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Pre-Monsoon Physico-Chemical and Trace Metal Analysis of Ground Water of Sarguja District, Chhattisgarh, India

Sanjay Jain[1*] and Rohit Kumar Bargah[2]
[1]Research Scholar, Dept. of Chemistry, Govt. S.P.M. College, Sitapur, Sarguja (C.G.), India, 497111(Affiliated to SGVV, Ambikapur, Dist. Sarguja, C.G., 497001)
[2]Assistant Professor and Head, Dept. of Chemistry, Govt. S. P.M. College, Sitapur, Sarguja (C.G.), India, 497111

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Corresponding Author:
Sanjay Jain

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ABSTRACT

Ground water is a vital source of water for human consumption, agriculture, and industrial purposes. However its quality is often compromised by various physicochemical and traces metal contaminants. This study aimed to analyze the physicochemical parameters and trace metal concentration in ground water samples of the tribal and rural district; Sarguja in the Chhattisgarh state. For this purpose, ten sampling locations were selected (site code no. SD-1 To SD-10) in all the seven blocks of Sarguja district for collection of water samples in the month of April 2024. The collected water samples were subsequent analyzed by the standard methods for various water quality parameters. Environmental sensitive index parameters such as temperature, pH, electrical conductivity, turbidity, TDS were analyzed instantly at the sampling spots while total hardness, total alkalinity, Calcium, Magnesium, potassium, sodium, fluoride, chloride, nitrate, sulphate, were analyzed as per the standard methods. Selected trace metal like cadmium, lead, iron and chromium were analyzed by using AAS. The procured results were compared with the standard values stipulated by the water monitoring agency WHO (2011) and BIS (2012). The statistical parameters like mean, SD, SE, % CV were systematically calculated. The range of concentration of Fe and F were between 0.14 to 3.42mg/L and 1.69 to 7.12 mg/L respectively. The result showed that many of samples exceeded the permissible limits for fluoride and iron. Residents of study field also suffering from different kinds of fluorosis. The study highlights the need for regular monitoring and remediation of ground water quality to ensure safe and sustainable use.

1. Introduction

Water is one of the essential components for the sustenance of life on the earth. [1]. about 97% of the earths water is found in ocean, 2 % is frozen as ice in poles etc. and remaining 1% is available to us in the form of fresh water, streams, lakes, and groundwater.[2]. Groundwater is water that occupies the pores or cervices in sand, sand stone, lime stone and other rocks [3] which is used for drinking, irrigation, industrial purposes all over the world. The importance of ground water for the existence of human society cannot be overemphasized [4]. Ground water is an essential component of the hydrological cycle and its quality is crucial for human health and environment. [5]. Discharge of industrial, agricultural and domestic wastes, geological formation, rainfall pattern and infiltration rates affect the ground water quality. Ground water contains wide varieties of dissolved inorganic chemical constituents in various concentrations as a result of chemical and biochemical interactions between water and the geological materials through which it flows [6-8], heavy metals like lead, copper, mercury, cadmium, chromium, iron etc. are enter in the water from many sources like industries, mines, vehicle exhaust, and weathering of rocks and soils. These metals reach man and animal through food chain as resulting damage any organ of the body like kidney, heart, liver etc. [9]. the quality of ground water is of vital concern for mankind since it is directly linked with human welfare and sustainable development [10-12]. Therefore, the quality of ground water needs to

[1]Author can be contacted at: *[1]Research Scholar, Dept. of Chemistry, Govt. S.P.M. College, Sitapur, Sarguja (C.G.), India*
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be regularly monitored. The present study is undertaken to assess the quality of ground water in sarguja district of Chhattisgarh state of India.

