Assessment of Drinking Water Quality through Physico-Chemical Indicators: A Case Study of Supebeda (Deobhog), Gariyaband (Chhattisgarh)

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Abstract
Water is an essential resource for all life forms and a critical component for ecological balance. The present study evaluates the physico-chemical characteristics of drinking water in Supebeda village, located in Gariyaband district of Chhattisgarh, which has reported a significant number of kidney-related ailments in recent years. To determine water quality, samples were collected from borewells and handpumps across two sites using the grab sampling method. These samples were tested for parameters such as pH, Electrical Conductivity (EC), Total Hardness (TH), Permanent Hardness (PH), Temporary Hardness (TempH), Carbon Dioxide (CO_2), Total Dissolved Solids (TDS) and Total Solids (TS) using standard analytical techniques recommended by APHA.
The analysis revealed that while most parameters like pH, EC, TH, TDS, and TS were within the permissible limits set by WHO and BIS, carbon dioxide levels exceeded the safe limits in certain samples. The pH values ranged from 6.34 to 8.4, indicating slightly acidic to moderately alkaline conditions. Electrical conductivity was highest at 1575 µS/cm and lowest at 357 µS/cm. Notably, high levels of hardness and dissolved solids were observed in a few locations, which may contribute to the growing health issues in the region.
These findings suggest that while the majority of the water sources in Supebeda are suitable for consumption, excess CO_2 and hardness in some samples could pose long-term health risks. The study highlights the urgent need for regular monitoring, community awareness, and effective water treatment solutions to ensure the safety and sustainability of drinking water resources in the area.

Keywords: Physico-chemical parameters, Water quality, Supebeda, Gariyaband, Groundwater, Carbon dioxide, Hardness, Drinking water

Introduction
Water is one of the most essential and abundant natural resources on Earth, covering nearly 70% of the planet's surface. It plays a critical role in maintaining the ecological balance and supporting life in all its forms. Every living organism, from the smallest microorganism to the largest mammal, depends on water for survival. For human beings, water is not only vital for drinking but also indispensable for domestic, agricultural, industrial, and recreational purposes. An adult human typically needs 2 to 5 liters

of clean drinking water every day, apart from the much larger volume required for cooking, washing, sanitation, irrigation, and other daily needs.

Despite its abundance, the availability of clean and safe water is diminishing rapidly due to various anthropogenic activities. Population growths, urbanization, industrial expansion, excessive use of chemical fertilizers and pesticides in agriculture, and poor waste management practices have severely deteriorated the quality of freshwater resources. Rivers, lakes, groundwater, and other natural water bodies are increasingly being contaminated with physical, chemical, and biological pollutants.

In India, nearly 80% of water pollution is attributed to the discharge of untreated domestic sewage. The lacks of effective sewage treatment infrastructure and improper disposal practices have further aggravated the issue. Contaminated water can lead to a wide range of health hazards including gastrointestinal infections, skin diseases, and long-term effects like kidney and liver damage. Therefore, the assessment of water quality through scientific analysis of its physico-chemical parameters has become a necessity.

Regular monitoring of water sources not only helps in identifying pollution levels but also aids in planning and implementing appropriate water treatment solutions. Ensuring access to safe and clean drinking water is essential for public health and overall sustainable development.

Objectives

To assess the physico-chemical parameters of drinking water in Supebeda village, including pH, Electrical Conductivity (EC), Total Hardness (TH), Permanent Hardness (PH), Temporary Hardness (TempH), Carbon Dioxide (CO_2), Total Dissolved Solids (TDS), and Total Solids (TS), to evaluate the water quality for human consumption.

1. To identify potential sources of contamination in Supebeda's groundwater by examining variations in key water quality parameters across different sampling sites, and to assess their compliance with the permissible limits set by WHO and BIS.
2. To examine the impact of water quality on public health, with a focus on understanding the relationship between elevated levels of hardness and CO_2 and the reported increase in kidney-related ailments in the region.
3. To recommend water treatment and management strategies, based on the findings of the physico-chemical analysis, to address any contamination issues and ensure the long-term safety and sustainability of drinking water resources in Supebeda.

