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Research Article

Assessment of Drinking Water Quality in Sambalpur Municipality Area, Odisha, India

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ABSTRACT

This study assesses the quality of drinking water in the Sambalpur Municipality area of Odisha, India, by examining its physicochemical and microbiological characteristics. Water samples were collected from diverse sources, including river water, ponds, borewells, and municipal supplies. Parameters such as pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO) were analyzed following World Health Organization (WHO) and Bureau of Indian Standards (BIS) guidelines. The results revealed that most samples met the acceptable limits for pH and TDS. However, elevated BOD and COD levels in some areas indicated organic contamination, likely originating from domestic sewage or industrial discharge. These findings emphasize the need for routine monitoring, infrastructure improvements, and public awareness initiatives to ensure a safe and sustainable drinking water supply for the urban population of Sambalpur.

INTRODUCTION

Background and Importance of Drinking Water

Water is the most essential natural resource sustaining all forms of life on Earth. It covers about 71 percent of the planet's surface, yet only around 3 percent is freshwater, and less than 1 percent of that is readily available for human

consumption (World Health Organization [WHO], 2022). Potable water refers to water that is safe for human use and free from harmful microorganisms and chemical pollutants. The quality of drinking water is influenced by both natural and human factors. Natural processes such as weathering of rocks and soil leaching contribute to changes in water chemistry, while anthropogenic activities including industrial effluents, sewage discharge,

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and agricultural runoff further degrade quality (Central Pollution Control Board [CPCB], 2021).

The WHO's Guidelines for Drinking-Water Quality emphasize preventive risk management through a multi-barrier approach, beginning with source protection, followed by proper treatment, and extending to safe distribution (WHO, 2022). Access to safe drinking water is recognized as a human right and is central to public health policy under the United Nations Sustainable Development Goal-6 Clean Water and Sanitation (United Nations, 2015). This global framework underscores that ensuring water safety is not only a technical challenge but also a moral and developmental responsibility. Water performs indispensable physiological and ecological functions. In the human body, which consists of approximately 60 percent water, it supports digestion, nutrient transport, temperature regulation, and excretion of metabolic waste (Centers for Disease Control and Prevention [CDC], 2023). Insufficient or unsafe water intake leads to dehydration, kidney malfunction, and metabolic imbalance. Beyond its biological significance, reliable access to clean water underpins agricultural productivity, industrial operations, and domestic well-being. In contrast, contaminated water contributes to waterborne diseases such as cholera, typhoid, and dysentery-illnesses responsible for hundreds of thousands of preventable deaths annually, particularly in developing nations (WHO, 2022). Economically, access to clean water improves labor productivity by maintaining a healthy workforce and reducing healthcare costs (World Bank, 2020). Environmentally, it sustains ecological balance, supports aquatic biodiversity, and regulates local and global climate systems. Therefore, sustained access to potable water is not merely a health imperative but also the foundation for social stability and economic growth. Safe drinking

water plays a vital role in preventing both acute and chronic diseases. Microbial pathogens such as *Escherichia coli*, *Vibrio cholerae*, and *Salmonella typhi* cause immediate gastrointestinal illnesses, while chemical contaminants like arsenic, fluoride, and lead causes chronic conditions such as cancer, fluorosis, and neurological disorders (Bureau of Indian Standards [BIS], 2012; Environmental Protection Agency [EPA], 2023). According to WHO (2022), contaminated water accounts for approximately 485,000 diarrheal deaths globally each year. The availability of safe drinking water also influences food security and gender equality. Inadequate access often forces households-especially women and children to spend hours collecting water, which limits time for education and economic activities (United Nations Children's Fund [UNICEF], 2021).

From a socioeconomic perspective, investments in clean water systems yield measurable benefits, as reductions in disease burden and healthcare expenditure outweigh the costs of infrastructure and treatment (World Bank, 2020). Thus, ensuring the availability of safe drinking water enhances not only public health but also the overall quality of life. It contributes to improved educational outcomes, social equity, and sustainable development across communities.

