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Analysis and Quantification of Physico-Chemical Characteristics of Surface and Ground Water in and Around Davanagere District

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***Abstract*: The study evaluated physical and chemical parameters of surface and groundwater from selected sites in Davanagere district, including Naganur, Kundawada, Avaragere villages, and the Thungabhadra River at Harihara and Honnali, based on BIS drinking water standards (IS 10500:2012). The results showed significant variations, turbidity in the river at Harihara and Honnali exceeded safe limits, while pH, total dissolved solids, and hardness varied near permissible levels. Chemical analysis revealed localized contamination with elevated manganese in Naganur Lake, high lead in borewells at Kundawada and Naganur, and nickel above limits in Avaragere borewell water, posing potential health risks. These findings indicate that some water sources do not meet BIS standards, reflecting both natural and human impacts. The study underscores the importance of regular water quality monitoring, effective treatment, and sustainable management to protect community health.**

***Keywords*: Physical and Chemical parameters, Surface and ground water, BIS drinking water standards.**

I. INTRODUCTION

Water quality can be assessed by its physical parameters and chemical characteristics, influenced by natural causes and human activities. Important parameters include pH, temperature, turbidity of water, dissolved oxygen (DO), Total hardness, alkalinity, nutrients (nitrate, phosphate, sulfate), and trace metals (iron, lead, cadmium, chromium, arsenic, mercury). Deviations from permissible limits set by the Bureau of Indian Standards (BIS: 10500) can pose risks and make water unsafe for drinking, also posing a risk to aquatic life as the dissolved oxygen is depleted due to contamination, and the ecosystem and environment are affected badly.

Surface waters are often vulnerable to direct pollution from a variety of sources, including the discharge of untreated sewage, leakage from septic tanks, leakage of sewerage pipes, chemical and oil spills, the discharge of industrial waste, agricultural runoff containing pesticides and fertilizers, along with urban stormwater drainage, which introduces various pollutants into the environment. These contaminants lead to increased organic matter, elevated nutrient levels, and heavy metals like lead and mercury.

Groundwater, while naturally filtered through layers of soil and rock, is not immune to contamination. The excessive application of fertilizers on agricultural lands can lead to the leaching of nitrates into groundwater supplies, resulting in elevated levels of these compounds. Additionally, the infiltration of pesticides used in farming can introduce harmful chemicals into the water table. Industrial activities may further contribute to groundwater pollution through the percolation of hazardous waste. Furthermore, the over-extraction of groundwater resources often results in increased mineral hardness and may cause the accumulation of toxic metals,

The growing need for fresh water is significantly straining both surface and groundwater supplies. As cities expand rapidly due to population growth and industrial development, the quality of our water sources is threatened by the discharge of pollutants. Intensive agricultural practices, such as the overuse of fertilizers and pesticides, worsen the situation by adding substantial amounts of pollutants, such as Toxic metals, arsenic, lead, zinc, chromium, and mercury, to our water systems. Nutrients from fertilizers, along with organic matter, heavy metals, and toxic chemicals, flow into rivers and lakes, turning them into unsafe and polluted reservoirs.

A. Study Area

Davanagere City is situated in the central region of Karnataka, about 260 kilometers from Bangalore, along the Pune-Bangalore National Highway No. 4. It can be found at a longitude of 75°55′E and a latitude of 14°28′N. Agricultural activities in the villages of Davanagere district significantly impact water quality. The use of fertilizers in farming introduces nitrates and phosphates into the soil, which can seep into groundwater, making it unsafe for drinking. Additionally, these nutrients can flow into rivers and lakes, leading to algal blooms that increase alkalinity and adversely affect fish life. Furthermore, pesticides can seep into groundwater, where they persist for a long time and are difficult to remove. This often requires additional treatment units for purification, making the process of treating such impurities in groundwater expensive.

To the west of Davangere city, the Thungabhadra River flows approximately 15 km away. For the physicochemical analysis, a sample of the Thungabhadra River was collected at Harihara Taluq. Additionally, another sample was taken near Honnali Taluq.

Samples were strategically collected near the villages of Davanagere, including Naganur (Lat 14.409627°, Long 75.907596°), Avaragere (Lat 14.431428°, Long 75.955169°), and Kunadawada (Lat 14.456215°, Long 75.894578°). This comprehensive sampling effort encompassed both surface water and groundwater sources to ensure a thorough analysis.

