

Evaluation of the Physio-Chemical Parameters of Drinking Water in the Bilaspur and Korla District, Chhattisgarh

EIRAHM KAISER

[M.Sc.](#) CHEMISTRY 2TH SEMESTER

DEPARTMENT OF CHEMISTRY

LCIT COLLEGE OF COMMERCE AND SCIENCE, BILASPUR, CHHATTISGARH

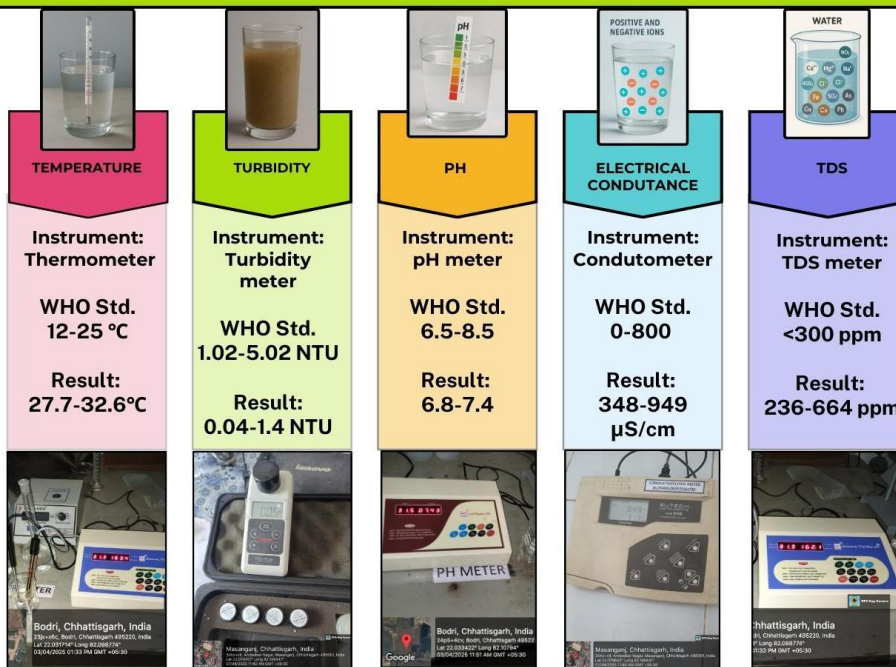
Abstract : Water quality is a critical determinant of public health and ecological integrity, necessitating comprehensive assessment of physio-chemical parameters and contaminants. This study investigates key water quality indicators- **pH, Turbidity, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Alkalinity, Total Hardness, Calcium Hardness, Magnesium Hardness**, and major anions **Chloride and Fluoride** content across diverse water sources to evaluate compliance with regulatory standards and identify contamination sources of Bilaspur District (Sarkanda, Bodri, Chakarbhatta, Belha) and Baikunthpur, Town of Koriya District, Chhattisgarh, India. Standard analytical protocols were employed: pH and EC measured electrometrically, turbidity via Nephelometry, TDS via TDS meter, Alkalinity, Hardness (total hardness, Ca hardness, Mg hardness), & Cl⁻ ions by Titration method, and Fluoride ion with ion-selective electrodes (ISEs). (APHA, AWWA, & WEF, 2017, 23rd ed.)

Results revealed spatial variability, with Turbidity (0.05-1.4 NTU), TDS (236.2- 664.4 mg/L), and Total Hardness (80.48-445.7 mg/L), Calcium Hardness (35.9-228.45 mg/L) and Magnesium Hardness (38.12-200.8 mg/L), exceeding WHO and BIS guidelines in several samples, indicating sediment load and mineralization. Chloride (up to 157.7 mg/L), Fluoride (up to 0.072 mg/L) concentrations in groundwater suggested agricultural infiltration and geogenic leaching, respectively. Strong inter-parameter correlations (e.g., EC-TDS, hardness-alkalinity) highlighted anthropogenic and natural influences, including industrial discharge, fertilizer use, and bedrock interactions. The study underscores the urgency of regular monitoring, source-specific remediation, and community awareness to mitigate health risks (e.g., methemoglobinemia, fluorosis) and ensure sustainable water management. This baseline dataset provides actionable insights for policymakers to prioritize interventions and align water safety practices with global sustainability goals.

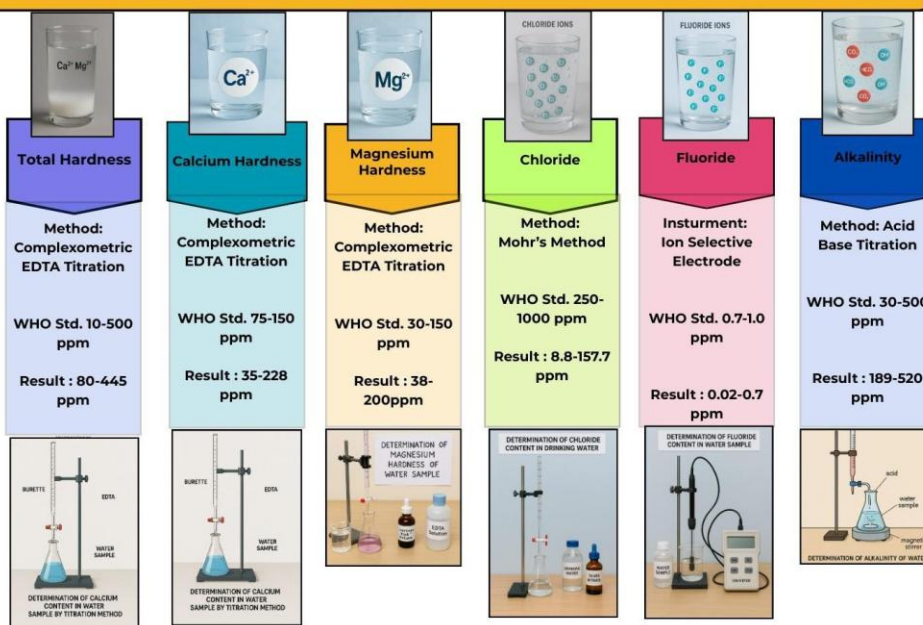
Keywords: pH, Electrical Conductivity, TDS, Turbidity, Total Hardness, ISEs, WHO and BIS etc.

GRAPHICAL ABSTRACT

Physical Parameters



Chemical Parameters



INTRODUCTION

Water, the universal solvent and the cradle of life, is an irreplaceable resource that sustains all forms of life on Earth. Covering approximately 71% of the planet's surface, It is the foundation of ecosystems, agriculture, industry, and human survival. Despite its abundance, only a small fraction- less than 1% of the Earth's water is accessible as freshwater or drinking water, making its quality and availability critical concerns for global health and development. (NOAA's 2025)

In the context of human consumption, water quality is governed by a delicate balance of physical, chemical, and biological parameters. Physical parameters like **temperature, turbidity, odour** and **taste** provide initial insights into water's usability, while chemical parameters- such as **pH, electrical conductivity, hardness, total dissolved solids (TDS), and concentrations of ions** (e.g., **chloride, sulfate, nitrate**) and **minerals** (e.g., **calcium, magnesium, potassium**) determine its safety and nutritional value. Essential minerals in water, including calcium for bone health, magnesium for enzymatic functions, and trace elements like **iron** and **zinc**, are vital for maintaining physiological processes. Conversely, contaminants such as heavy metals (**arsenic, lead, cadmium**), excessive **fluoride**, or **nitrates** can pose severe health risks, ranging from **gastrointestinal disorders** to chronic diseases like **cancer** and **skeletal fluorosis**. (4th ed.WHO, 2017)

This study examines the physical and chemical parameters of drinking water of **Seepat Chowk, Sarkanda, Bilaspur, (C.G.)** and **Baikunthpur** town of Koria District (C.G.) including **Temperature, Turbidity, pH, Total Dissolved Solids (TDS), Electrical Conductivity, Total Hardness, Alkalinity, Chloride and Fluoride**. These parameters are critical indicators of water potability, as deviations from permissible limits can render water unsafe for consumption. For instance, high turbidity may indicate microbial contamination, while elevated nitrate levels are linked to methemoglobinemia, particularly in infants. (WHO 2017) Similarly, excessive fluoride can cause dental or skeletal fluorosis, whereas heavy metals pose risks of toxicity and organ damage. (EPA 2022)

In addition to monitoring contaminants, the study emphasizes the importance of essential minerals in drinking water, such as calcium, magnesium, potassium, sodium, iron, and zinc. These minerals play vital roles in physiological functions: calcium and magnesium support bone health and metabolic processes, potassium and sodium regulate fluid balance and nerve function, while iron and zinc are crucial for hemoglobin synthesis and immune response.(WHO,2005) Maintaining an optimal balance of these minerals is key to preventing deficiencies or excesses that could compromise health.

Water is one of the most important form of matter.(Brown et al., 2020) It is essential for the survival of all living beings and plays an important role in our life nature of surface and ground water is deficient in any event, for costumming living and is getting disintegrated due to imprudent usage of water assets, dehumanizing way of association, industrialisation and other created exercises. Today numerous waterways get million liters of modern effluents .Ground water forms a major source of drinking water.(United States Geological Survey [USGS], 2022). Ground water is unltimate, most suitable fresh water resource with nearly balanced concentration of the salts for human consumption. High content of sodium in combination with chloride and nitrate in water raises the blood pressure and often damage the kidney of the body (WHO, 2017). the modern civilization, industrialization, urbanisation and increase in population have lead to fast degradation of our ground water quality.

REVIEW LITRATURE

Assessment of Groundwater Quality Parameters:

S. No .	Location	T °C	pH	EC µS/cm	Turbidity NTU	TDS Mg/L	Total Hardness Mg/L	Ca Mg/L	Mg Mg/L	Cl Mg/L	F Mg/L	Reference
	WHO standard	25-50	6.5-8.5	0-800	1.02-5.02	<300	10-500	75-150	30-150	250-1000	0.7-1.0	WHO (2017)
1.	Bhilai		7.64 - 8.86	498 - 618	0.82	187-345				35-74		Jena V. et al., 2012
2.	Bastar (Jagdalpur)	26	6.89			438	208	27	181	40	0.44	Behra B. et al., 2012
3.	Dantewada	25-27	6.65	1000		431.2	232.8			191.75		Behra B. 2013
4.	Raipur (shankarnagar)	22	7.9-7.8			364-504	100-280					Sharma P. et al., 2013
5.	Mungeli (Khudia Dam)	26	7.3-8.8		12.14		179			57.61		Upadhyay Dr M. 2013
6.	Bilaspur (Seepat)	19.5-28.7	7.6-7.8				111-166	34-39	18.7-42.1	26.37-46.7		Shrivastava D.K et al 2014
7.	Bilaspur	19-28	7.6-7.8				143-179	19-41.6				Shrivastava D.K. et al., 2014
8.	Risali	29	8.17		3	1170	450	144				Jindal M.K. et al., 2014
9.	Korba	25.6	7.39			930	356					Bhaskar M. et al., 2015
10.	Pendra	18.9	7.2			110	32			5.5		Bakshi Moh.I.etal., 2015
11.	Pendra (Kotmi)	18.9	7.0			109				6.0		Bakshi Moh.I.etal., 2015
12.	Bijapur	27	7.34	995.74		667.1	415.09	80.36	51.19	90.7	1.71	Munna K et al., 2016
13.	Raipur (Pandri)	25	6.5-8.5	450 - 1200	0.02-13	13-1026	150-300	35-80	25-55	120-270		Koshle A. et al. 2016
14.	Mungeli		6.9-7.2			163-256		24-28				Tiwari S. K. et al 2016
15.	Korea (Manendra garh)	35.5	6.58			175	144			4.998		Tripathi I.P. 2016

S. No .	Location	T °C	pH	EC µS/cm	Turbidity NTU	TDS Mg/L	Total Hardness Mg/L	Ca Mg/L	Mg Mg/L	Cl Mg/L	F Mg/L	Reference
	WHO standard	25-50	6.5-8.5	0-800	1.02-5.02	<300	10-500	75-150	30-150	250-1000	0.7-1.0	
16.	Bastar		7.2-8.2	480 - 1000			160-290	40-75	20-50	110-240	0.4-1.1	Kumar V et al. 2017
17.	Durg		7.3-7.4			163-256	200-270	50-160				Sar S.K. et al., 2017
18.	Raipur (WRS)		7.1-8.5				80-550	32.6-9-260	4.42-62.47	30.12-269.77	0.006-0.89	Jena V. et al.,2017
19.	Korba		6.9-8.0	550 - 1150			170-320	45-85	25-60	130-260	0.5-1.3	Das R. et al.,2018
20.	Raipur (Tilda)	28.36	7.64			165.34	172.3	43.2	44.6	41.45		Sinha D. 2018
21.	Bilaspur (Takhatpur)	20-23	7.2-7.9	697.3-755.32	4.6-5.3	498-500	211-225	45-50		162.52-170.45	0.4-0.95	Yadav R.K. et al, 2018
22.	Rajnandgaon					629-499		80				Paithviraj N. et al. 2018
23.	Kabirdham	28.6	7.3				220	41.87	42.12	39.23		Mishra R. 2018
24.	Bilaspur		6.8-7.9	500 - 1100			150-300	35-80	25-55	120-270	0.6-1.4	Verma S. & Sinha K. 2019
25.	Raipur (Siltara)		7.1-8.3	450 - 1200			180-350	40-90	20-60	100-250	0.5-1.2	Sharma A. Gupta R. 2020
26.	Raigarh (Jamgaon)		6.76			145.32		10.91	11.53	25.46		Shah I.A.2021
27.	Durg		7.0-8.2	600 - 1300			200-400	50-100	30-70	150-300	0.7-1.5	Patel M. et al.2021
28.	Bastar		6.9-7.9			254-381	100	0.9-4.0				Pali J.R. et al, 2021
29.	Bemetara	10-48	7.06	1808		1157	657	167	58	92	0.45	Sharma M .K. et al, 2022
30.	Surajpur		6.5-6.6	350	6.5-7	120-132	150	30-35		80-83	0.5-0.6	Devangan S.K. et al 2022
S. No	Location	T °C	pH	EC µS/cm	Turbidity NTU	TDS Mg/L	Total Hardness Mg/L	Ca Mg/L	Mg Mg/L	Cl Mg/L	F Mg/L	Reference
.				cm	NTU	L	ss Mg/L	L	L		L	

