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Periodic Water Quality Monitoring of Ground Water Sources in Jashpur District, Chhattisgarh, India

D. Sinha[1], S.K. Jain[2], A.K. Mishra[3], K.K. Dubey[4] and M.M. Vaishnav[5]*

1. Department of Chemistry, Govt. N. P.G. College of Science, Raipur, Chhattisgarh, **INDIA**
2. Department of Chemistry, Govt. R.B.S. NES P.G. College, Jashpur, Chhattisgarh, **INDIA**
3. Examination Controller, C.G. P.S.C., Raipur, Chhattisgarh, **INDIA**
4. Department of Physics, Govt. G.B. College, H'bazar, Korba, Chhattisgarh, **INDIA**
5. Department of Chemistry, Govt. G.B. College, H'bazar, Korba, Chhattisgarh, **INDIA**

Email: drmmvaishnav@yahoo.co.in

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ABSTRACT

The extensively study of ground water sources of entire Jashpur district has been taken in perspective of physico-chemical qualities of water. In our study, we have given the more emphasized the detection of fluoride and iron concentration in ground water sources. The analysis was done in the period of March, 2015 to February, 2016. At the period of investigation, ten sampling spots were selected and samples were collected in sterilized bottles. The collected samples were subjected for analysis technique by the standard methods. The experimental result were compared with the standard values stipulated by the monitoring agency BIS (2012) and WHO (2011). Some parameters such as Turbidity (125NTU, JD-5), Fluoride (5.90 mg L^{-1}, JD-8), Calcium (27.2 mg L^{-1}, JD-5), Magnesium (178 mg L^{-1}, JD-6), TH (436 mg L^{-1}, JD-6), DO (2.89 mg L^{-1}, JD- 2), COD (14 mg L^{-1}, JD-3), Iron (47.3 mg L^{-1}, JD-3), have been found beyond the standard values. In statistical parameters, the % CV was obtained upto 65.82 for iron. The correlation was established from +Ve to -Ve between selected qualities. The +Ve correlation was ranging from +0.022 (0.072) between pH vs K to +0.983 (17.33) between SAR vs Na. In negative correlation, the ranges were seen -0.03(-0.11) between K vs TDS to -0.89 (-6.26) between SAR vs DO. WQI was calculated from 926.5088 (JD-8) to 2896.6531 (JD-5), indicated water sources became contaminated by the undesirable chemical constituents study field.

Key words: Ground Water, Physico-chemical, WQI, % CV, Correlation coefficient.

INTRODUCTION

In developing countries viz. India, 90% population [1] including urban and rural areas are depends on Ground Water (GW) sources for different purposes, such as drinking, domestic irrigation, agricultural, industrial etc., Since last few decades, owing to population growth, socio-economic development, modernization in technology and climate change, the surface water became scarcity, hence the demand of GW sources has been increased [2]. The ground water quality is depended upon the hydrogeochemical composition, which are basic reason in variation of water qualities of GW sources.

Now the GW sources are gradually contaminated by the mixing of undesirable materials through naturally and anthropogenic means. In most of the industrial sector, the untreated effluents are continue discharging into nearly open pits, through seepage, the ground water sources are continue receiving pollutants. Metallic elements [**3**] are playing major role for creating GW pollution. The desirable amounts of the metallic ions are supported for the maintained the human health, but the higher concentration is acting as toxicants. In urban areas, large volumes of domestic cum septic wastes are storages in small areas, which are causing of pathogenic pollution of water sources. Feical pollution [**4**] in drinking water is causing reason of water born diseases such as Jaundice, Hepatitis, Dysentery, Diarrhoea etc. Hence due to these facts, the analytical measurements of GW quality is necessary for determine the suitability of different main kind goal with the time to time.

The Jashpur district is situated in the north-eastern corner of Chhattisgarh state, with geographical location 22°17' to 23°15' north latitude and 83°30' to 84°24' east latitude. The study field is covered geomorphologically by granitodes and small part with Deccan traps and Lamelas, Ultisols and Alfisole are main type of soils. The Jashpur district is spread over 6701 km^2 in which 8, 52, 043 peoples are residing as per report of 2011 census [**5**]. Average rainfall recorded from 1250 mm to 1600 mm during the study tenure. The area has highly undulating topographically. The occupation of the people is agricultural activity. The main crops growing paddy in 82% agricultural area. The silent sources of water is GW's, which is apply in the field of domestic, drinking, irrigation and small industrial sector. So far, the GW sources are unexplored, therefore, we have taken for the systematic analysis of physico-chemical quality of under surface water with over emphasized fluoride and iron ions.

