diagram is widely used to establish the relationship of water composition and aquifer lithological characteristics. Three distinct fields such as precipitation dominance, rock dominance and evaporation dominance areas are shown in the Gibbs diagram (Gibbs, 1970). The predominant samples fall in the rock dominance and evaporation dominance field of the Gibbs diagram in the both pre and post-monsoon periods (**Fig. 3**). The rock dominance field indicates the interaction between rock chemistry and the chemistry of the percolated waters under the subsurface.

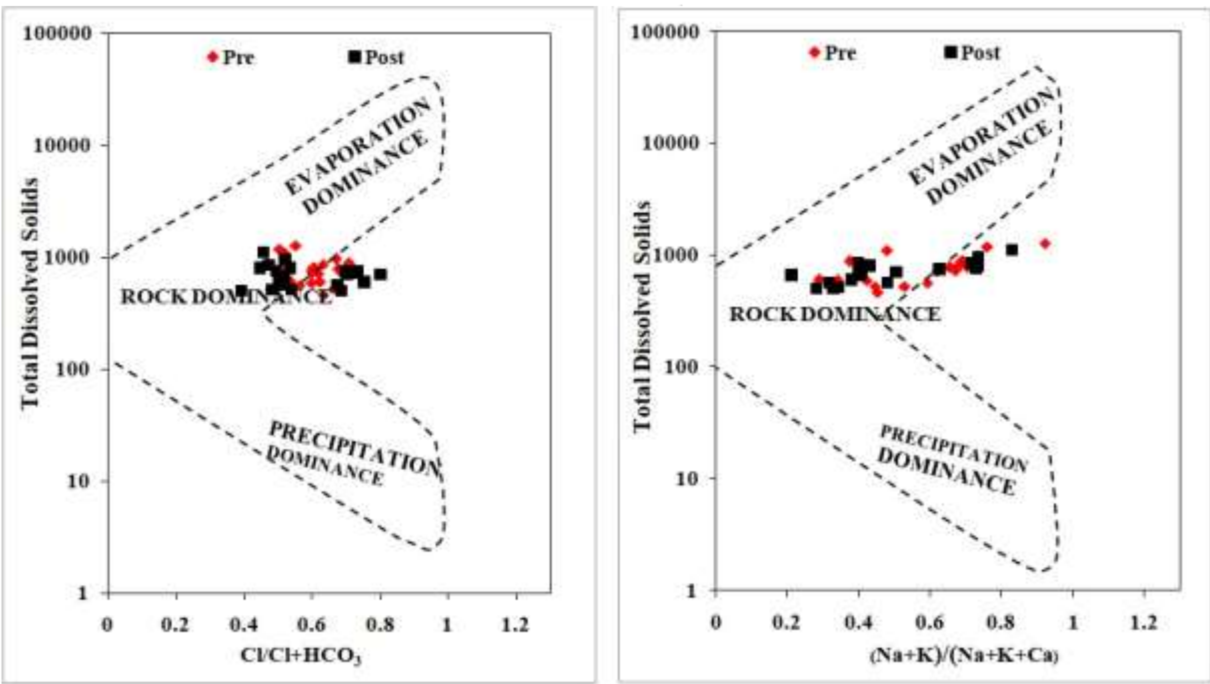

Fig. 3 Gibb's plot of the study area

Spatial distribution of Fluoride

The fluoride concentration in drinking water limits is 1.5 mg/L (BIS 2012; WHO 2011), which is used as an excessive water effect in dental and skeletal fluorosis (Laxman et al. 2019). Fluoride spatial interpolation levels within the observed region vary from 0.22 to 2.10 mg/l, with a mean of 0.99 mg/l, and 0.18 to 1.88 mg/l, with a mean of 0.70 mg/l in both monsoons. The acceptable limit of 1.5 mg/L (BIS 2012) Indian Standards has been exceeded in about 29 % and 26 % of samples, respectively (Table 1). The high spatial interpolation of fluoride turned into delineated with a different pattern, shown in Fig. 4. The high fluoride distribution is identified in northern, southern and southwestern parts of the region; the alkaline nature of water increases the anionic exchange in controlling the fluoride content in the aquifer regime (Saxena and Ahmed 2003).