	WHO standard	25-50	6.5-8.5	0-800	1.02-5.02	<300	10-500	75-150	30-150	250-1000	0.7-1.0	
31.	Janjgir (Naila)	19.7	7.43		0.54	497	221	64.4	14.7	84.6	0.31	Chandra K. etal, 2022
32.	Janjgir (Champa)	23.1	7.48		3.32	516	283	99	8.85	118	0	Chandra K. etal, 2022
33.	Janjgir (Khokhra)	22.20	7.18		1.73	350	159.1	32.7	18.83	62.98	0	Chandra K. etal, 2022
34.	Janjgir (Kera)	20	7.16		4.15	334	140.7	30.61	15.62	66.77	0	Chandra K. etal, 2022
35.	Janjgir (Sivrinaray an)	21.3	7.18		1.28	289	137	70.8	22.5	39.5	0.04	Chandra K. etal, 2022
36.	Janjgir (Khamhariy a)	22.4	7.24		2.2	320	149	31.1	17.2	56.2	0	Chandra K. etal, 2022
37.	Janjgir (pithampur)	20.6	7.38		8.33	303	285	106	25.7	194	0.94	Chandra K. etal, 2022
38.	Janjgir (Nawagarh)	22.1	7.2		1.95	366	171	37.6	18.8	57.2	0	Chandra K. etal, 2022
39.	Balrampur		8.7	801	1.7		28.5	9.88	0.92	90	5	Devangan S.K. etal.,2023
40.	Ambikapur (Kedarpur)		6.5	421	1.7		64	8		0.02		Devangan S.K. et al.,2025

Table: 1 Drinking Water Quality of Chhattisgarh

.				cm	NTU	L	ss Mg/L	L	L		L	
	WHO standard	25-50	6.5-8.5	0-800	1.02-5.02	<300	10-500	75-150	30-150	250-1000	0.7-1.0	
31.	Janjgir (Naila)	19.7	7.43		0.54	497	221	64.4	14.7	84.6	0.31	Chandra K. etal, 2022
32.	Janjgir (Champa)	23.1	7.48		3.32	516	283	99	8.85	118	0	Chandra K. etal, 2022
33.	Janjgir (Khokhra)	22.20	7.18		1.73	350	159.1	32.7	18.83	62.98	0	Chandra K. etal, 2022
34.	Janjgir (Kera)	20	7.16		4.15	334	140.7	30.61	15.62	66.77	0	Chandra K. etal, 2022
35.	Janjgir (Sivrinaray an)	21.3	7.18		1.28	289	137	70.8	22.5	39.5	0.04	Chandra K. etal, 2022
36.	Janjgir (Khamhariy a)	22.4	7.24		2.2	320	149	31.1	17.2	56.2	0	Chandra K. etal, 2022
37.	Janjgir (pithampur)	20.6	7.38		8.33	303	285	106	25.7	194	0.94	Chandra K. etal, 2022
38.	Janjgir (Nawagarh)	22.1	7.2		1.95	366	171	37.6	18.8	57.2	0	Chandra K. etal, 2022

39.	Balrampur		8.7	801	1.7		28.5	9.88	0.92	90	5	Devangan S.K. et al.,2023
40.	Ambikapur (Kedarpur)		6.5	421	1.7		64	8		0.02		Devangan S.K. et al.,2025

Table: 1 Drinking Water Quality of Chhattisgarh

Water quality analysis is mainly depended on chemistry. Nowadays, it is very important and essential to examine the water quality before it is used for any purposes. Water quality is determined by different physico- chemical parameters and the selection of parameters for testing of water quality we use review study of water quality parameter that are;

1. pH:

pH is a one if a one of the important parameter of water. It ranges between 0-14, if pH =7 then it is neutral, if pH < 7 then it acidic in nature and if pH >7 then it is alkaline in nature. The standard pH of drinking water according to WHO is 6.5-8.5, this is the desirable limit¹. pH value of Bhilai is 7.64-8.86 (**Jena V. et al. 2012**), pH value of Bastar(Jagadalpur) is 6.89 (**Behra B. et al. 2012**), pH value of Dantewada is 6.65 (**Behra B. 2013**), pH value of Raipur (Shankarnagar) is 7.9-7.8 (**Sharma P. et al. 2023**), pH value of Mungeli(Khudia Dam) is 7.3-8.8 (**Upadhyay Dr. M. 2013**), pH value of Bilaspur (seepat) is 7.6-7.8 (**Shrivastva D.K. et al., 2014**), pH value of Bilaspur is 7.6-7.8 (**Shrivastva D.K. et al., 2014**), pH value of Risali is 8.17 (**Jindal M.K. et al. 2014**), pH value of Korba is 7.39 (**Bhaskar M. et al. 2015**), pH value of Pendra is 7.2 (**Bakshi Moh. I. et al. 2015**), pH value of Pendra (Kotmi) is 7.0 (**Bakshi Moh. I. et al. 2015**), pH value of Bijapur is 7.34 (**Munna K. et al. 2016**), pH value of Raipur (pandri) is 6.5 (**S. K. et al 2016**), pH value of Korba (Manendragarh) is 6.58 (**Tripathi I.P. 2016**), pH value of Bastar is 7.2-8.2 (**Kumar V et al. 2017**), pH value of Durg is 7.3-7.4 (**Sar S.K. et al. 2017**), pH value of Raipur (WRS) 7.1-8.5 (**Jena V. et al. 2017**), pH value of Korba is 6.9-8.0 (**Das R. et al. 2018**), pH value of Raipur (Tilda) is 7.64 (**Sinha D. 2018**), pH value of Bilaspur (Takhatpur) is 7.2-7.9 (**Yadav R.K. et al., 2018**), pH value of Kabirdham is 7.3 (**Mishra R. 2018**), pH value of Bilaspur is 6.8-7.9 (**Verma S. & Sinha K. 2019**), pH value of Raipur (Siltara) is 7.1-8.3 (**Sharma A. & Gupta R. 2020**), pH value of Raigarh (Jamgaon) is 6.76 (**Shah I.A. 2021**), pH value of Bastar is 6.9- 7.9 (**Pali J.R. et al. 2021**), pH value of Bemetara is 7.06 (**Sharma M.K. et al. 2022**), pH value of Surajpur is 6.5-6.6 (**Devangan S.K. et al. 2022**), pH value of Janjgir (Naila) is 7.43 (**Chandra K. et al. 2022**), pH value of janjgir (Champa) is 7.48 (**Chandra K. et al. 2022**), pH value of Janjgir (Khokhra) is 7.18 (**Chandra K. et al. 2022**), pH value of Janjgir (Kera) is 7.16 (**Chandra K. et al. 2022**), pH value of Janjgir (Shivrinarayan) is 7.18 (**Chandra K. et al. 2022**), pH value of Janjgir (Khamhariya) is 7.24 (**Chandra K. et al. 2022**), pH value of Janjgir (Pithampura) is 7.38 (**Chandra K. et al. 2022**), pH value of Janjgir (Nawagarh) is 7.2 (**Chandra K. et al. 2022**), pH value of Balrampur is 8.7 (**Devangan S.K. et al. 2023**), pH value of Ambikapur (Kedarpur) is 6.5 (**Devangan S.K. et al. 2025**), 5-8.5 (**Koshle A. et al. 2016**), pH value of Mungeli is 6.9-7.2

2. Electrical Conductivity:

Electrical Conductivity in drinking water is a measure of its ability to conduct electricity, which is directly related to the amount of ions present. Electrical Conductivity of drinking water according to the IBS Should be less than 1000 $\mu\text{S}/\text{cm}$ (**IBS 2018**). The conductivity is significantly below the threshold, indicating low levels of dissolved ionic substances, which enhances the water's usability.

According to the review research paper Electrical conductivity of different region of Chhattisgarh is - Electrical conductivity of Bhilai is 498-618 $\mu\text{S/cm}$ (**Jena V. et al., 2012**), Electrical conductivity of Dantewada is 1000 $\mu\text{S/cm}$ (**Behra B. 2013**), Electrical conductivity of Bijapur is 995.74 $\mu\text{S/cm}$ (**Munna K et al., 2016**), Electrical conductivity of Raipur (Pandri) is 450-1200 $\mu\text{S/cm}$ (**Koshle A. et al.2016**), Electrical conductivity of Bastar is 480-1000 $\mu\text{S/cm}$ (**Kumar V et al. 2017**), Electrical conductivity of Korba is 550-1150 $\mu\text{S/cm}$ (**Das R. et al.,2018**), Electrical conductivity of Bilaspur (Takhatpur) is 697.3-755.32 $\mu\text{S/cm}$ (**Yadav R.K. et al, 2018**), Electrical conductivity of Bilaspur is 500-1100 $\mu\text{S/cm}$ (**Verma S. & Sinha K. 2019**), Electrical conductivity of Raipur (Siltara) is 450-1200 $\mu\text{S/cm}$ (**Sharma A. Gupta R. 2020**), Electrical conductivity of Durg 600-1300 $\mu\text{S/cm}$ (**Patel M. et al 2021**), Electrical conductivity of Bemetara 1808 $\mu\text{S/cm}$ (**Sharma M.K. et al. 2022**), Electrical conductivity of Surajpur 350 $\mu\text{S/cm}$ (**Devangan S.K. et al 2022**), Electrical Conductivity of Balrampur 801 $\mu\text{S/cm}$ (**Devangan S.K. 2023**), Electrical conductivity of Ambikapur (Kedarpur) 421 $\mu\text{S/cm}$ (**Devangan S.K. 2025**)

3. Turbidity:

Turbidity of Bhilai is 0.82 NTU (**Jena V. et al. 2012**), Turbidity of Mungeli (Khudia Dam) is 12.14 NTU (**Upadhyay Dr. M. 2013**), Turbidity of Risali is 3 NTU (**Jindal M.K. et al. 2014**), Turbidity of Raipur (Pandri) is 0.02 NTU (**Koshle A. et al. 2016**), Turbidity of Bilaspur (Takhatpur) is 4.6-5.3 NTU (**Yadav R.K. et al. 2018**), Turbidity of Surajpur 6.5-7 NTU (**Devangan S.K. et al. 2022**), Turbidity of Janjgir (Naila) is 0.54 NTU (**Chandra K. et al. 2022**), Janjgir (Champa) is 7.48 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Khokhra) is 1.73 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Kera) is 4.15 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Sivrinarayan) is 1.28 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Khamhariya) is 2.2 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Pithampur) is 8.33 NTU (**Chandra K. et al. 2022**), Turbidity of Janjgir (Nawagarh) is 1.95 NTU (**Chandra K. et al. 2022**), Turbidity of Balrampur is 1.7 NTU (**Devangan S.K. et al. 2023**), Turbidity of Ambikapur (Kedarpur) is 1.7 (**Devangan S.K. et al. 2025**).

4. TDS:

TDS of Bhilai is 187-345 ppm (**Jena V. et al. 2012**), TDS of Bastar (Jagdalpur) is 438 ppm (**Behra B. 2013**), TDS of Dantewada 431.2 ppm (**Behra B. 2013**), TDS of Raipur (Shankarnagar) is 364-504 ppm (**Sharma P. et al. 2013**), TDS of Risali is 1170 ppm (**Jindal M.K. et al. 2014**), TDS of Korba is 930 ppm (**Bhaskar M. et al. 2015**), TDS of Pendra is 110 ppm (**Bakshi Moh. I. et al. 2015**), TDS of Pendra (Kotmi) is 109 ppm (**Bakshi Moh. I. et al. 2015**), TDS of Bijapur is 667.1 ppm (**Munna K. et al. 2016**), TDS of Raipur (Pandri) is 1026 ppm (**Koshle A. et al. 2016**), TDS of Mungeli is 163-256 ppm (**Tiwari S.K. et al. 2016**), TDS of Korea (Manendragarh) is 175 ppm (**Tripathi I.P. 2016**), TDS of Durg is 163-256 ppm (**Sar S.K. et al. 2017**), TDS of Raipur (Tilda) is 165.34 ppm (**Sinha D. 2018**), TDS of Bilaspur (Takhatpur) is 498-500 ppm (**Yadav R.K. et al. 2018**), TDS of Rajnandgaon is 629-499 ppm (**Paithviraj N. et al. 2018**), TDS of Bastar is 254-381 ppm (**Pali J.R. et al. 2021**), TDS of Bemetara is 1157 ppm (**Sharma M.K. et al. 2022**), TDS of Surajpur is 132 ppm (**Devangan S.K. et al. 2022**), TDS of Janjgir (Naila) is 497 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Champa) is 516 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Khokhra) is 350 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Kera) is 334 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Sivrinarayan) is 289 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Khamhariya) is 320 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Pithampur) is 303 ppm (**Chandra K. et al. 2022**), TDS of Janjgir (Nawagarh) is 366 ppm (**Chandra K. et al. 2022**).