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B. Objectives

1. To carry out systematic sampling of local water sources by obtaining varied specimens from surface bodies (rivers and lakes) and from groundwater at several sites.
2. To conduct a thorough examination of essential physicochemical parameters and Toxic chemical substances.
3. To meticulously compare the analyzed values against the Bureau of Indian Standards (BIS)10500:2012.
4. To evaluate the general appropriateness for different applications.

II. METHODOLOGY

To thoroughly assess groundwater and surface water, it's crucial to employ a methodical strategy when choosing locations, taking into account a range of influencing factors. These include agricultural practices, industrial effluents affecting surface waters, sewage disposal, and domestic waste that may impact water quality. By carefully identifying these sites, we can collect samples where physicochemical parameters are altered. Analyzing these samples will help us determine the concentrations of potentially harmful substances. This information can then be compared against the acceptable limits set by the Bureau of Indian Standards (BIS), enabling us to take informed steps toward improving water quality and safeguarding public health.

A. Selection of Site

The locations were deliberately chosen based on their closeness to farming regions where fertilizers and pesticides are frequently applied. This offers a chance to investigate how these agricultural practices impact soil and groundwater quality, as the leaching of these chemicals can have serious consequences. Furthermore, assessing the effects of fertilizers and pesticides on surface water quality is essential for fostering healthier ecosystems. Additionally, it is vital to consider the influence of small-scale industries in the Davanagere area, which might elevate heavy metal levels in surface water. By concentrating on these industries, we can identify potential ways to reduce their environmental impact. Finally, exploring how domestic wastewater affects surface water quality provides an important opportunity to create effective management strategies that could enhance water safety and improve community health.

Paddy is extensively cultivated in the villages surrounding Davanagere, which necessitates the use of various pesticides. Initially, these chemicals pollute the soil, leading to the contamination of both surface water and groundwater. This study analyzes the influence of agricultural pesticides on the water sources in the villages close to Davanagere. The selected villages for this analysis are Naganur (Latitude: 14.409627°, Longitude: 75.907596°), Avaragere (Latitude: 14.431428°, Longitude: 75.955169°), and Kunadawada (Latitude: 14.456215°, Longitude: 75.894578°). Samples will be gathered from these villages to evaluate the effects of agricultural fertilizers, domestic wastewater flowing into surface water, and various industrial activities in the nearby regions.

have selected sample sites from the Thungabhadra River at Harihara and Honnali to investigate the effects of nearby industrial activities. This proactive approach allows us to learn a lot about the physicochemical parameters and possible heavy metal contamination in the river. Understanding these factors is crucial, as the water from the Thungabhadra River serves as a vital drinking source for the residents of the Davanagere district.

B. Sample Collection

We have undertaken a valuable initiative to collect samples from villages near Davanagere for thorough physicochemical analysis. The villages Naganur (Latitude 14.409627°, Longitude 75.907596°), Avaragere (Latitude 14.431428°, Longitude 75.955169°), and Kunadawada (Latitude 14.456215°, Longitude 75.894578°). The Tungabhadra River in the taluks of Harihar and Honnali will shed light on the river's condition. In particular, Sample 1 (labeled SR1) was collected close to Harihara, and Sample 2 (labeled SR2) was collected at Honnali.

Kunadawada village, situated near the Davanagere district, is strategically located by a lake that is a crucial source of drinking water for Davanagere city. This significance warrants thorough concentration analyses, including essential heavy metal tests that directly impact human health. A sample from Kundawada Lake, labeled SLK, has been meticulously collected for analysis. Additionally, two groundwater samples from Kunadawada village, designated as SGK1 and SGK2, have been gathered to appraise the effects of agricultural fertilizers and pesticides.

Naganur is situated approximately 6.5 km from the Davanagere district. In this area, farmers cultivate paddy crops on agricultural land, where fertilizers and pesticides are commonly used. These chemicals have the potential to contaminate both surface water and groundwater. For this analysis, samples were obtained from Naganur village lake and designated as SLN. Further, groundwater samples were gathered and marked as SGN1 and SGN2.