Overview of Sambalpur Municipality's Water Supply

Sambalpur Municipality, located in western Odisha, India, lies on the banks of the Mahanadi River and serves as one of the region's major urban centers. The municipal water supply system is managed jointly by the Sambalpur Municipal Corporation (SMC) and the Public Health Engineering Department (PHED). The city's primary source of water is the Mahanadi River, supported by groundwater from borewells and tube wells that serve as supplementary sources



(Government of Odisha, 2024). According to the latest municipal data, Sambalpur's treatment infrastructure has an installed capacity of about 57.5 million liters per day (MLD) derived from the Mahanadi River, along with an additional 7.82 MLD sourced from borewells and tube wells (Government of Odisha, 2024). Water from these sources undergoes sedimentation, filtration, and chlorination at treatment facilities near Hirakud before being distributed across the city. Despite this substantial capacity, seasonal fluctuations in river flow and increased turbidity during the monsoon months create operational challenges, requiring continuous monitoring and adaptive treatment methods to maintain safety and efficiency.

The municipal distribution network spans approximately 406 kilometers and is divided into 17 supply zones to maintain adequate pressure and ensure equitable distribution. Current infrastructure expansion projects aim to add an additional 27.6 kilometers of new pipeline to improve service coverage. The per-capita supply in Sambalpur is around 185.6 liters per capita per day (LPCD), which exceeds the Ministry of Housing and Urban Affairs benchmark of 135 LPCD (MoHUA, 2023). However, only about 30 percent of households currently have direct piped connections, leaving the majority reliant on public taps, hand pumps, or private borewells (Government of Odisha, 2024). Non-revenue water (NRW) comprising physical losses due to leakages, illegal connections, and meter inaccuracies remains a significant concern, estimated at nearly 68 percent. High NRW not only leads to resource wastage but also increases the potential for contamination through negative pressure infiltration in the pipeline network (CPCB, 2021). Upgrading aging infrastructure, replacing damaged pipes, and implementing smart

metering systems are essential measures to improve both operational efficiency and safety.

Service Levels and Challenges

Although Sambalpur's overall water quantity generally meets national standards, maintaining quality remains a major challenge. Several physical and chemical parameters occasionally approach or exceed permissible limits defined under BIS (2012) and WHO (2022) standards. Elevated biochemical oxygen demand (BOD) and chemical oxygen demand (COD) in some samples indicate organic pollution caused by sewage infiltration and industrial discharge. Similarly, variations in total dissolved solids (TDS) and pH reflect seasonal influences on source water composition. Groundwater sources in certain areas show high iron and fluoride concentrations, which can be attributed to both natural geological conditions and human activities. These contaminants necessitate regular monitoring and specialized treatment before distribution. Occasional detection of coliform bacteria in supply zones points to possible breaches in the distribution system or insufficient disinfection (BIS, 2012).

Sambalpur's drinking water management faces several interlinked challenges typical of rapidly urbanizing cities in India. Limited household connectivity means that only a third of the population has direct water access, resulting in inequitable supply and dependence on unsafe alternative sources. High non-revenue water due to leakage and unauthorized usage causes substantial losses and system inefficiencies (CPCB, 2021). Aging infrastructure, comprising old cast-iron and PVC pipelines, increases the risk of corrosion and contamination. Seasonal water scarcity during summer months, along with monsoon-induced turbidity, complicates treatment processes. Moreover, the lack of real-time water quality



monitoring and limited public awareness of safe storage and conservation practices further exacerbate these problems. Addressing these issues requires a holistic approach that integrates technology, institutional reform, and behavioral change. The use of smart sensors for continuous water quality monitoring, replacement of outdated pipelines, and strict enforcement of industrial effluent standards can significantly enhance system performance. Public engagement through awareness campaigns under government initiatives such as the Jal Jeevan Mission and Swachh Bharat Abhiyan can further strengthen community participation and accountability (Government of India, 2023). Sambalpur Municipality has made commendable progress in expanding its water supply capacity and improving service levels, several gaps persist in achieving universal access and consistent quality. Aligning municipal practices with WHO and BIS standards, modernizing infrastructure, and promoting public participation are essential steps toward establishing a sustainable, safe, and equitable drinking water system.

