



Assessment Of Physico-Chemical Parameters In Ground Water & Surface Water In And Around Afzalpur Taluk In Kalaburagi District, Karnataka, India

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Abstract: In this study, through the analysis of ground water and surface water samples collected from five places in Afzalpur taluk, Kalaburagi district in Karnataka, India. These ground water and surface water samples are collected on June 19th 2024. The main purpose of this analysis is to determine the quality of the ground water and surface water samples collected in Afzalpur taluk. In this water samples we have analysed some physicochemical parameters and heavy metal concentrations. Water samples have been collected by grab sampling. Samples have been collected in sampling bottles made up of PET which is coloured to protect from light, avoiding photosynthesis and preservation of certain compounds. For surface water samples, the sampling bottles were first rinsed with the sample water for about 3 times, after that the bottle is immersed into 10cms below the water surface, and surface water samples are collected. For ground water samples, water is made to run out for about 10 minutes and the sampling bottle is rinsed with sample water for about 3times, and ground water samples are collected. The physicochemical parameters and heavy metal concentrations of ground water and surface water samples collected were analysed in the Global Environment and Mining Services Laboratory, Hosapete, Vijayanagara district, Karnataka. Some of the Physicochemical parameters determined in this analysis are pH, Conductivity, Total Dissolved Solids (TDS), Turbidity, Total Hardness as CaCO₃, Calcium(Ca), Magnesium(Mg), Sulphate(SO₄), Sodium(Na), Potassium (K), Carbonates, Bicarbonates, Nitrate Nitrogen(NO₃), Chloride(Cl), Fluoride(F). Some of the heavy metal concentrations determined are Zinc(Zn), Copper(Cu), Iron(Fe), Lead(Pb), Manganese(Mn), Nickel(Ni). All the analysed data were compared to the WHO standards, ISO standards and IS standards for ground water samples. For surface water samples G.S.R 422 (E) Limits. The main goal of this analysis is to know about the water quality of that particular area where the samples are collected and to know about whether the water samples collected is suitable for drinking purposes.

KEY WORDS: Physicochemical studies, heavy metal concentrations, surface water, ground water, water quality analysis.

I. INTRODUCTION

Water analysis is a critical field focused on assessing the quality, availability, and sustainability of water resources. As global water demand continues to rise due to population growth, urbanization, and industrialization, the importance of advanced water analysis become paramount. As we know that, water is one of the most essential elements responsible for sustaining life on Earth. Despite the fact that the world's population of six billion people utilizes nearly 30% of the total accessible renewable water supply, billions still lack access to basic water resources [1-7]. The Earth's surface is composed of 71.11% water and 28.89% land. However, of the total water available, 97% is saline, and only 3% is freshwater [8].

Water resources are primarily derived from two main sources: groundwater and surface water. Groundwater is often the preferred choice for many consumers due to its perceived cleanliness and safety [9]. It is located beneath the Earth's surface, occupying the spaces between soil particles and rock formations. Groundwater originates from precipitation, such as rain, which infiltrates the ground and percolates through soil and rock layers. Its movement is generally slow and driven by gravity. Groundwater can be stored at varying depths, ranging from a few meters to hundreds of meters below the surface. The safety and quality of groundwater depend on several factors, including: i) the geology of the area, ii) human activities or land use practices, and iii) environmental and meteorological conditions [9]. Groundwater is often favored for drinking purposes because it undergoes natural filtration as it passes through soil and rock layers, which removes many impurities, making it relatively clean and safe for consumption and agricultural use. However, this natural filtration process does not eliminate all contaminants, and the quality of groundwater can vary significantly depending on local geological conditions and human activities.

Surface water, on the other hand, encompasses various sources such as streams, rivers, springs, ponds, lakes, and reservoirs. These water bodies are primarily replenished by precipitation within a watershed. Rivers are the most commonly utilized source of surface water globally, serving domestic, agricultural, and industrial needs [10]. Surface water is generally more susceptible to contamination compared to groundwater due to its direct exposure to the environment. Pollutants from agricultural runoff, industrial waste, and sewage can easily enter rivers, lakes, and streams, leading to significant water quality issues. As a result, surface water typically requires treatment before it is safe for drinking or other uses. In regions such as Afzalpur taluk, groundwater plays a critical role in irrigation, accounting for approximately 88% of the net irrigated area. Consequently, groundwater serves as the primary source of irrigation in this region. Additionally, the use of surface water benefits numerous villages for both agricultural cultivation and drinking purposes [11]. The water analysis will be driven by technological innovation, regulatory demands, and the urgent need to address water scarcity and contamination. The field will play a pivotal role in ensuring the availability of clean water for future generations while promoting sustainable water resource management.