2. Materials and Methods

2.1 Study Area

Surguja district, located in the northern part of Chhattisgarh state of India, holds a distinct position as one of the oldest districts in the region, boasting a rich historical and cultural legacy. The district's administrative hub is situated in Ambikapur.. Expanding across approximately 5,732 square kilometers, Surguja is home to a population of around 23.6 lakh, as recorded in the 2011 census. Positioned between 23°37'25" to 24°6'17" north latitude and 81°34'40" to 84°4'40" east longitude, the district enjoys an average elevation of 623 meters above sea level [13]. The district is biodiversity rich area dominated by tribal communities. About 58% of the area is occupied by high dense forest. Abundant natural resources, including coal, bauxite, iron ore, and limestone deposits, contribute to the economic prosperity of Surguja, making it a dynamic and multifaceted region within the state of Chhattisgarh. In Sarguja rainfall varies between 100-200 cms, mean annual temperature 26°-27°and humidity 60-80%. The district comprises rock formation of archean to Eocene age. Granitiods and the metasedimrnts belonging to the chhotanagpur gneissic complex form the basement of overlying gondwana sediments lameda beds and Deccan traps. These rocks are richest sources of metallic and non-metallic elements. this study area is significant due to its unique blend of natural resources, cultural heritage and environmental concerns. The districts ground water quality is a critical aspect of this study as it affects the health and livelihoods of the local population.

Fig 1: a. Locations of Sarguja in Chhattisgarh b. Locations of Ground Water Sites Sarguja

2.2 Collection of water samples:

Ground water samples were collected from all the seven blocks of Sarguja district. On the basis of environmental significance point of view, ten sampling spots were selected and assigned as SD-1 To SD-10. The samples were collected in the pre monsoon session of 2024 during the month of April. Water samples were collected in pre cleaned plastic containers of 1 L capacity. The collected water samples were preserved properly by keeping in refrigerator at 4^0C and adding of con. Nitric acid. Table 1 lists the locations of ground water sampling stations in the study field area.

Table 1: Geographical Locations of Sampling Spots

S.N.	Sampling station	Block	Sample ID	Latitude (N)	Longitude (E)	Source
1	Bada Damali	Ambikapur	SD-1	23.11917^0	83.194468^0	Hand pump
2	Bhapouli	Ambikapur	SD-2	23.212538^0	83.272436^0	Bore Well
3	Telaidhar	Batouli	SD-3	22.851884^0	83.494918^0	Bore Well
4	Soyda	Lakhanpur	SD-4	22.955073^0	83.124002^0	Hand pump
5	Tunguri	Lakhanpur	SD-5	22.95706^0	83.134014”	Bore Well
6	Ajirma	Lundra	SD-6	23.201027^0	83.284214^0	Hand pump
7	Udumkela	Mainpath	SD-7	22.822063^0	83.405113^0	Hand pump
8	Devgarh	Sitapur	SD-8	22.825361^0	83.451642^0	Hand pump
9	Dandgaon	Udaipur	SD-9	22.898328^0	82.840955^0	Hand pump
10	Gumga	Udaipur	SD-10	22.881629^0	82.831235^0	Bore Well

2.3 Analysis of water samples:

Collected ground water Samples were analyzed for different physico-chemical parameters such as, temp., pH, electrical conductivity (EC), total dissolved solids (TDS), Turbidity, Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Nitrate, Fluoride, Iron, Chromium, Lead, Cadmium, Chloride, Sodium, Potassium and Sulphate by using

standard methods as recommended by APHA [14], Trivedi and Goyal [15], and NEERI manual [16]. The experimental values were compared with the standard values stipulated by the BIS (2012) [17] and WHO (2011) [18] standards.

Table 2: Chemical Parameters and their Methods

S. No.	Name of Parameter	Method
1	Temperature	Thermo-meterically
2	pH	pHmetry
3	EC	Conductometry
4	Turbidity	Nephelometric
5	Total solid	Gravimetric
6	Total dissolved solid	Gravimetric
7	TSS	Mathematical method
8	Total alkalinity	Titrimetric
9	Total Hardness	Titrimetric
10	Ca-Hardness	Titrimetric
11	Mg-Hardness	Titrimetric
12	Fluoride	Ion selective electrode
13	Chloride	Silver nitrate
14	Nitrate	Spectrophotometically
15	Sulphate	Turbidimetrically
16	Na	Flame photometric
17	K	Flame photometric
18	Fe, Cr, Pb, Cd	AAS

3. Result and discussion

The variation in physico-chemical characteristics of the ground water of ten sampling station and different block of Sarguja district have been summarized in the tables 3, 4,5 and the interpretation of data has been made with the help of statistical tools**.**

3.1 Temperature

Temperature is one of the most essential parameters in the water. It has significant impact on growth and activity of environmental life and it greatly affects the solubility of such as dissolved oxygen in water. The temperature of the selected water samples were measured spontaneously by electronic nine parameter analyzer. The measured temperature of Selected samples varied from 22.7 ^{0} C (SD-4) to 23.7 ^{0} C (SD-9).

