PHYSICO-CHEMICAL PARAMETERS OF GROUND WATER (With Reference Of At Janjghir Champa Region in Chhattisgarh)

Harsha Tiwari

Assistant Professor, Department of Chemistry

Kalinga University Raipur (C.G.) – India.

Abstract : The study was carried out to assess the ground water quality and its suitability for drinking purpose in most rural habitations of Champa tehsil of district Janjhir Champa, Chhatisgarh, India. For this purpose, 50 water samples collected from hand pumps, open wells and bore wells of villages of study area were analysed for different physico-chemical parameters such as pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and total dissolved solids. pH value in the study area found from 7.0 to 8.1. EC ranges from 392-5152 µ mhos/cm and total alkalinity between 190 to 980 mg/L. Total hardness ranged from 60 to 2400 mg/L and calcium hardness from 20 to 1150 mg/L. Magnesium hardness varied from 40 to 1250 mg/L and chloride from 20 to 2000 mg/L. Values of nitrate concentration varied from 2 to 380 mg/L and fluoride from 0.3 to 9.6 mg/L while value of TDS ranges from 560 to 7360 mg/L. The study reveals that almost all parameters were exceeding the permissible limits. As per the desirable and maximum permissible limit for fluoride, nitrate, total dissolved solids and chloride in drinking water, determined by WHO BIS and ICMR standards, 44%, 14%, 24% and 42% of groundwater sources are unfit for drinking purposes respectively. Due to the higher fluoride level in drinking water several cases of dental and skeletal fluorosis have appeared in this region. After evaluating the data of this study it is concluded that drinking water of Champa tehsil is not potable and there is an instant need to take ameliorative steps in this region to prevent the population from adverse health effects.

Keywords: Groundwater quality, Physico-chemical parameters, Statistical Parameters

INTRODUCTION

Chhatisgarh is the ninth largest state in the country in terms of geographic spread. It has an area of 135,191 Sq kms being ninth largest state of the country having 4.11 % of the country's area and 17th-most populated state in the country but has low water resources i.e. 1% of the country's resources. The state has extreme climatic and geographical condition and it suffers both the problems of quantity and quality of water.

Review on the literature showed that no studies have been undertaken in the study area with regard to physico-chemical characteristics of water yet. So the objective of this study was to investigate the quality of drinking water (underground water) in most rural habitations of Champa Tehsil of Janjghir Champa, Chhatisgarh, India.
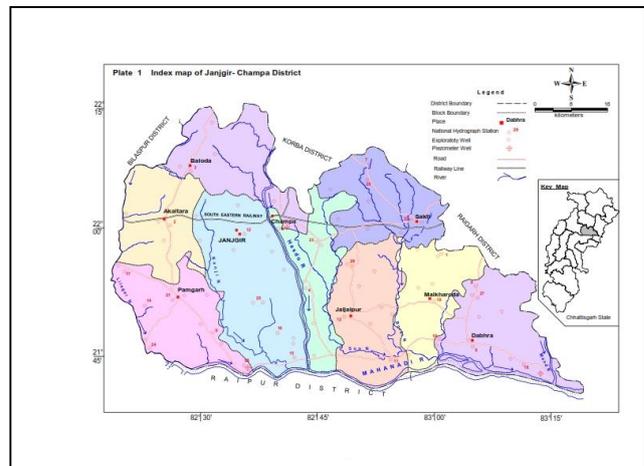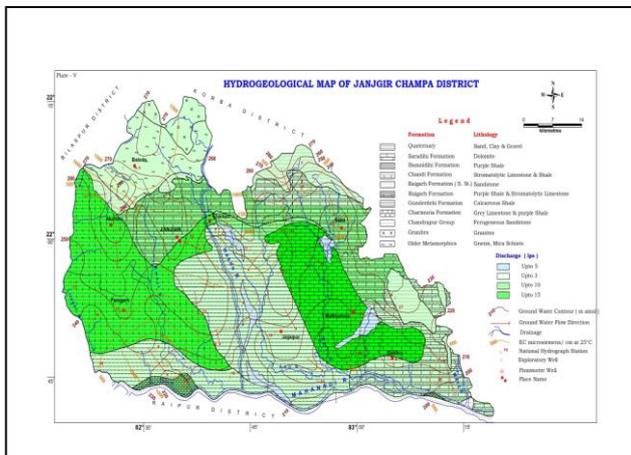
MATERIALS AND METHODS

Study Area

The District Janjgir-Champa was established on 25 May 1998. The district Janjgir-Champa is situated in the center of Chhattisgarh and so it is considered as Heart of Chhattisgarh. The District Head Quarter Janjgir of the district Janjgir-Champa is the city of Maharaja Jajawalya Dev of Kulchury dynasty. The Janjgir-Champa district is a major producer of Food Grains in the state Chhattisgarh. The Vishnu Mandir of Janjgir district reflects the golden past of this district. The Vishnu Mandir is an ancient artistic sample of Vaishnav community. The Hasdeobango project has been considered as life supporting canal for the district Janjgir-Champa.

Champa is quite a large town located in the state of Chhattisgarh, eastern India. It is a key business and education center of Janjgir-Champa district, with a few excellent colleges and numerous small and medium companies, working in such sectors as agriculture, fabric producing, metal and gold processing, etc. The town is a home to about 40,000 people.

The latitude of Champa, Chhattisgarh, India is 22.033178, and the longitude is 82.651733. Champa, Chhattisgarh, India is located at India country in the Towns place category with the gps coordinates of 22° 1' 59.4408" N and 82° 39' 6.2388" E.

There are no major surface water sources in the study area however, main sources of drinking water are open wells, hand pumps and bore wells.

Water Sampling

Ground water samples of a total of 50 sites from different wards of Champa Tehsil of Janjghir Champa district were collected in pre-cleaned and rinsed polythene bottles of two litre capacity with necessary precautions. (Brown et al. 1974) The samples were collected, during April 2020 to Feb 2021 from manually operated hand pumps, open wells and bore wells.

