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Research Article

ASSESSMENT OF GROUNDWATER QUALITY USING PHYSIOCHEMICAL PARAMETERS FOR DRINKING PURPOSE: A CASE STUDY OF TEHSIL ATHNER, MADHYA PRADESH, INDIA

***Mohd. Asif and R.S. Raghuwanshi**
Department of Geology, Govt. Motilal Vigyan Mahavidyalaya, Bhopal (M.P)
**Author for Correspondence:*
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ABSTRACT
Groundwater is the water that is frequently found beneath the surface of the earth as freshwater sources, and it is extensively utilized for home, agricultural, and drinking reasons throughout most of the world. The disposal of domestic, agricultural, and industrial waste on the surface of the land is causing the quality of groundwater to worsen daily. Thus, it is crucial to comprehend the availability and quality of groundwater in each place. In the current investigation, ten groundwater samples from the Tehsil Athner research region were gathered in April and May of 2022, during the pre-monsoon season, for physio-chemical examination to determine their appropriateness for human consumption. In Athner tehsil, Madhya Pradesh, the parameters findings were compared and examined with the acceptable/desirable and permissible levels for drinking purposes as per BIS (2012, 2015) and WHO (2017).

Keywords: *Physio-chemical Parameters; Groundwater Quality; BIS; WHO; Tehsil Athner*

INTRODUCTION
Since over 60% of irrigated agriculture and 85% of drinking water supplies in rural India depend on groundwater, it is an essential resource (Clifton *et al.,* 2010). India's agricultural sector currently uses the most water due to irrigation, but forecasts from the Ministry of Water Resources show that this demand would increase by 56% by the year 2050. Aquifers, which are subterranean water-saturated strata of formation that can supply a well with useable water, are frequently the source of groundwater. Typically, an aquifer can supply a well or spring with a commercially viable amount of water. Aquitard is a saturated area that does not economically yield a sustainable amount of water because to reduced hydraulic conductivity.
The yearly extraction of groundwater is far greater than the net average recharge from natural resources due to the increased use of groundwater for agricultural, municipal, and industrial needs. Crop failures, land subsidence, seawater intrusion in coastal aquifers, and other issues are the result of groundwater withdrawal from storage, which lowers water levels. Groundwater levels are frequently on the decline due to the unpredictable nature of the monsoon and the careless development of groundwater. As a result, there is an urgent need to artificially replenish groundwater by enhancing natural precipitation infiltration into subsurface formations using an appropriate recharge technique.

MATERIALS AND METHODS
1.1. STUDY AREA
The Indian state of Madhya Pradesh has the city of Betul in its south-central region. It is situated in a level region partly south of the Satpura Range and north of the Tapti River. Formerly called Badnur, Betul was established as a municipality in 1867. The district is situated on Toposheet No. 55 FJ, between the east longitudes of 78°33'00" and 77°04'15" and the north latitudes of 21°22' and 22°24'. The block that makes up the study area Athner is situated in Madhya Pradesh's Betul district. The area of the Athner is 853 square km. Athner consists of 101 villages, each of which has 44 gramme panchayats. The population of the Athner is 106793. It is situated between the northern scope of 21°36'30" and 22°38'30" and the eastern longitude of 77°54'15" and 77°57'0" in the toposheet numbers 55G14 and 55G15.The study area's location map is shown in fig. 1 below:

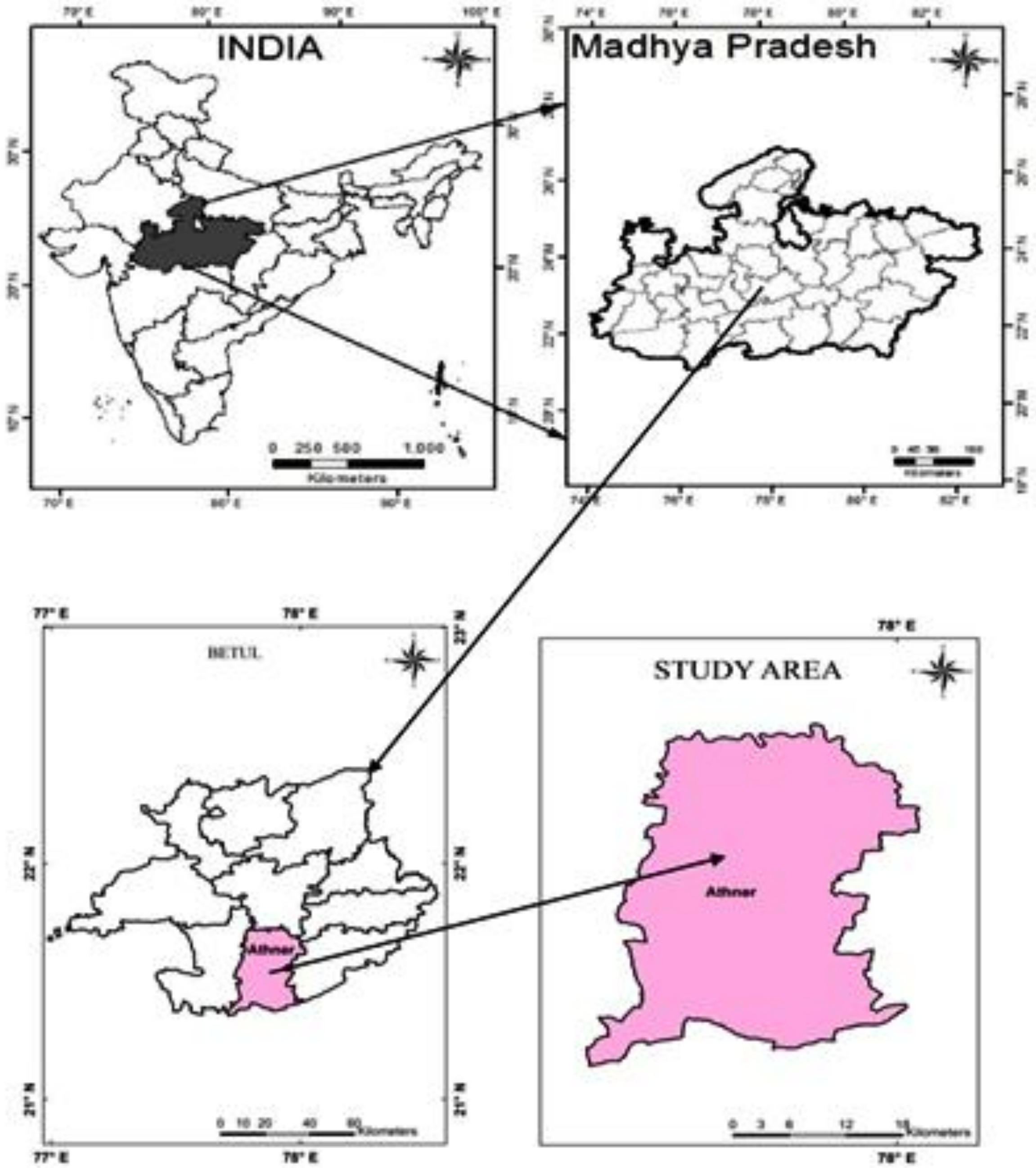

Fig1 Location Map of Study area (Athner)

2.2 Selection of sample Sites

The American Public Health Association's standard methods were followed when gathering groundwater samples from the study area in April and May of 2022, which is the pre-monsoon season (APHA, 2017). The global positioning system (GPS) was used to mark the sampling locations. Samples were taken from the site using hand pumps, tube wells of different depths, and dug wells. During the pre-monsoon, ten samples in total were gathered for physio-chemical examination. Samples were collected randomly from ten localities in the Betul district's Athner research region. The information about the sample locations and allocated sample numbers is provided below in Figures 2 and table 1, respectively.

