International Journal of Advanced Geosciences, 2 (1) (2014) 8-12

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International Journal of Advanced Geosciences

Journal home page: www.sciencepubco.com/index.php/IJAG
doi: 10.14419/ijag.v2i1.1696
Research Paper

GEOSCIENCES

Groundwater quality assessment from Tarali river sub basin of Krishna river basin, western Maharashtra (India)

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Abstract

The aims of present study to assessing drinking and irrigation water quality in Tarali river sub basin of Krishna river Basin, Western Maharashtra (India). The study area is lying between Latitude 17°23' to 17°38' N and Longitude 73°48' to 74°27' E. The area having steep to moderate slope and elevation ranges from 584-1171m above the Mean Sea Level (MSL). Basin exhibits hilly and mountain terrain forming ridges and Western Ghats with deep valley, plateaus and plain. The whole area can obtained in topographical sheets i.e. 47 G/14, 47 G/15 47 K/2, 47 K/3 covering area about 627 sq.km, acquired from survey of India. The climate of basin is semi-arid to sub-humid climate. Average annual rainfall is 800-1800mm in the study area. Field work was carried out during post monsoon 2012 (winter) and collect the groundwater samples from the both bank of Tarali River Sub Basin. Hydrogeochemical analysis was carried out using standard analytical techniques. A total 20 groundwater samples were collected from public water supply wells in the area under study. Draw the various plots on the basis of obtained results by using Aquachem geoscientific software.

Keywords: *Groundwater geochemistry, piper trilinear diagram, Wilcox diagram, box whisker plot, Tarali river sub basin, western Maharashtra (India).*

1. Introduction

Groundwater quality has become one of the most important aspects in our living environment and that chemistry of groundwater has a bearing on our health and livestock. We have being used water for drinking, domestic, agriculture and industrial purpose they are drawn from subsurface. Due to insufficient availability of surface water to meet the requirement of human activities groundwater remains only option to supply the increasing demand of water. In recent years groundwater contamination has been recognized as one of the major issues in India.

The human health problems caused by inorganic elements earlier reported from different part of India. These problems arise naturally and anthropogenically due to improper waste management, groundwater contamination, unnecessary use of fertilizers, insecticides in agricultural area for high yield (Golekar et al., 2013). The groundwater contamination, decrease in soil fertility is due to use of waste water for agricultural purposes without treatment (Golekar et al., 2013).

The area chosen for present study covering about 20 villages from Tarali River Sub basin of Krishna River Basin in Western Maharashtra, India for assessing drinking water quality of public water supply wells form medical hazard point of view. Location map of study area has shown in figure 1.

1.1. Geological setting

Study area geologically covered by Deccan Volcanic Province of India. In this area there are six different types of basaltic lava flows, which are topmost layer is generally red clayey material, called as “red bole’’ (GSI, 1987). Due to impact of the temperature, water and climate basalt is converted into the Laterite and capped on basalt. Hilly area has been found to be extensively capped by Laterites. Stratigraphic successions of Tarali River basin were presented in table 1. The area is covered by Deccan Plateau of Sahyadri ranges i.e. the residual hills ranges, well developed table lands and intermediate valleys forms the main geomorphic element present in the basin area. The river has largely been controlled by structural underlying basalt flows. Many streams are characterised by the straight segments.

1.2. Hydrogeological setting

The weathered and fractured traps are occurring in topographic lows form the main aquifer in the basin. The groundwater occurs under phreatic, semi-confined and unconfined conditions. Generally the shallower zones down to the depth of 20 m below ground level form phreatic aquifer. The water bearing zones occurring between the depths of 20 and 40 m are weathered interflow or shear zones and yield water under semi-confined conditions. Deep confined aquifers occur below the depth of 40 m.