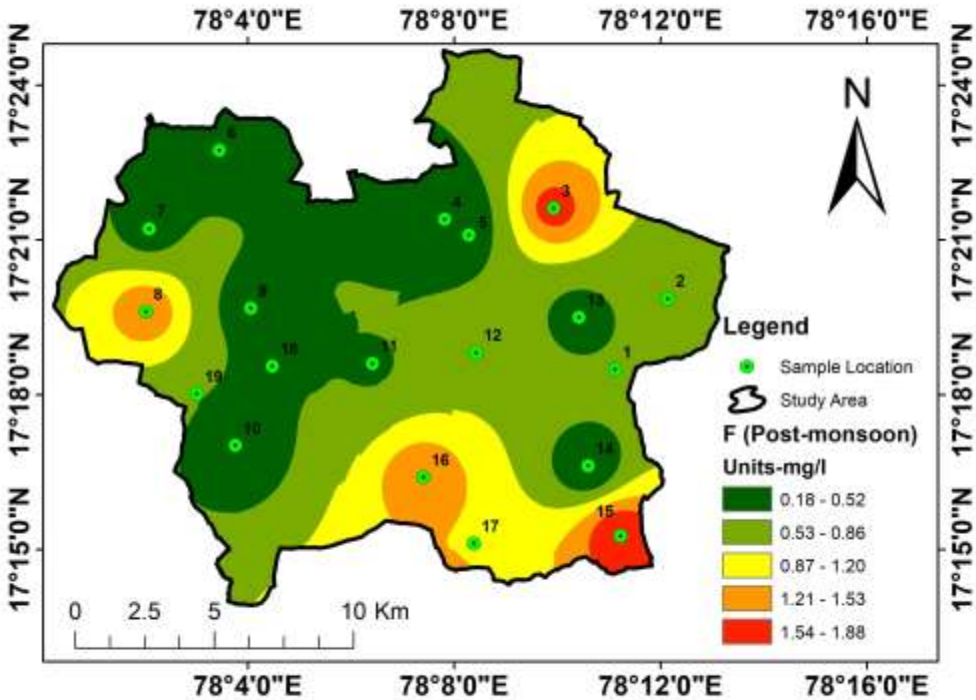

Fig. 4 Spatial distribution of fluoride during post-monsoon period

Spatial distribution of Nitrate

The groundwater trend was cumulative last few past decades in nitrate pollutants, because of the fast development of urban growth expansion, industrial development, in addition, uses of nitrate on fertilizers and horticulture purposes. The excess nitrate in drinking water can be affected to human health (Zhang et al. 2018).

In both monsoon seasons, NO_3^- levels range from 30 to 118 mg/l, with a mean of 51 mg/L, and 26 to 95 mg/L, with a mean of 47 mg/L in the pre-monsoon and post-monsoon seasons. (Table 1). As per the drinking water specification of nitrate is 45 mg/L (WHO 2011), it is no health risk of humans, 45 – 100 mg/L which causes of health effects of children and adults and >100 mg/L which it is very high health risk. As per the classification of nitrate are 12 groundwater samples fall under the “No health risk class”, whereas 8 of groundwater samples fall under the “high health risk class” in pre and post-monsoon seasons and 1 (Kowkuntla) of groundwater samples fall under the “Very high health risk class” in the pre-monsoon seasons respectively (Fig. 5).