3.2 pH

A pH range of 6.5-8.5 is normal acceptable as per guidelines suggested by WHO. The pH value of selected water samples was observed in the range of 7.40-9.42 which showed nature of water is slightly alkaline in nature. During the study period the highest value was found 9.42 at the SD-1 while lowest value was found 7.40 for SD-10. The pH has no direct adverse effect on health. It is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water [19].

3.3 Electrical conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electrical current [20]. The quantity of dissolved solids in water can be ascertained by determination of its conductivity. EC values were in the range of 141 microm/cm (SD-8) to 488 microm/cm (SD-9).

3.4 Total dissolved solids (TDS)

During the study TDS value varied from minimum 115 mg L^{-1} (SD-2) to maximum 385 mg L^{-1} (SD-1) .None of the sample showed above the excessive permissible limit as per BIS (2012), 500-2000 mg L^{-1} and WHO (2012), 500-1500 mg L^{-1}. TDS indicate the salinity behavior of ground water samples.

3.5 Turbidity

In most waters, turbidity is due to colloidal and extremely fine dispersions. The prescribed limit for turbidity for drinking water is 5-10 NTU. The value of turbidity was found from 1.35 (SD-1) to 26.20 (SD-4) NTU.

3.6 Total alkalinity (TA)

The permissible limit as per BIS (2012) is 300-600 mg/liter and as per WHO (2011) it is 200-600 mg/liter. The concentration of total alkalinity was found from 265 (SD-10) to 412 (SD-1) mg/l which is within the permissible limit. Alkalinity value of water gives an idea of natural salts present in water. The cause of alkalinity is the minerals which

dissolve in water from soil. The various ions that contribute to alkalinity value include bicarbonate, hydroxides, phosphate, borates and organic solids [21].

3.7 Total Hardness (TH)

The total hardness is defined as the sum of calcium and magnesium concentration expressed both as the calcium carbonate hardness in milligrams per liter. The standard value for TH is 300-600 mg L^{-1} as per BIS (2011) whereas as per WHO 100-500 mg L^{-1} . During the observation, the minimum TH was found at the sampling site no. SD-9, 252 mg L^{-1} while the maximum TH was found at sampling site no. SD-5, 325 mg L^{-1}. These results indicated; the total hardness didn't get imparting in the contamination of ground water sources.

3.8 Calcium

Calcium is a major component of natural water. It dissolves from rocks and soils which cause hardness [22]. In the study area, the minimum concentration of calcium ions was found at sampling site no. SD-3, 105 mg L^{-1} while maximum concentration at sampling site no. SD-5, 165 mg L^{-1}. The acceptable range as per BIS is 75 mg L^{-1} to 200 mg L^{-1}.

3.9 Magnesium

At the time of study, the minimum value was found at sampling site SD-9, 65 mg L^{-1} and maximum value at sampling site SD-1, 95 mg L^{-1} indicating the low concentration of magnesium ions. The acceptable range is 30 to 150 mg L^{-1} as per BIS 2011.Magnesium ions play a key role in total hardness. Magnesium generally occurs in lower concentration than calcium because of dissolution of magnesium is slow process and calcium is more abundant in earth crust [23].

3.10 Sulphate (SO_4^{2-})

Sulphate occurs naturally in water as a result of leaching from gypsum and other common minerals [24]. Discharge of industrial wastes and domestic sewage tends to increase its Concentration. The Sulphate concentration varied between 26.4 mg/L (SD-4) to 172 mg/L(SD-10), Which is within the prescribed limit.

