East African Scholars Journal of Engineering and Computer Sciences
OPEN ACCESS
Abbreviated Key Title: East African Scholars J Eng Comput Sci
ISSN: 2617-4480 (Print) & ISSN: 2663-0346 (Online)
Published By East African Scholars Publisher, Kenya

Volume-3 | Issue-6 | June-2020 | DOI: 10.36349/easjecs.2020.v03i06.015

Research Article

Evaluation of Geochemical parameters of groundwater for suitability of Drinking and irrigational needs: a case study from Northern plains of Karnataka state, India

Vijay B[1], Siddalinganahalli Manjappa[1], Santhosh B M[2], Harshavardhan A[2] and Suresh B*[3]

[1]Department of Chemistry, University BDT College of Engineering, Davangere, Karnataka, India
[1]Department of Chemistry, G.M. Institute of Technology, Davangeret, Karnataka, India
[2]Department of Chemistry, Sharanabasaveshwara College of science, Kulburgi, Karnataka, India
[3]Department of Civil Engineering, BIET, Davangere, Karnataka, India

Article History
Received: 18.05.2020
Accepted: 09.06.2020
Published: 23.06.2020

Journal homepage:
https://www.easpublisher.com/easjecs

Quick Response Code

Abstract: History of the ground water reveals that, compare to surface water safest water on the crust is ground water but due to changes in the waste management pollution has been entered into the ground and contaminated the liquid state of the crust. In the present work, an effort has been made to evaluate the geochemical parameters of the ground water indices for suitability of ground water for drinking and irrigational needs. Total fifty samples from different location and random sampling is considered as the best technique of selecting a representative sample. All the ground water samples are alkaline in nature and within the permissible limit of WHO and BIS guidelines. In the present study period, the occurrence of major cations and anions showing in the following category. $Na^{+}>Ca^{2+}>K^{=}>Mg^{2+} = F^{-} >HCO_3^{-}>CO_3^{-}>Cl^{-}$. Gibbs graph represents the two types of ratios between the TDS with $Na^{+}+K^{+}/Na^{+}+K^{+}+Ca^{2+}$ and $Cl^{-}/Cl^{-}+HCO_3^{-}$ cations and anion respectively. Precaution to taken before using for drinking purposes, but after proper treatment can be used for drinking as per WHO.

Keywords: Geochemical, suitability, drinking, irrigation, gibbs, SAR, USSL

INTRODUCTION

Groundwater is a main resource available on the earth crust for life; it plays an important role in irrigational activities indirectly and directly influences the health of much system in the nature. Depletion of ground water has been documented at regional and also global level due to many activities (MacDonald, A.M. *et al.*, 2016). Ground water is having a main role in its sustainability for various needs and also its quality is having a significant role in recent years (Kumar, S.K. *et al.*, 2009). Currently due to exhaustive agricultural, domestic and industrial activities also over grazing, variation in rainfall including mismanagement of underground water leads contamination in its (Salifu, M. *et al.*, 2013). Worldwide, agricultural activity is the chief abstractor and asset for consumers at the same time in India majority of the rural communities are applying in farming activities (Foster, S., & Garduno, H. 2013).

In India, agriculture represents geographically and significantly plays a role in overall growth of socio-economic condition. Last few years in India agricultural growth GDP have been reduced from 5.0 to 3.8 in 1996 – 2000 to 2011-2015 respectively. After this improvements in the technology, fertilizers also innovations in the seedling techniques made India is 7th largest country in the world for its export of agricultural products. But, on the other hand usage of enormous fertilizers and pesticide in agricultural activities deteriorated the quality of water in the earth crust (Kurdi, M. *et al.*, 2013).

History of the ground water reveals that, compare to surface water safest water on the crust is ground water but due to changes in the waste management pollution has been entered into the ground and contaminated the liquid state of the crust (Nikanorov, A.M., & Brazhnikova, L.V. 2009). The chemical constituents of the ground water controlled by gases, minerals and other organic constituents present in the crust and also due to human activity as a factor. Inside the aquifer due to natural factors like hydrological cycle geological factors balances the overall chemistry of the mantle layers of the crust (Raju, N.J. *et al.*, 2016).

***Corresponding Author:** Suresh B

In the northern plains of the Karnataka state has been selected for the present work. Agricultural is the chief pattern of this region and also main sources for drinking needs, Hence hydrological appraisal is required to identify the chemistry of ground water. In the present work, an effort has been made to evaluate the geochemical parameters of the ground water indices for suitability of ground water for drinking and irrigational needs. Find out the causes of the natural and human activities on chemistry of ground water.