Table 1: Stratigraphic successions of Tarali River basin

Period	Age	Lithology
Quaternary	Recent	Unconsolidated ,Consolidated sediments, Soil, alluvium, Laterite, etc.
Cretaceous	Upper Cretaceous to lower Eocene	Deccan Basalt

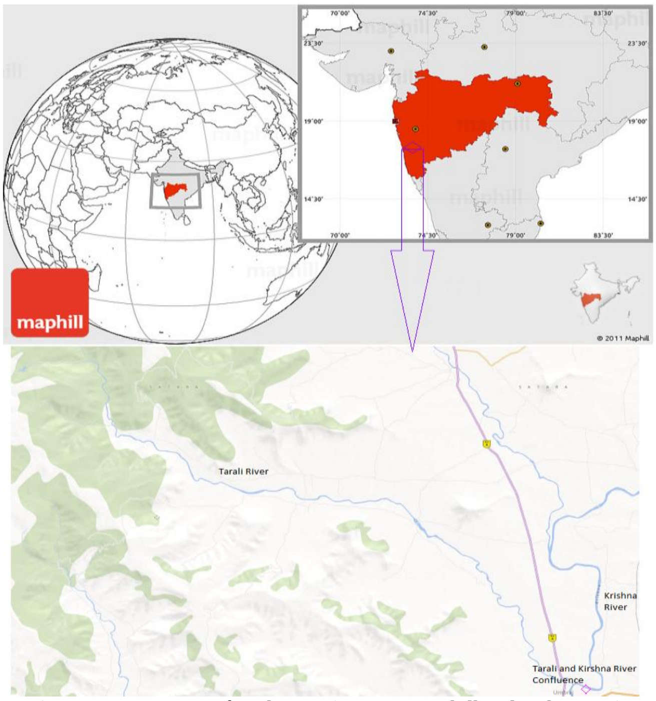

Fig. 1: Location map of study area (Source: Map hill and Wikimapia)

2. Materials and methodology

Field work was carried out during post monsoon 2012 (winter) and collect groundwater samples from the drinking water supply wells of the left and right bank of Tarali River Sub Basin of River Krishna, Maharashtra, India. Hydrogeochemical analysis was adopted by standard techniques (APHA, 1998). Physical parameters were analysed by using digital water analysis field kit. Ca^{2+}, Mg^{2+}, HCO_3^-, CO_3^{2-} and Cl^- ion determined by standard titrimetric methods. Na^+ and K^+ concentrations in groundwater samples were measured using an emission flame photometer. SO_4^{2-} and Fe were analysed by using spectrophotometer and Atomic Absorption Spectrometer respectively in the School of Environmental and Earth Science, North Maharashtra University, Jalgaon, India. Draw the various plots by using Aquachem geoscientific software like piper trilinear diagram, Wilcox Diagram, Box whisker plot and their interpretations.

3. Result and discussion

The result of physico-chemical analysis of groundwater samples from the study area were presented in Table 2. The result of Irrigation water quality parameters and groundwater type of the area were presented in Table 3. Statistical summary of hydrogeochemical parameter of groundwater from the study area were presented in Table 4. Hydrogeochemical relation-ship between various physico-chemical parameters were obtained by employing graphical and statistical methods viz., piper plot, Wilcox, Box Whisker plot and correlation coefficient.

3.1. Drinking water quality status

pH of groundwater from analysed samples, ranged from 6.4-7.4 with an average value of 6.9 (Table 2). The pH values for all groundwater samples were found within the permissible limits compared with the BIS (2012) standards established for drinking water. Electrical conductivity is a function of total dissolved solids (TDS) known as ions concentration, which determines the quality of water (Hem, 1989).

The EC values for all groundwater samples were found within the permissible limits according to BIS (2012) drinking water standards and can be used for irrigation purpose as well (Richards, 1954). The total dissolved salts in the groundwater ranged from 120.0 – 354.0 mg/L with an average value of 254.9 mg/L (Table 2). It was observed that the TDS in groundwater of all the samples were within the permissible limits compared with the BIS (2012).

The concentration of calcium in groundwater ranged from 33.1 - 94.2 mg/L with an average value of 70.2 mg/L (Table 2). The results showed that the level of calcium in 8 (40 %) groundwater samples was observed exceeds permissible limits compared with BIS (2012).

The concentration of magnesium in groundwater ranged from 15.1 - 86.7 mg/L with an average value of 38.6 mg/L (Table 2). The results showed that the level of magnesium in 12 (60 %) groundwater samples was observed exceeds permissible limits compared with BIS (2012).

The concentration of sodium in groundwater ranged from 62.1 - 170.2 mg/L with an average value of 121.0 mg/L (Table 2). The results showed that the level of sodium in all groundwater samples was observed within permissible limits compared with BIS (2012).