Physico-chemical Analysis

All the samples were analyzed for the following Physico-chemical parameters; pH, Electrical Conductivity (EC), Total Alkalinity (TA), Total Hardness (TH), Calcium hardness (Ca H), Magnesium hardness (Mg H), Chloride, Nitrate, Fluoride and Total Dissolved Solid (TDS). The analysis of water samples were out carried in accordance to standard analytical methods (APHA, 2005). All the chemicals used were of AR grade and double distilled water used for preparation of solutions. Details of the analysis methods are summarized in Table-1.

Table-1: Parameters and methods employed in the physicochemical examination of water samples

S.No.	Parameters	Unit	Method Employed
1	pH	-	Digital pH-meter
2	Electrical Conductivity	μ mhos/cm	Digital Conductivity-meter
3	Total Alkalinity	Mg/L	Titrimetric method (With HCl)
4	Total Hardness (as CaCO3)	Mg/L	Titrimetric method (with EDTA)
5	Calcium Hardness (as CaCO3)	Mg/L	Titrimetric method
6	Magnesium Hardness (as CaCO3)	Mg/L	Titrimetric method
7	Chloride (as Cl-)	Mg/L	Titrimetric method (With AgNO3)
8	Nitrate (as NO3-)	Mg/L	Spectrophotometric method
9	Fluoride (as F-)	Mg/L	Ion Selective Electrode
10	Total Dissolved Solids	Mg/L	Digital Conductivity-meter

Statistical Analysis

In the present study Minimum, Maximum, Average, Standard Deviation and Correlation coefficient (r) has been calculated for each pair of water quality parameters by using Excel spreadsheet for the experimental data.

The standard formulae were used in the calculation for statistical parameters are as follows (S.P. Gupta, 1999):

$$\text{Mean } (\mu) = \frac{\Sigma x}{n}$$

x = Value of Observation

n = Number of Observation

$$\text{Standerd Deviation } (\sigma) = \sqrt{\frac{n\Sigma x^2 - (\Sigma x)^2}{n(n-1)}}$$

$$\text{Karl Pearson's Coefficient of Corrrelation (r)} = \frac{n\Sigma xy - \Sigma x\Sigma y}{\sqrt{n\Sigma x^2 - (\Sigma x)^2}\sqrt{n\Sigma y^2 - (\Sigma y)^2}}$$

x, y = Values of array 1 and array 2 respectively.

n = Number of Observations

Table-2: Analysis of ground water quality parameters in villages of Bassi Tehsil (Jaipur, Rajasthan, India)

S.NO.	Sampling Site	Code	pH	EC	Alk. mg/l	TH mg/l	CaH mg/l	MgH mg/l	Cl– mg/l	NO3– mg/l	F– mg/l	TDS mg/l
1	Champa Ward No - 1	S1	8	2072	710	230	100	130	680	18	3.2	2960
2	Champa Ward No - 1	S2	7.8	840	660	120	50	70	280	37	1.5	1200
3	Champa Ward No - 1	S3	7.6	448	400	190	80	110	20	19	0.4	640
4	Champa Ward No - 1	S4	7.7	896	820	150	60	90	100	35	2.4	1280
5	Champa Ward No - 1	S5	7.7	616	470	600	250	350	300	13	3.3	880
6	Champa Ward No - 2	S6	7.7	487.2	390	100	40	60	130	3	2.1	696
7	Champa Ward No - 2	S7	7.3	980	290	120	40	80	100	26	1.26	1400
8	Champa Ward No - 2	S8	7.7	3136	400	2400	1150	1250	1000	359	0.74	4480
9	Champa Ward No - 2	S9	7.7	448	440	160	70	90	40	29	1.3	640
10	Champa Ward No - 2	S10	7.7	448	480	80	30	50	20	5	1.8	640
11	Champa Ward No - 3	S11	7.8	392	190	90	30	60	50	10	4.1	560
12	Champa Ward No - 3	S12	7	896	800	60	20	40	80	12	5.9	1280
13	Champa Ward No - 3	S13	7.8	728	700	100	40	60	60	2	1.9	1040
14	Champa Ward No - 3	S14	7.7	1848	400	560	200	360	480	8	0.9	2640

15	Champa Ward No - 3	S15	7.4	1176	680	340	160	180	280	14	1.3	1680
16	Champa Ward No - 4	S16	7.7	896	490	230	100	130	220	2	1.2	1280
17	Champa Ward No - 4	S17	7.6	448	340	140	60	80	30	6	0.3	640
18	Champa Ward No - 4	S18	8.1	616	570	120	50	70	40	3	2.4	880
19	Champa Ward No - 4	S19	7.7	560	380	200	80	120	100	8	2	800
20	Champa Ward No - 4	S20	7.8	406	320	200	90	110	40	10	1.3	580
21	Champa Ward No - 5	S21	7.8	5152	640	910	390	520	2000	54	2.9	7360
22	Champa Ward No - 5	S22	7.7	672	550	120	50	70	80	27	0.8	960
23	Champa Ward No - 5	S23	7.6	784	540	180	70	110	140	21	1.1	1120
24	Champa Ward No - 5	S24	7.9	1064	720	200	80	120	220	65	1.2	1520
25	Champa Ward No - 5	S25	7.6	1456	760	320	140	180	400	19	1.5	2080
26	Champa Ward No - 6	S26	7.6	616	980	160	70	90	170	39	2	880
27	Champa Ward No - 6	S27	7.7	784	800	120	60	60	90	37	2.1	1120
28	Champa Ward No - 6	S28	7.5	2520	780	320	150	170	1100	38	1.8	3600
29	Champa Ward No - 6	S29	7.4	2464	430	670	290	380	750	16	2.1	3520
30	Champa Ward No - 6	S30	7.6	784	640	100	40	60	80	16	8.4	1120
31	Champa Ward No - 7	S31	7.7	1512	500	400	160	240	510	10	0.7	2160
32	Champa Ward No - 7	S32	7.9	784	760	240	100	140	60	31	2.7	1120
33	Champa Ward No -	S33	7.7	784	680	80	30	50	40	10	1.4	1120