MATERIALS AND METHODS

Study area:

Karnataka state is situated in the southern peninsular India. Jagalur is one of the Taluk headquarters, situated about 48 Kms from Davangere district (corporation city), Karnataka state. The taluk comes under granite and gnessic formation which is generally called as "hard rock terrain". However, green stone belt consisting of chlorite-schist, micaschist along with clay formations have been observed in the hard rock formations of this region. The Jagalur Taluk Davangere district is surrounded by Haveri district at West, Bellary district at North, Chitradurga district at East and Shimoga district at South. Location details given in Figure 1.

Geology:

The geological location of Jagalur taluk lies in the Northern plains of Karnataka state, India (Fig.4.) covers an area of 984.50 sq. kms and lies in between 14^0 31’ 07’ latitude and 76^0 19’ 43’ longitude. As a whole, the region has rocky areas and dry land with an average elevation of 700.00 mts above mean sea level. It comprises 3 Hoblies and 142 villages with a total population of 1,36,765 as per 2001 census. The Jagalur Taluk has geographical area of 95527 hectares. Out of which, the total cultivable land is about 67133 hectares, barren land of 2220 hectares and non-agricultural land of 3383 hectares. It has a forest area of about 12688 hectares.

Meteorology:

The climate of Jagalur taluk is fairly humid. The mean monthly temperature ranges from 21^0C to 28^0C and maximum temperature during the month of April (39^0C to 40^0C). The relative humidity varies from 48% to 82% and it is highest during the months of August and September and is lowest during the months of January and February. The average rainfall of Jagalur taluk is 464.02mm (2001 census). The taluk region receives rainfall mainly from Southwest monsoon and partially from North east monsoon with an annual rainfall season spreading over a period of five to six months. The Southwest monsoon occurs from June to September amounting to about 67% and North east monsoon during October to December constituting to about 33% of the annual rainfall.

Sampling techniques:

APHA, 2005, have suggested a sampling design of the bore well waters in order to pursue the quality control and making forecasts to determine the extent of damage due to pollution. In the present investigation, random sampling design was considered. Random sampling design which is also known as probability sampling has an equal chance of inclusion of every item of an object in the sample. Random sampling ensures the law of statistical regularity, which states that “if an average of the samples chosen is a random one, the sample will have the same composition and characteristics as the object under consideration”. This is the reason why random sampling is considered as the best technique of selecting a representative sample.

Laboratory Test Conducted

Total fifty samples collected from northern parts of Karnataka, twelve different parameters were conducted to understand the values of variables in the selected ground water samples. EC and pH instruments were calibrated using standard buffer solution of respective variables. The collected ground water samples were examined for cations (Ca, Mg, Na and K) and anions HCO_3^-, Cl, F and CO_3^-) including hardness. The variables were analyzed as per the procedure (APHA. 2005). The results are applied for comprehensive geochemical appraisal. The apprised data were used to plot inter ionic graphs like WiIcox diagram (Wilcox, L.V. 1948), USSL diagram (US Salinity Laboratory. 1954) using Excel Microsoft version 2007.