5. Total Hardness:

TH of Bastar is (Jagdalpur) is 208 ppm (**Behra B. et al. 2012**), TH of Dantewada 232.8 ppm (**Behra B. 2013**), TH of Raipur (Shankarnagar) is 100 ppm (Sharma P. et al. 2013), TH of Mungeli (Khudia Dam) is 179 ppm (**Upadhyay Dr M. 2013**), TH of Bilaspur (Seepat) is 111-166 ppm (**Shrivastva D.K. et al. 2014**), TH of Bilaspur is 143-179 ppm (**Shrivastva D.K. et al. 2014**), TH of Risali is 450 ppm (**Jindal M.K. et al. 2014**), TH of Korba is 356 ppm (**Bhaskar M. et al. 2015**), TH of Pendra is 32 ppm (**Bakshi Moh. I. et al. 2015**), TH of Bijapur is 415 ppm (**Munna K. et al. 2016**), TH of Raipur (Pandri) is 300 ppm (**Koshle A. et al. 2016**), TH of Korba (Manendragarh) is 144 ppm (**Tripathi I.P. 2016**), TH of Bastar is 160-290 ppm (**Kumar V. et al 2017**), TH of Durg is 200-270 ppm (**Sar S.K. et al. 2017**), TH of Raipur is 550 ppm (**Jena V. et al. 2017**), TH of Korba 170-320 ppm (**Das R. et al. 2018**), TH of Raipur (Tilda) is 172.3 ppm (**Sinha D. 2018**), TH of Bilaspur (Takhatpur) is 211-225 ppm (**Yadav R.K. et al. 2018**), TH of Kabirdham is 220 ppm (**Mishra R. 2018**), TH of Bilaspur is 150-300 ppm (**Verma S. & Sinha K. 2019**), TH of Raipur (Siltara) is 180-350 ppm (**Sharma A. Gupta R. 2020**), TH of Durg is 200-400 ppm (**Patel M. et al. 2021**), TH of Bastar is 100 ppm (Pali J. R. et al. 2021), TH of Bemetara is 657 ppm (**Sharma M. K. et al. 2022**), TH of Surajpur is 150 ppm (Devangan S.K. et al. 2022), TH of Janjgir (Naila) is 221 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Champa) is 283 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Khokhra) is 159.1 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Kera) is 140 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Sivrinarayan) is 137 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Khamhariya) is 149 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Pitampur) is 285 ppm (**Chandra K. et al. 2022**), TH of Janjgir (Nawagarh) is 171 ppm (**Chandra K. et al. 2022**), TH of Balrampur is 28.5 ppm (**Devangan S.K. et al. 2023**), TH of Ambikapur is 64 ppm (**Devangan S.K. et al. 2025**).

6. Ca²⁺ ion:

Ca²⁺ ions in Bastar region is 27 ppm (**Behra B. et al. 2012**), Ca²⁺ ions in Bilaspur (Seepat) is 34-39 ppm (**Shrivastava D.K. et al. 2014**), Ca²⁺ ions in Bilaspur region is 19-41.6 ppm (**Shrivastava D.K. et al. 2014**), Ca²⁺ ions in Risali is 144 ppm (**Jindal MK et al. 2014**), Ca²⁺ ions in Bijapur is 80.3 ppm (**Munna K et al. 2016**), Ca²⁺ ions in Raipur (Pandri) is 80 ppm (**Khosle A et al. 2016**), Ca²⁺ ions in Mungeli is 24-28 ppm (**Tiwari S. K. et al. 2016**), Ca²⁺ ions in Bastar is 40-75 ppm (**Kumar V. et al. 2017**), Ca²⁺ ions in Durg is 50-160 ppm (**Sar S. K. et al. 2017**), Ca²⁺ ions in Raipur (WRS) is 32.69 ppm (**Jena V. et al. 2017**), Ca²⁺ ions in Korba is 45-85 ppm (**Das R. et al. 2018**), Ca²⁺ ions in Raipur (Tilda) 43.2 ppm (**Sinha D. 2018**), Ca²⁺ ions in Bilaspur (Takhatpur) is 45-50 ppm (**Yadav R.K. et al. 2018**), Ca²⁺ ions in Rajnandgaon is 80 ppm (Pithviraj N. et al. 2018), Ca²⁺ ions in Kabirdham is 41.7 ppm (**Mishra R. 2018**), Ca²⁺ ions in Bilaspur is 35-80 ppm (**Verma S. et al. 2019**), Ca²⁺ ions in Raipur (Siltara) is 40-90 ppm (**Sharma A. Gupta R. 2020**), Ca²⁺ ions in Raigarh (Jamgaon) is 10.9 ppm (**Shah I.A. 2021**), Ca²⁺ ions in Durg 50-100 ppm (**Patel M. et al. 2021**), Ca in Bastar drinking water is 0.9 - 4.0 gram (**Pali J.R. et al. 2021**), Ca²⁺ ions in Bemetara 167 ppm (**Sharma M.K. et al. 2022**), Ca²⁺ ions in Surajpur is 30-35 ppm (**Devangan S.K. et al. 2022**), Ca²⁺ ions in Janjgir (Naila) is 64.4 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Champa) is 99 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Khokhra) is 32.7 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (kera) is 66.77 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Sivrinarayan) is 70.8 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Khamhariya) is 31.1 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Pitampur) is 106 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in Janjgir (Nawagarh) is 37.6 ppm (**Chandra K. et al. 2022**), Ca²⁺ ions in balrampur drinking water is 9.88 ppm (**Devangan S.K. et al, 2023**), Ca²⁺ ions in Ambikapur (Kedarpur) drinking water is 8 ppm (**Devangan S.K. et al. 2025**).

7. Mg^{2+} ion:

Mg^{2+} ions in Bastar (Jagdalpur) drinking water is 181 ppm (**Behra B. et al. 2012**), Mg^{2+} ions in Bilaspur (Seepat) is 18.7-42.1 ppm (**Shrivastav a D.K. et al. 2014**), Mg^{2+} ions in Bijapur 51.19 ppm (**Munna K et al. 2016**), Mg^{2+} ions in Raipur (Pandri) is 25 ppm (**Khosle A. et al 2016**), Mg^{2+} ions in Bastar is 20-50 ppm (**Kumar V. et al. 2017**), Mg^{2+} ions in Raipur is 4.42-62.47 ppm (**Jena V et al. 2018**), Mg^{2+} ions in Korba is 25-60 ppm (**Das R. et al. 2018**), Mg^{2+} ions in Raipur (Tilda) is 44.6 ppm (**Sinha D. 2018**), Mg^{2+} ions in Kabirdham is 42.1 (**Mishra R. 2018**), Mg^{2+} ions in Bilaspur is 25-55 (**Verma S. et al. 2019**), Mg^{2+} ions in Bemetara is 58 ppm (**Sharma M.K. et al. 2022**), Mg^{2+} ions in Janjgir (Naila) is 14.7 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Champa) is 8.85 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Khokhra) is 18.83 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Kera) is 15.62 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Shivrinarayan) is 22.5 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Khamhariya) is 17.2 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Pitampur) is 25.7 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Janjgir (Nawagarh) is 18.8 ppm (**Chandra K. et al. 2022**), Mg^{2+} ions in Balrampur drinking water is 0.92 ppm (**Devangan S.K. et al. 2023**).

8. Chloride:

Cl^- ions in Bhilai's drinking water is 35.74 ppm (**Jena V. et al. 2012**), Cl^- ions in Bastar (Jagadalpur) drinking water is 40 ppm (**Behra B. et al. 2012**), Cl^- ions in Dantewada's drinking water is 191.7 ppm (**Behra B. 2013**), Cl^- ions in Mungeli drinking water is 57.61 ppm (**Upadhyay Dr. M. 2013**), Cl^- ions in drinking water of Bilaspur (seepat) is 26-46 ppm (**Shrivastav D.K. et al. 2014**), Cl^- ions in drinking water of Pendra is 5.5 ppm (**Bakshi Moh. I. et al. 2015**), Cl^- ions in drinking water of Pendra (Kotmi) is 6.0 ppm (**Bakshi Moh. I. et al. 2015**), Cl^- ions in drinking water of Bijapur is 90.7 ppm (**Munna K. et al 2016**), Cl^- ions in drinking water of Raipur is 120 ppm (**Koshle A. et al. 2016**), Cl^- ions in drinking water of Korba (Manendragarh) is 4.99 ppm (**Tripathi I.P. 2016**), Cl^- ions in drinking water of Bastar is 110-240 ppm (**Kumar V. et al. 2017**), Cl^- ions in drinking water of Raipur (WRS) is 30 ppm (**Jena V. et al. 2017**), Cl^- ions in drinking water of Korba is 130-260 ppm (**Das R. et al. 2018**), Cl^- ions in drinking water of Raipur (Tilda) is 41.45 ppm (**Shinha D. 2018**), Cl^- ions in drinking water of Bilaspur (Takhatpur) is 162-170 ppm (**Yadav R.K. et al. 2018**), Cl^- ions in drinking water of Kabirdham is 39.23 ppm (**Mishra R. 2018**), Cl^- ions in drinking water of Bialspur is 120-270 ppm (**Verma S et al. 2019**), Cl^- ions in drinking water of Raipur (Siltara) is 100 ppm (**Sharma A. Gupta R. 2020**), Cl^- ions in drinking water of Bemetara is 92 ppm (**Sharma M.K. et al. 2022**), Cl^- ions in drinking water of Surajpur is 80-83 ppm (**Devangan S.K. et al 2022**), Cl^- ions in drinking water of Janjgir (Naila) is 84.6 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Champa) is 118 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Khokhra) is 62.98 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Kera) is 66.77 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Shivrinarayan) is 39.5 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Khamhariya) is 56.2 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Pitampur) is 194 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Janjgir (Nawagarh) is 57.2 ppm (**Chandra K. et al. 2022**), Cl^- ions in drinking water of Balrampur is 90 ppm (**Devangan S.K. et al. 2023**), Cl^- ions in drinking water of Ambikapur (Kedarpur) is 0.02 ppm (**Devangan S.K. et al. 2025**).

8. Fluoride:

Fluoride ions concentration in Bastar (Jagdalpur) drinking water is 0.44 ppm (**Behra B. et al. 2012**), Fluoride ions concentration in Bijapur drinking water is 1.71 ppm (**Munna K. et al. 2016**), Fluoride ion concentration in Bastar's drinking water is 0.4-1.1 ppm (**Kumar V. et al. 2017**), Fluoride ions concentration in Raipur drinking water is 0.006 (**Jena V. et al. 2017**), Fluoride ions concentration in Korba drinking water is 0.5-1.3 ppm (**Das R. et al. 2018**), Fluoride ion concentration in Bilaspur (Takhatpur) is 0.4-0.95 ppm (**Yadav R.K. et al. 2018**), Fluoride ion concentration in drinking water of Bilaspur is 0.6-1.4 ppm (**Verma S. et al. 2019**), Fluoride ion concentration in drinking water of Raipur (Siltara) is 0.5-1.2 ppm (**Sharma A. Gupta R. 2020**), Fluoride ion concentration in drinking water of Durg is 0.7-1.5 ppm (**Patel M. et al. 2021**), Fluoride ion concentration in drinking water of Bemetara is 0.45 ppm (**Sharma M.K. et al. 2022**), Fluoride ions concentration in drinking water of Surajpur is 0.5-0.6 ppm (**Devangan SK et al. 2022**), Fluoride ion concentration in drinking water of Janjgir (Naila) is 0.31 ppm, Janjgir (Champa) is 0 ppm, Janjgir (Khokhra) is 0 ppm, Janjgir (kera) is 0 ppm, Janjgir (Sivrinarayan) is 0.04 ppm, Janjgir (Khamhariya) is 0 ppm, Janjgir (Pithampur) is 0.94 ppm & Janjgir (Nawagarh) is 0 ppm (**Chandra K. et al. 2022**), Fluoride ion concentration in drinking water of Balrampur is 5 ppm (**Devangan S.K. et al. 2023**).

MATERIALS & METHODS

1. pH (IS:3025, part 11,2002)

Apparatus: pH meter, I.D. No.

DL/PHED/BSP/EQU/03, Sr.No.1525

Procedure: There are following step to determine pH of water.

I. Preparation and calibration of pH meter

- ◆ Switch on the pH meter and allow it to warm up.
- ◆ Rinse the electrode with distilled water and blot gently with tissue paper.
- ◆ Calibrate the pH meter using standard buffer solutions:
- ◆ Place the electrode in pH 7.00 buffer solution.
- ◆ Adjust the meter to read exactly pH 7.00
- ◆ Rinse the electrode, blot dry, and repeat with pH 4.01 and pH 9.18 buffers to ensure accuracy the pH range.
- ◆ Ensure calibration is stable before proceeding.