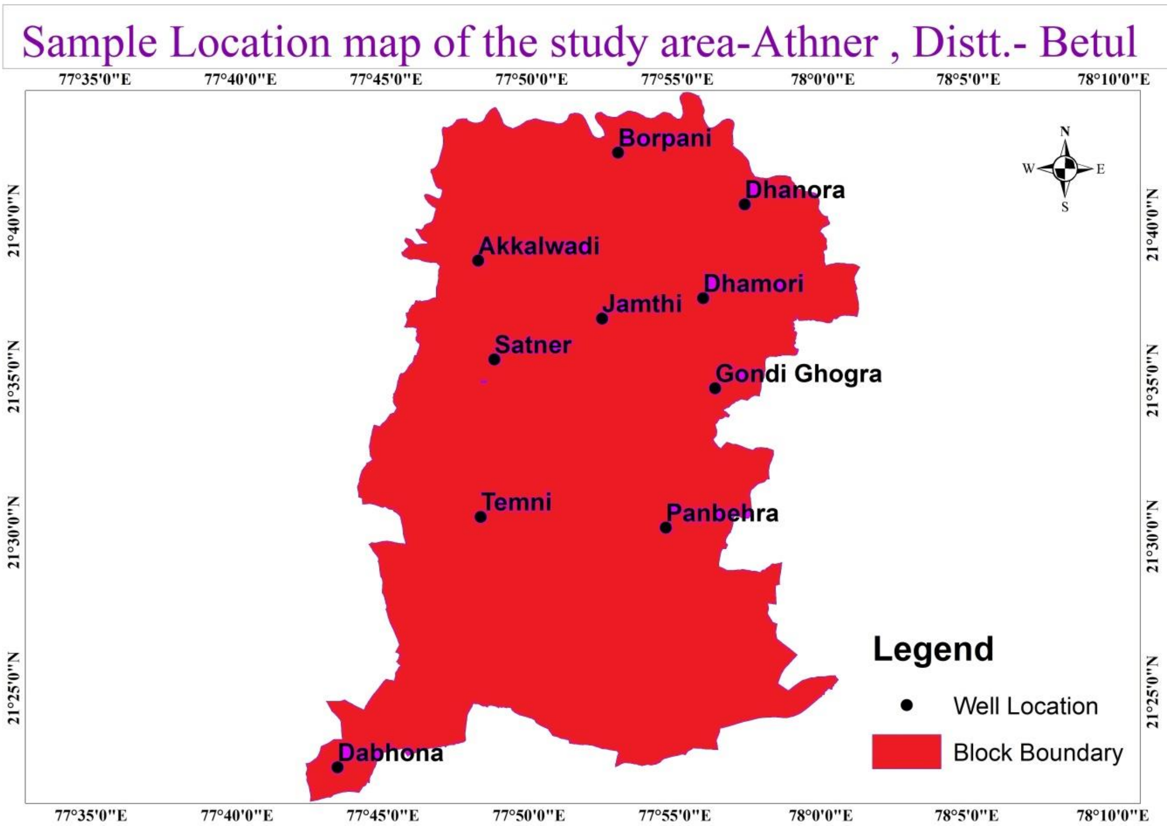

Fig. 2 Sample Location Sites

Table 1. Sample Site information of the Study area (Athner)

S.NO.	Location	Source	Assigned Sample No. of the location
1.	Dhanora	Groundwater	S1
2.	Borpani	Groundwater	S2
3.	Panbehra	Groundwater	S3
4.	Temni	Groundwater	S4
5.	Gondi Ghogra	Groundwater	S5
6.	Dhamori	Groundwater	S6
7.	Jamthi	Groundwater	S7
8.	Satner	Groundwater	S8
9.	Akkalwadi	Groundwater	S9
10.	Dabhona	Groundwater	S10