Avaragere village, situated near the Davanagere District, has provided a water sample from its lake, designated as SLA. Furthermore, we have collected two groundwater samples from Avaragere village, labeled SGA1 and SGA2.

Sampling is a crucial step in environmental monitoring, forming the foundation for dependable analytical results. With each sample collected and stored at 4°C in coolers, we take a significant step toward safeguarding our environment and ensuring a healthier future.

Table 1. Showing Label of Samples.

Location of Sample Collected	Label of Sample
Thungabhadra River Harihara	SR1
Thungabhadra River Honnali	SR2
Kundawada Lake	SLK
Kundawada groundwater point 1	SGK1
Kunadawada groundwater Point 2	SGK2
Naganur Lake	SLN
Naganur groundwater point 1	SGN1
Naganur groundwater Point 2	SGN2
Avaragere Lake	SLA
Average groundwater point 1	SGA1
Avaragere groundwater point 2	SGA2

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C. Physical Parameters Analysis

Physical parameters are those in which the water quality characteristics are measured, which describe the physical behaviour of water and the appearance of water. Electrical conductivity experiments help in assessing the concentration of ions, salts, and minerals, and knowing the salinity concentration. TDS, we can analyse organic and inorganic impurities. Turbidity caused by suspended impurities like clay or silt that scatter or absorb light can be determined.

Table 2: Physical parameters of water.

Sl. No.	Physicical Parameters Analysed	Instruments / Methodology
1	Electrical Conductivity (EC)	Digital conductivity meter
2	Total Dissolved Solids (TDS)	TDS meter
3	Turbidity	Nephelometer (Turbidity meter)

D. Chemical parameters Analysis

The analysis included measurements of pH, total hardness, calcium and magnesium hardness, as well as chloride concentration.

Table 3: Chemical parameters of water.

Sl. No.	Chemical Parameters	Analysis Techniques / Instrument
1	Total Hardness	EDTA Titration Method
2	Calcium Hardness	EDTA Titration Method
3	Magnesium Hardness	Computation Technique is utilized
4	Chloride	Mohr Method (Titration with Silver Nitrate)

E. Toxic Chemical Substances (Heavy Metals) Analysis

The determination of Toxic Chemical Substances (heavy metal) concentration in a water sample is done using an Atomic Absorption Spectrophotometer, and the following parameters were analyzed.

Table 4: Toxic Chemical Substances Heavy metals parameters.

Sl No	Heavy Metal Parameters	Analysis Techniques /Instrument
1	Iron (Fe)	Atomic Absorption Spectrophotometer
2	Manganese (Mn)	
3	Zinc (Zn)	
4	Copper (Cu)	
5	Lead (Pb)	
6	Chromium (Cr)	
7	Cadmium (Cd)	
8	Nickel (Ni)	

III. RESULTS AND DISCUSSION

A total of eleven samples were obtained from the Thungabhadra River and nearby villages. This collection included three surface-water samples (from Naganur, Kundawada, and Avaragere), two underground samples from the same villages, and six subsurface samples overall. Samples from the Thungabhadra river at Harihara Taluq and Honnali Taluq were collected and analysed to know the physical, chemical, and heavy metals concentration in these samples, and the results obtained are discussed below.

A. Physical Parameters

a. Electrical Conductivity:

Ions like calcium, magnesium, sodium, and sulfur enhance ionic conduction; their greater presence leads to higher electrical conductivity in water**.** Eleven samples tested for conductivity were within the permissible limits.

Table 5: Showing Electrical conductivity results.

Sample name	Electrical conductivity (µS/cm)	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
SR1	89.49	-	-
SR2	98		
SLK	118		
SGK1	116		
SGK2	118		
SLN	380.70		
SGN1	420.1		
SGN2	567.5		
SLA	458.3		
SGA1	756		
SGA2	747		

B. Total Dissolved Solids:

Inorganic salts (magnesium, sodium, potassium, chlorides, sulfates, nitrates) and organic impurities, which are dissolved in water sources, are measured using a TDS meter. The electrical conductivity of these inorganic and organic impurities was converted to TDS and measured as mg/l. Minerals from soil and rocks, agricultural runoff, and industrial effluents cause TDS in water. TDS Acceptable limits are 500 mg/l; the maximum permissible limit in case where the alternative water source is available is 2000 mg/l. Laboratory analysis confirmed that TDS values for all samples remained within the acceptable limit.