3.11 Nitrate (NO_3^-)

Groundwater contains nitrate due to leaching of nitrate through the percolating water. Groundwater can also be contaminated by sewage and other wastes rich in nitrates [25]. The acceptable limit for Nitrate concentration is 45 mg/L. The nitrate content in the study area varied in the range BDL (SD-4, 5, 9) to 15.0 mg/L (SD-8, 10) and found within the prescribed limit.

3.12 Fluoride (F^-)

During observation, concentration of fluoride was found in between 1.69 ppm (SD-4) to 7.12 ppm (SD-7) which is below and above the permissible limits. The cause of higher concentration of fluoride in ground water is due to weathering of fluoride bearing rocks. The balanced amount of fluoride ion is beneficial for human body health but in imbalance concentration it is leading to teeth and bone metabolic disorder. A concentration of up to 1.0 mg/L is desirable for dental health but higher concentration causes deleterious effect on health [26].

3.13 Chloride (Cl^-)

During the observation, the concentration of chloride was found from 222 mg/liter (SD-8) to 296 mg/liter (SD-9) which is below the permissible limit. Chloride is associated with pollution as an index, its excess concentration imparts a salty taste to water and people who are not accustomed to high chloride can be subjected to laxative.

3.14 Sodium

Sodium ion concentrations were found in between 15.0 mg/L (SD-7) to 123.0 mg/L (SD-9). Sodium ion concentration for all the investigated samples was found within the prescribed limit.

3.15 Potassium

In the present study, all the samples except SD-10 (9.80 mg/L) are found below detection limit. The major source of potassium in natural water is weathering of rocks but the quantities increase due to disposal of waste water.

3.16 Iron

Iron is a heavy metallic element and a certain amount of this metallic element is useful for blood formation. The average level is 1 mg/liter. Above this, it causes staining of laundry and ceramics ware. In our observation we have found 0.14 mg/L (SD-10) to 3.42 mg/L (SD-4) which is below and above the desirable limit. The higher concentration of Iron is due to Gondwana land group rocks.

3.17 Chromium

Cr is one of the most widely distributed heavy metal in the earth's crust [27]. It is normally found in two oxidation states, i.e., Cr^{3+} and Cr^{6+} in which Cr^{6+} is highly toxic. The acceptable limit for Cr is 0.005 mg/L. During the study period the concentration of Cr was varied from 0.01 mg/L (SD-1, 5, 8) to 0.04 mg/L (SD-2, 4).

3.18 Cadmium

Cadmium is considered to be an environmentally hazardous element because of its high toxicity and greater capability of accumulation and retention in the body of organism including humans. During this study, in all the samples the concentration of Cadmium was found below detection limit due to lacking of the sources.

3.19 Lead

Lead is a toxic heavy metal which is present in the natural environment but due to human and industrial activity the concentration of lead increases day by day. It passes to environment through the vehicular exhaust and may causes serious health problem to child hood below six years. It also causes blood pressure, kidney damages [28]. During our observation, the concentration of Lead was found in the ranges of 0.11 to 0.88 mg/liter due to deficiency of natural and anthropogenic sources [29].

Table 3. Analytical results of selected parameters for ground water sources

Parameter	Temp (C°)	pH	EC	Turbi.	TS	TDS	TSS	TA	TH	Ca^{2+}	Mg^{2+}	F^-	Cl^-	SO_4^{2-}	NO_3^-
SD1	22.8	9.42	374.0	1.35	540	385	155	412.00	265.0	132	95	7.10	255	44.00	3.00
SD2	23.1	9.05	182.0	2.03	320	115	205	360.00	278.0	122	85	2.98	244	78.05	2.00
SD3	23.0	9.00	311.0	1.44	560	340	220	375.00	305.0	105	76	2.00	263	65.33	3.00
SD4	22.7	8.50	295.0	26.20	560	305	255	326.00	282.0	156	89	1.69	228	26.24	2.00
SD5	22.9	8.50	432.0	2.14	340	230	110	332.00	325.0	165	85	3.00	266	76.32	0.00
SD6	22.8	9.00	265.0	8.23	360	180	180	315.00	255.0	144	75	3.30	254	62.00	0.00
SD7	23.2	9.00	260.0	1.55	380	240	140	382.00	280.0	126	78	7.12	231	22.80	0.00
SD8	23.1	8.50	141.0	9.35	360	135	225	289.00	268.0	148	72	1.90	222	32.00	15.00
SD9	23.7	8.20	488.0	7.44	440	285	155	354.00	252.0	141	65	2.99	296	56.20	0.00
SD10	23.0	7.40	328.0	13.50	520	335	185	265.00	265.0	132	72	2.76	278	172	15.00