METHODOLOGY

Study Area: Sambalpur Municipality Area

Location and Geography

Sambalpur Municipality is situated in the western region of Odisha, India, along the banks of the Mahanadi River. Covering an area of approximately 46.15 square kilometers, the city supports a population of around 300,000 people (Government of Odisha, 2024). As one of the oldest municipalities in Odisha, Sambalpur serves as a vital center for trade, education, and administration. The city's topography consists of gently undulating terrain, interspersed with small streams that drain into the Mahanadi River. The river serves as the primary source of surface water,

while groundwater is drawn from borewells and tube wells within the alluvial plains. Consequently, the region's water resources are influenced by both natural factors, such as rainfall and geology and human activities, including urbanization and industrial development.

Climate and Rainfall

Sambalpur experiences a tropical monsoon climate characterized by hot, humid summers and mild winters. The annual average temperature ranges from 22°C to 43°C (Odisha Meteorological Department, 2023). Rainfall is primarily concentrated during the southwest monsoon season, from June to September, with an annual average of 1,500-1,600 mm. The monsoon replenishes surface and groundwater resources but also increases turbidity and pollutant loads in the Mahanadi River. During summer, reduced river flow may cause localized water scarcity and lower treatment efficiency at municipal plants.

Water Sources

The Mahanadi River, particularly near the Hirakud Dam, serves as the main source of drinking water for Sambalpur. The water undergoes treatment through sedimentation, filtration, and chlorination before distribution to residential and commercial areas. Groundwater forms the secondary source, extracted via borewells and open wells across the municipality. However, groundwater quality varies significantly, with elevated iron and fluoride concentrations reported in certain localities due to geological and anthropogenic factors (Central Ground Water Board [CGWB], 2022). Other surface water bodies such as ponds, reservoirs, and minor streams including Putibandh Pond and Malti Jor serve as supplementary sources, particularly in peripheral areas lacking piped connections. These alternative sources are



more vulnerable to contamination and require regular monitoring.

Water Supply System

The Public Health Engineering Department (PHED) manages the treatment and distribution of drinking water across Sambalpur. The principal treatment facility, located near Hirakud, has an installed capacity of approximately 57.50 million liters per day (MLD), supplemented by 7.82 MLD from groundwater sources (Government of Odisha, 2024). Treated water is distributed through a 406-kilometer pipeline network divided into 17 supply zones to ensure adequate pressure and equitable delivery. Despite sufficient overall capacity, only about 30% of households possess direct piped connections, while the remainder depend on hand pumps or public stand posts. The per capita water supply averages 185.6 liters per capita per day (LPCD), which exceeds the national benchmark of 135 LPCD (Ministry of Housing and Urban Affairs [MoHUA], 2023). However, non-revenue water (NRW) representing losses from leaks, theft, and inaccurate metering remains alarmingly high at nearly 68%, indicating inefficiencies and potential contamination risks.

Water Quality Concerns

Previous municipal assessments and independent studies have identified several key concerns affecting water quality in Sambalpur:

- **Microbial Contamination:** Leakage from sewage lines and open drains allows pathogens such as *E. coli* and coliform bacteria to enter the water system.
- **Iron and Fluoride:** Some borewells contain high levels of these elements, which can cause health issues like anemia and fluorosis (Bureau of Indian Standards [BIS], 2012).

- **Turbidity and Suspended Solids:** During the monsoon, river water becomes muddy, increasing the load on treatment plants.
- **Industrial and Domestic Waste:** Untreated wastewater from urban settlements and nearby industries contributes to organic and chemical pollution.

These issues underscore the need for consistent testing, maintenance of the distribution network, and treatment optimization to ensure potable water quality.

Sample Collection and Site Selection

Water samples were collected from different sources within the Sambalpur Municipality area to ensure representative data. Eight sampling sites were chosen based on their importance in the water distribution network and community usage patterns. The selected sites were:

1. Mahanadi Ghat 1 (Sample 1)
2. Mahanadi Ghat 2 (Sample 2)
3. Putibandh Pond (Sample 3)
4. PHD Supply Water (Sample 4)
5. Borewell Water (Sample 5)
6. Chaurpur Water (Sample 6)
7. Malti Jor, Govindtola (Sample 7)
8. RO Treated Water (Sample 8)

Samples were collected in sterilized bottles and transported to the laboratory for testing. The containers were rinsed with the same sample water before collection to prevent contamination. Samples for chemical analysis were preserved with reagents such as nitric acid, while microbial



samples were analyzed within six hours of collection to maintain accuracy. All procedures followed the Standard Methods for the Examination of Water and Wastewater (American Public Health Association [APHA], 2017).