II. Measurement of Sample:

- ◆ Pour a sufficient amount of the water sample into a clean beaker.
- ◆ Rinse the electrode with distilled water and blot dry before immersing it into sample.
- ◆ Immerse the electrode in the sample. Ensure the electrode is fully submerged

and not touching the sides or bottom of the beaker.

- ◆ Wait for the pH reading to stabilize. Note the reading displayed on the pH meter.



2. Temperature

The temperature of the water sample was measured using a calibrated digital thermometer with an accuracy of -0.1 to $+0.1$ °C. Prior to measurement, the thermometer was allowed to equilibrate in the sample for a minimum of two minutes to ensure an accurate reading. All temperature readings were recorded immediately to minimize external influence and heat exchange with the environment. Measurements were conducted in a controlled setting to maintain consistency and reduce thermal fluctuations. Where necessary, the ambient room temperature was also recorded to assess any potential impact on the water sample temperature.

3. Electrical Conductivity: (ISO 7888: 1985)

Electrical conductivity is a measure of water's ability to conduct an electric current. This ability depends on the presence of dissolved ions in the water, such as salts, acids or bases. Pure water (distilled or deionized) has very low conductivity because it contains very few ions, while water with high levels of dissolved salts or minerals has high conductivity. According to the IBS Electrical Conductivity of drinking water should be less than $1000 \mu\text{S}/\text{cm}$. (IBS 2018)



Figure: 3

Factors affecting conductivity:

- ◆ **Concentration of ions:** more ions = higher conductivity
- ◆ **Temperature:** conductivity increases with temperature
- ◆ **Type of ions:** Some ions conduct electricity better than others.

Measurement of conductivity

Instrument Used: conductivity meter (EC meter)

ID No. DL/PHED/BSP/EQU/02,
Model-
Eutech Instruments Con 510

Basic Components:

1. Probs (sensor): Usually has two electrodes that go into the water sample.
2. Display units: shows the conductivity value in microsiemens per centimeter ($\mu\text{S}/\text{cm}$) or millisiemens per centimeter (mS/cm).

Steps to measure EC: (Dr.Panigrahi, S.K. & Mohanty L. 2023)

1. Calibrate the meter with a standard solution (as per manufacture's instructions).
2. Rinse the probe with distilled water and gently blot dry.
3. Dip the probs into the water sample, ensuring it's fully submerged.
4. Wait for the reading to stabilize.
5. Record the conductivity value.

2. Turbidity: (IS: 3025 part 10- 1984)

Definition: Turbidity refers to the cloudiness or haziness of water caused by suspended particles such as slit, clay, algae, organic matter, and inorganic substances (e.g. soil from erosion). it is an property indicating light scattering and absorption by these particles.

WHO states the range of **1.02 -5.02 NTU** can be used as drinking water.



Causes:

- **Natural Sources:** Soil erosion, algal blooms, sediment disruption from wildlife.
- **Human Activity:** Agriculture, deforestation, mining, construction and urban runoff.
- **Weather Events:** Heavy rainfall or storms that increase sediment runoff into water bodies.

Measurment:

- **Units :** Measured in Nephelometric Turbidity Units (NTU) using a *turbidimeter*, which quantifies light scattering. Older methods (e.g. Jackson Turbidity Units/JTU) are less common.
- **Related Parameter:** Differs from Total Suspended Solid (TSS), which measures the actual weight of particles.

Apparatus: Nephelometer Model : Thermo Scientific, **Model No.-** Eutech TN-100

Prodcedure: (IS; 3025 part 10 - 1984)

- a) **General measurment techniques:** Proper measurment techniques are important in minimizing the effects of instrument variables, as well as stray light and air bubbles. Regardless of the instruments used, the measurment will be more accurate, precise, and repeatable if close attention is paid to proper measurement technique.
- b) **Nephelometer calibration:** Follow the manufacture's operating instructions. Run at least one standard in each instrument range to be used. Make certain the naphelometer gives stable reading in all sensitivity ranges used.

- c) **Measurement of turbidity:** Gently agitate sample. Wait until air bubbles disappear and pour the sample into the cell and immerse it in an ultrasonic bath for 1 to 2 or apply vacuum degassing, causing complete bubble release. Read turbidity directly from the instrument display. (Dr.Panigrahi, S.K. & Mohanty L. 2023)

3. TDS:

Total Dissolve Solids (TDS) refers to the combined content of all inorganic and organic substances contained in a liquid that are present in a molecule, ionized, or micro-granular suspended form. These solids include salts, minerals, and metals dissolved in water and are typically expressed in milligrams per litre (mg/L) or parts per million (ppm). (U.S. [EPA], 2018).

Source of TDS:

- Natural source (rock weathering, springs)
- Agriculture runoff (fertilizers, pesticides)
- Urban runoff
- Wastewater discharges
- Industrial effluents (WHO, 2017)

Determination of TDS of water sample by TDS meter

Apparatus: ID No. DL/PHED/BSP/EQU/02, **Model-**
Eutech Instruments Con 510

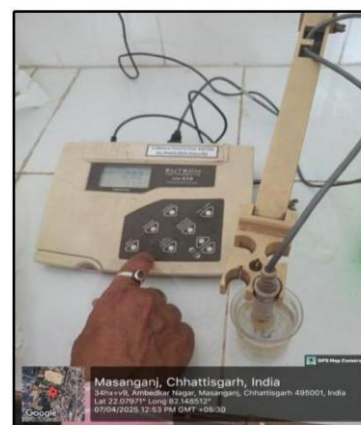


Figure: 5

Steps:

1. Calibration:

- To calibrate TDS meter dip TDS meter's electrode in 0.1KCl solution.

2. Sample Collection:

- Collect a fresh sample of the drinking water in a clean glass or beaker.
- Ensure the container is clean to avoid contamination.

3. Determination:

- Dip Electrode of TDS meter and hold it till values in TDS meter show's are stable, after note the reading. (APHA, AWWA, WEF, 23rd Edition)

4. Total Hardness:

Total hardness of water refers to the concentration of dissolved calcium and magnesium ions, which are the primary contributors to water hardness. These minerals are naturally present in water as it flows through soil and rocks, dissolving compounds like calcium carbonate and magnesium sulfate. Hard water can have significant effects on daily life, such as causing scale buildup in pipes and appliances, reducing the effectiveness of soaps and detergents, and leaving mineral deposits on surfaces. Understanding and measuring water hardness is essential for determining its suitability for various uses, including drinking, industrial processes, and household applications. By addressing water hardness, we can improve water quality and prevent potential damage to infrastructure and equipment. (IS: 3025 part 40 - 1991)

Determination of total hardness of water sample:

To determine the total hardness of water using the titration method, follow these steps:

1. **Prepare the Sample:** Take 50 mL of the water sample in a 250 mL conical flask.
2. **Add Buffer Solution:** Add 2–4 mL of ammonia buffer solution to maintain the pH around 10.
3. **Add Indicator:** Add 3–4 drops of Eriochrome Black T (EBT) indicator. The solution will turn wine red due to the presence of calcium and magnesium ions.
4. **Titrate with EDTA:** Slowly titrate the sample with 0.01N EDTA solution while stirring continuously. EDTA binds with calcium and magnesium ions.
5. **Observe the Endpoint:** The color of the solution changes from **wine red** to **blue**, indicating the endpoint of the titration. (Dr.Panigrahi, S.K. & Mohanty L. 2023)



Figure: 6

7 . Chloride:

Chloride is a naturally occurring anion found in various water source. It is commonly present in drinking water due to the dissolution of salt deposits, seawater intrusion, or as a result of human activities such as agricultural runoff and wastewater discharge. Chloride in excess imparts a salty taste to water, and people who are allergic to high chloride are subjected to laxative effects (Anitha et al.2011; Sadat-Noori et al. 2014).

Permissible Limit: According to World Health Organization (WHO), the acceptable limit of chloride in drinking water is typically around 250 mg/L. WHO recommends 2.3 grams of chloride should intake daily. (WHO, 2017)

Source: Chloride enters water supplies from both natural sources (such as rock and soils) and anthropogenic sources (such as road salts, fertilizers, and industrial effluents).

Physiological Role: Chloride is an essential electrolyte in the human body. It helps maintain fluid balance, acid-base balance, and is involved in the production of digestive juices (hydrochloric acid in the stomach).

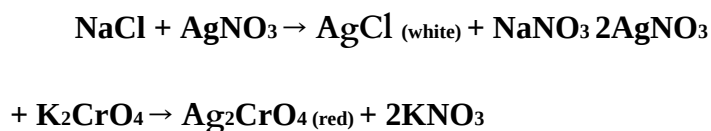
Determination of Chloride content in water sample by Mohr's Method : IS:3025 (part 32)-1988

Apparatus Required:

Burette with stand, measuring cylinder, beaker, dropper, stirrer.

Reagents: 5% Potassium chromate solution, standard AgNO_3 (0.01N) solution.

Mohr's Method: In this method, the acidity of the water is removed by adding CaCO_3 . Potassium chromate acts as an indicator for titration. Preferential precipitation of white silver chloride over red silver chromate is the principle of this method. The change of color from white to red indicates the endpoint. The reaction are;



Procedure:

1. 50 ml of the water sample is pipetted in a conical flask.
2. Two drops of potassium chromate are added to the sample.
3. The whole solution is titrated against standard silver nitrate solution from the burette with constant stirring. The red colour appearing at this stage does not persist and disappears on shaking.
4. The titration is carried out till faint red colour persists.
5. The step are repeated till three concordant reading are obtained.



Figure: 7

8 . Fluoride:

Fluoride is a naturally occurring mineral found in varying concentrations in water, soil, and food. It is known for its beneficial effects on dental health, particularly in the prevention of dental caries (tooth decay). Fluoride in drinking water is mainly due to the geogenic sources. Fluoride at low concentrations has a beneficial effects on teeth by preventing and reducing the risk of tooth decay (Arumugam 2010), whereas fluoride levels above 1.5 mg/l in drinking water can cause fluorosis (BIS, 2009).

WHO Guidelines: According to the World Health Organization (WHO), the **permissible limit for fluoride in drinking water is 1.5 mg/L (milligrams per liter)**

This guideline is intended to balance the protective effects against dental caries with the risk of adverse health effects from higher concentrations.

Determination of Fluoride content in water sample:

To determine the fluoride content in water sample use buffer solution TISAB (total ionic strength adjustment buffer) solutions are used primarily to determine the concentration of fluoride ion-selective electrodes (ISEs). (Frant & Ross, 1966; WHO, 2011)

S. NO. DL/PHED/BSP/EQU/01

Steps:

1. Sample preparation:

- Pipette out 25ml volume of water sample in a beaker.
- Add an equal volume of TISAB solution in beaker.
- Mix the sample and TISAB thoroughly using a magnetic stirrer.

2. Calibration of Electrode:

- Rinse the electrode with distilled water and blot dry.
- Immerse the fluoride ISE and reference electrode into the first standard solution.
- Record the mV reading once it stabilizes.
- Repeat with other standards.

3. Measuring the sample:

- Pipette out 25ml volume of water sample in a beaker.
- Add an equal volume of TISAB solution, (1:1) in beaker.
- Mix the sample and TISAB thoroughly using a magnetic stirrer.
- Note the value illustrate in display. (AOAC 1995 official methods of Analysis.975.08)



Figure: 8



9. Calcium:

drinking water,

Calcium is a vital mineral commonly found in contributing significantly to both water quality and human health. It plays a crucial role in the development and maintenance of strong bones and teeth, as well as in essential physiological processes such as blood clotting, muscle contraction, and nerve transmission. Drinking water serves as a supplementary source of calcium, especially in populations with limited dietary intake. Additionally, appropriate levels of calcium in water can improve its taste and reduce corrosion in water distribution systems. However, extremely high concentrations may lead to water hardness, which can impact plumbing and appliance

Figure: 9

efficiency. Maintaining balanced calcium levels in drinking water is therefore important for both public health and infrastructure sustainability. (WHO 2011)

Determination of Ca in drinking water sample: Panigrahi, Dr. S.K. & Mohanty L. (2023). *Environmental Engineering Laboratory Manual*

Apparatus Required:

1. 100 ml volumetric flask
2. 5 ml pipette

Reagents:

1. Calcium Carbonate, $\text{Ca}(\text{NO}_3)_2$
2. Sodium Chloride (NaCl)

Principle: Panigrahi, Dr. S.K. & Mohanty L. (2023). *environmental engineering Laboratory Manual*,

Determination of Calcium content in water required the principle of atomic spectroscopy, Atomic Spectroscopy is based on the Adsorption, Emission, or Fluorescence process of light by atoms or elementary ions. Information for atomic scale is obtained in two regions of the electromagnetic radiation (EMR) spectrum.

When the sample interacts with light radiation, the absorption process occurs. Ground - state electron of the sample atom tend to move to the excited states with the energy of absorbed light. This process can also be called excitation. Apart from light, heat can cause excitation. Since the excited state is unstable, electrons want to return to the ground state. When an excited electron turns back to its ground state radiation is emitted that is equal to the energy difference between excited and ground states. The emitted light is monochromatic and it has the same wavelength as the light absorbed in the excitation process. Depending on the excitation technique, absorbed or emitted light is measured. If the excitation source is flame, the emitted radiation is measured. On the other hand, absorption is measured when the lamp is used for excitation. Both are directly proportional to the number of atom in the sample.