	7											
34	Champa Ward No - 7	S34	7.5	1064	580	320	140	180	300	2	1.5	1520
35	Champa Ward No - 7	S35	7.9	1176	760	300	120	180	180	43	1	1680
36	Champa Ward No - 8	S36	7.7	1400	790	180	80	100	270	27	1	2000
37	Champa Ward No - 8	S37	7.7	840	620	100	40	60	100	41	9.6	1200
38	Champa Ward No - 8	S38	7.7	425.6	390	110	40	70	150	2	1.9	608
39	Champa Ward No - 8	S39	7.7	560	330	180	80	100	80	28	0.3	800
40	Champa Ward No - 8	S40	7.8	492.8	580	150	60	90	50	8	2.4	704
41	Champa Ward No - 9	S41	7.9	3528	510	980	460	520	570	10	1.8	5040
42	Champa Ward No - 9	S42	7.7	784	340	460	190	270	180	113	0.3	1120
43	Champa Ward No - 9	S43	7.8	2408	620	590	220	370	870	22	1.1	3440
44	Champa Ward No - 9	S44	7.6	1400	730	260	110	150	380	51	1.3	2000
45	Champa Ward No - 9	S45	7.8	1232	660	260	110	150	260	58	1	1760
46	Champa Ward No - 10	S46	7.7	1512	900	360	170	190	380	4	1.2	2160
47	Champa Ward No - 10	S47	7.3	1064	700	70	30	40	40	24	4.2	1520
48	Champa Ward No - 10	S48	7.6	896	780	100	40	60	120	2	1.2	1280
49	Champa Ward No - 10	S49	7.8	560	600	240	100	140	20	11	0.7	800
50	Champa Ward No - 10	S50	7.8	1456	300	980	510	470	400	380	0.4	2080

RESULT AND DISCUSSION

The respective values of all water quality parameters in the groundwater samples are illustrated in Table-2. All the results are compared with standard permissible limit recommended by the Bureau of Indian Standards (BIS), Indian Council of Medical Research

(ICMR) and World Health Organization (WHO), depicted in Table-3. Statistical Parameters of groundwater samples of study area are summarized in Table-4.

Table-3: Standards for drinking water quality

Parameter	pH	EC	TA	TH	Cl-	NO3-	F-	TDS
BIS : 1999	6.5-8.5	---	600	600	1000	100	1.5	2000
ICMR : 1975	7.0-8.5	---	600	600	200	50	1.5	1500
WHO : 2006	6.5-8.5	1400	120	500	200	45	1.5	500

Table-4: Statistical parameters of the different chemical constituents of ground water of the study area

S.No.	Parameter	Minimum	Maximum	Average	Standard Deviation
1	pH	7	8.1	7.684	0.1833
2	EC	392	5152	1170.23	912.57
3	TA	190	980	578	182.09
4	TH	60	2400	313	377.52
5	Ca H	20	1150	136.6	180.51
6	Mg H	40	1250	176.4	198.36
7	Cl-	20	2000	280.8	358.87
8	NO3-	2	380	36.56	71.71
9	F-	0.3	9.6	1.97	1.8
10	TDS	560	7360	1671.76	1303.68

pH: pH is measure of intensity of acidity or alkalinity of water. All chemical and biological reactions are directly dependent upon the pH of water system (Rao, 2006). In our findings pH varied between 7.0-1. Maximum pH was recorded at S18 in ward no. 4 and minimum pH was recorded at S12 in ward no.3 , which are not within the permissible limit prescribed by BIS, ICMR and WHO. The variation of pH in ground water samples of study area is depicted in Graph– 1, which shows that most of the samples are alkaline in nature. The pH of water is very important indication of its quality and provides information in many types of geochemical equilibrium or solubility calculations (Mitharwal et al., 2009).
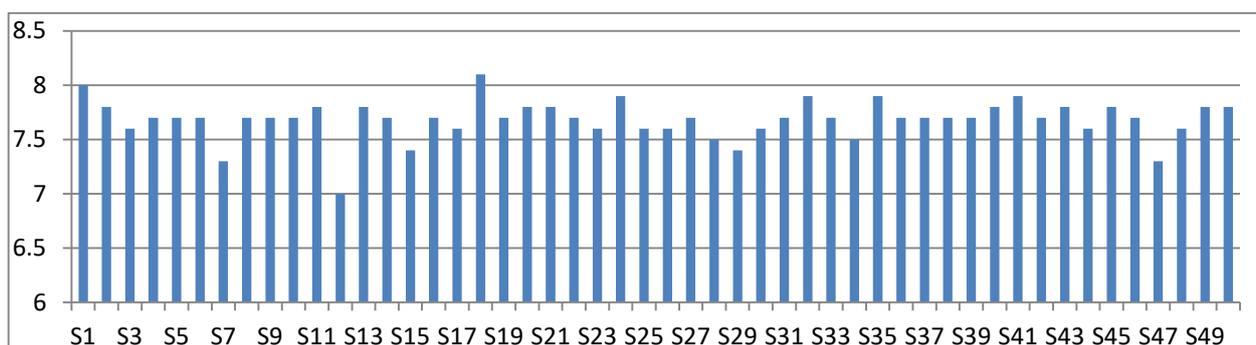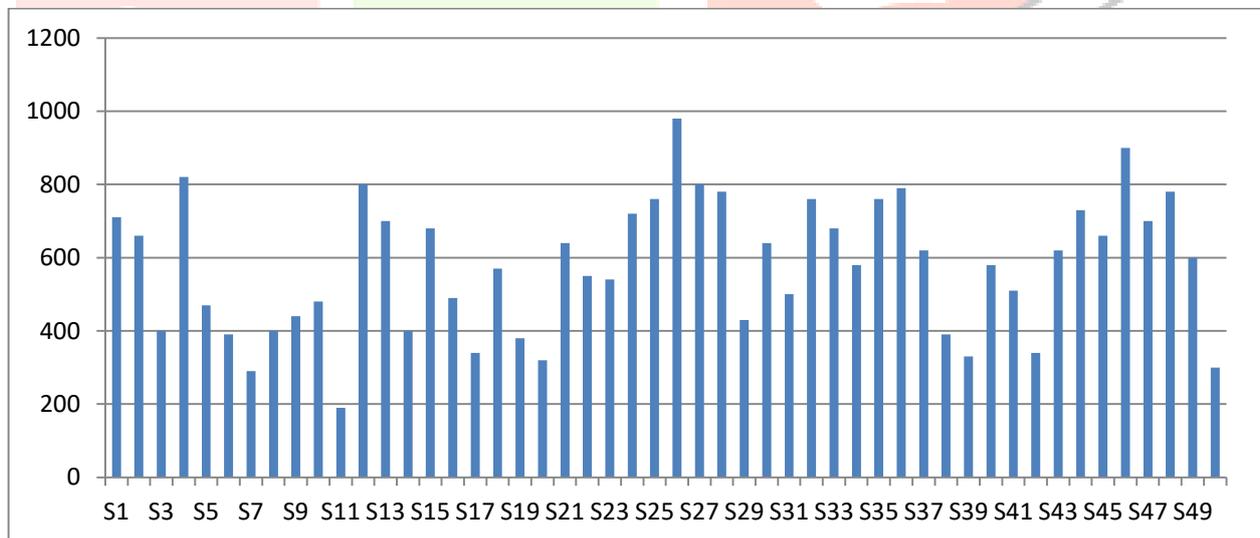