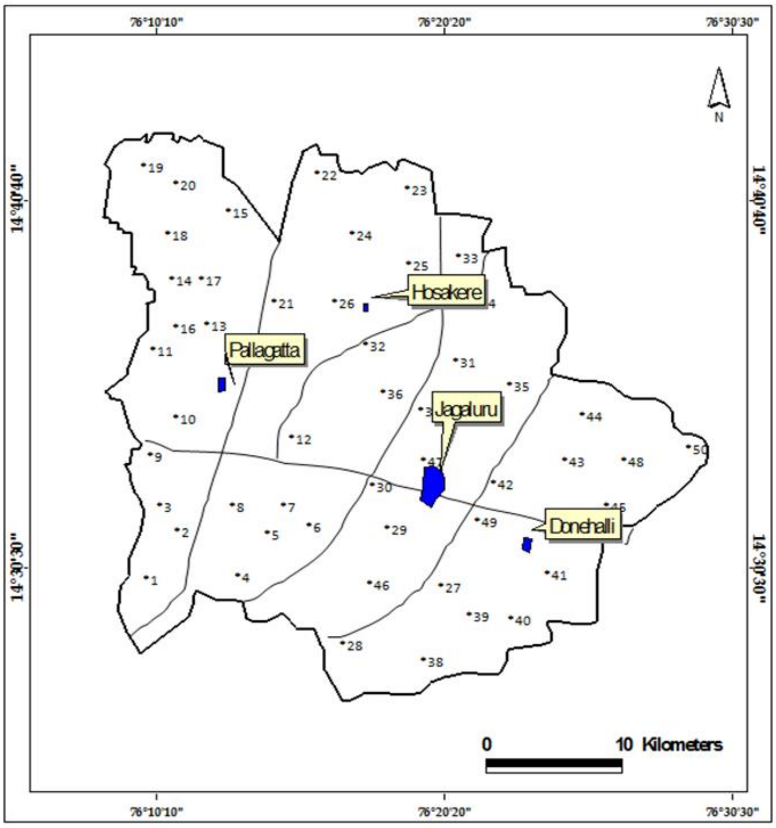

Figure 1: Map Showing Sampling Locations in Jagalur Taluk

RESULT AND DISCUSSION

To establish the accessibility of collected groundwater samples for drinking and agricultural needs was converse separately on compared the results with standard values of WHO and BIS guidelines (Table 1). All the ground water samples are alkaline in nature and within the permissible limit of WHO and BIS guidelines. The results are compared as per WHO guidelines about 40% and 06% of ground water samples are exceeded the limit of EC and TDS content respectively. Total hardness and calcium content shows that exceeded the permissible limit about 56% and 28% with respect to WHO guidelines but about 44% and 28% with respect to BIS guidelines. But only magnesium content exceeded 06% as per BIS guidelines given for drinking purposes. This may be due to presence of alkaline nature soil content means that presence of calcium and magnesium in the form of bicarbonates.

Table 1: Mean values in mg/L of groundwater samples in Southern parts of Karnataka

Parameters	**Min**	**Max**	**Mean**	**WHO Permissible limit (2004)**	**% of samples exceeded Permissible limit**	**BIS Permissible limit (2003)**	**% of samples exceeded Permissible limit**
pH	7.1	8.5	7.9	6.5-8.5	Nil	6.5-8.5	Nil
EC	896.00	2945.00	1347.50	1400	44	3000	Nil
TDS	564.00	1940.00	918.00	500-1500	06	2000	Nil
TH	375.00	947.00	561.00	100-500	56	600	44
Ca^{2+}	73.00	352.00	141.00	75-200	28	200	28
Mg^{2+}	30.00	145.00	74.50	50-150	Nil	100	06
Na^{+}	63.00	290.00	182.00	200	32	200	32
K^{+}	2.00	12.00	5.20	12	02	10	06
Cl-	140.00	490.00	265.50	200-600	Nil	1000	Nil
F^{-}	1.10	3.20	1.70	1.5	70	1.5	70
HCO_3^{-}	86.00	737.60	348.40	-	-	-	-
CO_3^{-}	22.30	190.90	90.20	-	-	-	-

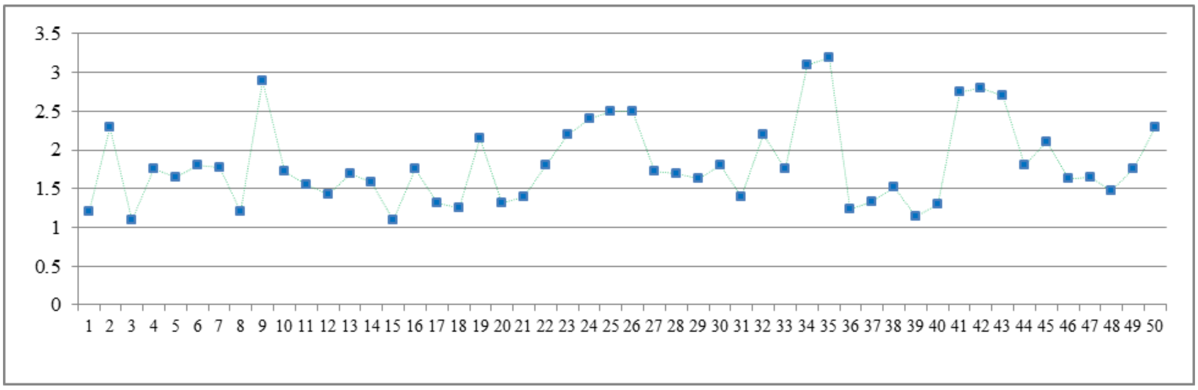

Figure 2: Fluoride values in mg/L of groundwater samples in northern plains of Karnataka

In the entire study, about 70% of the collected samples are indicating high fluoride content (Chaudhary, V. *et al.*, 2010). This may causes dental carries in the study area and also suffering peoples are using fluoride contaminated water as a source for drinking. A maximum rate of evaporation, transpiration, habitation time of the water in the aquifer area, extraction of water for irrigation from the earth crust and also modern irrigation technologies are the main factors are the enhancing in the fluoride content in the mantle layer of the earth (SubbaRao, N. 2003). Same trend of fluoride content indicated in different villages of Haryana study conducted by Meenakshi (Meenakshi, G.V. *et al.*, 2004).