MATERIALS AND METHODS

After selection of the ten water sampling spots, it was decided to collect water samples from tube-wells, bore-wells and open wells during the period of March, 2015 to February, 2016 in pre-cleaned plastics containers of 1 L capacity. The collected samples were preserved properly by the keeping in refrigerator at 4°C and adding of concentration nitric acid (Merck). The parameters Temperature, pH, EC, Turbidity, TDS, DO were measured on sampling spots by electronic analyzer (EI Model-172), TS, TH, TA, Ca, Mg, Cl, BOD, COD in laboratory by the volumetric and gravimetric method [**6-10**]. Sodium and Potassium were detected by the flame photometer, ferrous and fluoride ions were fixed by the ICP-AES and Ion selective electrode technique in instrumental section of BITS Ranchi, Jharkhand.

RESULT AND DISCUSSION

The experimental results of the study period, March, 2015 to February, 2016 has been depicted in the forms of statistical parameters such as Mean, SD, SE, %CV in Table 1. The obtained results are discussed in the following sub-headings:

pH: Ninety observation were note down from ten collected samples, during the period of study from 5.62 to 7.48 at the sampling site JD-4 in the month of November, 2015 and JD-8 in the month of December, 2015 respectively. 62 (68.88%) samples showed beyond the standard ranges < 6.50 to 8.50, while 28 (31.11%) samples under permissible ranges. The results showed the nature of water are slightly acidic to slightly alkaline in nature. These observed ranges of pH, 5.62 to 7.48 were also recorded in same sources by the H. Ayedun [**13**] and C. Dushiyanthan [**14**] in southern India and south-western Nigeria in 2011 respectively. pH showed high degree positive correlation with Mg (0.884, 5.998), COD (0.855, 5.227), K (0.850, 5.123). The % CV was note down 6.692.

EC: For measurement of EC of water samples, ninety readings were taken out. The minimum value was find out as 129.3 μscm^{-1} at the site JD-3 in the month of November, 2015 and maximum value was detected 727 μscm^{-1} at the site JD-6 in the month of June 2015 respectively. The observed ranges were under the acceptable ranging 400-2000 μscm^{-1} as per WHO (2011) [**12**]. 81(90%) readings covered below the desirable level, while 9 (10%) readings were under acceptable ranges. Thus the water of the study field was free from ionic pollutants. The maximum concentration was also

analyzed earlier by the H. Ayedun [13] in 2011 in GW of south-eastern Nigeria. The EC was established high degree positive correlations with the TS (0.865, 5.470) and COD (0.800, 4.230). The % CV was found out 42.732, it measures large variation in the value of EC among the selected spots.

Table 1. Statistical Analysis (March, 2015 to February, 2016).

Parameters	Mean	S.D.	Std. Error	Coff. of Var.
Tern	26.290	3.232	0.295	12.292
pH	6.340	0.424	0.039	6.692
EC	266.339	113.812	10.390	42.732
Turbidity	39.481	30.382	2.774	76.953
TS	313.167	91.247	8.330	29.137
TDS	171.331	69.256	6.322	40.423
TSS	141.836	57.693	5.267	40.676
TA	169.400	50.536	4.613	29.832
TH	154.133	68.827	6.283	44.654
Ca^{+2}	100.783	44.231	4.038	43.887
Mg^{+2}	53.350	26.613	2.429	49.884
Cl^{-}	56.159	9.9.1.7	0.905	17.658
DO	5.259	1.159	0.106	22.049
BOD	5.561	1.234	0.113	22.196
COD	9.313	1.521	0.139	16.337
Na^{+}	119.121	27.518	2.512	23.101
K^{+}	5.240	1.366	0.125	26.067
SAR	4.363	1.115	0.102	25.547
PS	61.704	9.992	0.912	16.193
RSC	-0.288	0.890	0.081	-309.174
HCO_3^{-2}	169.400	50.536	4.613	29.832
F^{r-1}	0.726	1.473	0.134	202.S68
Fe^{+2}	21.493	15.007	1.370	69.821