II. STUDY AREA AND DATA COLLECTION :

a. Sampling :

i) Study Area and Sampling Methodology

The study area, Afzalpur taluk, is located in the Kalaburagi district of Karnataka, India. It spans an area of 1,050 square kilometers and has a population of 180,071. Situated in the northern part of Karnataka, within the Deccan Plateau region, Afzalpur taluk lies between 17°03'30'' to 17°22'40'' North Latitude and 76°12'45'' to 76°42'35'' East Longitude. The region is bordered by Aland taluk and Maharashtra state to the north, Maharashtra state to the west, Gulbarga taluk to the east, and Jewargi taluk and Bijapur district to the south [11-12].

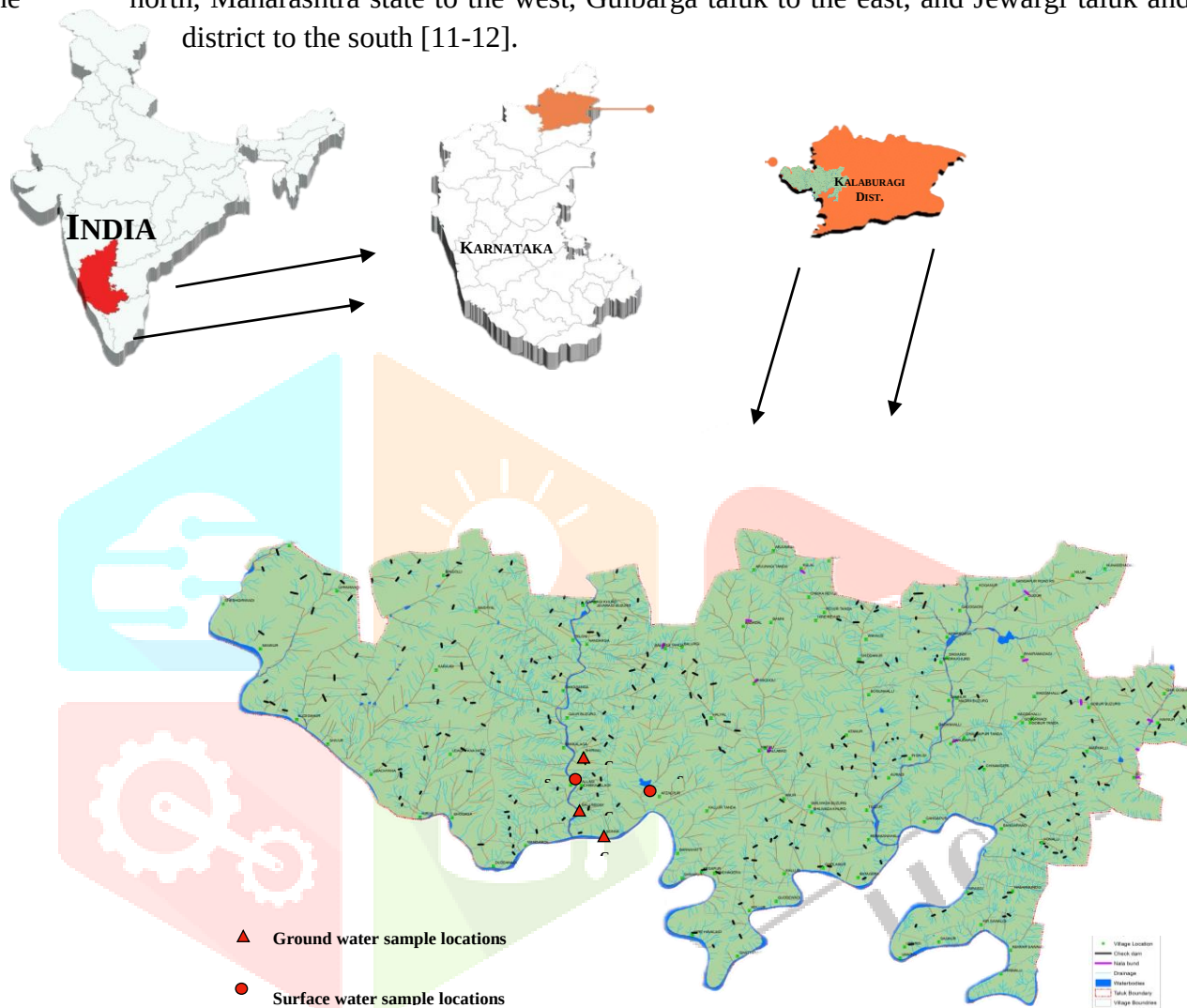


Figure1. Aquifer map of Afzalpur Taluk :