Study Area

The present study was conducted in Supebeda, a rural village situated in the Gariaband district of Chhattisgarh, India. Supebeda is located approximately 12 kilometers from Deobhog and nearly 220 kilometers from Raipur, the capital city of Chhattisgarh. The geographical coordinates of the village are 19.88°66′ N latitude and 82°71′19″ E longitude, placing it in a region that is largely agrarian and dependent on groundwater for its drinking and irrigation needs.

Supebeda has attracted attention in recent years due to a concerning rise in health-related issues among its residents, especially kidney-related diseases. Over the past decade, at least 71 cases of kidney ailments have been reported, which is significantly high for a village with a small population. This has raised serious public health concerns and prompted inquiries into the possible causes of the problem.

One of the most suspected factors is the quality of drinking water sourced from borewells and handpumps in the region.
Given the reliance of the village on groundwater and the increasing incidence of such health problems, a scientific assessment of physico-chemical parameters of drinking water in Supebeda has become critically important to understand the extent of contamination and its potential impact on human health.

Materials and Methods
Sample Collection
To assess the physico-chemical quality of drinking water in Supebeda village, grab sampling technique was employed. This method ensures that the sample collected at a single time point represents the water's characteristics accurately. Water samples were collected in clean, 1000 ml plastic bottles, which were thoroughly rinsed with the same source water before final collection to prevent any contamination.

Site	Site1	Site2	Site3
Source	Borewell	Handpump	well

Sampling Sites and Sources
Samples were collected from two different locations (Site 1 and Site 2) within the village. Each site included a combination of groundwater sources such as borewells, handpumps and well which are the primary sources of drinking water in the area.

Sample Handling and Transportation
Post collection, all water samples were stored at room temperature in airtight containers and transported to the laboratory for analysis within 24 hours to ensure reliability of results.

Standards for Comparison

The physico-chemical parameters obtained were analyzed and compared with the permissible limits set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS) for drinking water quality. This helped in evaluating the safety and suitability of the water for human consumption.

Analysis Techniques

The assessment of water quality in Supebeda village was carried out by analyzing various physico-chemical parameters of the collected water samples. The aim was to determine the safety and suitability of the drinking water sources used by the local population. All analytical procedures followed the standardized guidelines prescribed by the American Public Health Association (APHA, 1985) to ensure scientific validity and accuracy.

Water samples were tested in a well-equipped laboratory using a combination of digital instruments, titrimetric methods, and gravimetric techniques, depending on the nature of each parameter. Before starting the tests, all instruments were properly calibrated using standard solutions to minimize observational errors and enhance the precision and repeatability of results.

The key parameters selected for this study included pH, electrical conductivity, total hardness, permanent hardness, temporary hardness, carbon dioxide concentration; total dissolved solids (TDS), and total solids (TS). These parameters were chosen because they are reliable indicators of overall water quality and can directly or indirectly affect human health.

The detailed testing techniques used are summarized in the table below:

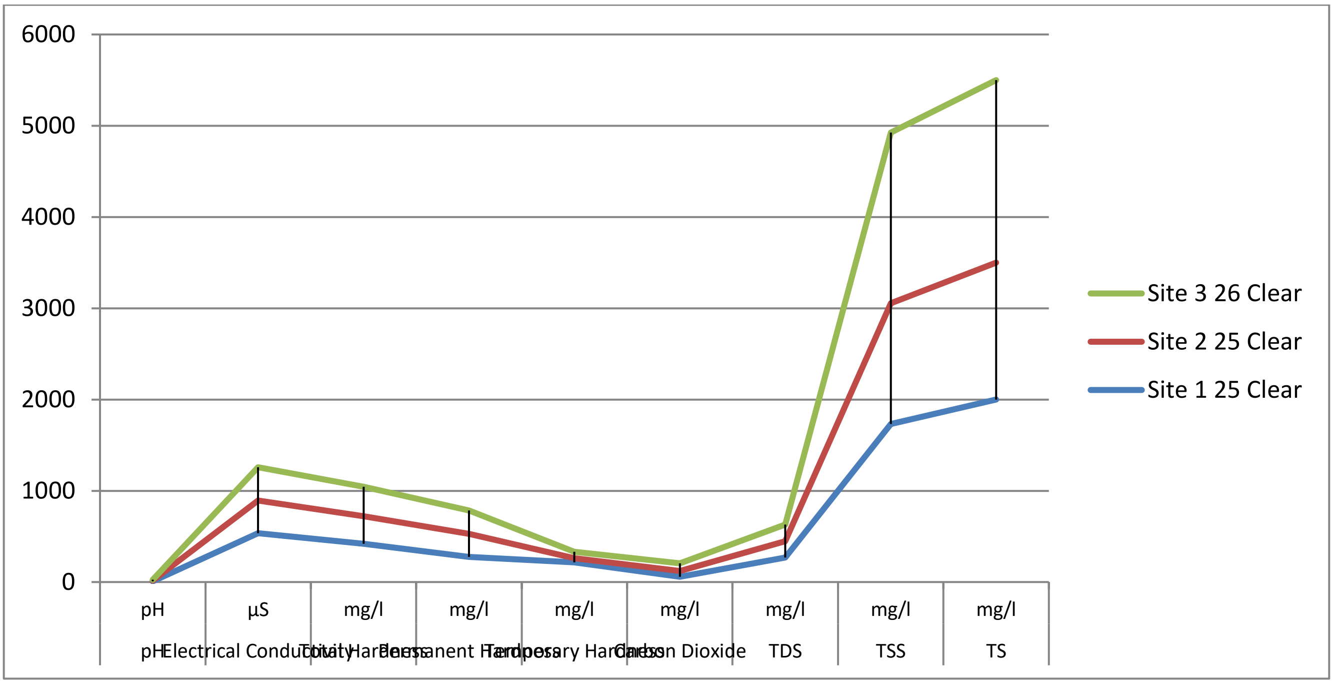
S.No.	Parameter	Method of Testing
1	pH	Digital pH Meter
2	Electrical Conductivity (EC)	Digital Conductivity Meter
3	Total Hardness (TH)	Titrimetric Method
4	Permanent Hardness (PH)	Titrimetric Method
5	Temporary Hardness (TempH)	Titrimetric Method
6	Carbon Dioxide (CO_2)	Titrimetric Method
7	Total Dissolved Solids (TDS)	TDS Meter & Titrimetric Method
8	Total Solids (TS)	Gravimetric Method

The pH value indicates the acidic or alkaline nature of water and was measured using a digital pH meter. Electrical conductivity (EC) was analyzed to estimate the total ionic concentration in the water using a digital conductivity meter. Various forms of hardness were determined by EDTA titration methods, which help understand the concentration of calcium and magnesium salts. Carbon dioxide levels were assessed through acid-base titration, while TDS was measured both using a TDS meter and titrimetric estimation for cross-verification. Total solids (TS), representing all dissolved and suspended matter, were determined through gravimetric drying and weighing.

The values obtained from all tests were then compared with the World Health Organization (WHO) and Bureau of Indian Standards (BIS) drinking water guidelines to assess their compliance and potential impact on human health. This analysis is crucial for identifying any need for water treatment or preventive measures in the region.

Results & Discussion

S.No.	Parameter	Method Used	Unit Measurement	WHO Limit	BIS Limit	Site 1	Site 2	Site 3
1	Temperature	-	°C	-	-	25	25	26
2	Colour	-	-	Agreeable	Agreeable	Clear	Clear	Clear
3	pH	Recorded by pH meter	pH	6.5-8.5	6.5-8.5	8	8.28	8.84
4	Electrical Conductivity	EC meter	µS	750	750	537	357	364
5	Total Hardness	Titrimetric	mg/l	200-600	200-600	420	300	325
6	Permanent Hardness	Titrimetric Method	mg/l	-	-	275	255	255
7	Temporary Hardness	Titrimetric Method	mg/l	-	-	215	45	70
8	Carbon Dioxide	Titrimetric Method	mg/l	>100	>100	59.4	62.7	83.6
9	TDS	TDS meter	mg/l	500-1200	500-1200	268	178	183
10	TSS	Gravimetric method	mg/l	100-200	100-200	1732	1322	1871
11	TS	Gravimetric method	mg/l	500-1500	500-1500	2000	1500	2000



The present study analyzed key physicochemical parameters of river water from three different sampling sites affected by rice mill wastewater in the Rajim region. The findings are discussed below:

Temperature and Colour

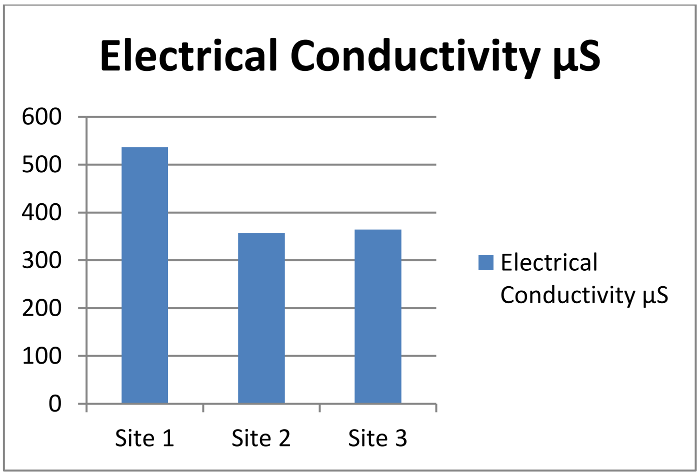
The temperature at all three sites remained between 25°C and 26°C, indicating no significant thermal impact from industrial discharge. The water appeared clear and visually clean at all locations, suggesting the absence of visible pollutants or suspended substances. This reflects a normal thermal condition and acceptable water quality in terms of colour and physical appearance.

pH

The pH values ranged from 8.0 at Site 1 to 8.84 at Site 3. Sites 1 and 2 were within the WHO/BIS acceptable range of 6.5–8.5, indicating safe conditions. However, Site 3 exceeded the upper limit, showing higher alkalinity. This increase may be due to alkaline effluents from rice mills, potentially harmful to aquatic ecosystems. Elevated pH levels can disrupt pH-sensitive biochemical processes in aquatic life, affecting their survival, growth, and reproduction in the river environment..

Electrical Conductivity (EC)

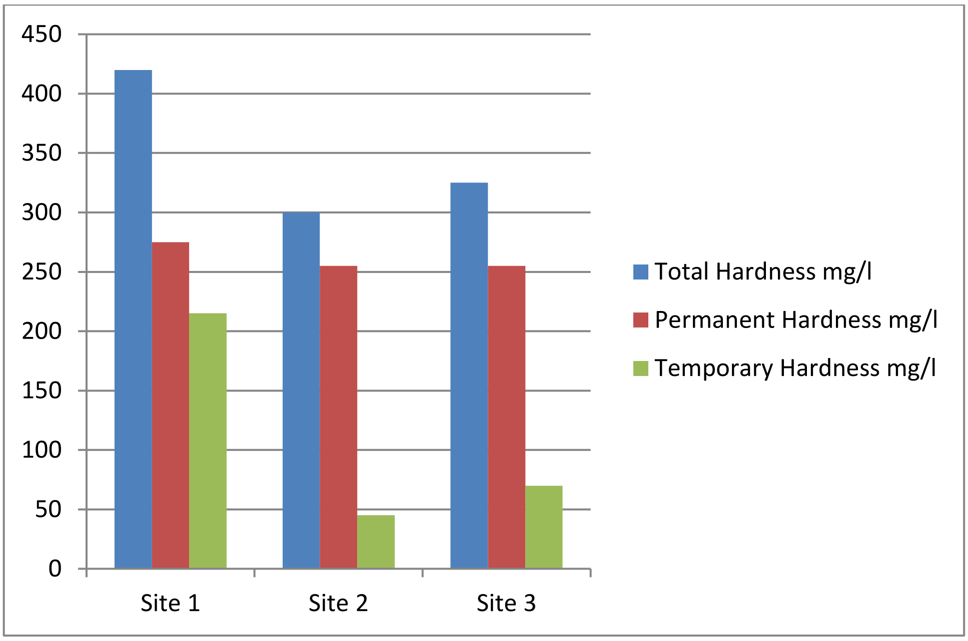
The electrical conductivity (EC) values at all three sites remained below the permissible limit of 750 µS, indicating acceptable water quality. Site 1 recorded the highest EC value at 537 µS, while Sites 2 and 3 showed lower values of 357 µS and 364 µS, respectively. These reduced values downstream suggest a moderate concentration of dissolved ions, possibly due to partial dilution or reduced discharge of ionic pollutants. This trend reflects a decline in ionic contamination along the river flow.