Turbidity: Out of 90 observations 77 readings (85.55%) above the excessive permissible level, while 4 readings (4.44%) were below the desirable limit and 7 (7.77%) observations were recorded under the acceptable ranges from the standard value stipulated by the BIS (5-8, 2012) [11] and WHO (2011, 5-10) [12]. A.P. Dwivedi [15] was also detected near about the same value (2.00 NTU) of their minimum concentration in GWS of Vindhyan plateau in 2013. Turbidity was showed high degree positive correlation with temperature (0.918, 7.725), TH (0.618, 6.056), Ca (0.818, 4.512), Mg (0.923, 7.618), Na (0.836, 4.830), SAR (0.801, 4.236), COD (0.852, 5.165). The %CV for turbidity was calculated out 76.953, which showed, very high differences between two spots in the reading of turbidity.

TS: Total solid measured the dissolved as well suspended ions in water. The minimum concentration 200 mgL^{-1} was detected at the sampling point JD-3 in the month of July, 2015, while the maximum concentration; 720 mg L^{-1} was determined at the site JD-6 in the month of April, 2015. In ninety collected samples, 84 (93.33%) showed below the desirable limit. Only 5 (5.55%) samples are accepting ranges. None of the sample contain showed above the permissible limit as per BIS (2012) [11] and WHO (2012) [12]. TS established high degree positive correlation with EC (0.865, 5.470), TSS (0.800, 4.222) and BOD (0.791, 4.100). The % CV was recorded 29.137.

TDS: The dissolved ions are reflux by the TDS. During the study period, the ranges were spread from minimum 80 mg L^{-1} JD-3 August, 2015 to maximum 426.30 mg L^{-1} at JD-3 June, 2015. These values were under the desirable limit. None of the samples showed above the excessive permissible limit as per BIS (2012) [11], 500-2000 mg L^{-1} and WHO (2012) [12] 500-1500 mg L^{-1}. The minimum and maximum concentration was also finding out by the A.O. Jayeola and A.C. Ogunyele [16] in 2014. TDS showed low degree positive correlation with pH (0.594, 2.337), EC (0.548, 2.075). The % CV was calculated 40.423, which is also large variation in concentration of TDS from sampling spot to spot.

Total Alkalinity: At the period of investigation, ninety readings were observed with minimum concentration 112 mg L^{-1} at the sampling site JD-10 in the month of December, 2015, whereas, the maximum concentration was seen at the sampling point JD-6 in the month of July, 2015 with the 274 mg L^{-1}. None of the values were found above the excessive permissible limit; 300-600 mg L^{-1} as per BIS (2012) [**11**] 200-600 mg L^{-1} and according to WHO (2011) [**12**]. Only 17 (18.88%) readings were calculated under the acceptable ranges and 73 values (81.11%) were observed below the desirable limit. TA showed positive correlation with Na (0.810, 4.520) BOD (0.782, 3.967). The % CV was calculated 29.832.

TH: The standard values for TH is 300-600 mg L^{-1} as per BIS (2011) [**11**] whereas, as per WHO (2012) [**12**] 100-500 mg L^{-1}. Out of ninety observations, the minimum concentration was fond at the sampling site JD-2, 78 mg L^{-1} in the month of November, 2015, while the maximum concentration was found at JD-6; 436 mg L^{-1} in the month of May, 2015. Only 7 (7.77%) readings were recorded in between acceptable ranges, and then remaining values 83 (93.33%) were below the desirable limit. These results indicated, the total hardness didn't great imparting in the contamination of GW sources. This minimum concentration 78 mg L^{-1} was also detected previously by the A.O. Jayeola [**16**] in 2014 in GW sources of Ikare-Akoko areas of south-western Nigeria, while the maximum concentration was also earlier reported near about this concentration by the A.K. Pandey *et al.*, [**17**] in 2014 in GWS of Digod tehsil of Kota district in Rajasthan, India. TH showed positive correlation with turbidity (0.886, 6.056), Ca (0.981, 16.06), Mg (0.791, 12.96) DO (0.851, 5.1114) Na (0.868, 6.122) SAR (0.815, 4.449). The % CV of total hardness was note down 44.65, which is indicated in among all sampling spots, the total hardness concentration is sufficient differences.