Graph- 1 (Comparison of pH parameter from various sample sites)

Electrical Conductivity: The electrical conductivity of water depends upon the concentration of ions and its nutrient status. Based on electrical conductivity values the water quality can be classified as poor, medium or good (Gulta, Sunita, & Saharan, 2009). In the present investigation maximum conductivity 5152 μ mhos/cm was observed at S21 in ward no.5 and minimum 392 μmhos/cm at S11 in ward no.3. The maximum limit of EC in drinking water is prescribed as 1400 μ mhos/cm (WHO: 2006), Samples are exceeding the permissible limit as shown in Graph- 2.
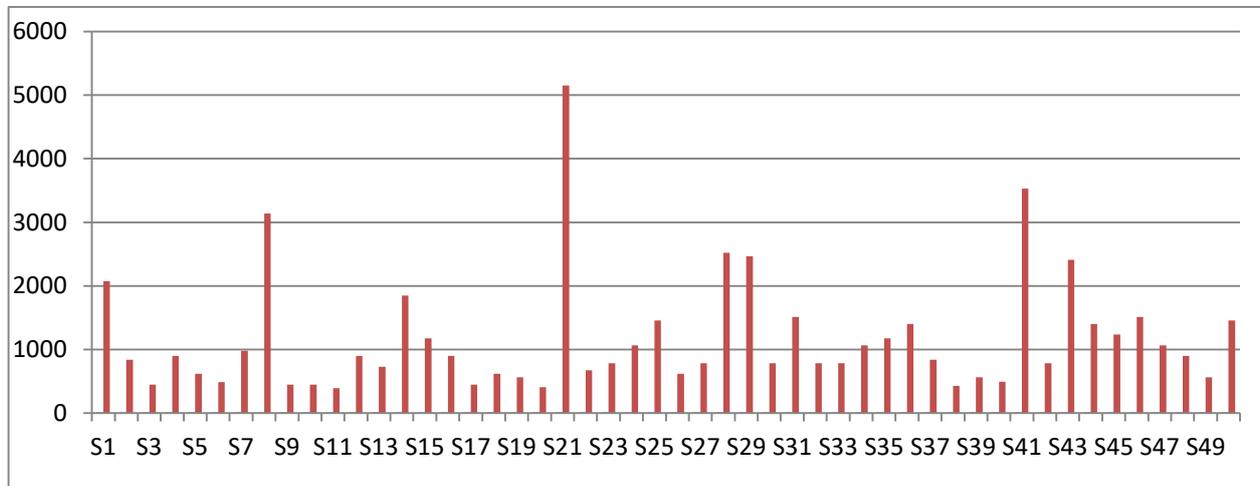
Graph- 2 (Comparison of EC parameter from various sample sites)

Total Alkalinity: Total Alkalinity ranges from 190 mg/L to 980 mg/L, the maximum value was recorded in ward no. 6 (S26) and minimum in ward no.3 (S11). Variation in total alkalinity of ground water samples is represented in Graph- 3 hich clearly depicts that these values are more than the permissible limits of BIS, ICMR and In ground water, most of the alkalinity is caused due to carbonates and bicarbonates.