Analytical Methods

Water analysis was conducted using standard laboratory procedures recommended by WHO and BIS (BIS, 2012; WHO, 2022). The study assessed physical, chemical, and biological parameters to determine overall quality.

Physical Analysis Method

1. **Turbidity:** Measured using a nephelometric turbidity meter and expressed in Nephelometric Turbidity Units (NTU). High turbidity indicates the presence of suspended solids.
2. **Total Dissolved Solids (TDS):** Determined by the gravimetric method or conductivity meter. It measures the total amount of dissolved minerals in water.
3. **Color:** Tested visually or using spectrophotometry. Color changes may indicate the presence of organic matter or metals such as iron and manganese.
4. **Temperature:** Recorded using a calibrated thermometer. It affects biological activity and chemical reactions.
5. **Conductivity:** Measured with a conductivity meter to estimate ion concentration.

Chemical Analysis Methods

1. **pH Measurement:** Conducted using a digital pH meter. The ideal range for drinking water is 6.5–8.5.

2. **Total Hardness:** Determined by the EDTA titration method to measure calcium and magnesium levels.
3. **Residual Chlorine:** Measured by the DPD colorimetric method to ensure adequate disinfection.
4. **Nitrate and Nitrite:** Estimated by spectrophotometric analysis. High concentrations indicate contamination from fertilizers or sewage.
5. **Fluoride:** Measured using an ion-selective electrode. Safe levels range from 0.5 to 1.5 mg/L.
6. **Arsenic and Heavy Metals (Lead, Mercury, Cadmium):** Detected by Atomic Absorption Spectroscopy (AAS) or Inductively Coupled Plasma Mass Spectrometry (ICP-MS).
7. **Dissolved Oxygen (DO):** Determined by Winkler's titration method. Low DO levels indicate organic pollution.
8. **Biochemical Oxygen Demand (BOD):** Measured after 5 days of incubation at 20°C to assess organic matter content.
9. **Chemical Oxygen Demand (COD):** Estimated using potassium dichromate digestion to measure total oxidizable pollutants.

Biological Analysis Methods

1. **Total Coliform and *E. coli* Tests:** Conducted using the Multiple Tube Fermentation (MTF) or Membrane Filtration (MF) methods.
2. **Bacteriological Plate Count:** Measured the total bacterial population using nutrient agar plates.



3. **Viral Detection:** Polymerase Chain Reaction (PCR) was used to detect viral pathogens such as norovirus and rotavirus.
4. **Protozoan Parasites:** Identified using immunofluorescence microscopy for *Giardia* and *Cryptosporidium*.
5. **Algal Toxins:** Detected using the Enzyme-Linked Immunosorbent Assay (ELISA) method to identify cyanobacterial toxins like microcystins.

Importance of Water Quality Analysis

Water quality analysis ensures that drinking water meets national and international safety standards. Regular testing helps detect pollutants early, evaluate treatment performance, and protect public health. Monitoring physical, chemical, and microbial characteristics provides a complete picture of water safety. In urban areas like Sambalpur, where both natural and human sources affect water quality, such analysis supports decision-making for sustainable management. It also aids in identifying areas that need

infrastructure upgrades and community awareness programs (WHO, 2022).

RESULTS AND DISCUSSION

Physical and Chemical Characteristics of Water Samples

The physical and chemical characteristics of the collected water samples from Sambalpur Municipality were analyzed to assess their suitability for drinking. Eight water samples were collected from different sites: Mahanadi Ghat 1, Mahanadi Ghat 2, Putibandh Pond, PHED Supply Water, Borewell Water, Chaurpur Water, Malti Jor (Govindtola), and RO-treated water. The analysis covered important parameters such as pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO).