Calcium: Seven readings (7.77%) were shown the above excessive limit and sixty two (68.88%) readings were under acceptable ranges as per BIS (2012) [11] 75 mg L^{-1} to 200 mg L^{-1} and remaining twenty one reading (23.33%) were below the desirable limit in out of ninety observations. The minimum concentration was note down as 272 mg L^{-1} at the sampling points JD-54 in the month of May, 2015. The calcium compounds are also contributed in total hardness. Thus minimum concentration was earlier reported as 56 mg L^{-1}, which was very close to recent reported value by the C. Dushiyanthan *et al.*, [**14**] in 2011. Calcium interrelated with the other parameter by the high degree positive correlation such as turbidity (0.818, 4.512), TH (0.981, 16.06), BOD (0.851, 5.134), COD (0.888, 6.122), SAR (0.815, 4.449). The % CV was also calculated 43.887, which measure vast changing in the concentration of Ca in from sample to sample.

Magnesium: Magnesium ions play a key role in total hardness. At the period of study, the minimum value was found as 24 mg L^{-1} at the sampling site JD-1 in the month of November, 2015 while, the highest value was observed as 178 mg L^{-1} in the month of May, 2017 at JD-6. Only seven (7.77%) observations were recorded above the excessive permissible level as per BIS (2012) [**11**] standards, five (5.55%) readings were below the acceptable ranges. This minimum concentration was also seen as 25 mg L^{-1} by the Rajkumari Surywanshi [**18**] in 2014 in and around the Pune areas. The positive correlation was formulated with BOD (0.897, 6.443), COD (0.779, 3.940), Na (0.945, 9.152), SAR (0.898, 6.477), HCO_3 (0.717, 3.940). The %CV was calculated 49.884, indicated wide variation in dissolved amount of magnesium compounds in among the selected spots.

Fluoride: Thirty observations were analysed in the study period. The ranges were formulated from 0.04 mg L^{-1} to 5.90 mg L^{-1}. The minimum and maximum concentration was detected at the site JD-5 and JD-8 in the month of November, 2015 and September, 2015 respectively. Three (10%) observations were findings above the excessive level and four (4.44%) observations were under acceptable ranges while thirteen samples (47.33%) showed below the desirable ranges. The standard values for drinking water is 1 to 1.2 mg L^{-1} BIS (2012) [**11**] 1 to 1.5 mg L^{-1} (WHO, 2011) **[12**]. K.M. Reddy and J.R. Prasad [**19**] was also assessed this minimum concentration; 0.04 mg L^{-1} in 2003 in Wazirabad areas of Nalgonda district, while the V. Sunitha *et al.*, [**20**] was also reported earlier the maximum concentration 5.51 mg L^{-1}, which was very close to recently reported concentration in GW

sources. Fluoride was didn't established any positive correlation with other parameters of water. The % CV was calculated 202.968, which in indicated the vast differences in concentration of fluoride ion in selected water samples.

Table 2. WQI (Mar, 2015 to February 2016).

Sampling Spot	Σqiwi	ΣWi	WQI= Σqiwi/ΣWi
JD-l	45651.93800	23.65338586	1930.038188
JD-2	51064.77402	23.65338586	2158.877985
JD-3	51932.33101	23.65338586	2195.555905
JD-4	64368.52153	23.65338586	2721.323784
JD-5	68515.65535	23.65338586	2896.653179
JD-6	43379.10487	23.65338586	1833.949064
JD-7	66566.63998	23.65338586	2814.254178
JD-8	21915.07109	23.65338586	926.5088396
JD-9	42937.71238	23.65338586	1815.288205
JD-10	31915.36018	23.65338586	1349.293516

Chloride: Chloride is dissolved in water as negative anion. At the period of testing all the ninety (100%) readings were obtained below the desirable limit, when it is compared with the standard value as per BIS (2012) [**11**] and WHO (2011) [**12**]; 200-1000 mg L^{-1}. The minimum concentration of chloride ion was seen as 35.60 mg L^{-1} at the sampling site JD-8 in the month of May, 2015, while the maximum concentration was found 92.60 mg L^{-1} on the sampling site JD-5 in the month of May, 2015. These minimum and maximum concentrations were very close to the previously seen as 34 mg L^{-1} and 91.1 mg L^{-1} by the P.G. Sabu [**21**] in 2014. Chloride formed positive correlation with Na (0.655, 2.746) and SAR (0.638, 2.663). The % CV was calculated as value 17.658.