Graph- 3 (Comparison of Total Alkalinity parameter from various sample sites)

Total Hardness: Hardness is the property of water which prevents lather formation with soap and increases the boiling point of water. Hardness of water mainly depends upon the amount of calcium or magnesium salt or both (Singh et al. 2012). It is an important criterion for determining the usability of water for domestic, drinking and many industrial supplies (Mitharwal et al., 2009). In our findings the value of hardness fluctuates from 60 mg/L to 2400 mg/L (Graph-4), which are beyond the permissible limit as prescribed by BIS, ICMR and WHO. The minimum value was found in S12 in ward no. 3 and maximum value was found in samples S8 ward no. 2.
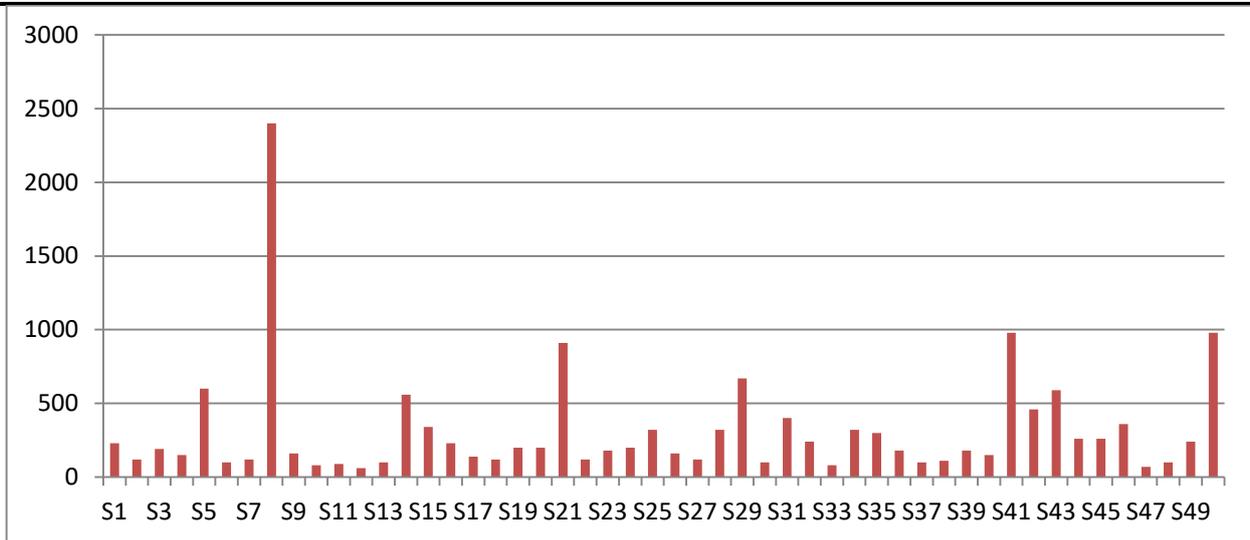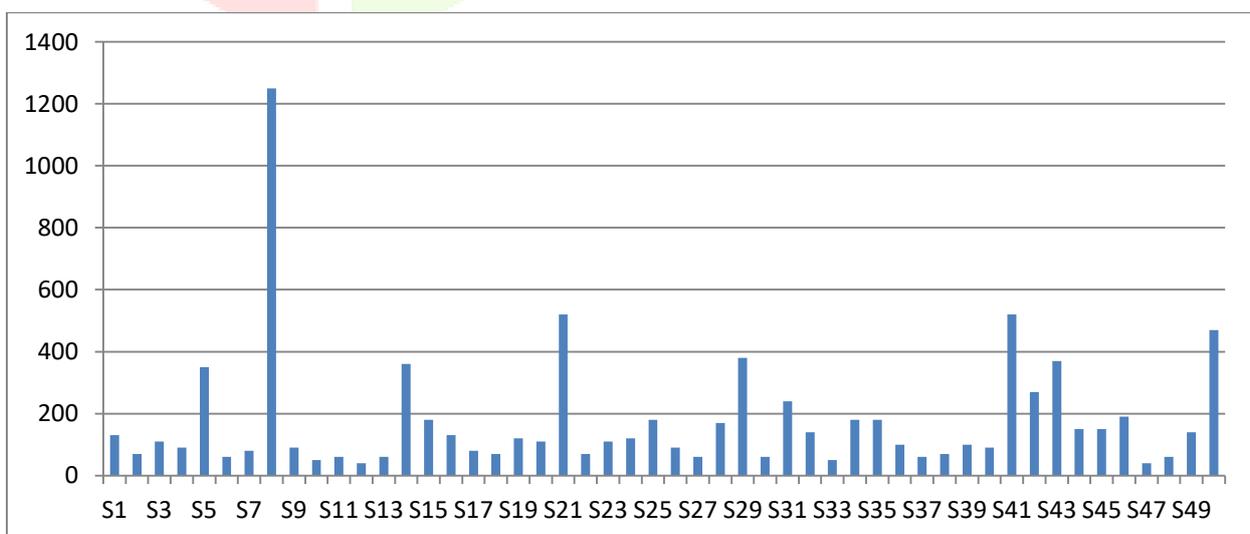
Graph- 4 (Comparison of Total Hardness parameter from various sample sites)

Calcium Hardness: Calcium Hardness varies from 20 mg/L to 1150 mg/L as illustrated in Graph-5 It may be due to the presence of high amounts of calcium salts in ground water samples.
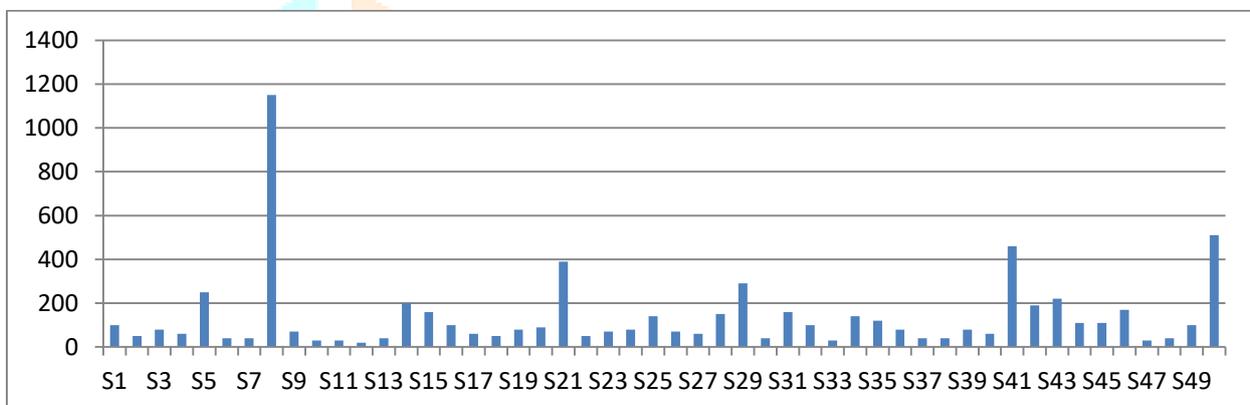