2.3 Methodology and Physio-chemical Data Analysis

Water samples were gathered in single-lather plastic bottles and subjected to appropriate testing techniques. In order to measure characteristics such as Turbidity, pH, Electrical Conductivity (EC), calcium (Ca^{+}), magnesium (Mg^{2+}), chloride (cl-), Fluoride (F^{-}), Sulphate (SO_4^{2-}), Nitrate (NO_3^{-}), Ammonia (NH_4^{+}), Iron (Fe^{+}), and Sodium (Na^{+}), the samples were transferred to the Water Testing Laboratory. The pre-monsoon parameter data were compared and examined with the acceptable/desirable and permissible levels for drinking purposes as per BIS (2012, 2015) and WHO (2017). Tables 2 and 3 present the statistical analysis conducted throughout the summer and, respectively, the correlation matrix of the parameters analysed for groundwater quality. The correlation matrix and statistical analysis of the several groundwater quality metrics were developed and examined utilizing SPSS.

Table 2 Statistical analysis of Groundwater parameters during pre-monsoon Season

	Drinking water standards (April-May, 2022)		Statistical Analysis of observed data during Pre-monsoon				
Statistical analysis of Groundwater parameters during pre-monsoon Season (April-May) and its coherence with BIS and WHO standards	Parameters (unit)	BIS (2012,2015) *	WHO (2017)	Min	Max	Mean	SD (σ)
	Na^+ (mg/l)	200	200	60	110	77	14.60
	pH (On Scale)	6.5–8.5	7—8	6.3	8.1	7.28	0.58
	EC (µS/cm)	750–3000	–	673.2	1500.2	986.82	279.85
	TH as $CaCO_3$ (mg/l)	200–600	100-500	220	700	416.2	152.64
	TDS (mg/l)	500–2000	600–1000	338.6	730.1	492.39	20209.96
	Fe (mg/l)	1.0	0.3	0.1	4.5	1.15	1.56
	Ca^{2+} (mg/l)	75–200	100–300	40	98	70.9	19.40
	Mg^{2+} (mg/l)	30–100	–	16	45	30.1	7.88
	Cl^- (mg/l)	250–1000	250	30	78	56.8	17.22
	$SO4^{2-}$ (mg/l)	200–400	250	28	88	57.1	22.57
	NO_3 (mg/l)	45	50	20	80	46.7	21.12
	F^- (mg/l)	1–1.5	1.5	3	0.3	1.11	1.02
	$NH4^{2+}$	5-15	15	0.4	0.3	0.10	0.01
	Turbidity (NTU)	1-5	5	3.9	32	12	10.49

Table 3: Correlation matrix of groundwater parameters during Pre-monsoon Season 2022

Parameters	TURBIDITY	Na	PH	EC	TH	TDS	Fe+	Ca+	Mg+	Cl^-	SO_4^+	NO_3^-	F^-	$NH4^+$
TURBIDITY	1													
Na	0.142	1												
PH	0.301	-0.080	1											
EC	0.124	-0.682	0.258	1										
TH	-0.403	-0.481	0.036	0.453	1									
TDS	0.088	-0.650	0.270	0.994	0.459	1								
Fe+	0.618	-0.549	0.336	0.385	0.179	0.311	1							
Ca+	0.471	0.096	-0.583	0.116	-0.298	0.087	0.136	1						
Mg+	0.576	-0.264	0.515	0.433	-0.243	0.447	0.379	0.140	1					
Cl^-	-0.372	0.216	0.145	-0.400	-0.462	-0.333	-0.587	-0.493	0.060	1				
SO_4^+	0.285	-0.203	0.142	0.597	0.345	0.557	0.401	0.187	-0.147	-0.64	1			
NO_3^-	0.118	0.127	0.114	-0.043	0.597	-0.012	0.192	-0.092	-0.121	-0.38	0.171	1		
F^-	-0.291	-0.251	0.046	0.212	0.940	0.223	0.172	-0.283	-0.255	-0.47	0.205	0.793	1	
$NH4^+$	-0.110	-0.552	0.044	0.431	-0.203	0.421	0.021	-0.054	0.475	0.33	-0.206	-0.751	-0.437	1

RESULTS AND DISCUSSION

1.2. Groundwater Quality Parameters

The research area's groundwater quality is established using the previously listed metrics. The several study parameters that were taken into consideration are stated in the lines that follow: In this study, references to drinking water standards have been consulted from the World Health Organization (WHO 2017) and the Bureau of Indian Standards (BIS 2012, 2015).