Flame photometry or flame emission spectroscopy is an atomic emission technique. There is no need for a light source. The flame serves both as an atomizer and an excitation source. It is suitable for the qualitative and quantitative determination of several cation, especially for metals that are easily excited to higher energy levels at flame temperature. These metals are Na, K, and Ca. In this technique, first aerosols are formed from sample solution by a jet of compressed gas carries the aerosols into a flame where atomization takes place. Atomization is the conversion of sample aerosols into an atomic vapour by flame. When a sample is atomized, a substantial fraction of the metallic constituents is reduced to gaseous atoms, and also depending on the temperature of the flame a certain fraction of these atoms are ionized. Then, electron of the formed atoms are excited to the upper state. Light is emitted at characteristic wavelengths for each metal as the electron returns to the ground state.

A flame is formed by two components: fuel and oxidant. The Temperature of the flame changes depending on the fuel and oxidant types and their proportions. In flame photometers generally, natural gas is used as fuel and air is the oxidant.

Procedure: Panigrahi, Dr. S.K. & Mohanty L. (2023). *environmental engineering Laboratory Manual*.

Flame Photometric Determination of Calcium in Drinking Water Sample;

1. Prepare 100 ml of 1000 mg/L Ca stock solution from $\text{Ca}(\text{NO}_3)_2$.
2. Prepare 100 ml of 10, 20, 30, 40, and 50 mg/L standard Ca solution from 1000 mg/L Ca stock solution.
3. Select Ca as the analyte from the instrument.
4. Adjust the fuel/ oxidant ratio and burner position by aspirating 30 mg/L standards Ca solution.
5. Measure the emission intensities of all standard Ca solutions (including the blank solution) and sample solution after necessary dilutions.
6. Make 10 replicate measurements of 10 mg/L Ca standard solution to calculate the limit of detection (LOD).

10. Magnesium

To determine Magnesium content in water as per IS: 3025 (part 46): 1994.

This standard prescribes three methods for the determination of magnesium:

- a) Gravimetric method as magnesium pyrophosphate
- b) Volumetric method using EDTA**
- c) Atomic absorption spectrophotometric method.

We use for the determination of Mg content in water sample titration method as, **Volumetric Method Using EDTA:**

Apparatus Required: Hot plate

Reagents :

1. Indicator solutions
 - a) Potton and reeder and indicator solution -
 - b) Murexide (Ammonium Purpurate) indicator solution
 - c) Erichrome black T indicator (EBT indicator)
2. Standard zinc solution, 0.01 M
3. Buffer solution
 - a) Dissolve 70 g of ammonium chloride and 570 ml of 30% ammonium solution (relative density 0.88 to 0.90) in water and makeup to 1 litre.
 - b) Sodium hydroxide 1 N- Dissolve 40 g of sodium hydroxide and dilute to 1 litre with distilled water.
4. Standard EDTA solution 0.001M
5. Triethanolamine solution 10% (m/v)
6. Potassium cyanide solution 10% (m/v)
7. Hydroxylamine hydrochloride solution 10% (m/v)
8. Inhibitor and complexing agents
9. Pre- treatment of polluted water

Theory:

When a water sample containing both calcium and magnesium is titrated with EDTA at pH 10, using EBT as an indicator, which estimates values of calcium and magnesium. In a separate titration against EDTA at pH 12 to 13 range using murexide or Patton and Reeder's indicator, calcium is selectively estimated. From these two values, magnesium content may be calculated. Below 1 mg/L concentration, it is desirable to use atomic absorption spectrophotometric method. (APHA 2017)

Procedure:

- Take a suitable aliquot of the solution, expected to contain approximately 10 to 30 mg of calcium and magnesium in a 500 ml conical flask.
- Add 10 ml of hydroxylamine hydrochloride solution, 2 ml of potassium cyanide solution, and 25 ml of triethanolamine solution.
- Dilute to 150-200 ml and add a sufficient amount of buffer solution to bring the pH to 10 to 0.1
- Add 3 to 4 drop of EBT indicator solution and titrate with 0.01 M EDTA solution till the red colour changes to pure blue endpoint free from violet tinge.
- It is easier to note the endpoint by comparing the colour with that of a previously titrated solution having a pure blue endpoint, where a slight excess of EDTA solution has been added.

11. Alkalinity: (IS 3025 part-23) - 1986

Material Required :

- ◆ Water sample
- ◆ Standard 0.02 N sulfuric acid (H_2SO_4).
- ◆ Phenolphthalein indicator
- ◆ Methyl orange or mixed indicator (bromocresol green-methyl red)
- ◆ Burette, pipette, conical flask, and beaker
- ◆ Distilled water.

Theory: The alkalinity of water is a measure of how acid it can neutralize. When a water sample that has a pH of greater than 4.5 is titrated with acid to a pH 4.5 endpoint, all OH^- , CO_3^{2-} and HCO_3^- will be neutralized. For pH more than 8.3, add phenolphthalein indicator, and the color changes to pink color. This pink color is due to the presence of hydroxyl ions. If sulphuric acid is added to it, the pink color disappears i.e. OH^- ions are neutralized. Then add a mixed indicator, and the blue color appears. While adding acid, the color changes to orange and this color change indicates that all the CO_3 and HCO_3 have been neutralized. This is the endpoint.

Total Alkalinity: Total alkalinity is the total concentration of bases in water expressed as parts per million (ppm) or milligrams per liter (mg/L) of calcium carbonate (CaCO_3). These bases are usually bicarbonates (HCO_3) and carbonates (CO_3), and they act as a buffer system that prevents drastic changes in pH. For example, in water with low alkalinity, pH might fluctuate

from 6 or lower to as high as 10 or above; while in high alkalinity waters, pH might fluctuate from about 7.5 to 8.5. Total alkalinity is not the same as hardness. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are primarily responsible for hardness. However, in most waters, alkalinity and hardness have similar value because the carbonates and bicarbonates responsible for total alkalinity is usually brought into the water in the form of calcium carbonate or magnesium carbonate. Water with high total alkalinity are not always hard, since the carbonates can be brought into the water in the form of sodium or potassium carbonate.

Procedure: Preparation of Reagents

- 1. Std. 0.01 N H_2SO_4 Solution:** Dilute 2.8 ml of concentrated H_2SO_4 to 1 liter with distilled water. Dilute 100 ml of this solution to again 1 liter for getting 0.01 N H_2SO_4 . Standardize with 0.01 N Na_2CO_3 using methyl orange as an indicator.
- 2. Std. 0.02 N AgNO_3 solution:** 3.40 g of AgNO_3 is dissolved in double distilled water and make up to 1 liter. This is to be standardized against the standard NaCl or KCl solution and stored in the amber- colored bottle away from light.
- 3. Phenolphthalein indicator:** 0.25% solution in 60% ethyl alcohol.
- 4. Methyl orange indicator:** 0.1% solution in distilled water.
- 5. Mixed Indicator:** Dissolve 100 mg bromocresol green and 20 mg methyl red in 100 ml 95% ethyl alcohol or 100 ml of distilled water.

Testing of water sample:

1. Rinse the burette with 0.02 N Sulphuric acid and discard the solution.
2. Fill the burette with 0.02 N sulphuric acid and adjust it to zero.
3. Pipette out 10 ml of sample and pour it into 250 ml of the conical flask.
4. Add a few drops of phenolphthalein indicator to the contents of the conical flask. The color of **the solution will turn pink**. This color change is due to the alkalinity of hydroxyl ions in the water sample.
5. Titrate it against 0.02 N sulphuric acid till the pink color disappears. This indicates that all the hydroxyl ions are removed from the water sample.
6. Note down the titter value. The value is used in calculating phenolphthalein alkalinity.
7. To the same solution in the conical flask add a few drops of mixed indicator.
8. The color of the solution turns blue. This color change is due to CO_3^{2-} & HCO_3^- ions in a water sample.
9. Continue the titration from the point where stopped for the phenolphthalein alkalinity.
10. Titrate till **the solution becomes red**. The entire evolution of sulphuric acid is noted down and it is accountable for calculating the total alkalinity. (IS 3025 part- 23-1986)



Figure: 10



Figure: 11

RESULT AND DISCUSSION

Location 1- Bilaspur, Chhattisgarh, India.

Bilaspur district is located in the central part of Chhattisgarh state, India, lying between **latitude 21°47' to 23°8' North** and **longitude 81°14' to 83°15' East**. It is situated on the fertile plains of the **Arpa River**, a tributary of the Seonath River, which greatly influences the district's agriculture and landscape.

Bilaspur is also headquarter of **South Eastern Coalfields Limited**. Chhattisgarh's second largest **power plant of NTPC is in Seepat**. Powergrid Seepat pools electricity from other power plant in region and transmits electricity to Delhi via one of longest HVDC line.

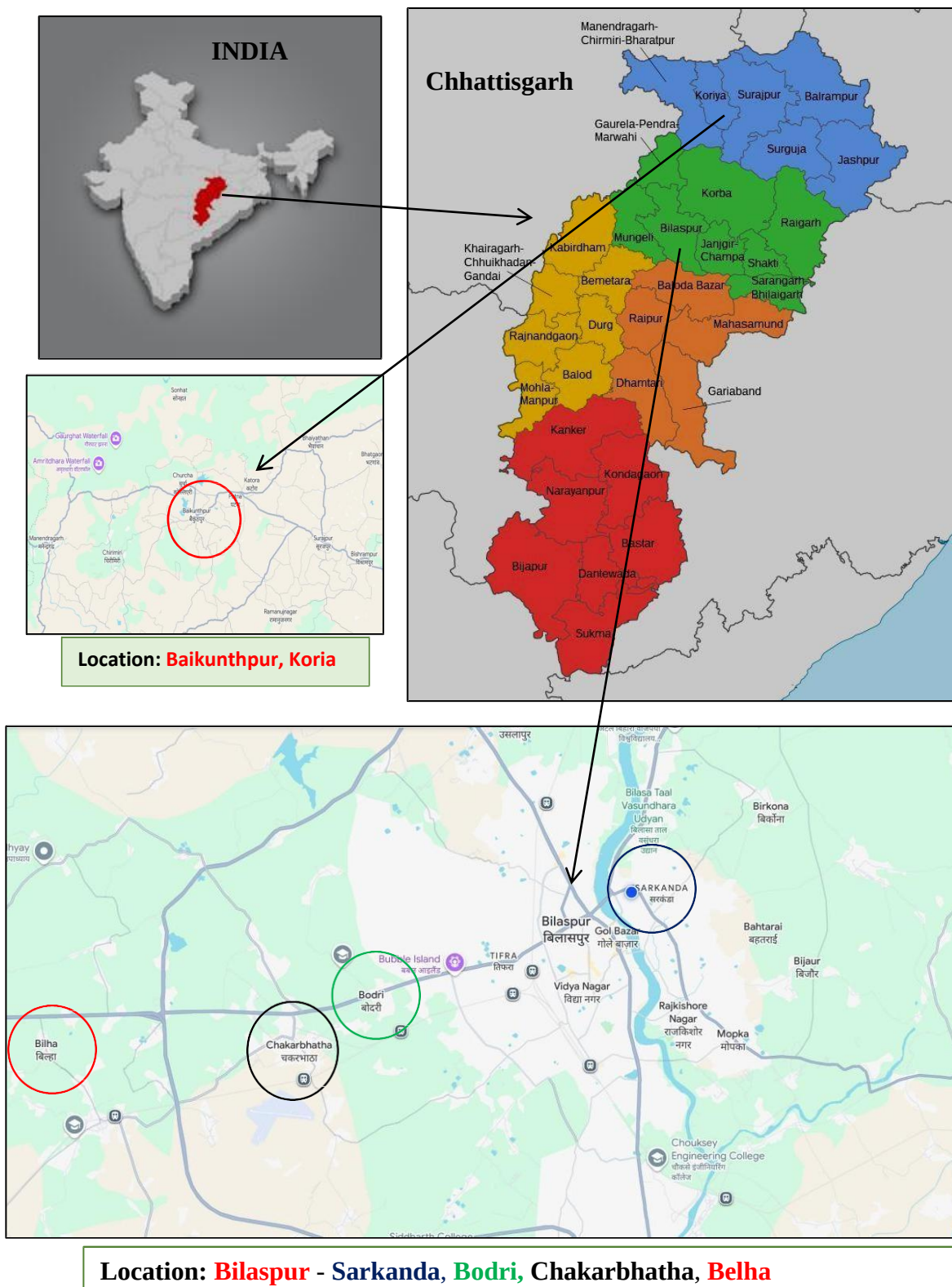
Industries- Around Bilaspur, there are many industrial areas, including Tifra, Sirgitti and Silpahri Industrial Growth Centres. Sirgitti, Silpahri and Tifra around Bilapur are major industrial areas near Bilaspur. Located on the outskirts of Bilaspur city Sirgitti Industrial Centre is spread over an area of approx. 338 hectares. With about 324 industries it provides direct employment to 4431 persons. Silpahari Industrial Centre is another industrial area near Bilaspur and is home to many sponge iron industries. Tifra Industrial Area situated on the outskirts of Bilaspur city is spread over an area of approx. 65 hectares. Many chemical, PVC footwear, HDPE woven sacks, polythene bags and sheets, soft drinks and other units are located here. CSIDC or Chhattisgarh State Industrial Development Corporation Limited is responsible for the development of maintenance of all these industrial areas in and around Bilaspur. Chhattisgarh Laghu Evam Sahayak Udyog Sangh or CLSUS is an association of industries which represents all major industries of Bilaspur and Chhattisgarh. BEC Fertilizers - a unit of Bhilai Engineering Corporation is situated in the Sirgitti Industrial Area.