II. Water Sampling and Collection

A total of five water samples were collected from Afzalpur taluk, comprising three groundwater samples and two surface water samples. Sampling was conducted using PET (polyethylene terephthalate) bottles to ensure the integrity of the samples for physicochemical parameter analysis and heavy metal concentration assessment [9]. The groundwater samples were labeled as GW-1, GW-2, and GW-3, while the surface water samples were designated as SW-1 and SW-2.

GW-1: Collected from Sonna at Latitude 17.177754° and Longitude 76.318897°.

GW-2: Collected from Belundgi at Latitude 17.191508° and Longitude 76.328705°.

GW-3: Collected from Shirwad at Latitude 17.228184° and Longitude 76.308316°.

SW-1: Collected from Algi K at Latitude 17.205395° and Longitude 76.306595°.

SW-2: Collected from Afzalpur Lake at Latitude 17.204766° and Longitude 76.353333°.

All samples were collected on June 19, 2024, and transported to the laboratory within 24 hours of collection to ensure minimal alteration in water quality parameters. The samples were subsequently analyzed for physicochemical properties and heavy metal concentrations to assess water quality in the study area (as mention above). This systematic sampling approach provides a representative dataset for evaluating the groundwater and surface water resources in Afzalpur taluk, contributing to a better understanding of water quality and its implications for local communities.

b. Analysis of Physicochemical Parameters and Heavy Metals:

The physicochemical parameters of the water samples, including pH, conductivity, total dissolved solids (TDS), turbidity, total hardness, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), carbonates (CO_3^{2-}), bicarbonates (HCO_3^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), and fluoride (F^-), were determined using standard methods as recommended by the American Public Health Association (APHA). These methods ensure accurate and reliable measurements of water quality parameters, which are essential for assessing the suitability of water for drinking, irrigation, and other purposes.

In addition to physicochemical analysis, the concentrations of heavy metals, including zinc (Zn), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), and nickel (Ni), were measured using a Flame Atomic Absorption Spectrophotometer (FAAS). This technique is widely recognized for its precision and sensitivity in detecting trace levels of heavy metals in water samples. The use of FAAS ensures the accurate quantification of metal concentrations, which is critical for evaluating potential contamination and its associated health and environmental risks. The combination of physicochemical and heavy metal analyses provides a comprehensive assessment of water quality, enabling the identification of potential pollutants and their sources. This approach is vital for developing effective water management and remediation strategies in the study area.

III. MATERIALS AND METHODS :

Groundwater and surface water samples were collected from five distinct locations within the study area, as illustrated in the map above. The sampling sites were strategically selected, with distances between each location ranging from 4 to 7 kilometers. The analysis of the collected samples was conducted in accordance with the standard methods outlined in the APHA 23rd Edition (2017) and 24th Edition (2023) [1-2][12]. The parameters analyzed, along with their respective methods of determination, are detailed in Table 1. These methods ensure the accuracy and reliability of the results, providing a comprehensive assessment of water quality in the study area.

Table 1: List of Parameters and Methods of Determination

Parameter	Methods of determination	Reference
pH	Electrometric methods	APHA 23 rd /24 th Edition
Conductivity	Conductivity meter	APHA 23 rd /24 th Edition
Total dissolved solid(TDS)	Gravimetric method	APHA 23 rd /24 th Edition
Turbidity	Nephelometric method	APHA 23 rd /24 th Edition
Total harness	EDTA titrimetric method	APHA 23 rd /24 th Edition
Calcium(Ca)	EDTA titrimetric method	APHA 23 rd /24 th Edition
Magnesium(Mg)	Calculation method	APHA 23 rd /24 th Edition
Sodium (Na)	Flame photometry method	APHA 23 rd /24 th Edition
Potassium (K)	Flame photometry method	APHA 23 rd /24 th Edition
Chloride(Cl)	Argentometric method	APHA 23 rd /24 th Edition
Carbonates(CO_3^{2-})	Titrimetric method	APHA 23 rd /24 th Edition
Bicarbonates(HCO_3^-)	Titrimetric method	APHA 23 rd /24 th Edition
Sulphate (SO_4^{2-})	Turbidimetric method	APHA 23 rd /24 th Edition
Nitrate(NO_3^-)	UV Spectrophotometric method	APHA 23 rd /24 th Edition
Fluoride (F^-)	SPADNS method	APHA 23 rd /24 th Edition
Heavy Metals (Zn, Cu, Fe, Pb, Mn, Ni)	Flame atomic absorption Spectrophotometric(FAAS)	APHA 23 rd /24 th Edition