The concentration of potassium in groundwater ranged from 3.5 - 37.1 mg/L with an average value of 15.1 mg/L (Table 2). The results showed that the level of potassium in 13 (65%) groundwater samples was observed exceeds permissible limits compared with BIS (2012).

The concentration of chloride in groundwater ranged from 57.7 - 165.1 mg/L with a average value of 116.8 mg/L (Table 2). The results showed that the level of chlorides in all samples of groundwater was within permissible limits compared with BIS (2012).

The concentration of sulphate in groundwater ranged from 0 - 44.9 mg/L with an average value of 20.1 mg/L (Table 2). The results showed that the level of sulphate in all samples of groundwater is within permissible limits compared with BIS standards for drinking.

The concentration of HCO_3^- in groundwater ranged from 122 - 793 mg/L with an average value of 417.5 mg/L (Table 2). The results showed that the level of HCO_3^- in 18 (80%) groundwater samples was observed exceeds permissible limits compared with BIS standards for drinking.

The Fe in the groundwater ranged from 0.41-1.42 mg/L with an average value of 0.64 mg/L. Fe concentration compared with BIS (2012) standards set for the drinking water. The results showed that the level of Fe in 17 (85%) groundwater samples was observed exceeds permissible limits compared with BIS standards for drinking. Higher concentration Fe in drinking water they lead to inky favour (Deshpande et al., 2011). The Fe results revealed due to the presence of Fe in lateritic rocks; the lateritic rocks are major geogenic source of Fe in groundwater from the study area.

3.2. Irrigation water quality parameters

Sodium absorption ratio (SAR)

SAR is express as (Richard, 1954),

$$SAR = \frac{Na}{\sqrt{(Ca+mg)/2}} \quad (1)$$

All ionic values are in meq/l.

Classification of water with reference to the SAR (Raghunath, 1987) values less than 10 it is indicates excellent for irrigation. The SAR of municipal groundwater ranged from 1.5-4.9 with an average value of 3.0 (Table 3). The results showed that the groundwater under S1class (SAR<10).

Residual Sodium Carbonate (RSC)

Lloyd and Heathcote (1985) have classified irrigation water based on RSC as Suitable (< 1.25), marginal (1.25 to 2.5) and not suitable (> 2.5). The values for RSC is calculated as per Eaton (1950),

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca + Mg) \quad (2)$$

All ionic values are in meq/l

Accordingly the all groundwater is suitable for irrigation except one sample (Daphalwadi) because its RSC value is > 2.5.

3.3. Graphical representations

Piper diagram (1944)

The Hill-Piper diagram is used to infer hydrogeochemical facies. The concept of hydrochemical facies was developed in order to understand and identify the water composition in different classes. A trilinear diagram was created to classify the groundwater from different parts of the study area and to reveal any groupings, similarities or trends of the samples. The HCO_3^- -Cl^--SO_4^{2-} anion triangle plotted show groundwater samples have bicarbonate and chloride type end members and sulphate is not present in significant proportion. The Ca^{++} - Mg^{++} - Na^+ cation triangle shows that the major cations present in the sample are Ca^{++} and Na^+. The two triangles projected onto the main diamond field account for a number of hydrochemical groupings (Figure 2). It shows that alkalies (Na^+ + K^+) exceed alkaline earths (Ca^{++} + Mg^{++}) alkalies and strong acids (HCO_3^- + CO_3^{2-}) exceed weak acids (SO_4^{2-} + Cl^-). The dominant hydrochemical facies (5samples out of 20 samples) is Na^+ - Ca^{++} - HCO_3^- - Cl^- followed by Na^+ - Ca^{++} - Mg^+- HCO_3^- - Cl^- (4 samples) and Ca^{++} - Na^+ - Cl^- - HCO_3^- (3 samples).

US Salinity Hazard Wilcox (1955) Diagram

SAR (Sodium Adsorption Ratio) is an important parameter for determining suitability of groundwater to irrigation because it is a measure of alkali / sodium hazards to crops (Richard, 1954). Kumaresan and Riyazuddin (2006) discussed their results using Wilcox diagram (Wilcox, 1955) and illustrate that the only one sample falls in C1S1 category which is indicating low salinity and low sodium and remaining all groundwater samples fall in the field of C2S1, indicating medium salinity and low sodium water.

This diagram (Figure 3) indicates type of salinity hazards. It is evident that, most of the groundwater samples fall under category C2S1 which is indicates groundwater of study area medium salinity and sodium hazards.