Graph-5 (Comparison of Calcium Hardness parameter from various sample sites)

Magnesium Hardness: Magnesium Hardness of groundwater is varying from 40 mg/L to 1250 mg/L as shown in Graph- 6. High values of magnesium hardness can be attributed to the large amounts of magnesium salts in ground water.


Graph-6 (Comparison of Magnesium Hardness parameter from various sample sites)

Chloride: Chloride contents in fresh water are largely influenced by evaporation and precipitate Chloride ions are generally more toxic than sulphate to most of the plants and are best indicator of pollution (Rao, 2006). Chloride found high during the study ranged from 20 mg/l to 2000 mg/l (Graph-7). Minimum value was observed at samples S3, S10 and S49 in ward no. 1, 2, 10 resp. and maximum value was observed at S21 in ward no.5. These unusual concentrations may indicate pollution by organic waste. Chloride salts in excess of 100 mg/1 give salty taste to water and when combined with calcium and magnesium, may increase the corrosive activity of water (Tatawat and Singh- Chandel, 2007).
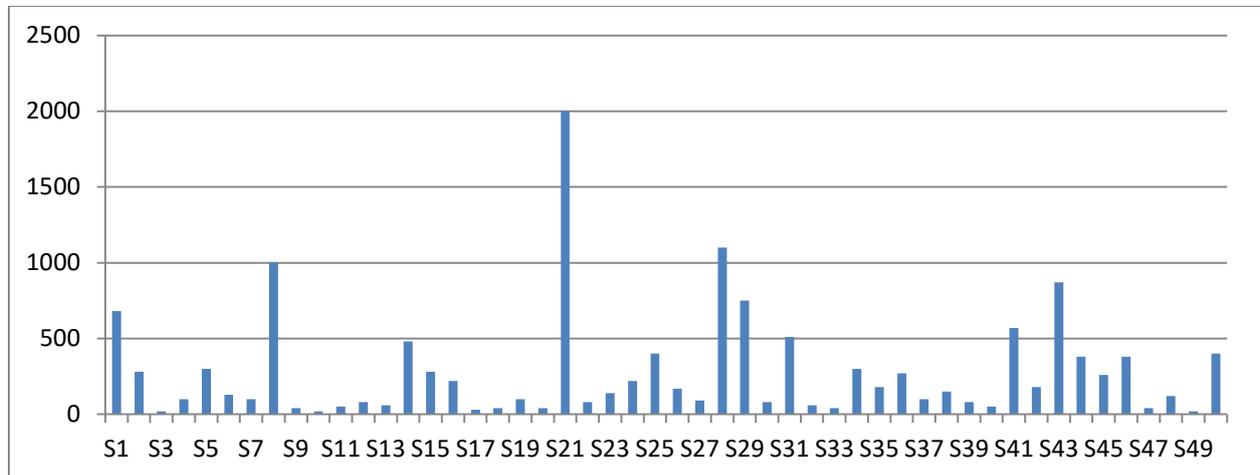
Graph-7 (Comparison of Chloride parameter from various sample sites)

