International Journal of Geology, Earth & Environmental Sciences ISSN: 2277-2081
An Open Access, Online International Journal Available at http://www.cibtech.org/jgee.htm
2023 Vol. 13, pp. 67-75/Shoib and Vineesha
Research Article

EVALUATION OF GROUNDWATER QUALITY FOR DRINKING PURPOSES USING PHYSICOCHEMICAL PARAMETERS OF DISTRICT SHOPIAN, (JAMMU AND KASHMIR) INDIA

***Shoib Maqbool and Vineesha Singh**
Department of Earth Sciences, Barkatullah University, Bhopal, 462026, India
**Author for Correspondence: loneshoib96@gmail.com*

ABSTRACT
Groundwater is an important natural resource for domestic, agricultural and industrial purpose in several countries. The groundwater quality and its management need to be given greater attention around the globe. Dumping of the industrial, agricultural and domestic waste leads to the deterioration of groundwater quality day by day. Hence, it is the need of hour to check the quality of the groundwater and its abundant availability is very important. In the present study, evaluation of groundwater quality for drinking purposes was carried out in district Shopian by means of various physio-chemical analyses. Groundwater samples were collected from 14 wells in June-July 2021. The results of the parameters were compared and analyzed with the acceptable/desirable and permissible limits according to BIS (2012, 2015) and WHO (2017) for drinking purpose in Shopian district. The parameters like Fe^{2+} and pH at some locations in the study area were exceeding the permissible limit, thereby affecting the quality of groundwater and making it unfit for drinking purpose.

Keywords: *Groundwater Quality; Physio-chemical Parameters; BIS; WHO; District Shopian*

INTRODUCTION
Groundwater is often contained in aquifers: an aquifer is an underground water saturated stratum of formation that can yield usable amounts of water to a well. Usually, an aquifer can produce an economically feasible quantity of water to a well or spring. A saturated region that, due to lower hydraulic conductivity, does not yield a sustainable amount of water in an economic fashion is called aquitard. Groundwater is a vital resource for rural areas in India as more than 60 per cent of irrigated agriculture and 85 per cent of drinking water supplies are dependent on it (Clifton et al. 2010). Agricultural demand for irrigation is already the single largest draw on India's water, yet estimates by the Ministry of Water Resources indicate that by the year 2050 irrigation needs will rise by 56%. Due to erratic nature of monsoon and indiscriminate development of groundwater often results in declining trend of groundwater levels. Therefore, there is an immediate need for artificial recharge of groundwater by augmenting the natural infiltration of precipitation into subsurface formation by some suitable method of recharge. In the present study different physicochemical parameters of groundwater are examined and the obtained results are compared with standard values setup by various organizations like WHO AND BIS. Many researchers have used the same technique for groundwater quality assessment. Vineesha *et al.*, (2008) have also assessed the groundwater quality by means of various physicochemical parameters in parts of Gwalior for agricultural purposes.

MATERIALS AND METHODS
1.1. Study Area
The district Shopian derives its name from the town "SHOPIAN" about which "Frederic Drew", while justifying the basis of its nomenclature, states that it is the distortion of word **" SHAH PAYAN"** *i.e*, Royal Stay but as per locals the district derives its name from Kashmiri word **"SHINNEH –YEN"**(Snow Defile) meaning an area which experiences heavy snowfall. Shopian has been an ancient town of Kashmir. The total geographical area of the District is about 612.19 sq. kms and has a population of 2.66 lac as per census 2011. The district falls in Survey of India Degree sheet no 43K/13, 46K/14, O/1 and is located between 33°29' to

33°50' North latitude and 74°32' to 75°5' East longitude with an average elevation of 3042 meters. Shopian is a historical town and has gained importance from the times of Mughal rulers. Shopian was one out of six *Wazarat* Headquarters in Kashmir from 1872-1892 A.D. The district is flanked by District Budgam in northeast, District Pulwama in north, District Anantnag in east and District Kulgam in southwest. The mighty Pir Panjal Range separates district Shopian from District Rajouri and Poonch. The Location Map of District Shopian is given below in the fig. 1:

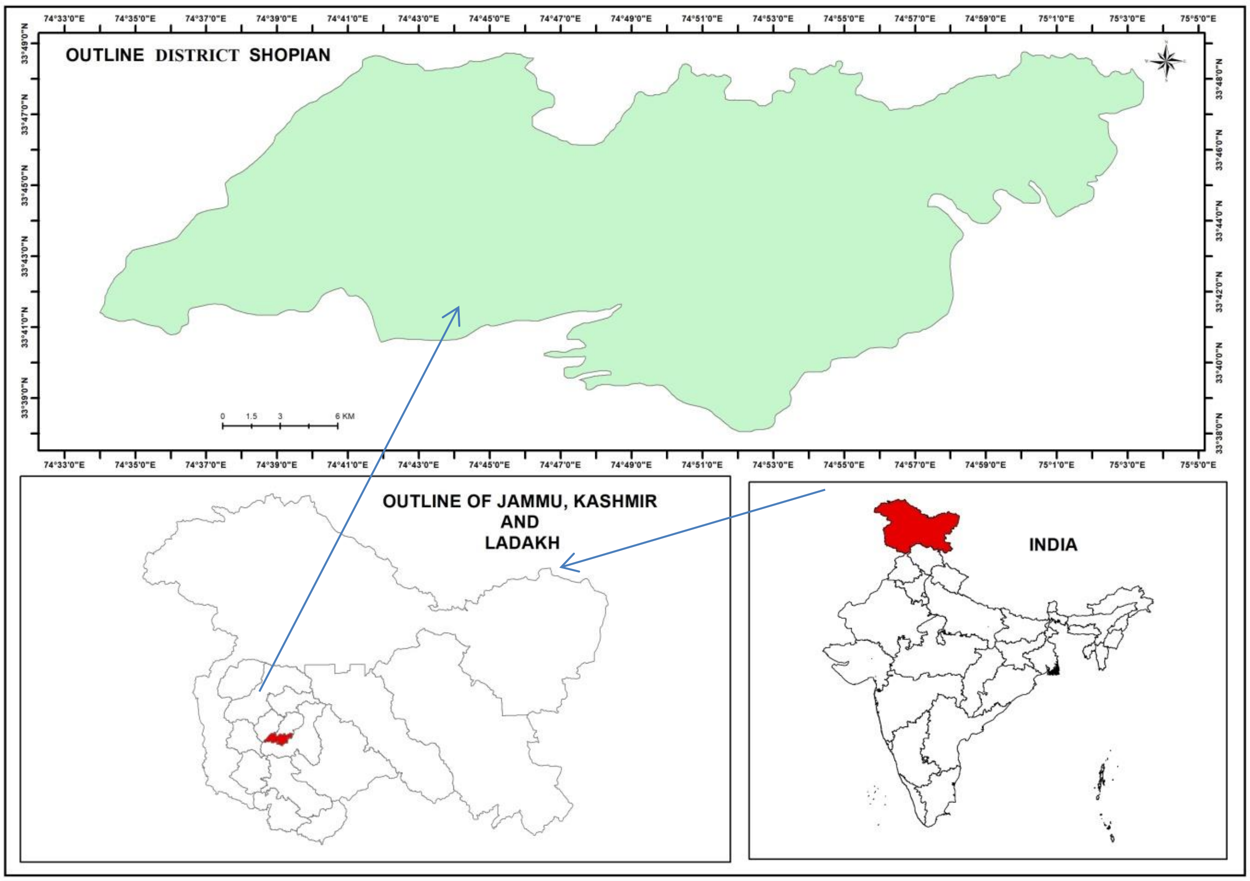

Figure 1: Location Map of District Shopian

2.2 Selection of sample Sites

The groundwater samples were collected during the summer season (June-July 2022) from the study area according to standard procedures of the American Public Health Association (APHA, 2017). The sampling locations were marked with the help of global positioning system (GPS). Samples were collected from the location through hand pump and tube wells of varying depth. A total of 14 samples were collected during summer for physio-chemical analysis. The samples were collected randomly from all the seven (07) tehsils of the study area. The sample site location and their related information are given below in the fig 2 and table 3 respectively.