These systematic approaches to water quality analysis ensure the reliability and comparability of the results, providing valuable insights into the physicochemical and heavy metal characteristics of the water samples. The uses of the standardized methods facilitate the identification of potential contaminants and support the development of effective water management strategies.

IV.RESULTS & DISCUSSIONS

The results of the physicochemical and heavy metal analysis for both groundwater and surface water samples are presented in Table 2 (Groundwater Samples) and Table 3 (Surface Water Samples). The findings provide a comprehensive understanding of the water quality in the study area, highlighting variations in key parameters and their implications for human health and environmental sustainability.

Groundwater Samples (Table 2): The analysis of groundwater samples (GW-1, GW-2, and GW-3) revealed the following key observations:

1. pH: The pH values of groundwater samples ranged from 7.03 to 7.12, indicating slightly alkaline to neutral conditions. These values fall within the permissible limits set by regulatory standards, suggesting suitability for drinking and irrigation purposes.
2. Conductivity and TDS: Conductivity and total dissolved solids (TDS) levels varied between 2850 $\mu\text{S}/\text{cm}$ to 3300 $\mu\text{S}/\text{cm}$ and 1710 to 1980 mg/L, respectively. Higher TDS values in certain samples may indicate the presence of dissolved salts and minerals, which could affect water quality for drinking and agricultural use.
3. Total Hardness: The total hardness ranged from 818.1 to 1121.1 mg/L as CaCO_3 , with some samples exceeding the permissible limits. This could be attributed to the presence of calcium and magnesium ions, which are common in groundwater due to geological formations.
4. Major Ions: Concentrations of calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) were within acceptable limits in most samples. However, elevated levels of sodium in GW-2 suggest potential salinity issues.
5. Anions: Chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), and fluoride (F^-) levels were generally within safe limits, except for nitrate in GW-3, which exceeded the permissible limit, possibly due to agricultural runoff or improper waste disposal.
6. Heavy Metals: Concentrations of heavy metals such as zinc (Zn), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), and nickel (Ni) were below detectable limits or within safe thresholds, indicating minimal contamination from industrial or anthropogenic sources.

Surface Water Samples (Table 3): The analysis of surface water samples (SW-1 and SW-2) yielded the following results:

1. pH: The pH values ranged from 7.57 to 8.89, indicating neutral to slightly alkaline conditions. These values are within the acceptable range for surface water bodies.
2. Conductivity and TDS: Conductivity and TDS levels were higher compared to groundwater, ranging from 1760 to 2400 $\mu\text{S}/\text{cm}$ to 1070 to 1440 mg/L. This is likely due to the accumulation of dissolved salts and pollutants from surface runoff.
3. Turbidity: Turbidity levels were elevated in both samples, particularly in SW-2, indicating the presence of suspended particles and organic matter. This highlights the need for proper treatment before consumption.
4. Total Hardness: Total hardness values were within permissible limits, suggesting moderate mineral content in surface water.
5. Major Ions and Anions: Concentrations of calcium, magnesium, sodium, potassium, chloride, sulphate, and bicarbonate were within safe limits. However, nitrate levels in SW-1 were slightly elevated, possibly due to agricultural activities in the vicinity.
6. Heavy Metals: Heavy metal concentrations were generally low, with iron (Fe) showing slightly higher levels in SW-2, likely due to natural geological processes or anthropogenic activities.