Data Interpretation

The test results were compared with the World Health Organization (2022) standards for safe drinking water. The recommended values are summarized below:

Parameter	Acceptable Range	Remarks
pH	6.5 – 8.5	Neutral to slightly alkaline water is ideal
Total Dissolved Solids (TDS)	< 1000 mg/L	Higher values affect taste
Biochemical Oxygen Demand (BOD)	≤ 6 mg/L	Indicates organic pollution
Chemical Oxygen Demand (COD)	≤ 10 mg/L	Represents oxidizable impurities
Dissolved Oxygen (DO)	4 – 6 mg/L	Essential for aquatic health
Chlorine (Residual)	0.2 – 5.0 mg/L	Ensures microbial disinfection

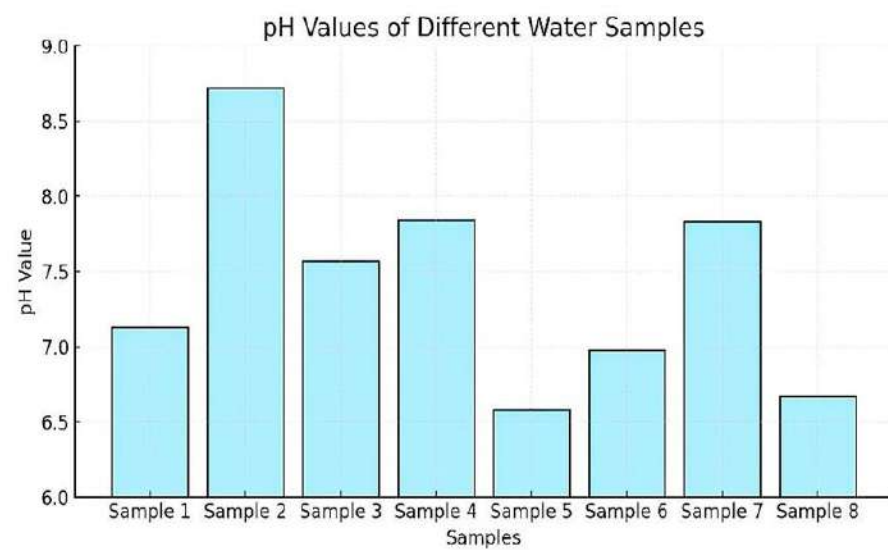
The comparison of these parameters helps determine whether the drinking water in Sambalpur Municipality complies with WHO and BIS guidelines.

Ph

The pH values of the samples ranged between **6.58 and 8.72**. This range indicates that the water varies from slightly acidic to slightly alkaline. According to the **World Health Organization (2022)** and **Bureau of Indian Standards (2012)**, the desirable pH for drinking water lies between **6.5 and 8.5**. Most samples were within this limit, except a few that showed slightly higher values,



which may be attributed to the presence of carbonates and bicarbonates. High pH levels can affect the efficiency of disinfection and cause scale formation in pipelines. Low pH values, on the other hand, may increase corrosion and lead contamination.