Except Temperature (^{0}c), pH, EC (micromhos/cm), Turbidity (NTU), all parameters have been measured in mg/L.

Table 4: Analytical results of selected metallic ions in ppm for ground water samples

Parameter	Fe	Na	K	Cr	Pb	Cd
SD1	0.30	70.0	BDL	0.01	0.11	BDL
SD2	0.32	18.0	BDL	0.04	0.14	BDL
SD3	0.17	30.6	BDL	0.02	0.18	BDL
SD4	3.42	24.9	BDL	0.04	0.88	BDL
SD5	0.55	18.5	BDL	0.01	0.48	BDL
SD6	0.24	18.2	BDL	0.02	0.13	BDL
SD7	0.58	80.5	BDL	0.02	0.14	BDL
SD8	0.75	15.0	BDL	0.01	0.19	BDL
SD9	0.71	123.0	BDL	0.03	0.13	BDL
SD10	0.14	64.7	BDL	0.02	0.13	BDL

Table-5: Statistical analysis of selected parameters of ground water samples

Parameter	N	Min.	Max.	Mean	SD	SE	CV (%)	BIS 2012	WHO 2011
Temp.	10	22.7	23.7	23.0	0.283	0.0895	1.229		
pH	10	7.40	9.42	8.57	0.572	0.181	6.68	6.5-8.5	6.5-8.5
EC	10	141	488	307.6	105.7	33.43	34.37	750-2250	400-2000
Turbidity	10	1.35	26.20	7.32	7.87	2.48	107.51	1-5 NTU	5 NTU
TDS	10	115	385	255	90.92	28.75	35.65	500-2000	500-1500
TH	10	252	325	277.5	22.60	7.14	8.14	200-600	100-500
Ca^{2+}	10	105	165	137	17.48	5.52	12.75	75-200	75-200
Mg^{2+}	10	65	95	79	9	2.88	11.50	30-100	30-150
TA	10	265	412	341	44.55	14.09	13.06	200-600	200-600
F^-	10	7.12	1.69	3.48	1.98	0.628	57.01	1-1.5	1-1.5
SO_4^{2-}	10	26.24	172	63.49	42.97	13.59	67.68	200-400	200-600
Cl^-	10	222	296	253.7	23.31	7.37	9.19	250-1000	200-1000
NO_3^-	10	0.00	15.0	4.0	5.42	1.87	148.13	45	50
Fe	10	0.14	3.42	0.72	0.974	0.308	135.7	0.3-1.0	0.3
Na	10	18.0	131.0	46.3	36.51	11.54	78.79	75-200	200
K	10	0.00	9.80	0.98	3.099	0.98	316.22	10	25
Cr	10	0.01	0.04	0.02	0.011	0.0035	51.60	0.05	0.05
Pb	10	0.11	0.88	0.25	0.25	0.0778	98.06	0.01	0.01
Cd	10	BDL	-	-	-	-	-	0.003	0.003