3.1.1 Hydrogen ion concentration (pH)

Water's potential of hydrogen (pH) is a measurement of the amount of hydrogen ions it contains that determines whether it is acidic or alkaline. The groundwater's pH, or hydrogen ion concentration, is a crucial chemical factor in assessing its quality. Higher pH will induce the formation of toxic trihalomethanes (Trivedy & Geol 1986).The permissible limit of pH of water as per WHO 2017 is 7.0-8.0. The pH of groundwater in the study area ranges from 6.3-8.during the pre-monsoon season (April-May,2022). All of the groundwater samples in the study area were within the permissible limit except sample no. S5. Alkalinity in drinking water will affect the mucous membranes of Human body (IS: 10500-1991).

3.1.2 Electrical conductivity (EC)

Since electrical conductivity is a measure of water's ability to conduct electrical current and is a direct result of TDS, it is an essential criterion in determining the quality of groundwater for irrigation and drinking (Harilal, et. Al., 2004). Ion exchange and solubilization in the aquifer will be caused by the greater EC differences (Sanchez Perez and Tremoloeres, 2003). The electrical conductivity was found to be in the range of 673.2 - 1500.2 µS/cm in the pre-monsoon season.

3.1.3 Total dissolved solids (TDS)

TDS calculates the total amount of dissolved organic and inorganic substances in water. The milligrams per litre (mg/L) is the most widely used unit TDS in groundwater vary significantly over time and location due to varying solubility minerals in different geological regions (Indirabai & George 2002).The TDS of the study area during the pre-monsoon is 338.6-730.1 mg/l. The permissible limit of TDS for drinking water quality standards is 1500mg/l as per WHO (2017). Based on the classification of TDS by Freeze and Cherry and Catroll, 100% of water is fresh water during pre-monsoon Season.

3.1.4 Total Hardness (TH)

The mineral content of a water sample that is irreversibly dissolved by boiling is measured as total hardness. The amount of cations (magnesium and calcium) and anions (carbonates, bicarbonates, Sulphates, and chlorides) in water determines its hardness. Low Hardness means presence of low level of beneficial ions like calcium and magnesium. Pre-monsoon Total hardness values varied from 220-700 mg/l in the study area. High Hardness leads to reduction in efficiency of water heaters and also the leathering action of the soap gets decreased (Deepali et al 2011). The total hardness of groundwater is calculated by using the relation suggested by **(Sawer and Mccartly, 1967).** and according to this classification; the table 4 represents the details of the groundwater.

Table 4: Classification of groundwater quality based on Total hardness (Sawer and Mccartly, 1967).

Nature of Water	Range of TH as $CaCO_3$ in mg/l	Samples Nos. of the locations
		Pre-monsoon Season
Soft	<75	Nil
Moderately Hard	75-150	Nil
Hard	150-300	S3 and S8
Very Hard	>300	S1,S2, S4, S5,S6,S7, S9 and S10

3.1.5 Iron (Fe)

The desirable limit of the Iron is 0.1mg/l and it has been recommended by WHO 2017 for drinking purpose. The highest amount of iron found in the pre-monsoon is 4.5 mg/l. The range of Iron varies from 0.1-4.5 mg/l in the study area during pre-monsoon Approximately four samples (Sample. Nos. S2, S5, S9, S10) during the pre-monsoon season exceeds the maximum permissible limit as recommended by WHO drinking standards.