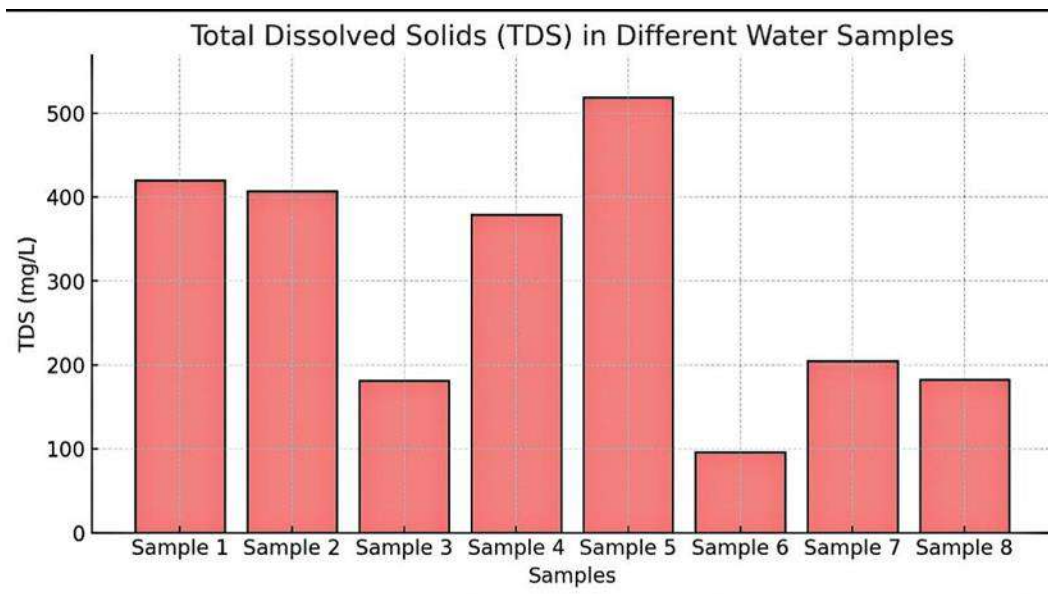
	POND (SAMPLE 1)	MAHANADI 1 (SAMPLE 2)	MAHANADI 2 (SAMPLE 3)	MALTI JOR (SAMPLE 4)	BORE WELL (SAMPLE 5)	RO WATER (SAMPLE 6)	PHD SUPPLY (SAMPLE 7)	CHAURPUR (SAMPLE 8)
TDS	420	407	181	379	519	96	205	183
PH	7.13	8.72	7.75	7.84	6.58	6.98	7.83	6.67
CHLORINE	-	-	-	-	-	-	2PPM (FRC)	-
COD	80	55	48	68	13	-	4	75
BOD	22	18	14	19	2	-	1	18
TEMPERATURE	25.2	30	29	27.8	25	28	27.8	27.2
DO	3.8	4.1	5.5	4.3	5.35	6.4	6.8	6.5
COLOUR	Slightly Muddy	Slightly Muddy	Colorless	Slightly yellowish	Slightly Yellowish	Pure white Water color	Colorless	Colorless
ORDOR	Muddy	Slightly Muddy	Slightly Muddy	Unpleasant	Iron	Neutral	Chlorinated water	Neutral

Total Dissolved Solids (TDS)



TDS concentrations varied between **96 and 519 mg/L**, well within the WHO (2022) limit of **1,000 mg/L** for drinking water. This indicates good overall water quality. Slightly higher TDS levels observed in groundwater sources such as borewells reflect the natural dissolution of

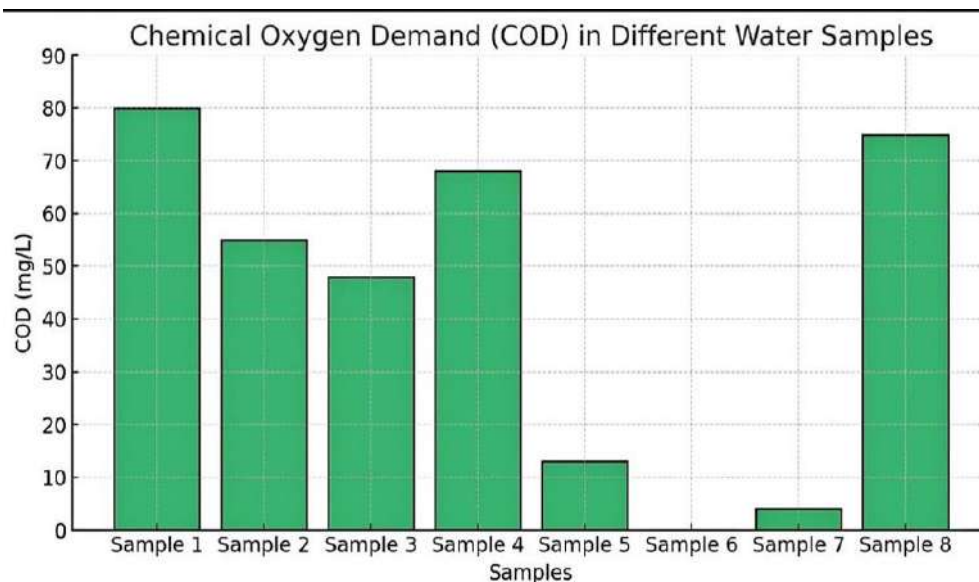
minerals like calcium and magnesium. In contrast, surface water samples, particularly those treated by the municipal system or RO units, showed relatively low TDS, confirming effective treatment and minimal mineral loading.