DO: In out of ninety readings, the minimum dissolved oxygen was detected as 2.89 mg L^{-1} at the site JD-2 in the month of January, 2015. However, 6.99 mg L^{-1} was seen as maximum value at the site JD-3 in the month of December, 2015. As per WHO (2011) [**12**] the standard ranges for DO as 5-6 mg L^{-1} and BIS (2011) [**11**] suggested the acceptable value should be 5 mg L^{-1}. 18 observations (20%) were crossed the upper limit, 22 readings (24.44%) were estimated under acceptable ranges. 23 readings (25.55%) were below the acceptable ranges, thus the one fifth water samples are suffering from less dissolved oxygen owing to oxygen reducing chemicals. Near about same values were also reported by the earlier scientist K.V. Sastri *et al.*, [**22**]. DO showed high degree negative correlation with SAR (-0.89, -6.26) PS (-0.91, -6.94), Na (-0.78, -3.94. The % CV was calculated 22.049 among obtained observations of all selected spots.

BOD: The minimum concentration was estimated on 3.38 mg L^{-1} at site JD-10 in the month of November, 2015, but the maximum concentration was assessed as 8.51 mg L^{-1} at the site JD-3 in the month of May, 2015. The WHO (2011) [**12**] and BIS (2012) [**11**] has proposed 5 mg L^{-1} as the upper limit for drinking water. 64 values (71.11%) crossed the upper limit, while the remaining 26 (28.88) were below the standard limit, it means the maximum collected water samples are affected by the BOD constituents. P.C. Mishra *et al.*, [**23**] was also observed very close of this value; 3.40 mg L^{-1} in GWS of the steel city Orissa in the year of 2005. BOD positive correlated with turbidity (0.769, 3.809), TS (0.791, 4.100), TA (0.782, 3.967), Ca (0.778, 3.916), Mg (0.897, 6.443). Negative correlation was also established with DO (-0.78, -3.94). The % CV was found out 22.196.

COD: The standard value of COD is stipulated by BIS (2012) [**11**] and WHO (2011) [**12**] 10 mg L^{-1} for drinking water. In ninety observations, the minimum value was note-down at the location spot JD-4 as 7.02 mg L^{-1} in the month of September, 2015 and maximum concentration was seen at the site JD-3, 14.10 mg L^{-1} in the month of May, 2015. 21 observations (22.33%) were above the limit of standard value, whereas 64 readings (76.66%) were below the upper limit. These ranges were already reported by the farmers author A.P. Dwevedi [**15**] in the years of 2013 in GWS of Rewa district. The

COD has established positive correlation with temperature (0.892, 6.250) EC (0.800, 4.230), Turbidity (0.852, 5.165), TS (0.720, 3.282). TH (0.796, 4.169), Ca (0.777, 3.903), Mg (0.779, 3.940). The % of CV was estimated 16.337, which is not sufficiently high concentration changes among selected GW sources.

Sodium: Sodium is an alkaline metal, which is dissolved in GWS through seepage or weathering of underground rocks. In our study period, the low concentration of sodium ion was detected 71.2 mg L^{-1} at the location of JD-8 in the month of September, 2015, whereas the 156.20 mg L^{-1} was found as the maximum concentration at the site JD-3 in the month of September, 2015. BIS (2012) [**11**] and WHO (2011) [**12**] as per the threshold value for drinking water is 200 mg L^{-1}. The all recorded values were below the upper limit, as indicating, water sources are didn't sufficiently contaminated by the sodium. This maximum value was also reported previously by the L. Elango *et al.*, [**24**] in the year of 2006 of Chengalpet region. The sodium positively correlated with the Temperature (0.735, 3.428), TH (0.888, 6.122). Ca (0.804, 4.290), Mg (0.945, 9.152), BOD (0.921, 7.471) with DO negatively correlated (-0.85, -5.13). The % CV was calculated 27.101.