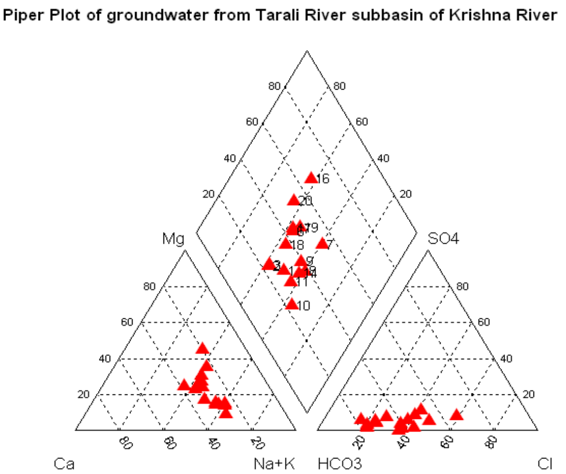

Fig. 2: Piper hill diagram of the groundwater

Box whisker plot

The Box and Whisker plot displays a statistical summary of major elements in groundwater samples. The central box represents the values from the lower to upper quartile (25th to 75th percentile). The middle line represents the median. A vertical line extends from the minimum to the maximum values. The Box and Whisker plot has shown in figure 4.

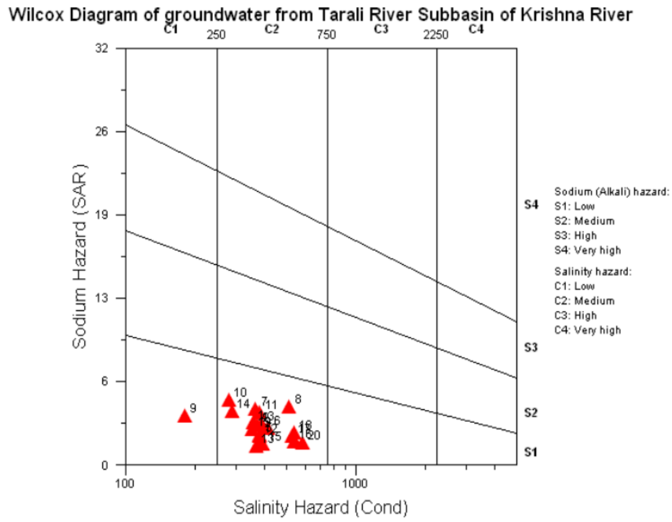

Fig. 3: Wilcox salinity hazard diagram of the groundwater

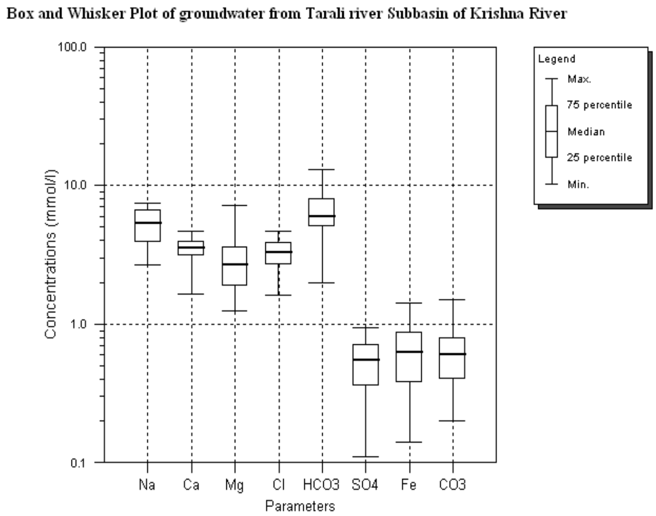

Fig. 4: Box whisker plot of the groundwater

3.4. Correlation coefficient

The correlation between various hydro geochemical parameters are obtained from the correlation coefficients (Table 5). The results show a very good correlation between TDS and EC (0.98). Mg^{++} show good correlation between bicarbonate (0.69) and iron (0.57). Good correlation is also noted between Na^+ and HCO_3^- (0.63) and HCO_3^- and Fe (0.67). Correlation coefficient reveals various interrelationships among cations, anions, alkalinity and total hardness in the groundwater samples.