Total, Permanent, and Temporary Hardness

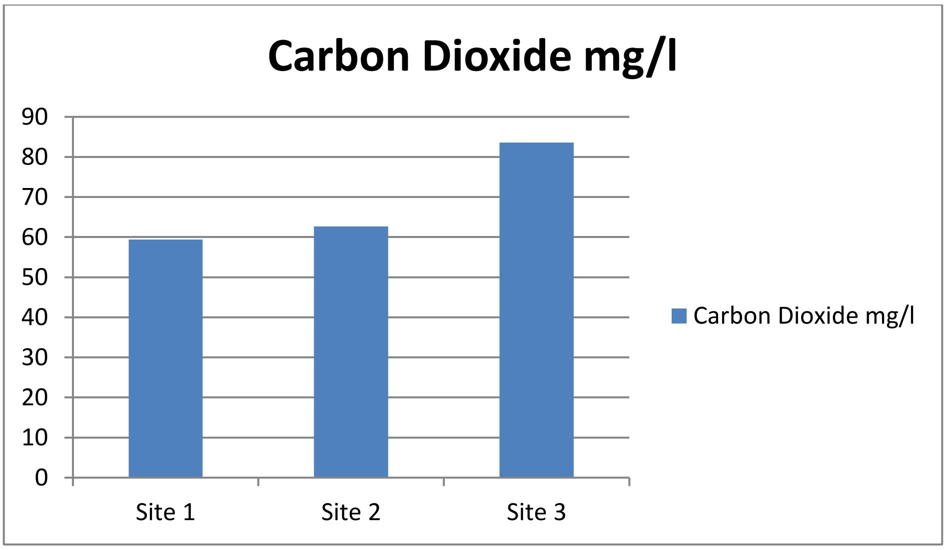
Total hardness at Site 1 was found to be 420 mg/l, which exceeds the BIS permissible limit of 300 mg/l, indicating significant mineral enrichment likely due to upstream rice mill effluent discharge. In contrast, Sites 2 and 3 recorded total hardness within acceptable limits, reflecting comparatively lower contamination. Elevated hardness at Site 1 suggests the presence of calcium and magnesium salts introduced through industrial runoff. Permanent hardness values across all sites ranged between 255–275 mg/l, indicating a consistent level of non-carbonate hardness primarily due to chlorides and sulfates of calcium and magnesium. Temporary hardness, which arises from bicarbonates, varied from 45 mg/l

(Site 2) to 215 mg/l (Site 1), further confirming mineral contributions from anthropogenic sources. The decreasing trend of hardness downstream suggests dilution or natural attenuation processes. Overall, the data indicate significant hardness-related contamination at Site 1, likely influenced by nearby rice mill activities, with improving water quality at downstream sites.



Carbon Dioxide (CO_2)

Carbon dioxide concentrations ranged from 59.4 mg/l at Site 1 to 83.6 mg/l at Site 3, indicating a rising trend downstream. The highest CO_2 level at Site 3 suggests increased microbial respiration or decomposition of organic matter, likely due to rice mill effluents. Elevated CO_2 can reduce dissolved oxygen levels, leading to stress on aquatic organisms. Such conditions may disturb the aquatic ecosystem by affecting respiration, reproduction, and survival of sensitive species, highlighting potential pollution from organic waste.



Total Dissolved Solids (TDS)