Trilinear piper diagram was adopted to express water quality based on the ions present in the selected ground water in the area. Piper diagram gives the presence of cations and anions also categorize the dominant ion in selected water samples. As per the study reveals that in the selected area most of the ground water samples are comes under bicarbonate ions, it's may be due to alkaline nature ($CaMgHCO_3$) of soil condition in the region (Piper, A.M. 1944) Figure 3.

In the present study period, the occurrence of major cations and anions showing in the following category. $Na^+ > Ca^{2+} > K^= > Mg^{2+} = F^- > HCO_3^- > CO_3^- > Cl^-$. Sodium and Fluoride ions are indicating maximum content in the entire study (Table 1). In the present study, Gibbs (19970) diagram proposed to understand the precipitation, interaction between the rock and water including evaporation rate in the underground water. Gibbs graph represents the two types of ratios between the TDS with $Na^+ + K^+ / Na^+ + K^+ + Ca^{2+}$ and $Cl^- / Cl^- + HCO_3^-$ cations and anion respectively. Figure 3 (Gibbs1) and Figure 4 (Gibbs II) represents most of the ground water samples from dominance in the study area. The study indicates, chemistry of water is controlled by rock water interaction in the mantle layer of the crust (Alam, F. 2013) and (Raju, N.J. *et al.*, 2013).

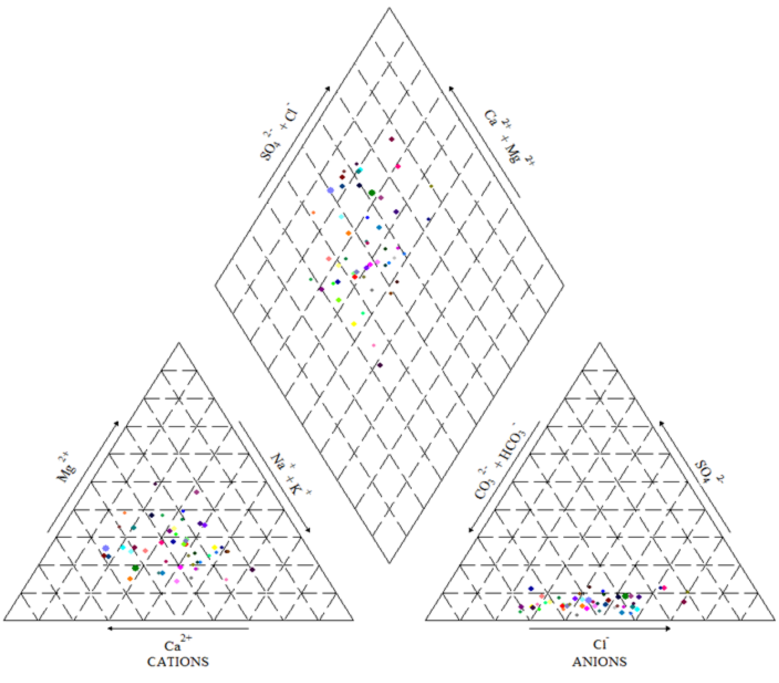

Figure 3: Triangular piper diagram of samples for northern plains of Karnataka

Wilcox (1948) proposed a scheme to classify the ground water for irrigational needs using %Na and EC content. As per the Wilcox the study reveals that 19 ground water samples are comes good to permissible, 18 samples under permissible to doubtful category. 8 samples are comes under doubtful to unsuitable but only one sample showing unsuitable category (Figure 5). Figure 6 shows that USSL diagram, which shows the fitness of the ground water samples for irrigational needs. USSL plot gives relationship between SAR and EC content also sodium and salinity hazard (Richars, 1954 and USSL, 1954). The USSL diagram represents all the ground water samples are lies in the field of C1-S1(19 Samples), C1-S2 (9 Samples) C1-S3 (3 samples), C1-S4 (1 Sample), C2-S1(8 samples), C2-S2 (5 Samples), C2-S3 (2 Samples), C3-S1 (3 Samples) and C4-S1 (1amples). Based on the USSL diagram Low sodium and Salinity hazard suitable all plants and drainage should be good (Figure 6). Ground water samples are also shown above 50, it indicates unsuitable for irrigation needs and ground water samples are indicating the water can be used by enhancing basic nature of soil. The magnesium ratio ranges from 20.9 to 67.9. Out of fifty samples only 10 samples are showing unfit for irrigational activity (Table 2). Table 2 also indicates the KI values and categorized water into 3 classes. Based on the result, KI values ranges between 0.2 to 1.6, Except 4 samples all the samples are indicating below 1 index hence all the collected ground water samples can be used for irrigational activity (Srinivasamoorthy, *et al.*,., 2014).