RESULTS

TABLE - 2 : RESULTS OF GROUND WATER SAMPLES

Parameters	Unit	GW-1	GW-2	GW-3	Permissible Limits	Excessive Limits
pH	-	7.12	7.03	7.08	6.5 - 8.5	NR
Conductivity	µS/cm	2850	3250	3300	-	-
Total dissolved solids	mg/L	1710	1950	1980	500	2000
Turbidity	NTU	0.8	5.5	1.3	1	5
Total Hardness (CaCO ₃)	mg/L	818.1	1090.8	1121.1	200	600
Calcium (Ca)	mg/L	173.72	226.24	234.32	75	200
Magnesium(Mg)	mg/L	93.26	127.62	130.007	30	100
Sulphate (SO ₄ ²⁻)	mg/L	735.54	682.59	702.55	200	400
Sodium (Na)	mg/L	107.95	79.15	70.23	-	-
Potassium (K)	mg/L	0.00	0.00	17.06	-	-
Carbonates(CO ₃ ²⁻)	mg/L	0.00	0.00	0.00	-	-
Bicarbonates(HCO ₃ ⁻)	mg/L	357.00	346.8	316.2	200	600
Nitrate (NO ₃ ⁻)	mg/L	19.64	20.15	19.58	45	NR
Chloride (Cl)	mg/L	292.26	546.82	538.62	250	1000
Fluoride (F)	mg/L	1.14	0.96	0.73	1	1.5
Zinc (Zn)	mg/L	BDL	BDL	BDL	5	15
Copper (Cu)	mg/L	BDL	BDL	BDL	0.005	1.50
Iron (Fe)	mg/L	BDL	BDL	BDL	0.30	NR
Lead (Pb)	mg/L	BDL	BDL	BDL	0.001	NR
Manganese (Mn)	mg/L	BDL	BDL	BDL	0.10	0.30
Nickel (Ni)	mg/L	BDL	BDL	BDL	0.002	NR

TABLE - 3 : RESULTS OF SURFACE WATER SAMPLES

Parameters	Unit	SW-1	SW-2	G.S.R 422 (E) Limits
RESULTS				
pH	-	7.57	8.89	5.5 - 9.0
Conductivity	µS/cm	1760	2400	-
Total dissolved solids	mg/L	1074	1440	-
Turbidity	NTU	2.3	0.8	-
Total Hardness (CaCO ₃)	mg/L	464.6	747.4	-
Calcium (Ca)	mg/L	113.12	141.4	-
Magnesium(Mg)	mg/L	44.17	95.71	-
Sulphate (SO ₄ ²⁻)	mg/L	432.34	452.63	-
Sodium (Na)	mg/L	47.6	138.75	-
Potassium (K)	mg/L	0.00	0.00	-
Carbonates(CO ₃ ²⁻)	mg/L	0.00	30.6	-
Bicarbonates(HCO ₃ ⁻)	mg/L	183.6	153.00	-
Nitrate (NO ₃ ⁻)	mg/L	14.86	18.42	10.0
Chloride (Cl)	mg/L	259.27	452.54	-
Fluoride (F)	mg/L	0.37	0.68	2.0
Zinc (Zn)	mg/L	BDL	BDL	5.0
Copper (Cu)	mg/L	BDL	BDL	3.0
Iron (Fe)	mg/L	BDL	BDL	3.0
Lead (Pb)	mg/L	BDL	BDL	0.1
Manganese (Mn)	mg/L	BDL	BDL	-
Nickel (Ni)	mg/L	BDL	BDL	3.0