Table 2: Analytical results of hydrogeochemical parameter of groundwater from the study area all values are expressed in mg/L except EC in µs/cm and pH

Sample ID	Village	WL	pH	EC	TDS	TH	Ca^{++}	Mg^{++}	Na^+	K^+	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	Fe
1	Murud	4.5	6.8	357.8	230.7	176.0	78.2	26.8	128.8	19.5	88.8	24.0	439.2	0.0	0.78
2	Tarale	5.4	6.9	372.2	239.7	224.0	94.2	67.1	158.7	15.6	113.6	19.2	701.5	0.0	0.92
3	Pali	4.2	6.7	391.5	253.1	232.0	78.2	76.9	163.3	11.7	117.2	28.8	732.0	6.0	0.87
4	Shirgaon	3.9	6.8	366.8	234.8	214.0	58.3	86.7	156.4	19.5	124.3	0.0	793.0	12.0	1.42
5	Vadgaon	5.8	7.1	382.5	248.6	166.0	79.4	59.5	110.4	3.5	134.9	0.0	530.7	18.0	0.87
6	Indoli	6.2	7.2	416.7	263.0	206.0	83.8	36.1	121.9	4.3	145.6	33.6	366.0	12.0	0.76
7	Umbraj	3.9	6.8	367.2	234.8	178.0	57.6	21.2	149.5	21.1	148.0	26.6	244.0	45.0	0.41
8	Dusale	4.1	6.9	513.0	319.9	228.0	55.7	22.0	154.1	6.6	129.9	9.6	366.0	24.0	0.36
9	Bhorgewadi	6.4	7.0	180.5	120.1	192.0	62.3	22.0	135.7	9.8	104.7	19.2	305.0	36.0	0.87
10	Daphalwadi	5.2	6.9	280.4	145.2	304.0	65.5	15.1	170.2	13.7	69.4	38.4	549.0	24.0	0.78

11	Jambhekarwadi	3.6	6.7	383.4	241.0	276.0	72.7	23.9	154.1	18.7	94.2	33.6	488.0	0.0	0.96
12	Bagalwadi	3.2	7.2	381.2	258.9	147.0	79.8	27.3	89.7	12.5	165.1	0.0	274.5	0.0	0.14
13	Murud	1.2	7.4	369.5	253.1	248.0	83.2	32.7	62.1	21.1	94.2	0.0	366.0	0.0	0.15
14	Parmale	5.5	6.7	289.8	191.3	314.0	68.4	22.8	154.1	18.3	105.1	44.6	427.0	0.0	0.52
15	Morewadi	3.7	7.3	394.2	245.5	289.0	79.2	43.7	71.5	10.5	57.7	0.0	427.0	0.0	0.63
16	Gayakwadwadi	4.2	6.9	540.0	354.4	302.0	65.1	27.0	68.1	9.8	127.8	26.4	122.0	0.0	0.45
17	Ghatewadi	6.3	6.8	529.2	319.9	217.0	73.7	36.6	91.5	37.1	138.5	11.0	305.0	24.0	0.63
18	Jambhe	3.7	7.1	539.1	344.5	378.0	71.1	42.7	108.1	29.3	145.9	5.3	427.0	15.0	0.38
19	Benol	5.4	6.9	355.1	240.1	346.0	64.3	32.9	108.1	9.8	136.7	44.9	305.0	0.0	0.25
20	Taloli	4.7	6.4	585.9	358.8	370.0	33.1	48.3	64.4	9.8	94.1	37.4	183.0	18.0	0.74

Where, WL = Water Level in meters below the surface

Table 3: Irrigation water quality parameters and type of groundwater from the study area