2.3 Methodology and Physio-chemical Data Analysis

Water samples were collected in polyethylene bottles (one liter) and were tested with the help of water testing kit. The samples were transported to the Sub Divisional Water Testing Laboratory Zainapora for obtaining parameters like electrical conductivity, TDS, and pH with the help of pH meter and Conductivity meter and the remaining parameters which include Total Hardness (TH), Calcium (Ca^{+}), Magnesium (Mg^{2+}), Chloride (cl^{-}), Fluoride (F^{-}),Sulphate ($SO4^{2-}$), Nitrate ($NO3^{-}$), Ammonia ($NH4^{+}$) and Iron (Fe^{+}) obtained on spot by means of field water testing kit.

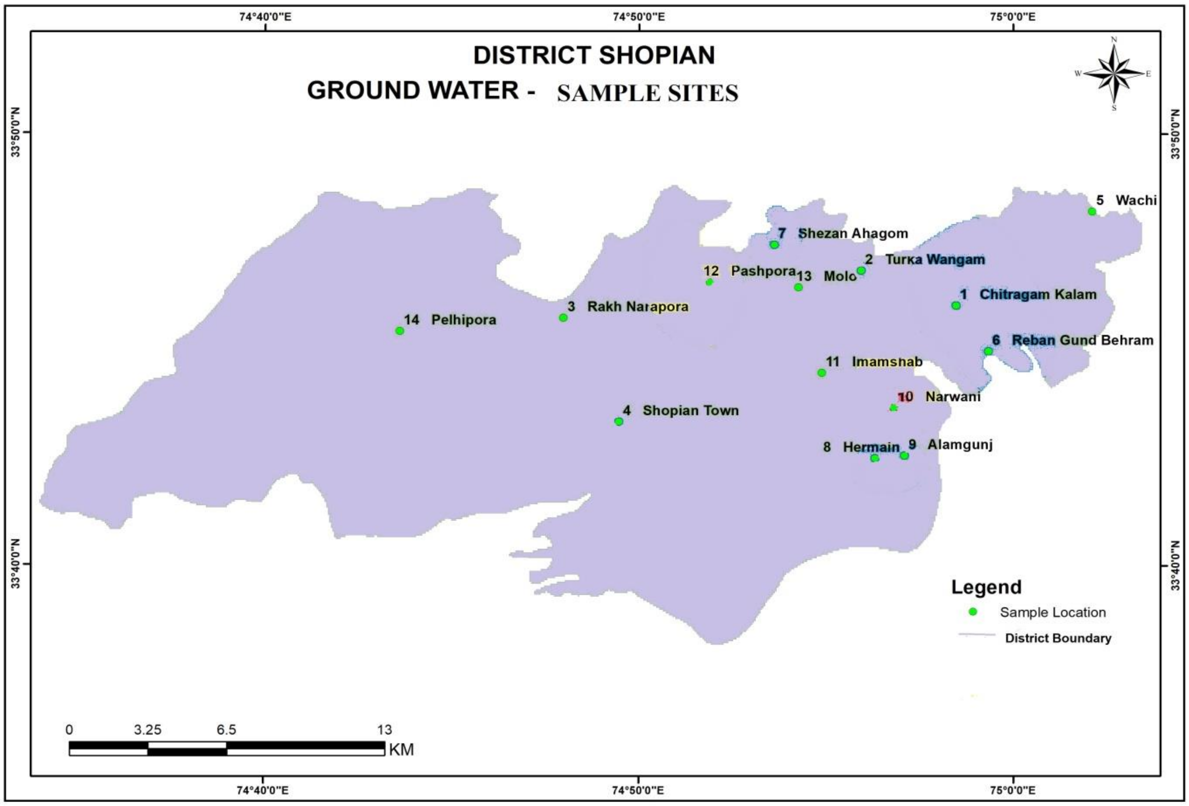

Figure 2: Sample site location

Table 1: Sample Site information of the Study area (Shopian)

S.NO.	Location	Source	Assigned Sample no.s of the locations
1.	CHITRAGAM KALAN	Groundwater	15
2.	Turka Wangam	Groundwater	17
3.	Rakh Narapora	Groundwater	23
4.	Shopian Town	Groundwater	27
5.	Wachi	Groundwater	26
6.	Reban Gund Behram	Groundwater	24
7.	Shezan Ahagom	Groundwater	25
8.	Hermain	Groundwater	28
9.	Alamgunj	Groundwater	22
10.	Narwani	Groundwater	21
11.	Imamshab	Groundwater	20
12.	Pashpora	Groundwater	19
13.	Molo	Groundwater	16
14.	Pelhipora	Groundwater	18