Power plants – Bilaspur has India's second largest power plant of NTPC at Sipat which generates power of 2980 MW with 3 units of 660 MW each and 1 unit of 1000 MW. Many thermal power plants are coming up in the surrounding area of Bilaspur. Also notable are Nova, KSK, Gitanjali, Mahanadi etc.

Location 2- Baikunthpur, Korla, Chhattisgarh, India.

is a small town and the administrative headquarters of **Koriya district** in the northern part of **Chhattisgarh**, India. It lies close to the borders of Madhya Pradesh and is part of the Chhattisgarh plateau region. Baikunthpur is situated at an elevation of approximately **529 meters (1,736 feet)** above sea level, giving it a relatively moderate climate compared to the low-lying plains of the state. The town is surrounded by lush forests, rolling hills, and a network of small rivers and streams, notably influenced by the **Hasdeo River**, an important tributary of the Mahanadi River system. The region is rich in mineral resources, particularly coal, with the **South Eastern Coalfields Limited (SECL)** operating in and around Baikunthpur, contributing significantly to the local economy.

Area of Sample Collection

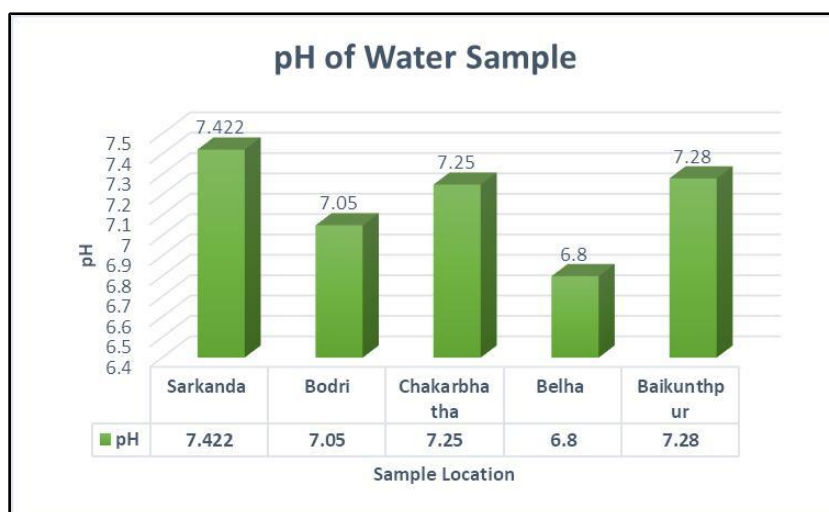


S.N o.	Parameters	WHO standard	As per IS-10500-2012 drinking water		Sample Location				
			Desirable limit	Permissible limit	Bilaspur				Koria
					S-1	S-2	S-3	S-4	S-5
					Sarkanda	LCIT College, Bodri	Chakrabhat ha	Belha	Baikunthpu r
01	Temp. °C	12-25	-	-	32.6	27.7	30.8	30.8	31.5
02	pH	6.5-8.5	6.5-8.5	6.5-8.5	7.422	7.05	7.25	6.8	7.28
03	Turbidity (NTU)	1.02-5.02	1	5	0.05	0.07	0.047	0.069	1.4
04	EC µS/cm	0-800	-	-	949	720.2	755.1	727.0	348.2
05	TDS ppm	<300	500	1200	523.4	379.6	382.7	664.4	236.2
06	TH ppm	10-500	200	600	381.52	360.5	291.16	445.7	80.48
07	Ca ²⁺	75-150	75	200	200.8	218.4	183.7	228.45	35.9
08	Mg ²⁺	10-30	30	100	180.72	141.3	107.96	200.8	38.12
09	Cl ⁻	250-1000	250	1000	126.36	68.6	63.828	157.7	8.865
10	F ⁻	0.7-1.0	1	1.5	0.043	0.72	0.085	0.078	0.021
11	Alkalinity	30-500	200	600	401.88	386.7	425.66	520.89	189.4

Table : Experimental Data

Discussion:

1. pH : According to the WHO guideline the pH range of drinking water should be 6.5 - 8.5, All the water sample (S-1, S-2, S-3, S-4, and S-5) that's pH respectively 7.422, 7.05, 7.25, 6.8, & 7.28 is measured at optimum temperature was found to safe for drinking and lies in the range of WHO Standard.



if $\text{pH} < 6.5$ then its acidic nature that make cause of health issues as follows,

I. Metal Contamination:

Low pH water is more acidic and can corrode pipes, causing metals like lead, copper, and iron to dissolve into the water, which can be toxic if consumed over time. (U.S. Environmental Protection Agency [EPA], 2012).

II. Health Issues:

- **Stomach irritation:** Acidic water can upset your stomach or cause mild **gastrointestinal** issues if consumed regularly.
- **Teeth problems:** Over the time, acidic water may weaken tooth enamel.
- **Long term exposure:** If heavy metals like lead get into the water, they can cause serious heart problems like kidney damage, developmental issues in children, and high blood pressure.
- **Skin irritation:** Bathing or washing with very acidic water can cause dryness or irritation on sensitive skin. (EPA, 2012)

If $\text{pH} > 8.5$ can also create health issues that are,

I. Digestive issues: Drinking very alkaline water (pH much higher than 8.5) can sometimes cause nausea, vomiting, or stomach discomfort, especially for people not used to it. (Heathline, 2020)

II. Skin problems: Breathing or showing in hing pH water may cause dry, itchy skin irritation for some people. (Heathline, 2020)

III. Mineral imbalance: Over time, consuming very alkaline water could disturb the body's natural pH balance, leading to metabolic alkalosis- a condition where the body's fluids become too alkaline. (Heathline, 2020)

Symptoms of metabolic alkalosis include:

- Muscle twitching or cramps
- Hand tremors
- Confusion
- Nausea
- In severe cases, it can affect heart and lung funtion.

IV. Reduced nutrient absorption: Avery high pH in water might interfere with the body's ability to absorb certain nutrients (like calcium and magnesium) properly.

2. Turbidity:

Turbidity of taken water sample is found to be safe for drinking purpose and according to the WHO range of drinking water is 1.02 -5.02 NTU. The S-1, S-2, S-3, S-4, & S-5 has 0.05, 0.07, 0.047, 0.069. 1.4 NTU respectively. All location water are safe for drinking. When turbidity is high in drinking water, it usually means there are a lot of suspended particles - like dirt, clay, silt, organic matter, and even microorganisms - floating around in it. (U.S. Environmental Protection Agency [EPA], 2022) This can cause several problems:

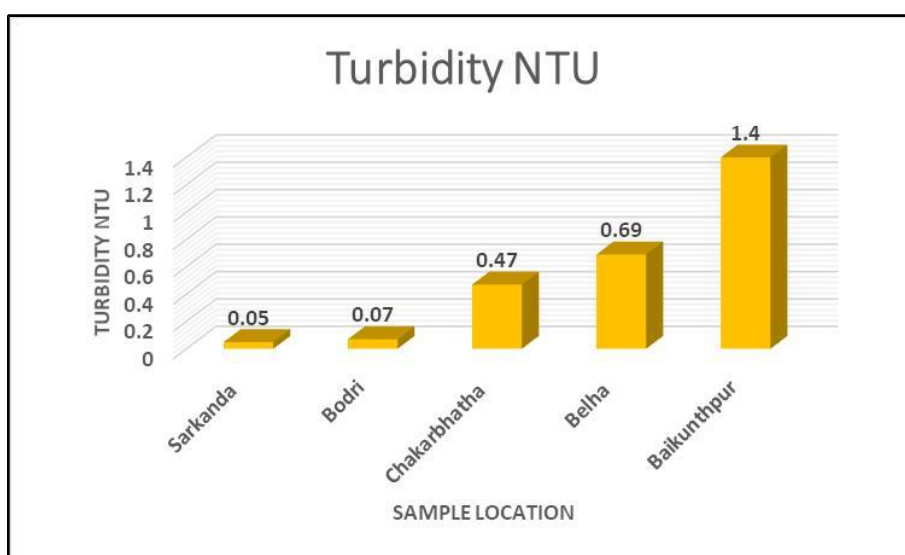
Health risks: High turbidity can protect harmful bacteria, viruses, and parasites from disinfection (like chlorine treatment), making people more likely to get sick from waterborne diseases (such as **giardia or cryptosporidium infections**). (Cotruvo et al., 2004)

Poor appearance and taste: Water can look cloudy, dirty, or colored, and might even taste or smell bad, making it unappealing to drink.

Disinfection challenges: Cloudy water can make it harder for disinfectants (like chlorine or UV light) to reach and kill pathogens. (Montgomery, 1985)

Pipe and system issues: Turbidity can clog pipes, filters, and other parts of water treatment and distribution systems, making maintenance more difficult and expensive. (Spellman, 2013)

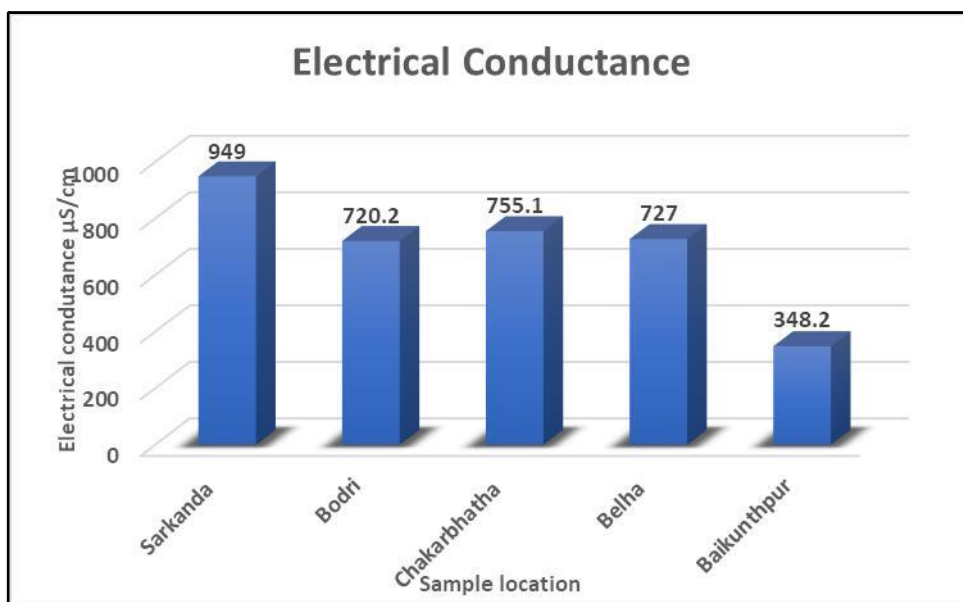
High turbidity is often a sign that water needs better filtration or more treatment before it's safe to drink.



3. Electrical Conductance:

Electrical conductance (or conductivity) of drinking water measures its ability to carry an electrical current, which depends largely on the presence of dissolved ions like salts, minerals, and metals. It is typically expressed in microsiemens per centimeter ($\mu\text{S}/\text{cm}$). (Sawyer, McCarty, & Parkin, 2003)

The taken water sample S-1, S-2, S-3, S-4, & S-5 has respective electrical conductance is 949, 720.2, 755.1, 727.0, & 348.2 and all sample water was found to be safe for drinking purposes.



According to the **World Health Organization (WHO)** guidelines, electrical conductivity itself is **not a direct health concern** but serves as an important indicator of water quality. A high conductivity value usually signals elevated concentrations of dissolved substances, which could point to contamination from natural sources or human activities (such as sewage, agricultural runoff, or industrial waste).(WHO,2017)

The WHO does **not prescribe a strict limit** for electrical conductivity in drinking water. However, it recommends that drinking water typically should have a conductivity of **less than 400–600 $\mu\text{S/cm}$** for it to be considered acceptable for taste and general use. Water with very high conductivity may taste salty, be corrosive to pipes, and affect the performance of household appliances. (WHO,2017)

If conductivity is high, a detailed chemical analysis is advised to identify specific contaminants like sodium, chloride, nitrate, or heavy metals, some of which may have health risks. (Tchobanoglous, Burton, & Stensel, 2003)

4. Total Dissolve Solides:

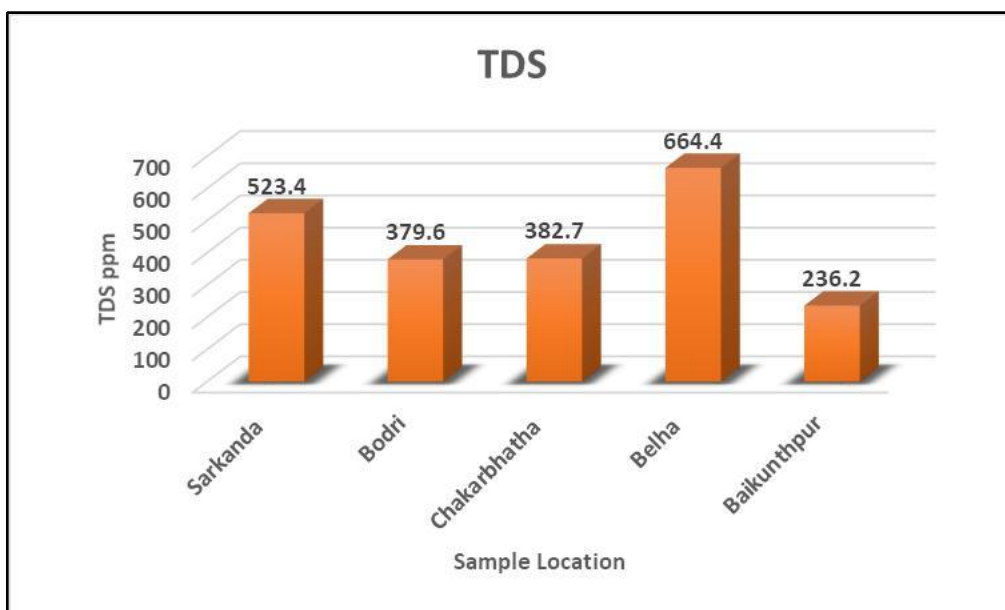
Total Dissolved Solids (TDS) refer to the combined content of all inorganic and organic substances dissolved in water. These substances include minerals, salts, and metals. (Viessman & Hammer, 2009)

WHO Standard Range:

The World Health Organization (WHO) does not set a strict health-based guideline for TDS, as TDS itself is not generally considered a direct health hazard. However, WHO suggests the following for the acceptability of drinking water based on taste and palatability: (WHO, 2017)

TDS less than 300 mg/L	Excellent
TDS between 300–600 mg/L	Good
TDS between 600–900 mg/L	Fair
TDS between 900–1200 mg/L	Poor
TDS greater than 1200 mg/L	Unacceptable

S.No.	Sample Location	TDS (mg/L)	Category
01	Sarkanda Bilaspur	523.4	Good
02	LCIT College, Bodri	379.6	Good
03	Chakarbhatha, Bilaspur	382.7	Good
04	Belha, Bilaspur	664.4	Fair
05	Baikunthpur, Korla	236.2	Excellent



What Happens When TDS is High in Drinking Water: (WHO, 2017)

Taste and Palatability: Water may taste salty, bitter, or metallic.