3.1.6 Calcium (Ca^{2+})

Parameter of quality Hardness and calcium have a direct and mutually connected relationship. High calcium content water is regarded as hard and should not be used for residential water supplies. Human health is negatively impacted by water with high calcium content. Ionic pollutants will originate from municipal potential sources such as sewage, home and industrial wastes, which provide complicated amounts of calcium, sulphate, and nitrate ions (Somusunduram et al, 1993). The calcium content of the groundwater samples varies from 40–98 mg/l during pre-monsoon. The permissible limit of the calcium is 200mg/l as per WHO (2017) drinking water quality standards and none of the samples is exceeding the permissible limit.

3.1.7 Magnesium (Mg^{2+})

The magnesium parameter like calcium is related to Total Hardness and their higher concentrations in water leads to poor lathering and the deterioration of clothes and encrustation of water supply system. The magnesium concentration of water varies from 16 to 45 mg/l during pre-monsoon season. The permissible limit of magnesium is 150mg/l. All the samples of the study area are within the permissible limits.

3.1.8 Chloride (Cl^-)

Chloride is frequently linked to ions such as sulphates, carbonates, potassium, and sodium. Unusual concentrations of chloride can result from sewage waste contamination, salting of trees, and the leaching of saline residue in soil (Karnath 1999).The chloride in the groundwater samples of the study area ranging from 30-78 mg/l during the pre-monsoon. All the samples were within the maximum tolerable limit (250mg/l) of drinking water as per WHO 2017 drinking water standards.

3.1.9 Sulphate (SO_4^{2-})

Due to the breakdown of minerals, atmospheric deposition, and other human activities like mining and fertilizers, sulphate ends up in groundwater. Gypsum has a significant role in the high concentration of Sulphates found in many aquifers worldwide. Catharsis, dehydration, and diarrhea can result with higher suphates in drinking water. The pre-monsoon season ranges in suphates' value from 28-88 mg/l. All of the samples fall below the WHO's 2017 drinking water guidelines' permitted level.

3.1.10 Nitrate (NO_{3^-})

One of the most crucial factors in determining the quality of water is nitrate. It is the most stable nitrogen oxidised form. It is produced in water by air nitrogen fixation and the breakdown of organic materials. It is found in groundwater as fertilisers containing nitrate. Blue baby illnesses or mathemoglobinemia in infants can be caused by high nitrate concentrations in water over 45 mg/l (Comly 1945, Gilly et al., 1984). The maximum permissible limit of nitrate is 50 mg/l and in the study area it ranges from 20-80 m/l during the pre-monsoon season and all the samples collected were within permissible limits of WHO (2017) drinking water standards except samples nos. S2, S3, S7 and S10.

3.1.11 Fluoride (F^-)

Fluoride is considered a trace element that is present in groundwater and can be found naturally in soil and water. Because fluoride minerals are found in bedrock, there is a higher concentration of fluoride in groundwater (Handa, 1975). The concentration of the fluoride content in the study area during the pre-monsoon season is in the range of 0.2 mg/l to 3.0 mg/l. All the samples are within the permissible limits as recommended by WHO (2017) drinking water standards except sample nos. S7 and S10.

3.1.12 Ammonia ($NH4^+$)

Ammonia is a chemical made up of four hydrogen atoms and one nitrogen atom (NH4+).This naturally-occurring substance is a result of the breakdown of organic materials like manure and urine, as well as a component of some chemical goods and fertilizers. The range of ammonia obtained during the pre-monsoon in the study area is 0.1 to 0.4 mg/l. All of the samples fell under the WHO's (2017) permissible level for drinking water.

3.1.13 Sodium (Na^+)

According to Purushothman *et al.,* (2012), salt concentration has a significant role in the classification of irrigation water quality because it reacts with soil to reduce its permeability. The soil's clay particles absorb sodium when it is present in high concentration irrigation water. This causes the displacement of Ca2 and Mg2 from the soil and the exchange of Na in the water. The sodium in the study area ranges from 60-110 mg/l during pre-monsoon and all the collected samples were within the permissible limit as per WHO (2017) and BIS drinking water standards.