IV. DISCUSSIONS:

The analysis of groundwater and surface water samples revealed significant variations in physicochemical parameters, which were compared against the WHO and IS:10500:2012 standards for groundwater, and G.S.R 422 (E) standards for surface water. The findings are discussed below, focusing on the implications of each parameter for water quality and its suitability for various uses. The pH values of groundwater samples (GW-1, GW-2, GW-3) ranged from 7.03 to 7.12, while surface water samples (SW-1, SW-2) ranged from 7.57 to 8.89. These values fall within the acceptable range of 6.5–9 for aquatic life, indicating that the water is neither highly acidic nor alkaline. This suggests that the water is suitable for most biological and chemical processes. Groundwater conductivity ranged from 2850 to 3300 $\mu\text{S}/\text{cm}$, while surface water ranged from 1760 to 2400 $\mu\text{S}/\text{cm}$. The higher conductivity in groundwater indicates a greater concentration of dissolved ions, likely due to mineral leaching from soil and rocks. This suggests higher salinity in groundwater compared to surface water, which could affect its suitability for irrigation and drinking. Groundwater TDS ranged from 1710 to 1980 mg/L, exceeding the WHO recommended limit of 500 mg/L, while surface water TDS ranged from 1074 to 1440 mg/L. High TDS levels in groundwater may indicate pollution or natural mineralization, which could affect taste and pose health risks if consumed over long periods. Groundwater turbidity ranged from 0.8 to 5.5 NTU, while surface water ranged from 0.8 to 2.3 NTU. The lower turbidity in groundwater suggests fewer suspended particles, making it clearer than surface water. However, surface water turbidity levels are still within acceptable limits, indicating minimal contamination from silt or organic matter. Groundwater hardness ranged from 818.1 to 1121.1 mg/L, significantly higher than surface water (464.6–747.4 mg/L). The high hardness in groundwater is likely due to the presence of calcium and magnesium ions, which can affect its suitability for domestic and industrial use by causing scaling in pipes and appliances. Groundwater calcium levels ranged from 173.72 to 234.32 mg/L, higher than surface water (113.12–141.4 mg/L). While calcium is essential for biological functions, excessive levels can lead to scaling and aesthetic issues. The absence of a specific WHO guideline for calcium suggests that its management should focus on preventing aesthetic problems. Groundwater magnesium levels ranged from 93.26 to 130.007 mg/L, higher than surface water (44.17–95.71 mg/L). Like calcium, magnesium is essential but can cause aesthetic issues at high concentrations. Groundwater sulphate levels ranged from 682.59 to 735.54 mg/L, exceeding the WHO limit of 500 mg/L, while surface water ranged from 432.34 to 452.63 mg/L. High sulphate levels in groundwater may impart a bitter taste and indicate potential contamination from industrial discharges or natural sources. Groundwater sodium levels ranged from 70.23 to 107.95 mg/L, while surface water ranged from 47.6 to 138.75 mg/L. Although there is no specific WHO guideline for sodium, elevated levels can affect taste and pose health risks for individuals on sodium-restricted diets. Potassium was detected in groundwater (0–17.06 mg/L) but was absent in surface water. The low levels of potassium suggest minimal contamination, and its absence in surface water indicates no significant agricultural or industrial runoff. Alkalinity levels were not explicitly reported, but the WHO guideline range is 20–200 mg/L. Alkalinity is crucial for buffering pH changes and supporting aquatic life, and its management is essential for maintaining water quality. Groundwater nitrate levels ranged from 19.58 to 20.15 mg/L, while surface water ranged from 14.86 to 18.42 mg/L. These levels are below the WHO limit of 50 mg/L, indicating minimal risk of nitrate contamination, which is often associated with agricultural runoff. Groundwater chloride levels ranged from 292.26 to 546.82 mg/L, exceeding the WHO aesthetic limit of 250 mg/L, while surface water ranged from 259.27 to 452.54 mg/L. High chloride levels can affect taste and indicate potential contamination from industrial or natural sources. Groundwater fluoride levels ranged from 0.73 to 1.14 mg/L, within the WHO limit of 1.5 mg/L, while surface water ranged from 0.37 to 0.68 mg/L. Fluoride levels are within safe limits, balancing dental health benefits and the risk of fluorosis. The concentrations of these trace metals were below the detection limit (BDL) in both groundwater and surface water samples. This indicates minimal contamination from industrial or natural sources, and the water is safe from heavy metal toxicity.

V. CONCLUSIONS :

The analysis of groundwater and surface water samples, compared against the IS:10500:2012 standards for groundwater and G.S.R. 422 (E) standards for surface water, revealed that certain parameters fall within acceptable limits, while others exceed the permissible range. Parameters such as calcium (Ca), magnesium (Mg), sulphate, and turbidity were found to be above the acceptable limits, indicating potential issues related to natural mineralization or contamination. On the other hand, parameters like nitrate and fluoride were present below the acceptable range, posing no immediate health risks. To address the parameters exceeding the acceptable limits, precautionary measures such as the implementation of filtration systems, chemical treatments, identification of contamination sources, and regulatory interventions can be adopted. These steps will help minimize the levels of excessive parameters and ensure the water's suitability for drinking, domestic use, and industrial applications. The heavy metal concentrations in both groundwater and surface water samples were found to be below the detection limit (BDL), which is a positive indicator of water quality. This can be attributed to the natural dilution of water through rainfall, mixing with larger water bodies, or the presence of other substances that reduce metal concentrations. The absence of heavy metals offers significant advantages for human health and ecological safety, including the protection of aquatic ecosystems, plants, and other organisms. Additionally, the water is suitable for agricultural use, reducing the risk of heavy metal accumulation in soil and crops, thereby ensuring food safety.

Overall, the findings highlight the importance of continuous monitoring and management of water quality to maintain long-term environmental health. By preventing the buildup of toxic substances and addressing excessive parameters, sustainable water resources can be preserved, ensuring the well-being of both human populations and ecosystems.

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