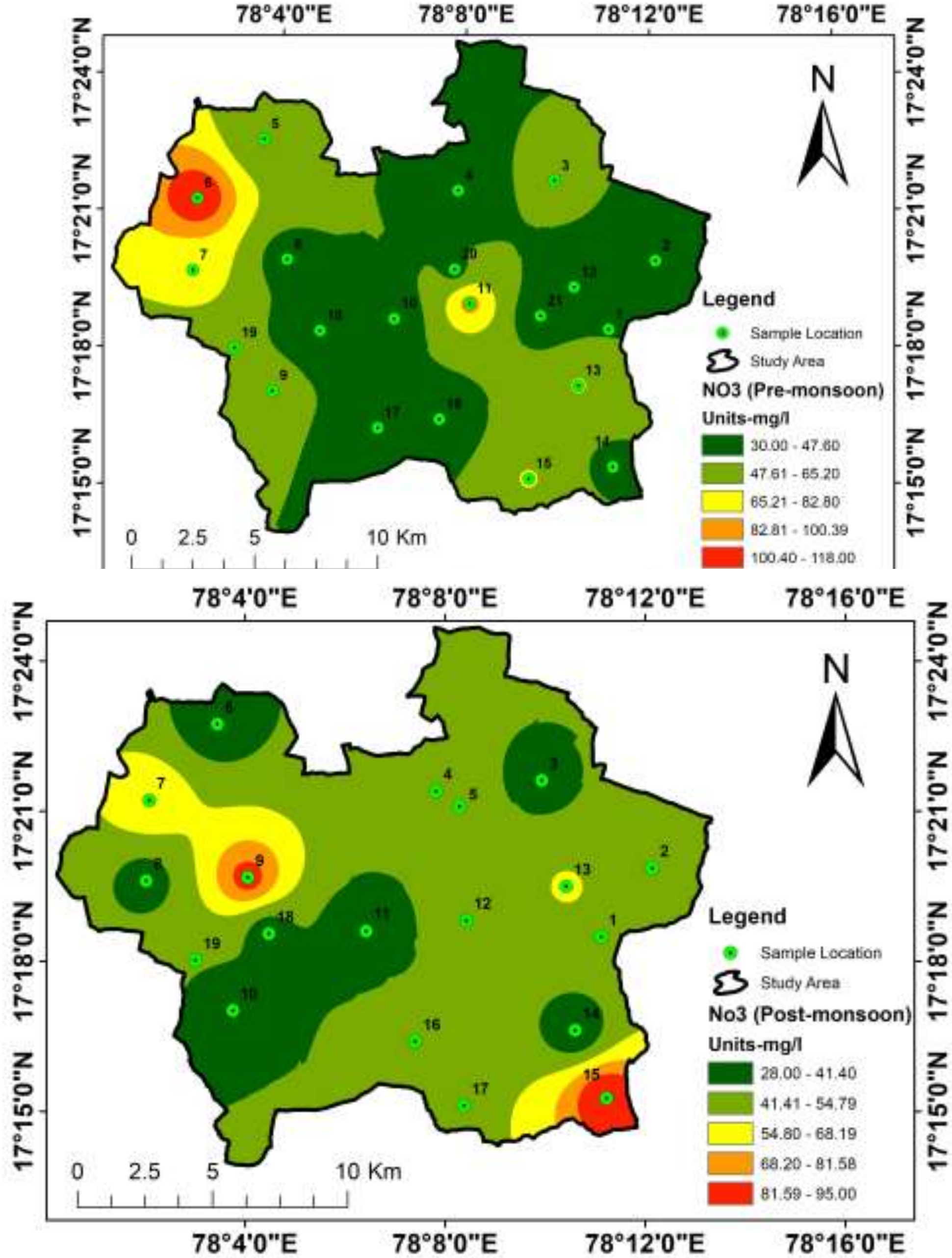

Fig. 5 Spatial distribution of nitrate during post-monsoon period

Conclusion

The study area is the Chevela mandal of Ranga Reddy district, Telangana State, India with a total spread of 240 km^2. The geology of the study area is grey and pink granites occupy dominant portion of the study area. These rocks are composed of quartz, feldspar, biotite and hornblende. The present study is an attempt to demarcate fluoride-vulnerable zones and to identify major geochemical process controlling the incidence of fluoride in the groundwater of study area. The excess concentration of nitrate indicates that the fertilizers and domestic sewages could be leached into the subsurface. Groundwater quality variation is mostly described by mineral dissolution from rock water interactions in the aquifer, which is the outcome of the evolution of anthropogenic activities and ion exchange processes within the groundwater According to the Piper diagram classified categories during both seasons NaCl, Mixed CaMgCl and CaCl, are the result of weathering and dissolution of rocks. According to the Gibbs diagram majority of samples are fall in the rock and evaporation dominance field in the both pre and post-monsoon periods.

References

APHA (2012) Standard methods for the examination of water and wastewater, 22nd edn. American Public Health Association, Washington, DC, USA.

Ayoob, S., Gupta, AK., (2006) Fluoride in drinking water: a review on the status and stress effects. Crit Rev Environ Sci Tech 36:433–487

BIS Bureau of Indian Standards Drinking water-specification (2003) IS: 10500, New Delhi

Craig, E., Anderson, MP., (1979) The effects of urbanization of ground water quality. A case study of ground water ecosystems. Environ

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

Karanth, KR., (1987) Quality of groundwater and groundwater exploration. Tata McGraw – Hill Publishing Co.Ltd, New Delhi, pp 217–275, 437–509

Laxman Kumar D, Satyanarayana E, Ratnakar Dhakate, Praveen Raj Saxena (2019) Hydrochemical characteristics with respect to fluoride contamination in groundwater of Maheshwaram mandal, RR district, Telangana state, India, Groundwater for Sustainable Development 8:474-483

Meenakshi, RC., (2006) Fluoride in drinking water and its removal. J Hazard Mater B137:456–463

Piper, AM., (1994) A graphic procedure in the geochemical interpretation of water analysis. Trans Geophysics union 25:914–923

Ramanaiah, SV., Venkatamohan, S., Rajkumar, B., Sarma, PN., (2006) Monitoring of fluoride concentration in groundwater of Prakasham district in India: correlation with physico-chemical parameters. J Environ Sci Eng 48:129–134

Sarath Prasanth, SV., Nagesh, NS., Jitheshlal, KV., Chandrasekar, N., and Gangadhar, K., (2012) Evaluation of groundwater quality and in suitability for drinking and agricultural use in the coastal stretch of Alappuza District, Kerala, India. Appl Water Sci: Doi:10.1007/s13201-012-0042-5

Saxena, V., Ahmed, S., (2003) Inferring chemical parameters for the dissolution of fluoride in groundwater. Environ Geol 43(6):731– 736

Susheela, AK., (1999) Fluorosis management programme in India. Curr Sci 77:1250–1256

Subba Rao, N., (2011) High-fluoride groundwater, Environ Monit Assess 176:637-645

WHO, (2004) WHO Guidelines for drinking water quality. World Health Organization, Geneva

WHO, (2011) WHO Guidelines for drinking water quality, 4th Edn. World Health Organization, Geneva

Zhang Y, Wu J, Xu B (2018) Human health risk assessment of groundwater nitrogen pollution in Jinghui canal irrigation area of the loess region, northwest China. Environ Earth Sci.77:273.