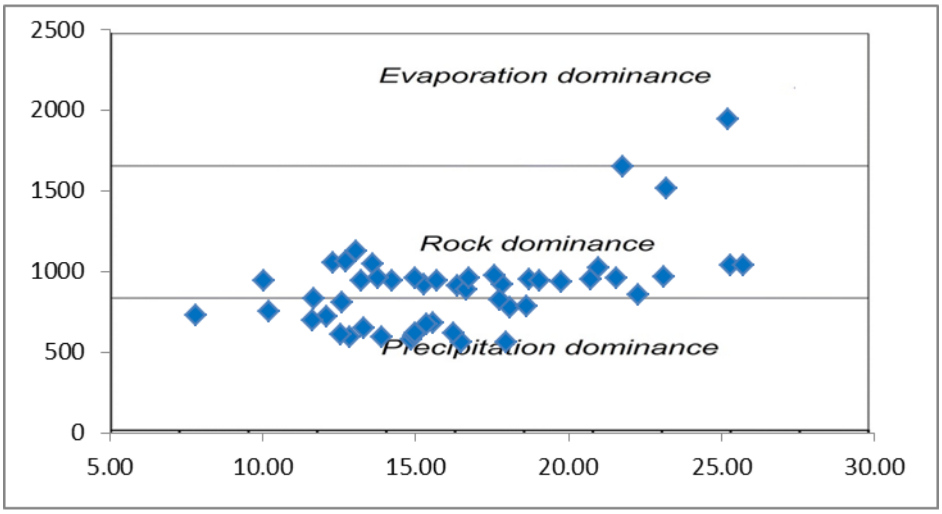

Figure 3: Groundwater chemistry (Gibbs I) [TDS, mg/L and Na+k/Na+K+Ca,meq/L].

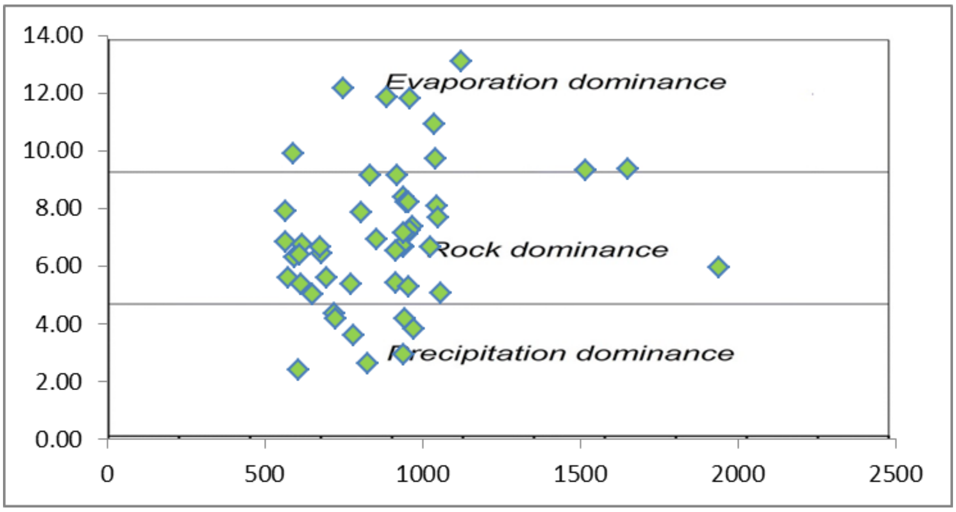

Figure 4 Groundwater chemistry (Gibbs II) [TDS, mg/L and $Cl/Cl+HCO_3$,meq/L].