Potassium: The standard value of K for drinking water is 10 mg L^{-1} as per BIS (2012) [**11**] and 25 mg L^{-1} WHO (2011) [**12**]. In the study time, ninety observations were taken out. The minimum and maximum values were looked as 2.89 mg L^{-1} and 9.66 mg L^{-1} at the site JD-1 and JD-8 in the month of March, 2015 and November, 2015 respectively. All the values were seen under the limit value. This maximum concentration was also detected in 2015 in GWS in Kanyo city of Turky as 9.00 mg L^{-1} by the M.T. Nalbantcilar and D. Pinarkara [**25**]. Potassium correlated positively with DO (0.637, 2.619). The % CV was calculated as 26.067, which is sufficiently as high as indication, the concentration of potassium in vastly changes from location to location.

Iron: Thirty observations were taken in the period of study in which the minimum concentration was recorded as 0.10 mg L^{-1} at the sampling site JD-8 in the month of November, 2015 and the maximum concentration was observed as the 47.73 mg L^{-1} at the sampling site JD-3 in the month of November, 2015. Only three values (10%) were below the upper limit remaining observation (90%) were crossed the upper limit; 1.0 mg L^{-1} as per BIS (2012)[**11**] and WHO (2011) [**12**]. This minimum concentration was already detected earlier by the P.B. Vyas [**26**] in Gandhi Nagar township in 2011. The % CV was estimated as 69.827%. Which is indicated the iron concentration are high degree fluctuated from spot to spot.

SAR: This parameter was calculated for ninety water samples which ranges were found from 1.80 mg L^{-1} at the sampling site JD-8 in the month of Dec. 2015, while the maximum concentration was seen as 7.20 mg L^{-1} at the sampling site JD-2 in the month of May, 2015. All the observations were under the acceptable ranges as per BIS (2012) [**11**]. The maximum value was also finding out by the G.K. Sethi [**2**]. SAR established high degree positive correlation with Temperature (0.801, 4.236), TA (0.824, 4.611), TH (0.815, 4.449), Mg (0.898, 6.477), DO (0.872, 5.655), Na (0.835, 4.812), with DO found negative correlation (-0.39, -6.26). The % CV was calculated 25.847.

PS: Percentage of sodium was calculated in 90 observations in which 72 samples (80%) were above the threshold limit, while the remaining concentration was under the acceptable limit 20-60. The minimum data was detected as 33.99 mg L^{-1} at the location site JD-9 in the month of December, 2015. However the maximum value was measured as 76.79 mg L^{-1} at the site JD-2 in the month of May, 2015. Earlier scientist G.K. Sethi [**2**] was also measured the PS around our noted value as 34.17 mg L^{-1}. The %CV was computed as 16.193.

RSC: In the study tenure, the RSC was computed as minimum -0.03 mg L^{-1} at the sampling site JD-2 in the month of April, 2015, while the maximum value was found as 0.65 mg L^{-1} at the site JD-3 in the month of December, 2015. The ranges of RSC were below the acceptable values; 1.25 to 2.5.

G.K. Sethi and his co-worker were also found out earlier [2] as -0.05 in 2010, which was very vicinity to our reported value.

Bi-carbonate: Bicarbonate is also one of the pollutants, which is measured in the ranging value as 96 mg L^{-1} at the site JD-1 in the month of November, 2015, while the maximum concentration was reported as 302 mg L^{-1} at the site JD-8 in the month of December, 2015. This maximum concentration was also detected earlier by the Abhaym Yarde *et al.*, [27] in 2014 of Nagpur district (M.S.). The bicarbonate established high degree positive correlation with BOD (0.782, 3.967), Na (0.819, 4.520), SAR (0.824, 4.611), PS (0.740, 3.480). The % CV was calculated 29.832.

CONCLUSIONS

The scientifically assessment has been taken of GWS of Jashpur district (C.G.) India. At the tenure of the analytical monitoring, the twenty one parameters were observed for ten water samples up to continue 12 months, which, were collected from the ten different spots. Every spots are located at the equal distance. The results for turbidity (125 NTU) at the JD-5, TH (476 mg L^{-1}) at JD-6, fluoride (5.90 mg L^{-1}) at the JD-8, DO (2.89 mg L^{-1}) at JD-2, Iron (47.73 mg L^{-1}) at JD-3, Bicarbonate (302 mg L^{-1}) at JD-8 were obtained at the alarming level, which makes the GWS unfit for any human development purposes. The chemical impurities come in GWs through weathering of under surface rock. So we have suggested to people of the study areas, prior purification is must before all type's application of ground water sources.

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