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Table 6: Showing Results of TDS in mg/l

Sample Name	TDS in mg/l	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
SR1	58	500 mg/l	2000mg/l
SR2	60		
SLK	75		
SGK1	53		
SGK2	58		
SLN	228		
SGN1	240		
SGN2	403		
SLA	280		
SGA1	474		
SGA2	463		

c. Turbidity:

Turbidity is caused due to suspended impurities in the water source. The turbidity is measured by using a Nephelometer. the permissible limit should be below 5 NTU if no other alternative source is available for drinking purposes. All eleven samples were tested, and the Thungabhadra river source results were above the permissible limits of IS10500:2012. Elevated turbidity results from domestic sewage entering the river combined with sediment from eroded soil transported into the river by rain-driven runoff. As the sample was collected during the rainy season, the turbidity was found to be high. Furthermore, the sample which is collected at Naganur Lake has high values of Turbidity due to the flow of domestic wastewater into the lake.

Table 7: Showing Results of Turbidity in NTU

Sample Name	Turbidity in NTU	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
SR1	12.60	1 NTU	5 NTU
SR2	10.80		
SLK	2.20		
SGK1	1.10		
SGK2	1.50		
SLN	5.40		
SGN1	1.20		
SGN2	1.00		
SLA	3.60		
SGA1	1.60		
SGA2	2.10		

B. Chemical Parameters:

These chemical properties indicate the composition and quality of water. These concentration assessments help in the analysis of water and its suitability for safe drinking, agricultural use, and industrial purposes. The chemical parameters are commonly pH, alkalinity, Hardness, Chlorides, Sulfates, Nitrates, and Fluoride. In this analysis, the pH, Total Hardness, and Chlorides are analysed to assess the suitability of water for drinking and agricultural purposes.

a. pH

While pH readings for surface water, groundwater, and the Thungabhadra River meet Indian standards, the pH of sample 6 (from Naganur Lake) is almost at the permissible boundary., which shows that alkalinity levels, which make water taste bitter and may affect agricultural land and crops. Furthermore, if they are for industrial purposes, they may cause scaling in boilers and pipes.

Table 8: Showing results for pH

Sample name	pH	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source.
SR1	7.34	6.5-8.5	No relaxation
SR2	7.46		
SLK	7.74		
SGK1	7.66		
SGK2	7.72		
SLN	8.44		
SGN1	7.46		
SGN2	7.26		
SLA	8.20		
SGA1	7.47		
SGA2	7.42		

b. Total Hardness:

The measure of the concentration of divalent ions, mainly Calcium and Magnesium, present in water, expressed in mg/l of CaCO3 equivalent. The acceptable limits and permissible limits of Total hardness, Calcium (as Ca), and magnesium (as Mg) are as below.

Table 9: showing Acceptable and Permissible Limits

Sl. No.	Chemical Parameters	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
1	Total Hardness (as $CaCO_3$), mg/l	200	600
2	Calcium (as Ca), mg/l	75	200
3	Magnesium (ad Mg), mg/l	30	100

The samples were tested to find Total hardness, Calcium hardness, and Magnesium hardness and the concentration of Calcium (as Ca) and Magnesium (as Mg) are determined and the results shows that the sample collected from Avaragere

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lake and groundwater sample are above the acceptable limits for Total hardness but within permissible limits as per IS 10500: 2012 and the Magnesium (as Mg) in Avaragere lake and ground water is high but within the permissible limit. The results obtained for all the samples are below.

Table 10: Showing results of Total Hardness, Calcium, and Magnesium Hardness

Sample Name	Total hardness as $CaCO_3$, mg/l	Calcium hardness as $CaCO_3$, mg/l	Magnesium hardnessas $CaCO_3$, mg/l	Calcium (as Ca), mg/l	Magnesium (as Mg), mg/l
SR1	108	28	80	11.20	37.44
SR2	56	20	36	8.00	16.85
SLK	76	32	44	12.80	20.59
SGK1	68	36	32	14.40	14.98
SGK2	72	32	40	12.80	18.72
SLN	172	68	104	27.20	48.67
SGN1	148	88	60	35.20	28.08
SGN2	156	96	60	38.40	28.08
SLA	242	88	160	35.20	74.88
SGA1	252	76	176	30.40	82.37
SGA2	262	80	180	32.00	84.24

c. Chloride

The combination of hydrochloric acid with the base results in the formation of Chlorides. In water, they are present in the form of sodium chloride, potassium chloride, and calcium chloride. The various sources are due to the minerals in rocks and soil, and due to industrial effluents high concentration of chloride makes water taste salty. The acceptable limits of Chloride as Cl in mg/l are 250 mg/l, and the permissible limits in case where an alternative source is not available are 1000 mg/l.The samples from surface water and groundwater are tested, and the results are within the acceptable and permissible limits. The results obtained are as below.