Nitrate: During the study Nitrate fluctuated between 0 to 380 mg/l (Graph -8). Which are beyond the permissible limit of BIS, ICMR and WHO. In presence of high concentration of nitrate drinking water is toxic (Umavathi et al. 2007). Due to higher concentration (over 100 mg/L) of nitrate in water, infants, less than six month old, are suffering from methamoglobinemia or blue baby disease.
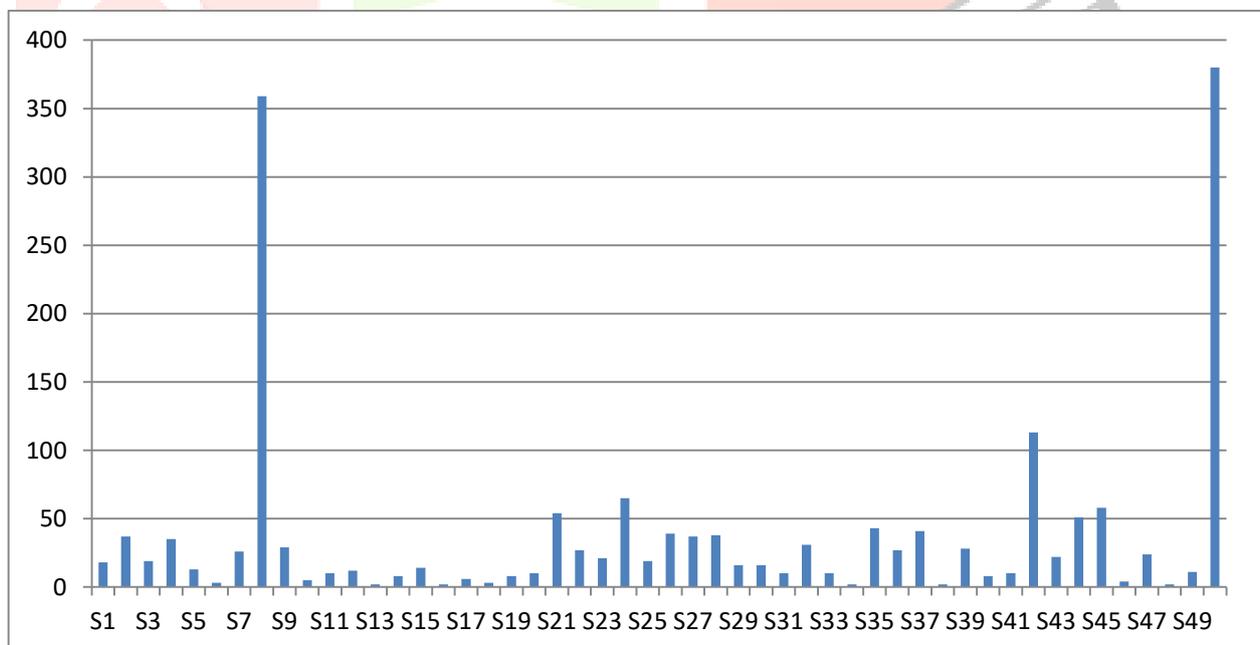
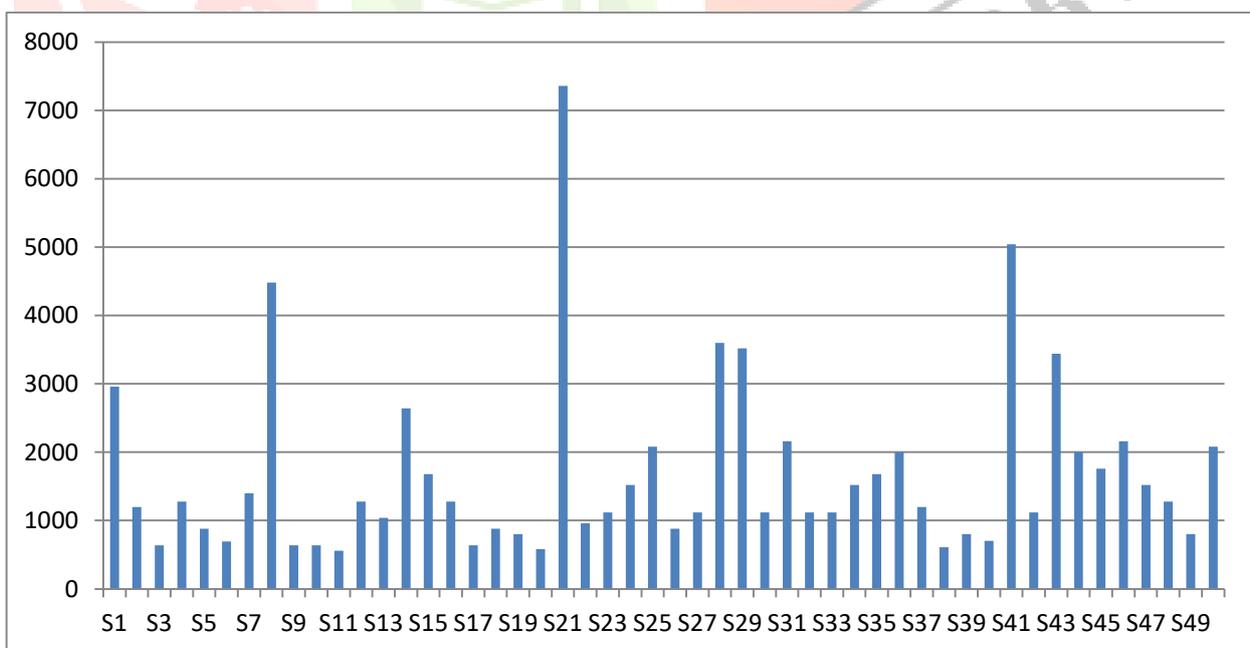**Graph-8** (Comparison of Nitrate parameter from various sample sites)

Fluoride: Fluoride is important in human nutrition for the normal development of bone The required level of fluoride is 1.0 to 1.5 mg/L. Higher concentration of fluoride in ground water appears to create dental, skeletal and non-skeletal fluorosis (Saxena and Saxena, 2013). Fluoride concentration in sampling sites ranges from 0.3 to 9.6 mg/L in ground water samples, with lowest value 0.3 mg/L (S17, S39 and S42) in ward no. 4, 8, 9 resp. and highest value 9.6 mg/L (S37) in ward no.8 . As shown in Table-2 most of the

samples are having fluoride concentration more than the permissible limit and suffering from the acute fluoride problems.
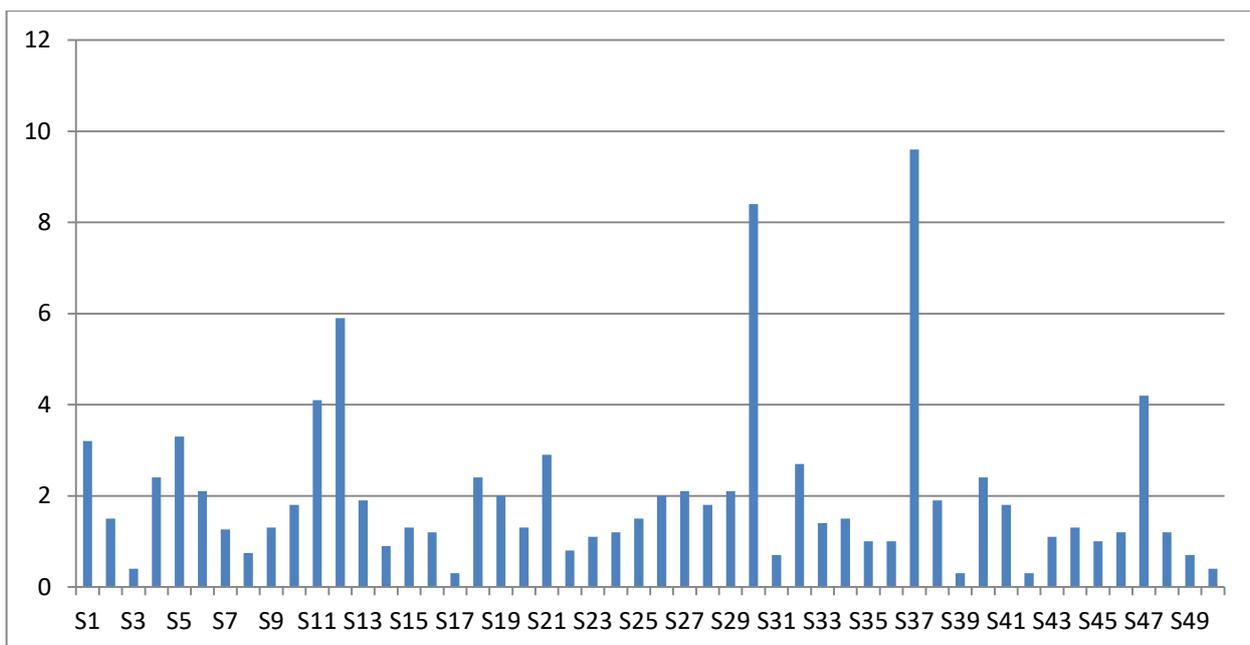
Graph-9 (Comparison of Fluoride parameter from various sample sites)