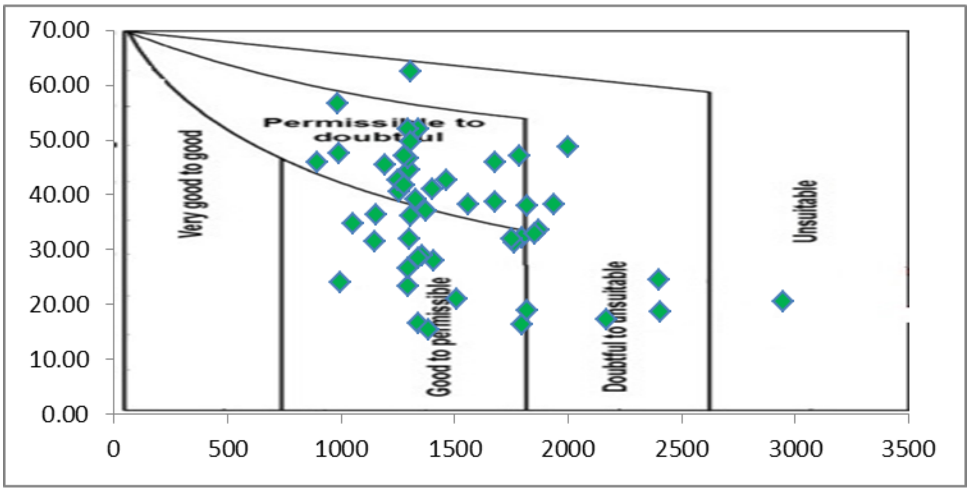

Figure 5 Categorization of groundwater samples on the basis of EC and %Na using Wilcox

Table 2: Suitability of Agricultural activity in the study area

Sample code	SAR	%Na	Mg Ratio	Kelly's Index	Gibbs 1	Gibbs 2	Sample code	SAR	%Na	Mg Ratio	Kelly's Index	Gibbs 1	Gibbs 2
JG-1	0.36	28.02	34.73	0.38	20.73	7.09	JG-26	0.35	28.53	26.24	0.39	25.22	5.94
JG-2	0.47	32.10	48.83	0.46	13.25	6.65	JG-27	0.50	32.92	54.35	0.48	18.10	5.35
JG-3	0.60	37.98	47.15	0.60	15.27	5.42	JG-28	0.48	31.94	57.59	0.45	18.65	3.57
JG-4	0.87	47.50	44.05	0.88	16.51	6.84	JG-29	0.50	34.84	43.53	0.51	16.74	8.23
JG-5	0.29	24.13	32.73	0.31	13.62	8.07	JG-30	0.44	31.54	47.17	0.44	13.06	13.09
JG-6	0.80	46.04	38.52	0.83	14.85	5.59	JG-31	0.70	40.63	57.46	0.66	12.31	7.67
JG-7	1.20	56.75	33.58	1.28	17.98	7.90	JG-32	1.06	51.90	51.26	1.03	13.32	5.00
JG-8	0.66	42.62	24.27	0.73	23.11	7.38	JG-33	1.09	52.06	51.61	1.07	12.09	4.34
JG-9	0.62	38.69	44.78	0.62	19.77	6.68	JG-34	0.71	42.70	42.37	0.73	11.64	5.59
JG-10	0.89	47.09	49.87	0.88	17.84	9.13	JG-35	0.78	45.46	38.17	0.81	12.61	7.85
JG-11	0.60	38.16	44.52	0.61	14.22	8.41	JG-36	0.98	49.57	51.77	0.95	17.76	2.60
JG-12	0.24	21.02	33.27	0.26	16.36	6.53	JG-37	0.30	23.37	49.66	0.30	10.03	4.16
JG-13	0.52	37.10	26.90	0.57	21.58	7.23	JG-38	0.24	18.94	60.48	0.22	7.81	4.17
JG-14	0.60	38.28	46.15	0.60	18.73	8.20	JG-39	0.65	39.15	57.02	0.61	12.75	5.04
JG-15	0.64	41.07	32.43	0.68	25.29	9.73	JG-40	0.52	32.04	67.88	0.46	13.79	5.28
JG-16	0.18	16.45	40.36	0.19	15.57	6.43	JG-41	0.73	44.61	35.89	0.77	14.96	2.41
JG-17	0.17	15.35	45.88	0.17	11.70	9.14	JG-42	0.66	41.77	39.91	0.68	14.98	5.39
JG-18	0.50	33.68	46.73	0.50	16.67	11.85	JG-43	0.76	46.55	28.25	0.83	13.90	9.90
JG-19	0.25	20.53	42.18	0.25	15.69	7.14	JG-44	0.49	36.09	26.76	0.54	12.86	6.29
JG-20	0.20	18.60	28.46	0.22	23.21	9.31	JG-45	0.79	47.09	34.38	0.84	16.26	6.74
JG-21	0.18	16.21	31.08	0.19	21.77	9.35	JG-46	1.60	62.52	47.73	1.59	14.99	11.79
JG-22	0.30	24.53	34.72	0.31	17.58	3.81	JG-47	0.78	46.02	34.27	0.83	22.27	6.90
JG-23	0.43	31.34	40.71	0.44	19.06	2.91	JG-48	0.36	26.66	51.65	0.35	10.23	12.17
JG-24	0.19	17.29	28.04	0.20	20.97	6.66	JG-49	0.94	48.66	47.62	0.93	15.38	6.66
JG-25	0.35	28.93	20.93	0.39	25.70	10.94	JG-50	0.51	36.35	33.44	0.54	12.57	6.39