The results of the parameters during summer were compared and analyzed with the acceptable/desirable and permissible limits according to BIS (2012, 2015) and WHO (2017) for drinking purpose. The statistical analysis during summer is given in Tables 4 and the correlation matrix of the analyzed groundwater quality parameters is given in the Table 5. The statistical analysis and the correlation matrix of various groundwater quality parameters, was created and has been analyzed using MS Excel 2010.

Table 2: Statistical analysis of Groundwater parameters during Summer Season

	Drinking water standards during Summer			Statistical Analysis of observed data			
Statistical analysis of Groundwater parameters during Summer Season (June-July) and its coherence with BIS and WHO standards	Parameters (unit)	BIS (2012, 2015)	*WHO (2017)	Min	Max	Mean	SD (σ)
	pH (On Scale)	6.5–8.5	7—8	7.2	8.7	8.15	0.41
	EC (µS/cm)	750–3000	–	296	870.3	600.96	190.40
	TH as $CaCO_3$ (mg/l)	200–600	200	100	221	172.21	46.03
	TDS (mg/l)	500–2000	600–1000	148	435.1	300.46	95.20
	Fe (mg/l)	1.0	0.3	0.1	4.5	1.05	1.71
	Ca^{2+} (mg/l)	75–200	100–300	20	90	50.35	26.49
	Mg^{2+} (mg/l)	30–100	–	12	35	24.21	7.30
	Cl^{-} (mg/l)	250–1000	250	15	80	43.28	24.01
	$SO4^{2-}$ (mg/l)	200–400	250	19	80	38.85	16.55
	NO_3 (mg/l)	45	50	14	36	22.57	7.63
	F^{-} (mg/l)	1–1.5	1.5	0.1	0.3	0.19	0.04
	$NH4^{2+}$	5-15	15	0.1	0.3	0.13	0.06
	Turbidity (NTU)	1-5	5	2.1	20.4	6.73	6.16

RESULT AND DISCUSSION

1.2. Groundwater Quality Parameters

Based on the mentioned parameters the groundwater quality of the study area is determined. In the following lines, the various parameters considered in the study are being discussed: The Bureau of Indian Standard (BIS 2012, 2015) and World Health Organization (WHO 2017) of drinking water standards have been considered as a reference in this study.

3.1.1 Hydrogen ion concentration (pH)

A rapid rise in pH of water is due to addition of salts. 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 7-8.7 during the summer season (June-July). Majority of the groundwater samples in the study area were alkaline in nature. Alkalinity in drinking water will affect the mucous membranes of Human body (IS: 10500-1991).

3.1.2 Electrical conductivity (EC)

Electrical Conductivity (EC) of water is the ability to carry an electric current, measured in microsiemens per centimeter (µS/cm). The conductivity of the water increases due to the presence of charged particles. The larger differences of the EC will results in ion exchange and solubilisation in aquifer (Sanchez Perez & Tremoloeres 2003). The electrical conductivity was found to be in the range of 296-870.3 µS/cm during summer season.