Scaling and Deposits: High TDS can cause scale buildup in pipes, boilers, and household appliances.

Aesthetic Issues: Water may appear cloudy or leave a residue on surfaces.

Health Issues Related to High TDS:

Digestive Problems: High levels of certain minerals like sodium, sulfate, or magnesium can cause gastrointestinal irritation or diarrhea.

Kidney Stress: Consistently consuming water with excessive mineral content may stress the kidneys, especially in individuals with pre-existing kidney problems.

Other Risks: If the TDS is high due to harmful contaminants like arsenic, nitrate, or lead, there could be serious health risks including toxicity, cancer, and neurological damage.

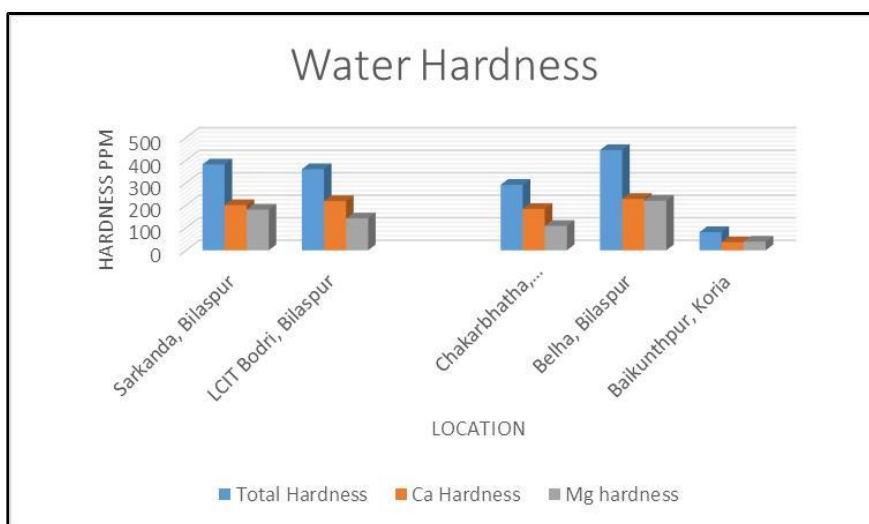
According to the WHO range the selected area's drinking water is found to be safe for drinking purpose.

Total Hardness: Total hardness refers to the concentration of divalent metal ions, primarily calcium (Ca^{2+}) and magnesium (Mg^{2+}), in water. It is usually expressed in milligrams per liter (mg/L) as calcium carbonate (CaCO_3). Hardness in water is mainly caused by the presence of dissolved calcium and magnesium salts, such as bicarbonates, chlorides, and sulfates. (Sawyer, McCarty, & Parkin, 2003)

The World Health Organization (WHO) suggests that the acceptable range for total hardness in drinking water should be between **80 to 100 mg/L**, but it can be tolerated up to **500 mg/L** depending on taste and other local factors. (WHO, 2017)

Total hardness of water sample (S-1, S-2, S-3, S-4, & S-5) is respectively 381.52 ppm, 247.2 ppm, 291.16 ppm, 445.7 ppm, & 80.48 ppm.

S.No.	Sample Location	TH mg/L	Ca Hardness	Mg Hardness	Category
01	Sarkanda, Bilaspur	381.52	200.8	180.72	Fair
02	LCIT Bodri, Bilaspur	360.5	218.4	141.3	Good
03	Chakarbhatha, Bilaspur	291.16	183.7	107.96	Good
04	Belha, Bilaspur	445.7	228.45	220.8	Fair
05	Baikunthpur, Korla	80.48	35.9	38.12	Excellent



If Total hardness is less in water contain means low concentration of Ca^{2+} and Mg^{2+} . According to the experimental result the best water for drinking that contain enough amount of Ca^{2+} and Mg^{2+} is Baikunthpur water that's Total Hardness is 80.48 ppm.

For example: When you boil water and notice white, chalky deposits inside your kettle - that's because of total hardness.

These white deposits are mainly **calcium carbonate** and **magnesium carbonate** that come from the calcium and magnesium ions dissolved in "hard" water. The **total hardness** measures how much of these minerals are present. The harder the water, the more scaling and buildup you'll see on kettles, pipes, and bathroom fixtures.(Linsley, Kohler, & Paulhus, 1982)

Other everyday examples include:

- Soap not lathering easily with hard water.
- Needing more detergent to wash clothes.
- Cloudy spots on glassware after dishwashing.

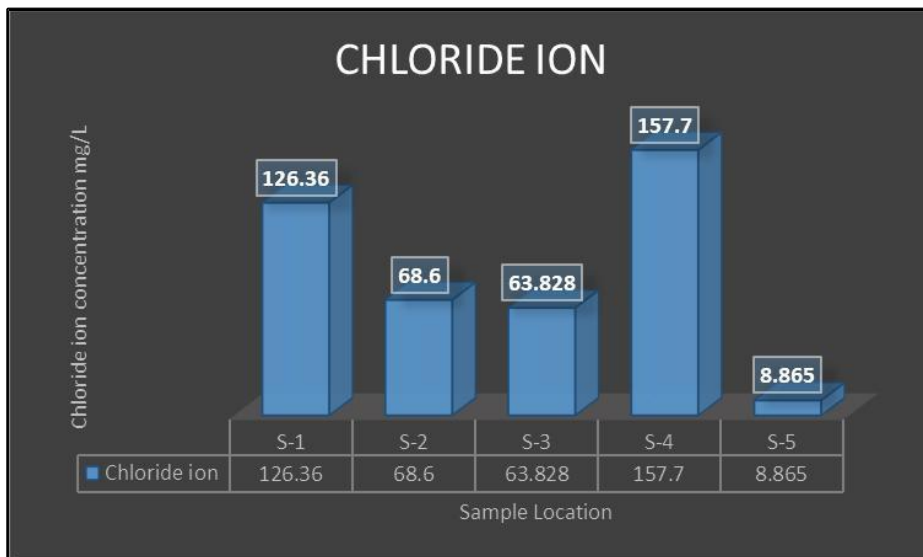
Results coordinates with the evidence that - **Baikunthpur** water does not leave any white cast after boil water and low amount of detergent make high amount of foam. On the other hand bilaspur total hardness is high so need more detergent to wash cloths and leave white cast on boiling water. Its prove that Bilaspur has high amount of calcium and magnesium. **Sarkanda, Bodri, Chakarbhatha** and **Belha**, has high amount of calcuim and magnesium and also coordinate with the public statement that water is leave white cast after boiling and also leave white cast after washing cloths and dishwashing.

Chloride & Fluoride : Chloride and Fluoride Content in Drinking Water Sample

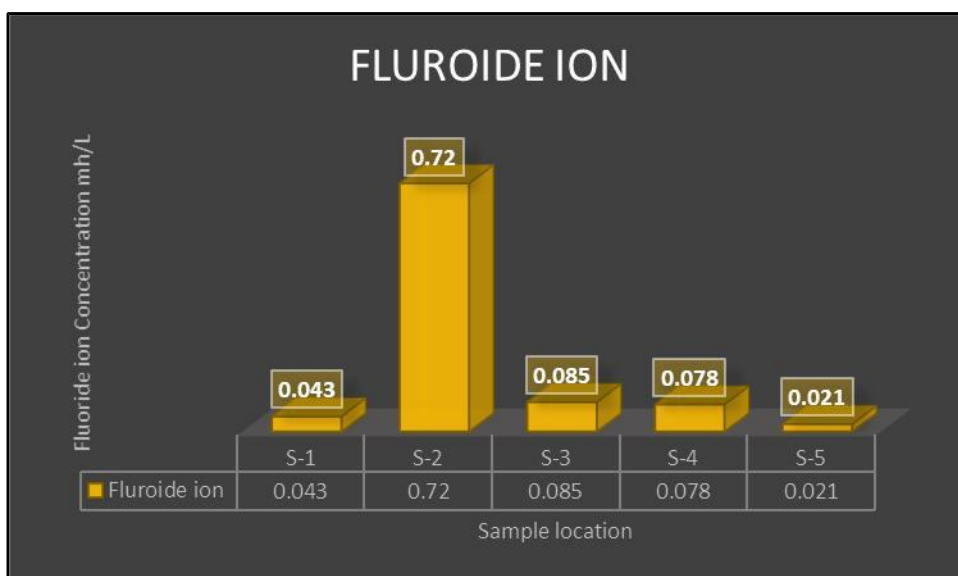
S.No.	Sample Location	Cl ⁻ mg/L	F ⁻ mg/L
		WHO Stand. 250-1000 mg/L	WHO stand. 0.7-1.0 mg/L
01	S-1, Sarkanda, Bilaspur	126.36	0.043
02	S-2, LCIT College, Bodri, Bilaspur	68.6	0.72
03	S-3, Chakarbhatha, Bilaspur	63.828	0.085
04	S-4, Belha, Bilaspur	157.7	0.078
05	S-5, Baikunthapur, Korla	8.865	0.021

The concentrations of chloride (Cl⁻) and fluoride (F⁻) ions in the collected drinking water sample were determined using standard laboratory methods. Chloride content was analyzed using the argentometric titration method, while fluoride content was determined using a fluoride ion-selective electrode.

The chloride concentration was found to be for S-1, S-2, S-3, S-4, and S-5 is 126.36, 68.6, 63.828, 157.7, and 8.865 mg/L respectively, which is well below the World Health Organization (WHO) permissible limit of 250 mg/L for safe drinking water. And the best water for drinking is Baikunthpur water which has lowest Chloride ion present is 8.865 mg/L. This indicates that the water sample does not pose any risk of high salinity or taste alteration due to chloride.



The fluoride concentration was found to be for S-1, S-2, S-3, S-4, and S-5 is 0.043, 0.72, 0.085, 0.078, and 0.021 mg/L, also within the acceptable range defined by WHO (1.5 mg/L). This level of fluoride is considered safe and may even contribute positively to dental health without posing risks of fluorosis.



These findings suggest that the drinking water sample analyzed is within safe limits for both chloride and fluoride content and suitable for human consumption.

Conclusion:

The study of the physico-chemical parameters of drinking water in Bilaspur and Korba districts of Chhattisgarh highlights the significance of maintaining water quality for public health. The analysis revealed varying levels of key parameters such as pH, turbidity, total dissolved solids (TDS), hardness, and concentration of essential minerals like calcium, magnesium, and chloride. While most of the samples met the permissible standards for drinking water as per national and international guidelines, a few samples from specific regions showed deviations, as per the result **Bilaspur** has high TDS and high Total Hardness, (specially Belha region) in comparison of **Korba** district. These variations suggest the need for regular monitoring, improved water treatment facilities, and community awareness to prevent waterborne diseases.

It is crucial to address areas with elevated pollutant levels to ensure safe drinking water for the local populations. This study underscores the importance of proactive measures such as water purification, proper sanitation, and governmental interventions to ensure the sustainability of clean drinking water in these districts. Further research and continued monitoring are recommended to ensure the safety and health of the residents in both Bilaspur and Korba districts.