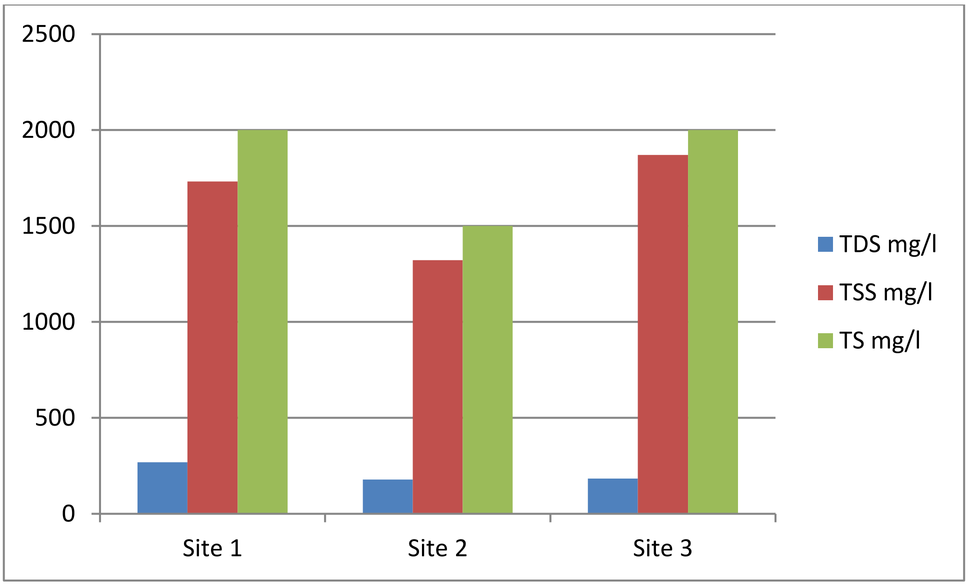
TDS values at all three sites were within the permissible limits of 500–1200 mg/l, with Site 1 recording the highest value at 268 mg/l. While these levels are not alarming, the relatively higher TDS at Site 1 suggests greater presence of dissolved inorganic and organic matter, possibly from rice mill effluents. Dissolved solids contribute to water salinity and may affect taste, conductivity, and aquatic life. The gradual decrease in TDS downstream indicates potential dilution and reduced contaminant input.

Total Suspended Solids (TSS)

TSS values at all sampling sites were significantly above the standard permissible limit of 100–200 mg/l, indicating severe pollution. Site 3 recorded the highest TSS at 1871 mg/l, followed by Site 1 with 1732 mg/l, and Site 2 also showing elevated levels. Such high suspended solids hinder light penetration, reduce photosynthetic activity, and contribute to sedimentation, which degrades aquatic habitats and affects biodiversity. The primary sources of this pollution are likely rice husk particles, bran residues, and untreated solid waste from nearby rice mills. These findings highlight an urgent need for effective waste management and treatment practices in the region.

Total Solids (TS)

Total solids (TS) values were found to be 2000 mg/l at Sites 1 and 3, and 1500 mg/l at Site 2, all exceeding permissible limits. These elevated levels indicate a significant pollution load, confirming the presence of both suspended and dissolved solids. The high TS concentrations align with the influence of rice mill effluents, including organic waste and particulate matter. Such pollution can degrade water quality, harm aquatic life, and disrupt ecological balance in the affected river stretch.



Graphical Analysis Included:

1. EC and CO_2 Comparison: A correlation between electrical conductivity and carbon dioxide Site 3 shows the highest pH, Carbon Dioxide, TSS, and TS, indicating greater pollution.

2. Site 1 consistently has higher values for Electrical Conductivity, Hardness, and TDS, suggesting a stronger upstream effluent influence.
3. Site 2 generally shows moderate values, possibly due to dilution or reduced direct contamination.

Conclusion

The water quality study conducted on samples from Supebeda provides important insights into the physico-chemical characteristics of the water. Most of the parameters, including pH, Electrical Conductivity (EC), Hardness (Total Hardness, Permanent Hardness, and Temporary Hardness), Total Dissolved Solids (TDS), and Total Solids (TS), were found to be within the permissible limits set by the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). These parameters indicate that the water quality in terms of mineral content and physical characteristics is generally acceptable for consumption.

However, the study also revealed elevated levels of Carbon Dioxide (CO_2) in some of the samples, exceeding the acceptable limits. High CO_2 concentrations could be indicative of organic contamination, possibly from biological activity or pollutants, which could affect water quality and its suitability for drinking. This suggests the presence of potential contamination that may require treatment, such as aeration or filtration, to ensure the water is safe for consumption.

In light of these findings, it is recommended that regular monitoring of water quality be conducted, particularly for CO_2 levels, and that water treatment measures be implemented to address any identified contamination. Enhanced water management systems, including periodic assessments and upgrades, would help maintain the overall water quality and ensure safe and reliable drinking water for the community. Regular water quality testing is crucial for proactive management and safeguarding public health.

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