CONCLUSION

The following conclusions were drawn from the present research work:

- The permissible limit of pH of water as per WHO 2017 is 7.0-8.0. The pH of groundwater in the study area ranges from 6.3-8.during the pre-monsoon season (April-May,2022). All of the groundwater samples in the study area were within the permissible limit except sample no. S5.
- The TDS of the study area during the pre-monsoon is 338.6-730.1 mg/l. The permissible limit of TDS for drinking water quality standards is 1500mg/l as per WHO (2017). Based on the classification of TDS by Freeze and Cherry and Catroll, 100% of water is fresh water during pre-monsoon Season.
- For the parameter Iron, four samples (Sample. Nos. S2, S5, S9, S10) during the pre-monsoon season exceeds the maximum permissible limit as recommended by WHO (201) drinking standards.
- The maximum permissible limit of nitrate is 50 mg/l and in the study area it ranges from 20-80 m/l during the pre-monsoon season and all the samples collected were within permissible limits of WHO (2017) drinking water standards except samples nos. S2, S3, S7 and S10.
- The concentration of the fluoride content in the study area during the pre-monsoon season is in the range of 0.2 mg/l to 3.0 mg/l. All the samples are within the permissible limits as recommended by WHO (2017) drinking water standards except sample nos. S7 and S10.

REFERENCES

APHA (2017). *Standard Methods for the Examination of Water and Wastewater (23rd ed.). Washington DC*: American Public Health Association.

Catroll D (1962). Rainwater as a chemical agent of geological Process, A view. *USGS Water supply*, **1533** 18-20.

Clifton, Craig, Rick E, Susan H, Rafik H, Gabrielle P & Carolina P (2010). Groundwater Governance, A Global Framework for Action. GEF, World Bank, UNESCO-IHP, FAO and IAH. Groundwater and climate change adaptation. *Thematic Paper No 12.*

Comly H H (1945). Cyanosis in infants caused by nitrates in well water.*Journal of American Association* **129**, 12-114.

Deepali M, Malpe DB & Zade AB (2011). Geochemical characterization of ground water from Northeastern part of Nagpur urban, Central India. *Environ. Earth Sci*., **62**, 1419-1430

Freeze RA, & Cherry JA (1979). Groundwater Prentice Hall Inc. Englewood, Cliffs. New Jersey

Gilly G, Carrao G & Favilli S (1984). Concentrations of nitrates in drinking water and incidence of gastric carcinomas, First descriptive study of the Piemonate region, Italy.*Journal of Science of the Total Environment*, **34** 35-37

Handa BK (1975). Geochemisty and Genesis of fluoride containing groundwater in India.*Groundwater Journal*, **13**(3) 275-281.

Hem JD (1985). Study and interpretation of the chemical characteristics of natural waters,USGS. *Water Supply Book 2254*, 3rd Edition, 263-264.

Indirabai WPS & George S (2002). Assessment of drinking water quality in Selected areas of Tiruchirappali town after floods, *Pollution Research*, **21**(3), 243-248.

IS: 10500-1991. Bureau of Indian Standards, New Delhi.

Karnath,K.R.(1999). Groundwater Assessment development and Management. *Tata Mc-Graw Hill, New Delhi*.

Ragunath HM (1987). Groundwater *Wiley Eastern Ltd., New Delhi, India*, 563.

Sanchez-Perez JM & Tremoloeres M (2003). Change in groundwater chemistry as a consequence of suppression of floods. The case of Rhine flood plain. *Journal of Hydrology*, **270**, 89-104.

Somasundaram MV, Ravindran G & Tellam JH (1993). Groundwater Pollution of the Madras Urban aquifer, India.*Groundwater,* **31**(4) 4-11.

Trivedy RK & Goel PK (1986). Chemical and Biological methods of water pollution studies. *Environmental Publications*, Karad, India.