Table 3: Correlation matrix of groundwater parameters during summer

correlation matrix Summer data	*TEMPERATURE (°C)*	*PH*	*ELECTRICAL CONDUCTIVITY (µS/cm)*	*TOTAL HARDNESS(mg/l)*	*TDS (mg/l)*	*IRON (mg/l)*	*CLACIUM (mg/l)*	*MAGNESIUM (mg/l)*	*CHLORIDE(mg/l)*	*SULPHATE(mg/l)*	*NITRATE(mg/l)*	*FLORIDE(mg/l)*	*AMMONIA(mg/l)*
TEMPERATURE (°C)	1												
PH	-0.07596	1											
ELECTRICAL CONDUCTIVITY (µS/cm)	-0.11902	0.282423	1										
TOTAL HARDNESS (mg/l)	-0.0696	0.672748	0.523976	1									
TDS(mg/l)	-0.11901	0.282491	1	0.523975	1								
IRON(mg/l)	-0.15987	0.541758	0.525821	0.492951	0.525923	1							
CLACIUM (mg/l)	-0.35572	0.498967	0.197414	0.546129	0.197465	0.80848	1						
MAGNESIUM (mg/l)	0.111497	0.128192	-0.07909	0.074383	-0.07917	0.373821	0.398876	1					
CHLORIDE (mg/l)	-0.20196	0.289742	-0.33971	-0.17027	-0.33949	0.338817	0.376533	-0.0258	1				
SULPHATE (mg/l)	-0.63769	0.017928	0.117609	0.045253	0.117685	0.070892	0.246531	-0.08682	0.114659	1			
NITRATE (mg/l)	-0.88939	0.196868	0.095172	0.158542	0.095077	0.172036	0.394543	0.143801	0.034296	0.601447	1		
FLORIDE(mg/l)	-0.30545	-0.09772	-0.22542	-0.03093	-0.22545	0.071063	0.093953	-0.06178	-0.04532	0.057333	0.394318	1	
AMMONIA (mg/l)	0.149976	0.073232	0.08489	-0.05823	0.084941	-0.02485	-0.19158	0.131767	-0.03252	-0.2075	0.05001	0.091394	1

3.1.3 Total dissolved solids (TDS)

TDS is calculated by summing up all the major cations and anions present in the water. 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 summer is 148-435.1 mg/l. The permissible limit of TDS for drinking water quality standards is 1500mg/l as per WHO (2017). Catroll (1962), Freeze & Cherry (1979) have classified the nature of groundwater based on TDS is given in Table 6.

Table 4: Classification of groundwater based on TDS (Catroll 1962; Freeze & Cherry 1979)

Type of water	Range of TDS in mg/l	Summer season	
		No. of Samples	% of Samples
Fresh water	0 - 1000	14	100%
Brackish water	1000 – 10,000	Nil	Nil
Saline water	10,000- 100,000	Nil	Nil
Brine water	>100,000	Nil	Nil

Based on the classification of TDS by Freeze and Cherry and Catroll, 100% of water is fresh water during Summer Season.

3.1.4 Total Hardness (TH)

Low Hardness means presence of low level of beneficial ions like calcium and magnesium. 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 Hem (1985) and Ragunath (1987) and according to this classification; the table 7 represents the details of the groundwater.

Table 5: Classification of groundwater quality based on Total hardness

Nature of Water	Range of TH as $CaCO_3$ in mg/l	No of Samples
		Summer season
Soft	<75	Nil
Moderately Hard	75-150	04 (29%)
Hard	150-300	10 (71%)
Very Hard	>300	Nil

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 maximum concentration the iron recorded during the summer season is 4.5 mg/l. The range of Iron varies from 0.1-4.5 mg/l and 0.1-4.5 mg/l in the study area during the summer. Around 3 number of samples (17,23,26) during the summer season exceeds the maximum permissible limit as recommended by WHO drinking standards.

3.1.6 Calcium (Ca^{2+})

In view of municipality potential sources like sewages, household waste and industrial wastes that contribute the complex amount of calcium, sulphate and nitrate ions will leads to origin of ionic pollutants (Somusunduram et al 1993). The calcium content of the groundwater samples varies from 20-90 mg/l during Summer. 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 12 to 35mg/l during summer. 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^{-})

The pollution by sewage waste, leaching of saline residue in soil and salting in trees may leads to abnormal concentration of chloride (Karnath 1999). The chloride in the groundwater samples of the study area ranging from 15-30 mg/l during the summer. 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-})

The value of suphates ranges from 19-80 mg/l during summer season and all the samples are within the permissible limit as recommended by WHO 2017 drinking water standards.

3.1.10 Nitrate (NO_3^-)

Nitrate occurs in the groundwater in the form of nitrate fertilizers. High concentration of nitrate in water more than 45mg/l may cause mathemoglobinemia in infants or blue baby diseases (Comly 1945, Gilly *et al.*, 1984). The maximum permissible limit of nitrate is 50 mg/l and in the study area it ranges from 14-36 mg/l during the summer season and all the samples collected were within permissible limits of WHO (2017) drinking water standards.