Table 11: Showing results for Chloride as Cl in mg/l.

Sample Name	Chloride (Cl), in mg/l	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
SR1	35.99	250 mg/l	1000 mg/l
SR2	49.98		
SLK	37.99		
SGK1	43.99		
SGK2	41.99		
SLN	55.98		
SGN1	57.98		
SGN2	59.98		
SLA	77.98		
SGA1	61.98		
SGA2	63.98		

C. Toxic Chemical Substances (Heavy Metals) Analysis

Heavy metals often exist in water in ionic form and are highly toxic even when concentrations are small. These contaminants originate from natural processes like volcanic eruptions and rock erosion, as well as human activities such as pesticide runoff, industrial wastewater release, and sewage disposal. These heavy metals are highly toxic, which affects human health and aquatic life. Hence, the toxic chemical substances (heavy metals) concentration within the acceptable limits, Copper concentration and Chromium is found to be zero, and the concentration of Iron in SGK1, SLN, and SGN2 is higher than the acceptable limits, Lead in the SGK1 sample is high, and Nickel concentration in SGA2 is higher than the acceptable and permissible limits of drinking water. The results of heavy metals are listed below.

Table 12: Showing Permissible limits of Heavy metals.

Sl. No.	Heavy metals	Acceptable Limit IS 10500: 2012	Permissible Limits in Absence of an Alternate Source
1	Iron (as Fe), mg/l	0.3	No relaxation
2	Manganese (as Mn), mg/l	0.1	0.3
3	Zinc (as Zn), mg/l	5	15
4	Copper (as Cu), mg/l	0.05	1.5
5	Lead (as Pb), mg/l	0.01	No relaxation
6	Chromium (as Cr), mg/l.	0.05	No relaxation
7	Cadmium (as Cd), mg/l	0.03	No relaxation
8	Nickel (as Ni), mg/l	0.02	No relaxation

Table 13: Showing Results for Toxic Chemical Substances (Heavy Metals)

Sample Name	Iron (Fe), mg/l	Manganese (Mn), mg/l	Zinc (Zn), mg/l	Lead (Pb), mg/l	Cadmium (Cd), mg/l	Nickel (Ni), mg/l
SR1	0.905	0.044	0.024	0.00	0.00	0.00
SR2	0.638	0.024	0.017	0.00	0.00	0.00
SLK	0.049	0.031	0.008	0.00	0.00	0.00
SGK1	0.008	0.015	0.011	0.052	0.00	0.00
SGK2	0.009	0.018	0.009	0.00	0.00	0.00
SLN	0.100	0.072	0.003	0.023	0.00	0.00
SGN1	0.000	0.023	0.011	0.00	0.006	0.00
SGN2	0.005	0.015	0.047	0.068	0.014	0.00
SLA	0.064	0.036	0.005	0.000	0.000	0.002
SGA1	0.016	0.009	0.063	0.000	0.013	0.00
SGA2	0.232	0.014	0.196	0.034	0.00	0.088

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IV. CONCLUSION

The analysis and quantification of various physico-chemical parameters and heavy metals over the selected villagesNaganur, Avaragere, and Kundawada, in which the surface water and underground samples are collected and analysed for various concentrations, reveals the quality of water. The results obtained after analysis show that the physico-chemical parameters are within the permissible limits and are found safe for drinking and agricultural purposes, except certain subsurface water. The Thungabhadra River samples that are analysed are also within the acceptable limits and permissible limits, except for some parameters like turbidity and TDS, which can be easily removed by the primary and secondary treatment processes of the water treatment plant. Further, it requires more attention to remove the iron concentration in water before supplying it for drinking purposes**.**

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