References:

1. Brown, T. L., LeMay, H. E., Bursten, B. E., Murphy, C. J., & Woodward, P. M. (2020). *Chemistry: The central science* (14th ed.). Pearson.
2. United States Geological Survey. (2022). *Groundwater: A vital resource*. <https://www.usgs.gov/special-topics/water-science-school/science/groundwater>
3. World Health Organization. (2017). *Guidelines for drinking-water quality* (4th ed.). <https://www.who.int/publications/i/item/9789241549950>
4. Patil P.N., Sawant D.V., Deshmukh R.N. "Physico-Chemical Parameters for Testing of Water" *Rasayan J. Chem.*, (2012) vol. 5, page no. 4
5. Patil P.N., Sawant D.V., Deshmukh R.N. "Physico-Chemical Parameters for Testing of Water" *International journal of environmental science* (2012), vol. 13, No. 3
6. Jena V. Dixit S. and Gupta S. "Physico Chemical parameters assesment of ground water in different sites of Bhilai city, Chhattisgarh" *Rasayan J. chem.* (2012) vol.5 no.4
7. Sharma P., Dubey A. "physico chemical Analysis of Surface and ground water of Abhanpur Block in Raipur District, Chhattisgarh , india," *IJITEE*(2013) Vol. 2, issue 5
8. Shrivastava D.K., Yadav S., Chandra T.P., "Evaluation of physico- chemical quality of drinking water in bilaspur district of chhattisgarh state" *IJSR* (2012) vol. 3, page no. 358
9. Upadhyay Dr. Manish, Gupta V.L. "Analysis of water quality using physio-chemical parameter of khudia dam in mungeli, district chhattisgarh" *IOSR Journal of engineering* (2013), Vol. 3, issue 1
10. Khosle. A, et al. "study of physico-chemical characteristics of surface and ground water in raipur region of Chhattisgarh (India)," *IJSR* (2013)
11. Shrivastava D.K., Yadav S., Chandra T.P., Evaluation of physico- chemical Quality of Drinking Water in Bilaspur District of Chhattisgarh State, *International Journal of Science and Research (IJSR)*, 2014, 3(6), 1267-1271
12. Jindal M.K., Deshmukh P., Tamrakar R., Testing Analysis of Drinking Water Quality of Underground Water located near Rural area of Risali Chhattisgarh, India, *International Research Journal of Environment Sciences*, 2014, 3(5), 44-47
13. Bhaskar M., Dixit A.K., Water Quality Appraisal of Hasdeo River at Korba in Chhattisgarh, India, *International Journal of Science and Research (IJSR)*, 2015, 4(9), 1251-1258.

14. Ghosh N.C., Singh R.P., Sonkusare M.M., Singh S., Mittal S., Assessment of Water Quality of 31Lakes for Drinking and Irrigation purpose in Raipur City, Chhattisgarh, India, *Journal of Engineering Research and Applications*, 2015, 5(2), 42-49
15. Tiwari S.K., Dahare R., Patel H., Sahu N., Sinha B.L., Pandey V.K., Study on parameterization and water Quality Analysis of village ponds in Mungeli District, Chhattisgarh, *E M International*, 2016, 35(2), 95-103.
16. Sattari M.T., Joudi A.R., Kusiak A., Estimation of Water Quality parameter with *Data-Driven Model American Water Works Association*, 2016, 232-239
17. Sar S.K., Sahu M., Singh S., Diwan V., Jindal M., Arora A., Assessment of Uranium in ground water from Durg District of Chhattisgarh State and its correlation with other quality parameters, *J Radioanal Nucl Chem*, 2017
18. Singh S., Pasupuleti S., Singh S., Villuri V.G.K., An Integrated approach for Evaluation of Ground Water Quality in Korba District, Chhattisgarh, using Geometric Techniques *Journal of Environmental Biology*, 2017, 38, 865-872.
19. M.F. Alam, N.C. Dafader, S. Sultana, N. Rahma and T. Taheri, “physico-chemical parameter of drinking water” *JMES*, (2017) vol. 8, issue 6, page no 2076-2083
20. Sinha D. “Physico- Chemical Analysis of Drinking water quality of Bemetara town of Chhattisgarh state” *IJRAR* (2018), Vol. 5, issue 3
21. Yadav R.K., Augur M.R., post monsoon season selected physico- chemical parameters & Trace metals for Testing of Ground Water of Takhatpur Area, Bilaspur, Chhattisgarh, India, *International Research Journal of Natural and Applied Sciences*, 2018, 5(2), 6-69.
22. Deshmukh S.S. “physicochemical analysis of water quality parameter: A review” *JETIR* ,(June 2019), vol. 6 issue 6
23. Rahman M. “A critical review of the Physico- Chemical Analysis of Drinking water *IJFMR* (July 2019), Vol. 1, issue 1.
24. Devangan R., et al. “assesment of ground water quality in Durg district of Chhattisgarh state, India (2020)
25. Prithviraj N., Tripathi J.K., Panda S., Barik K.K., Quality Assessment of ground water in the western parts of Chhattisgarh (Rajnandgaon District), *India, Centurion University of Technology and Management (CUTM)*, 2020, 40(1), 97-103.
26. Pali J.R., Chandrakar T., Aradhna A., Sharma G.K., Signh D.P., Sahu P., Sahu D., Dapak M., Siddiqui D.A., Assessment of seasonal variation in Irrigation Water Quality of Indravati River in Bastar District of Chhattisgarh, *International Journal of current Microbiology and Applied Sciences*, 2021, 10(2), 757-762.
27. Gadekar D.J., Sonkar S. “The study of physio-chemical characteristics of drinking water: A case study of Nimgaon Jali village,” *international advanced research journal in science, engineering and technology*, june (2021) vol. 8, issue 1
28. Ahmed S.I., Sonkar A.K., Kishore N., Jhariya D., evaluation of Ground Water Quality in Jampali Coal Mine, Raigarh, Chhattisgarh. India, *Environmental Quality Management*, 2021, 31(3), 9-17
29. M.K. Sharma et al. “Assesment of ground water quality and its controlling processes in Bemetara District of Chhattisgarh state”, *India Applied water science* (2022), vol. 12, page no. 102.
30. Dewanagan S.K., Minj N., Namrata, Nayak N., physico-chemical Analysis of Water taken from Well Located in Morbhanj Village, Surajpur District, Chhattisgarh, India, *International Journal of Research Publication and Reviews*, 2022, 3(12), 696-698
31. Tiwari N., Yadav R.K., Hydro-Chemical Analysis of Ground Water of Korba, Chhattisgarh India, *Bulletin of Environment, Pharmacology and Life Sciences*, 2022, 12(1), 78-90.
32. Dewanagan S.K., et al. “Physico-chemical properties of water in Budha Aama Tourist Area, Batauli, Ambikapur, Chhattisgarh ;A Study”, *IRJMETS* (2023), vol 5, issue 12.
33. Dewanagan S.K., Minj Dipti “ Evaluation of physico-chemical properties of water source in Dewara. *IJSRED*, (2023) vol. 6 issue 6
34. Dewanagan S.K. et al, “Comparative analysis of physico chemical parameters in different source of water of Gangapur Area, Latori, District Surajpur, Chhattisgarh” *International journal of science research & engineering development* (2023) Vol. 6, Page No.6

35. Swarnkar A.K., Bajpai S., Ahmad I., study on performance of wet lands and impact on Water Quality in a densely populated Urban area in Amanak, Raipur, Chhattisgarh, India, *Advance in Environmental Technology*, 2024, 10(1), 1-11.
36. Panigrahi, Dr. S.K. & Mohanty L. (2023).environmental engineering Laboratory Manual, (IS:3025, part 11,2002)
37. American Public Health Association. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). APHA Press.
38. Bureau of Indian Standards (BIS). (2018). *Drinking water - Specification (IS 10500:2018)*. New Delhi: BIS
39. Panigrahi, Dr. S.K. & Mohanty L. (2023).environmental engineering Laboratory Manual, ISO 7888 (1985)
40. Panigrahi, Dr. S.K. & Mohanty L. (2023).environmental engineering Laboratory Manual, (IS; 3025 part 10 - 1984)
41. U.S. Environmental Protection Agency. (2018). *Secondary drinking water standards: Guidance for nuisance chemicals*.
<https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance- nuisance-chemicals>
42. World Health Organization. (2017). *Guidelines for drinking-water quality* (4th ed.).
<https://www.who.int/publications/i/item/9789241549950>
43. American Public Health Association. (2017). *Standard methods for the examination of water and wastewater* (23rd ed.). APHA Press.
44. Anitha, V., Anbarasu, K., & Venkatramanan, S. (2011). Hydrogeochemistry and groundwater quality studies in Vaniyar watershed, Tamil Nadu, India. *International Journal of Environmental Sciences*, 2(2), 579–591.
45. Sadat-Noori, S. A., Ebrahimi, K., & Liaghat, A. M. (2014). Assessment of surface water quality using multivariate statistical techniques: A case study of the Gharasoo River in Iran. *Environmental Earth Sciences*, 72(12), 4829–4840. <https://doi.org/10.1007/s12665-014-3370-5>
46. Arumugam, K. (2010). *Groundwater quality and its suitability for drinking and agricultural use in Vellore district, Tamil Nadu, India* (Doctoral dissertation, Annamalai University).
47. Bureau of Indian Standards. (2009). *Indian standard: Drinking water — Specification (IS 10500:2009)*. New Delhi: Bureau of Indian Standards.
48. Frant, M. S., & Ross, J. W. (1966). Electrode for sensing fluoride ion activity in solution. *Science*, 154(3756), 1553–1555.
<https://doi.org/10.1126/science.154.3756.1553>
49. World Health Organization. (2011). *Guidelines for drinking-water quality* (4th ed.).
<https://www.who.int/publications/i/item/9789241548151>
50. Association of Official Analytical Chemists (AOAC). (1995). *Official methods of analysis* (16th ed., Method 975.08). AOAC International.
51. World Health Organization. (2011). *Calcium and magnesium in drinking-water: Public health significance*.
<https://www.who.int/publications/i/item/9789241563550>
52. Panigrahi, Dr. S.K. & Mohanty L. (2023).environmental engineering Laboratory Manual, (IS; 3025 part 46 - 1994) (116-121)
53. American Public Health Association. (2017). *Standard methods for the examination Manual*, 66-69 (IS; 3025 part 23 - 1986) NTPC Limited. (n.d.). Sipat. Retrieved May 2, 2025, from <https://ntpc.co.in/sipat>
54. U.S. Environmental Protection Agency. (2012). *Corrosivity of water*.
<https://www.epa.gov/sites/default/files/2015-09/documents/epa816f15003.pdf>
55. U.S. Environmental Protection Agency. (2012). *Corrosivity of water*.
<https://www.epa.gov/sites/default/files/2015-09/documents/epa816f15003.pdf>
56. U.S. Environmental Protection Agency. (n.d.). *Secondary drinking water standards: Guidance for nuisance chemicals*. Retrieved from [https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance- nuisance-chemicals:contentReference\[oaicite:10\]](https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance- nuisance-chemicals:contentReference[oaicite:10])

57. UCLA Health. (n.d.). *Ask the doctors: Is water with a high pH safe to drink?* Retrieved from [https://www.uclahealth.org/news/article/ask-the-doctors-is-water-with-a-high-ph-safe-to-drink:contentReference\[oaicite:16\]](https://www.uclahealth.org/news/article/ask-the-doctors-is-water-with-a-high-ph-safe-to-drink:contentReference[oaicite:16])
58. Mayo Clinic. (n.d.). *Alkaline water: Better than plain water?* Retrieved from <https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-answers/alkaline-water/faq-20058029> Mayo Clinic
59. World Health Organization. (2006). *pH in drinking-water*. Retrieved from <https://cdn.who.int/media/docs/default-source/wash-documents/wash-chemicals/ph.pdf>
60. Healthline. (n.d.). *Alkaline water: Benefits, side effects, and dangers*.
61. Sofi, G., et al. (2018). The effect of drinking water pH on the human gut microbiota and glucose regulation. *Journal of Clinical Biochemistry and Nutrition*, 63(1), 1–5.
62. WebMD. (n.d.). *What is alkaline water?*
63. MedicineNet. (n.d.). *What is the best pH level for drinking water?* Retrieved from
64. Verywell Health. (n.d.). *Alkaline water and cancer*. Retrieved from <https://www.verywellhealth.com/alkaline-water-and-cancer-5082535>
65. U.S. Environmental Protection Agency. (2022). *Turbidity*. Retrieved from <https://www.epa.gov/ground-water-and-drinking-water/national-primary-drinking-water>
66. Cotruvo, J. A., Dufour, A., Rees, G., Bartram, J., Carr, R., Cliver, D. O., & Craun, G. F. (Eds.). (2004). *Waterborne zoonoses: Identification, causes, and control*. World Health Organization.
67. Spellman, F. R. (2013). *Drinking water treatment: Principles and insights*. CRC Press.
68. Montgomery, J. M. (1985). *Water treatment: Principles and design*. John Wiley & Sons.
69. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry for environmental engineering and science* (5th ed.). McGraw-Hill.
70. Tchobanoglous, G., Burton, F. L., & Stensel, H. D. (2003). *Wastewater engineering: Treatment and reuse* (4th ed.). McGraw-Hill.
71. Viessman, W., & Hammer, M. J. (2009). *Water supply and pollution control* (8th ed.). Pearson Education.
72. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry for environmental engineering and science* (5th ed.). McGraw-Hill.
73. Linsley, R. K., Kohler, M. A., & Paulhus, J. L. (1982). *Hydrology for engineers* (3rd ed.). McGraw-Hill.

Copyright & License:

© Authors retain the copyright of this article. This work is published under the Creative Commons Attribution 4.0 International License (CC BY 4.0), permitting unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.