3.1.11 Fluoride (F^{-})

The occurrence of higher concentration of fluoride in the groundwater is due to bedrocks containing fluoride minerals (Handa 1975). The concentration of the fluoride content in the study area during the summer season is in the range of 0.1mg/l to 0.3 mg/l. All the samples are within the permissible limits as recommended by WHO (2017) drinking water standards.

3.1.12 Ammonia ($NH4^{+}$)

It is not typically found in freshwater drinking sources but a variety of events, including burning fossil fuels, fertilizing crops, ranching, and the leeching of sewage and septic tanks, may potentially produce ammonia. Additionally, areas with soils rich in humic substances and iron may contain higher natural contents. The range of ammonia obtained during the summer is 0.1-0.3 mg/l.

CONCLUSION

- The pH value of the entire study area is found to be alkaline in nature. The locations with sample no.s (15,17,18,19,22,23,26,27,28) were exceeding maximum permissible limit for this parameter as recommended by WHO 2017 drinking water standards and the remaining locations were upto the standard for human consumption.
- The parameter Total Hardness is related to presence of calcium and Magnesium ions in water and in the study area this parameter is also found to be within the permissible limit as per WHO 2017

drinking water standards. Hardness value ranged from 100-221 mg/l during Summer Season and all the samples of the study area have portability for drinking purpose.

- Moderately hard water and Hard water is found in the study area in both the Summer season.
- Calcium and magnesium are commonly found in the rocks forming minerals. The Calcium and the magnesium content of the study are within the permissible limits as per WHO 2017 drinking water standard.
- Regarding the Iron (Fe^{+}), around three locations with sample no.s (17,23,26) collected during Summer are found to be exceeding the permissible limits values of WHO 2017 drinking water standards.
- Regarding the Nitrate (NO_3^{-}) its maximum permissible limit is 45 mg/l and in the study area it ranges from 14-36 mg/l during the Summer season and the samples are within the permissible limits values of WHO (2017).
- The Phosphate (SO_4^{2-}) and Nitrate (NO_3^{-}) parameters were also within maximum permissible limits as per WHO (2017) drinking water standards.
- The electrical conductivity was found to be in the range of 296-870.3 µS/cm during summer season and all the samples were with the maximum permissible limit values of WHO 2017 drinking water standards.
- For parameters like Ammonia ($NH4^{+}$), Chloride (Cl^{-}) and Fluoride (F^{-}) all were within the permissible limit values of WHO (2017) drinking water standards and were suitable for human consumption in the study area.
- The overall quality of the samples collected was good and acceptable for most of the parameters recommend by WHO (2017) for drinking purpose except few locations were exceeding the maximum permissible limit of the parameters like Iron and pH.

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 ProcessA 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, WorldBank, 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, D.B., & Zade, A.B. (2011). Geochemical characterization of ground water from Northeastern part of Nagpur urban, Central India. *Environment and Earth Sciences*, **62**, 1419-1430

Freeze, R.A., & Cherry, J.A. (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, B.K. (1975). Geochemisty and Genesis of fluoride containing groundwater in India. *Groundwater Journal*, **13**, 3, 275-281.

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

Indirabai, W.P.S, & 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, H.M. (1987). Groundwater *Wiley Eastern Ltd., New Delhi, India*, 563.
Sanchez-Perez, J.M., & Tremoloeres M. (2003). Change in groundwater chemistry as a consequence of suppression of floods. The case of Rhine flood plain. *Journal of Hydrology*, 270, pp.89-104.
Singh, V., & Singh, U.C. (2008). Assessment of groundwater quality of parts of Gwalior (India) for agricultural purposes. 1. 10.17485/ijst/2008/v1i4/29241.
Somasundaram, M.V., Ravindran, G., & Tellam J.H. (1993). Groundwater Pollution of the Madras Urban aquifer, India.*Groundwater*,**31**, 4, 4-11.
Trivedy, R.K., & Goel, P.K. (1986). Chemical and Biological methods of water pollution studies. *Environmental Publications*, Karad, India.

Copyright: *© 2023 by the Authors, published by Centre for Info Bio Technology. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY-NC) license [https://creativecommons.org/licenses/by-nc/4.0/], which permit unrestricted use, distribution, and reproduction in any medium, for non-commercial purpose, provided the original work is properly cited.*