Sample ID	SAR	RSC	Groundwater type
1	3.2	1.1	Na-Ca-HCO_3-Cl
2	3.1	1.3	Na-Mg-Ca- HCO_3
3	3.1	2.0	Na-Mg-Ca- HCO_3
4	3.0	3.3	Mg-Na- HCO_3-Cl
5	2.3	0.4	Mg-Na-Ca- HCO_3-Cl
6	2.8	-0.8	Na-Ca-Mg- HCO_3-Cl
7	4.3	0.9	Na-Ca-Cl- HCO_3
8	4.4	2.2	Na-Ca- HCO_3-Cl
9	3.8	1.3	Na-Ca- HCO_3-Cl
10	4.9	5.3	Na-Ca- HCO_3
11	4.0	2.4	Na-Ca- HCO_3-Cl
12	2.2	-1.7	Ca-Na-Mg-Cl- HCO_3
13	1.5	-0.8	Ca-Na-Mg- HCO_3-Cl
14	4.1	1.7	Na-Ca- HCO_3-Cl
15	1.6	-0.6	Ca-Mg-Na- HCO_3
16	1.8	-3.5	Ca-Na-Mg-Cl- HCO_3
17	2.2	-0.9	Na-Ca-Mg- HCO_3-Cl
18	2.5	0.4	Na-Ca-Mg- HCO_3-Cl
19	2.7	-0.9	Na-Ca-Mg- HCO_3-Cl
20	1.7	-2.0	Mg-Na-Ca- HCO_3-Cl

Table 4: Statistical summary of hydrogeochemical parameter of groundwater from the study area all values are expressed in mg/L except EC in μs/cm and pH

Statistical summary	pH	EC	TDS	TH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	CO_3^{2-}	Fe	SAR	RSC
Maximum	7.4	540.0	354.4	378.0	94.2	86.7	170.2	37.1	165.1	44.9	793.0	45.0	1.42	4.9	5.3
Minimum	6.4	180.5	120.1	147.0	33.1	15.1	62.1	3.5	57.7	0.0	122.0	0.0	0.14	1.5	-3.5
Average	6.9	399.8	254.9	250.4	70.2	38.6	121.0	15.1	116.8	20.1	417.5	11.7	0.64	3.0	0.6
Standard Deviation	0.23	99.1	62.3	68.6	13.3	19.9	36.6	8.3	28.0	15.9	177.0	13.6	0.32	1.0	2.0
Permissible limit	6.5-8.5	1400	500	300	75	30	250	10	250	250	300	-	0.3	10	2.5
Samples exceeds limits	19	0	0	7	8	12	0	13	0	0	16	-	17	0	1
Percentage	85	0	0	35	40	60	3	65	0	0	80	0	85	0	5

Table 5: Correlation coefficient of major elements in groundwater from the study area

	EC	TDS	TH	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	SO_4^{2-}	HCO^{3-}	CO_3^{2-}	Fe
EC	1.00											
TDS	0.98	1.00										
TH	0.35	0.31	1.00									
Ca^{++}	-0.27	-0.21	-0.39	1.00								
Mg^{++}	0.15	0.17	-0.08	0.15	1.00							
Na^{+}	-0.49	-0.54	-0.23	0.05	0.09	1.00						
K^{+}	0.17	0.15	0.10	0.08	-0.03	-0.01	1.00					
Cl^{-}	0.29	0.36	-0.30	0.04	0.08	-0.02	0.07	1.00				
SO_4^{2-}	-0.15	-0.19	0.42	-0.30	-0.32	0.32	-0.17	-0.17	1.00			
HCO^{3-}	-0.33	-0.35	-0.17	0.39	0.69	0.63	0.05	-0.21	-0.17	1.00		
CO_3^{2-}	-0.06	-0.14	-0.22	-0.48	-0.19	0.25	0.08	0.20	-0.02	-0.20	1.00	
Fe	-0.22	-0.29	-0.18	-0.03	0.57	0.48	-0.06	-0.30	0.04	0.67	0.09	1.00

4. Conclusion

The database in this study contains 09-ions analysis data of 20 sampling sites from Tarali river basin in Western Maharashtra, India. Sodium is the dominant cation; bicarbonate and chloride are the dominant anions in most of the groundwater samples from the area under study. The dominant hydrochemical facies (5 samples out of 20 samples) is Na - Ca-HCO_3-Cl followed by Na - Ca - Mg-HCO_3 - Cl (4 samples) and Ca- Na- Mg - Cl- HCO_3 (3 samples). Higher concentration Fe in drinking water from the study area they may be lead to inky favour and other related diseases. The high concentrations of Fe metals indicate that the groundwater chemistry is controlled largely by laterite weathering.

Acknowledgement

Authors indebted to Department of Science and Technology, Government of India for the project Fellowship awarded to one of the author RBG under the scheme of DST Major Research project Grant. Author officially acknowledge to North Maharashtra University, Jalgaon, India. The author also would like to thanks unknown reviewers for their valuable comments and suggestions, which improved the quality of this manuscript.

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