Chemical Oxygen Demand (COD)

COD values varied between **0 and 80 mg/L**, suggesting differences in organic pollution levels across sites. High COD values, particularly in untreated pond and borewell samples, indicate the presence of organic and inorganic matter such as sewage, detergents, and industrial effluents

(Central Pollution Control Board [CPCB], 2021). In contrast, treated municipal and RO water samples had very low COD levels, showing the effectiveness of purification processes. WHO (2022) recommends COD levels below **10 mg/L** for potable water. Therefore, samples exceeding this threshold are considered polluted and require treatment before consumption.



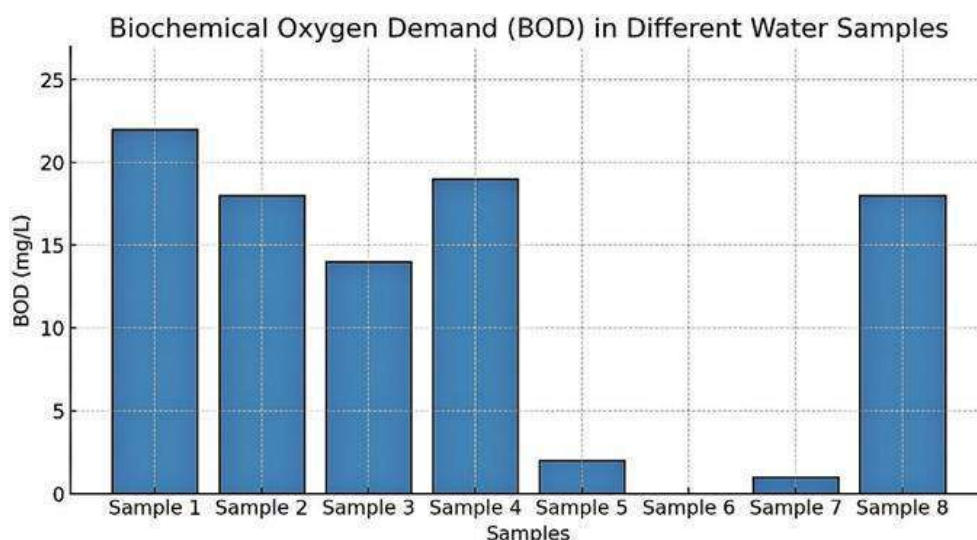
Biochemical Oxygen Demand (BOD)

The BOD of the samples ranged from **0 to 22 mg/L**. This wide variation reflects differences in microbial activity and organic load. A BOD value above **5 mg/L** is an indicator of organic pollution and possible microbial contamination (BIS, 2012). The higher values recorded in untreated pond water and some groundwater sources may result from the decomposition of organic matter and sewage infiltration.

Municipal supply and RO water showed lower BOD, indicating effective disinfection and minimal microbial activity. However, the high BOD in some samples suggests the need for regular chlorination and maintenance of distribution pipelines

Biochemical Oxygen Demand (BOD)