Total Dissolved Solids: Total dissolved solid is an important parameter for drinking water and water to be used for other purposes beyond the prescribed limit, it imparts a peculiar taste to water and reduce its potability (Sandeep Mitharwal et al., 2009). Total dissolved solids are composed mainly of carbonates, bicarbonates, chlorides, phosphates and nitrates of Calcium, Magnesium, Sodium, Potassium, Manganese, organic matter salt and other particles (Siebert et al., 2010). In the present finding TDS value varied from 560 to 7360 mg/L ,which is also not within the prescribed permissible limit Maximum TDS recorded at S21 in ward no. 5 and minimum at S11 in ward no.3 .

Graph-10 (Comparison of Total Dissolved Solid parameter from various sample sites)

Correlation of Water Quality Parameters

In the present study the correlation coefficients (r) among various water quality parameters have been calculated and the numerical values of correlation coefficients (r) are tabulated in Table- 5. Correlation coefficient (r) between any two parameters, x and y are calculated for parameter such as water pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, and total dissolved solids and negative correlations with total alkalinity and fluoride. EC has been found to show negative correlations with fluoride while all other parameters are positively correlated with EC. Out of the 55 correlation coefficients, 6 correlation coefficients (r) between the TDS and EC, Cl- and EC (0.9356), CaH and TH (0.9960), MgH and TH (0.9967), CaH– hardness, chloride, nitrate, fluoride and MgH (0.9856), Cl and TDS (0.9356) total dissolved solids of the ground water samples. The degree of line association between any two of the water quality parameters as measured by the simple correlation coefficient (r) is presented as 10×10 correlation matrix. The pH has been found to show positive correlation with electrical conductivity, total hardness, calcium hardness, are found to be with highly significant levels ($0.8 < r < 1.0$), and 1 correlation coefficient gives the significant ($0.5 < r < 0.6$) level of r values. There are 11 value of r which belongs to the moderate significant coefficient levels ($0.6 < r < 0.8$). 42 cases were calculated out positive correlation while 13 cases were calculated out negative.

Table-5: Correlation coefficient (r) among water quality parameters

Parameter	pH	EC	TA	TH	CaH	MgH	Cl-	NO3-	F-	TDS
pH	1									
EC	0.066409	1								
TA	-0.05966	0.126011	1							
TH	0.11245	0.675377	-0.21285	1						
CaH	0.10808	0.649326	-0.20733	0.996065	1					
MgH	0.115658	0.694464	-0.21642	0.996742	0.985672	1				
Cl-	0.067813	0.935698	0.086155	0.626557	0.595912	0.650161	1			
NO3-	0.096462	0.2878	-0.20395	0.733078	0.768854	0.695509	0.282504	1		
F-	-0.1871	-0.04261	0.184705	-0.20385	-0.20083	-0.2052	-0.07125	-0.1674	1	
TDS	0.066409	1	0.126011	0.675377	0.649326	0.694464	0.935698	0.2878	-0.04261	1

CONCLUSION

The analysis of ground water samples collected from different wards of Champa in District Janjghir Champa revealed that, in samples almost all water quality parameters (pH, electrical conductivity, total alkalinity, total hardness, calcium hardness, magnesium hardness, chloride, nitrate, fluoride and TDS) are beyond the permissible limit as per BIS, ICMR and WHO standards. In comparison to all other parameters there is an acute problem of extremely high levels of Fluoride, Nitrate, Total Dissolved Solids and Chloride. As only 56% of ground water samples have fluoride content with in the permissible limit (> 1.5 mg/L, WHO) and remaining 44% of samples are having very high fluoride concentrations. The favourable factor which contributes to rise of fluoride in ground water is presence of fluoride rich rock salt system. The nitrate ion concentration of 14% of total samples was more than 45 mg/L. Some samples contain this concentration upto 380 mg/L. The increased nitrate level in the ground water samples may be due to the consumption of large quantity of nitrogenous fertilizers like urea, NPK and cattle-shed along with municipal wastes. 24% of ground water samples are having TDS more than 2000 mg/L (relaxed permissible limit as per BIS standards) and 42% ground water samples reported the Chloride level more than 200 mg/L.

The results of current study indicate that the drinking water, used by the people residing in wards of Champa, is not potable. So, the proper environment management plan must be adopted to control drinking water pollution immediately. Based on these results and analysis of water samples, it is also recommended to use water only after boiling and filtering or by Reverse Osmosis treatment for drinking purpose by the individuals to prevent adverse health effects.

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