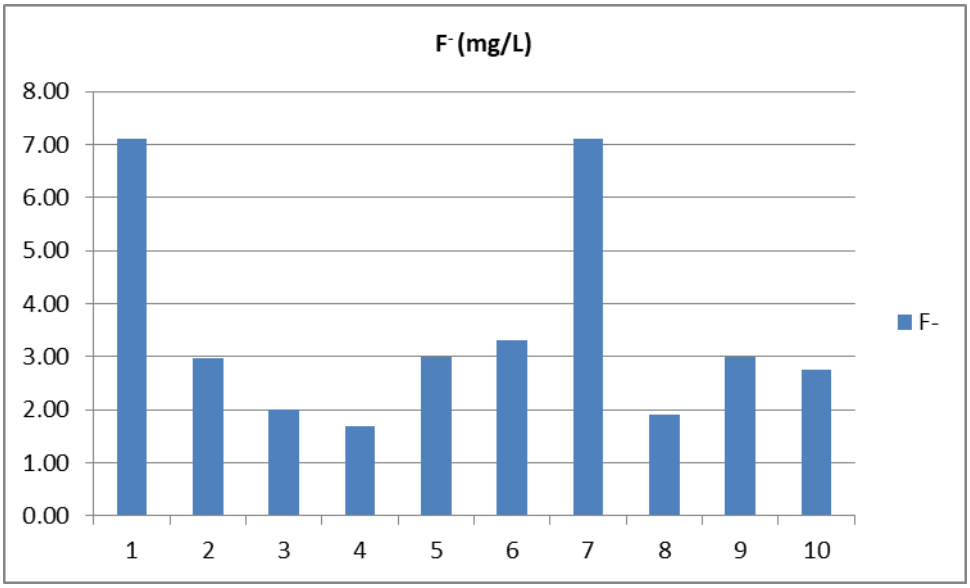

Fig 1. Variation of Fluoride concentration in sampling spots

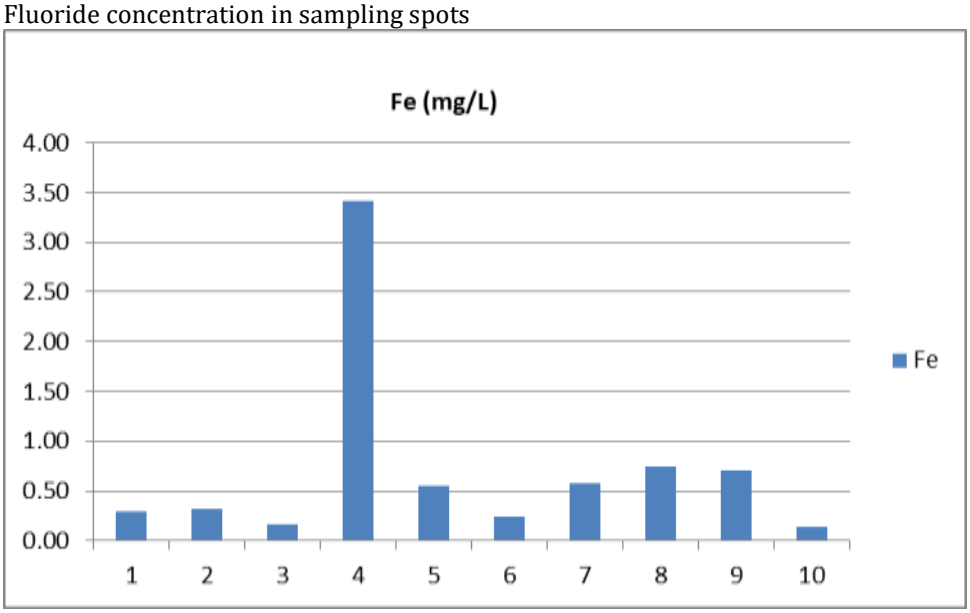

Fig 2. Variation of iron value in sampling spots

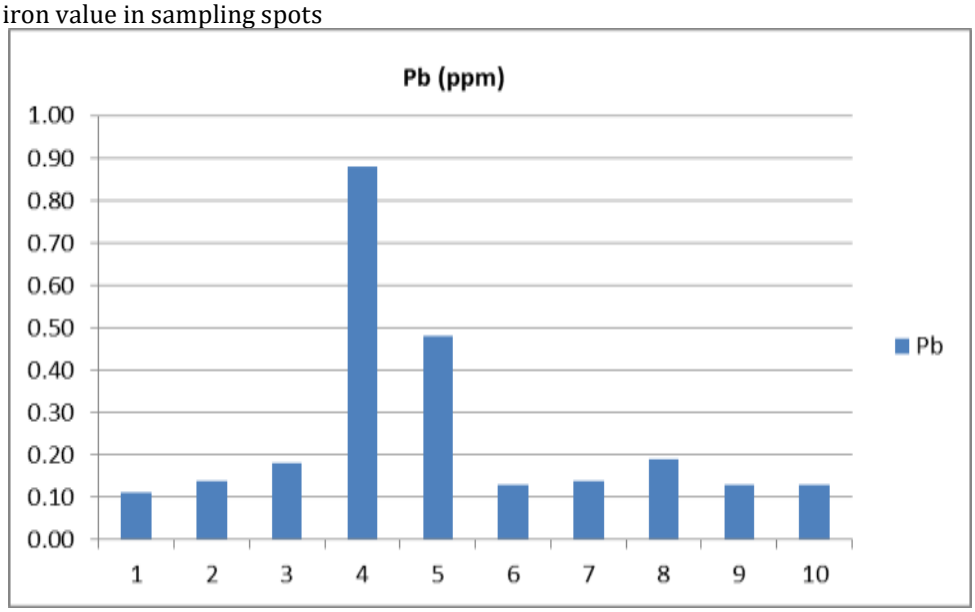

Fig 3. Variation of lead concentration

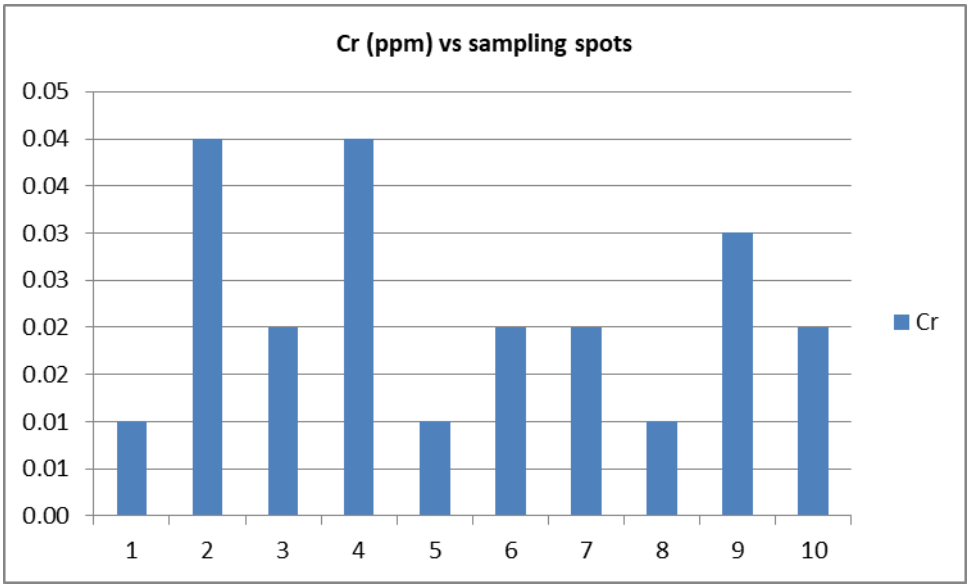

Fig 4. Variation of Cr concentration in selected sampling spots

4. Conclusion

Present study emphasizes the importance of physicochemical and traces metal analysis in ground water quality assessment. This study also focused the fluoride, iron, and some other toxic metallic ion concentration in different ground water sources. The concentration of fluoride (7.12 mg/L) and iron (3.42 mg/L) were detected up to alarming level. The procured values were above the excessive the permissible level as per standard values prescribed by WHO and BIS. The concentration of all these elements is created adverse effect on health of human being. People residing of study field are also suffering by the bone, teeth and gastrointestinal metabolic disorder. Indigenous technologies should be adopted for the removal of fluoride and iron from ground water sources and to make water fit for different human development uses. The finding can also be used to develop strategies for ground water management and remediation in Sarguja district.

5. Conflicts of interest:

The authors declare no conflict of interest.

6. Acknowledgement

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