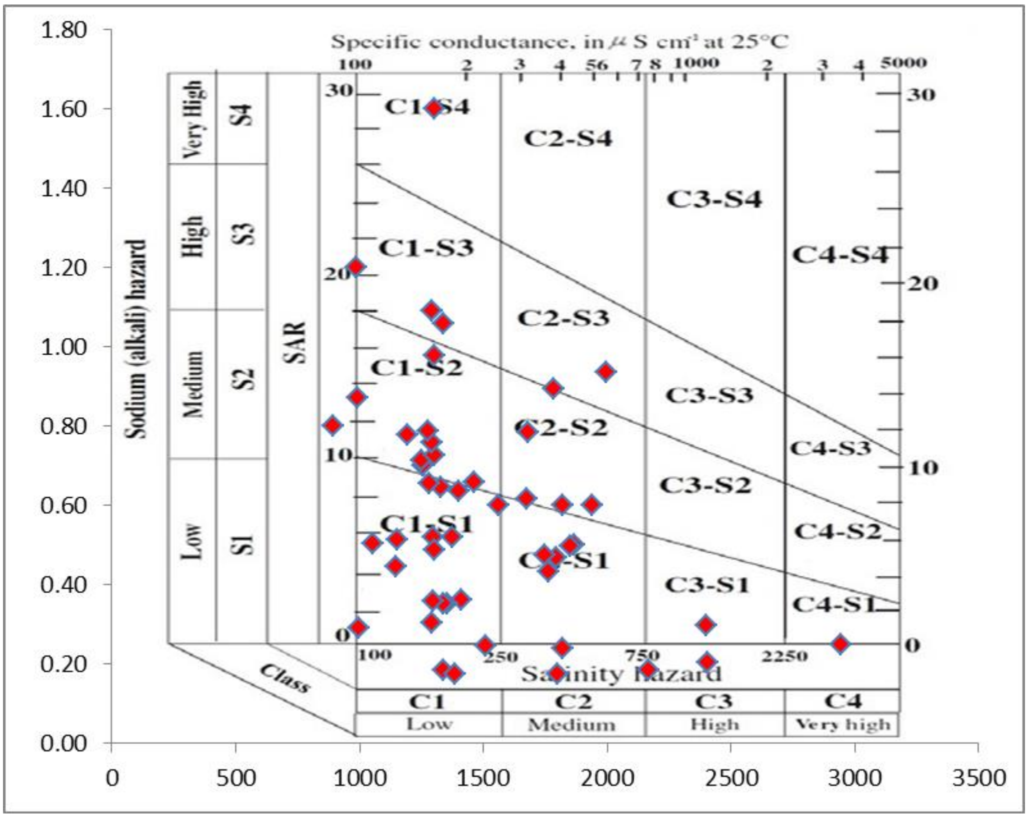

Figure 6 Comparison between salinity and sodium hazard using USSL diagram

CONCLUSIONS

The aim of the present paper is to realize the geochemistry and hydrological characteristics in ground water of northern plains, Karnataka. As per the study it reveals that geology is the chief causes for the deterioration of ground water in the study area. High level of EC and Fluoride are the main causes for the contamination problem in drinking needs. The value of EC and Fluoride encourages the community based water treatment units should be set up to avoid human health hazards. In the present study period, the occurrence of major cations and anions showing in the following category. $Na^{+}>Ca^{2+}>K^{-}>Mg^{2+} = F^{-} >HCO_3^{-}>CO_3^{-}>Cl^{-}$. 60% of the samples of the study area is unfit for drinking purposes since calcium and magnesium contents are high. Precaution to taken before using for drinking purposes, but after proper treatment can be used for drinking as per WHO. Finally outcome of the work help to understand the water quality for proper management and used for drinking and irrigational purposes.

Conflicts of Interest

The authors state that they have no conflicts of interest.

REFERENCES

1. Alam, F. (2013). Evaluation of hydrogeochemical parameters of groundwater for suitability of domestic and irrigational purposes: a case study from central Ganga Plain, India. *Arabian Journal of Geosciences*, *7*, 4121–4131. doi:10.1007/s12517-013-1055-6
2. APHA. (2005). Standard methods for the examination of water and waste water. (21th ed.). Washington.
3. Chaudhary, V., Kumar, M., Sharma, M., & Yadav, B. S. (2010). Fluoride, boron and nitrate toxicity in ground water of northwest Rajasthan, India. *Environmental monitoring and assessment*, *161*(1-4), 343-348.
4. Foster, S., & Garduno, H. (2013). Groundwater-resource governance: Are governments and stakeholders responding to the challenge? *Hydrogeology Journal*, *21*(2), 317–320.
5. Gibbs, R.J. (1970). Mechanism controlling world's water chemistry. *Science*, *170*, 1088–1090.
6. Kumar, S.K., Rammohan, V., Sahayam, J.D., & Jeevananadam, M. (2009). Assessment of groundwater quality and hydrogeochemistry of Manimuktha river basin, Tamil Nadu, India. *Environ Monit Assess* 159:341–351.
7. Kurdi, M., Tabasi, S., Eslamkish, T., & Hezarkhani, A. (2013). Hydrogeochemical study to evaluate the suitability of water for irrigation purpose at Qareh sou catchment, North of Iran. Elixir
8. MacDonald, A.M., Bonsor, H.C., & Ahmed, K.M. (2016). Groundwater quality and depletion in the Indo-Gangetic basin mapped from in situ observations. Nat Geosci. https ://doi.org/10.1038/ngeo2 791.

9. Meenakshi, G.V., Kavita, R., & Malik, A. (2004). Groundwater quality in some villages of Haryana, India: focus on fluoride and fluorosis. *J Hazard Mater* 106:85–97.
10. Nikanorov, A.M., & Brazhnikova, L.V. (2009). Water chemical composition of rivers, lakes and wetlands. *Types and Properties of Water*, *2*, 42–80.
11. Piper, A.M. (1944). A graphic procedure in the geochemical interpretation of water-analyses. *Transactions, American Geophysical Union*, *25*, 914–923.
12. Raju, N.J., Patel, P., Reddy, B.S.R., Suresh, U., & Reddy, T.V.K. (2016). Identifying source and evaluation of hydrogeochemical processes in the hard rock aquifer system: Geostatistical analysis and geochemical modeling techniques. *Environmental Earth Sciences*, *75*(16), 1157.
13. Raju, N.J., Shukla, U.K., & Ram, P. (2011). Hydrogeochemistry for the assessment of groundwater quality in Varanasi: a fast-urbanizing center in Uttar Pradesh, India. *Environmental Monitoring and Assessment, 173*, 279–300. doi:10.1007/s10661-010-1387-6
14. Richards, L.S. (1954). Diagnosis and importance of saline and alkali soils. Washington, DC: US Department of Agriculture Handbook 60.
15. Salifu, M., Yidana, S.M., Osae, S., & Armah, Y.S. (2013). The influence of the unsaturated zone on the high fluoride contents in groundwater in the Middle Voltaian Aquifers—the Gushegu District, Northern Region of Ghana. *J Hydrogeol Hydrol Eng 2*, 2.
16. Srinivasamoorthy, K., Gopinath, M., Chidambaram, S., Vasanthavigar, M., & Sarma, V.S. (2014). Hydrochemical characterization and quality appraisal of groundwater from Pungar sub basin, Tamilnadu, India. *Journal of King Saud University - Science*, *26*, 37–52.
17. SubbaRao, N. (2003). Groundwater quality: focus on fluoride concentration in rural parts of Guntur district, Andhra Pradesh, India. *Hydrol Sci 48*(5), 835–847.
18. US Salinity Laboratory. (1954). Diagnosis and improvement of saline and alkali soils (p. 160) (Agriculture Handbook NO. 60). USDA.
19. Wilcox, L.V. (1948). The quality of water for irrigation use. Vol. 40. Washington, DC: US Department of Agriculture Technology Bulletin 962.