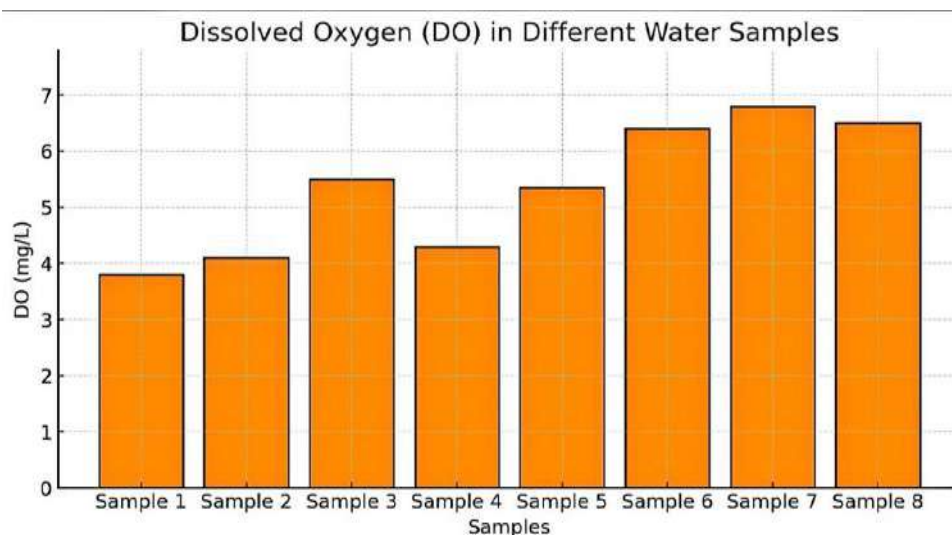
The BOD values ranged from 0 to 22 mg/L, showing significant variation among sampling sites. Values exceeding 6 mg/L (WHO standard) reflect high organic pollution and potential microbial activity. Elevated BOD levels were observed in samples from ponds and borewells, likely due to sewage infiltration and organic matter decomposition. Low BOD values (0–3 mg/L) in municipal and RO-treated water confirmed effective purification and reduced microbial load. Persistent high BOD in some areas underscores the need for regular chlorination and pipeline maintenance to prevent contamination.



Dissolved Oxygen (DO)

DO levels in the samples ranged from 3.8 to 6.8 mg/L, showing variability depending on source type and treatment level. WHO (2022) recommends a DO concentration between 4 and 6 mg/L for good-quality water. Samples with DO

levels below 4 mg/L indicate oxygen depletion, often caused by organic decomposition and limited aeration, while higher DO levels reflect clean, well-aerated water. The relatively high DO in municipal supply and RO-treated samples indicates effective treatment and minimal organic pollution.



Overall Water Quality Assessment

The analysis of physical and chemical parameters indicates that most treated water samples from the municipal supply and RO units meet WHO and BIS standards. However, samples from untreated sources, especially ponds and borewells, show

deviations in BOD, COD, and DO values, suggesting localized contamination. The average TDS and pH levels indicate acceptable drinking quality, but high organic load in some samples reflects the influence of human activities such as domestic waste disposal and agricultural runoff. The presence of moderate turbidity and elevated

organic matter during the monsoon season can be linked to increased sediment flow from catchment areas. High BOD and COD values are particularly concerning, as they point to possible sewage leakage and improper waste disposal in some parts of the city. Similar findings were reported by Roy

et al. (2023), who observed that organic pollution in surface water increases during rainfall due to runoff from surrounding settlements.

The comparison of parameters with WHO standards is summarized below:

Parameter	Observed Range	WHO Standard	Remarks
pH	6.58 – 8.72	6.5 – 8.5	Within safe limit (some slightly alkaline)
TDS	96 – 519 mg/L	< 1000 mg/L	Safe for consumption
BOD	0 – 22 mg/L	≤ 6 mg/L	High in some samples
COD	0 – 80 mg/L	≤ 10 mg/L	Indicates organic pollution
DO	3.8 – 6.8 mg/L	4 – 6 mg/L	Satisfactory to good

Overall, the findings suggest that water quality in Sambalpur Municipality is **moderately good** but requires attention to **organic pollution control** and **microbial safety**. Continuous monitoring is necessary to prevent health risks and ensure safe drinking water supply throughout the year.

Microbial Contamination and Health Risk

Indications of Microbial Contamination

High BOD and COD values observed in certain samples imply the presence of microbial growth and organic pollution. Microorganisms thrive in oxygen-deficient environments with abundant organic nutrients. Areas where BOD exceeded 10 mg/L and DO dropped below 5 mg/L are particularly susceptible to microbial proliferation (WHO, 2022). These results indicate potential contamination by domestic wastewater or leaching from septic tanks. Water from open ponds and borewells near populated zones are particularly vulnerable. The detection of coliform bacteria in earlier municipal reports also supports this finding (Government of Odisha, 2024).

Potential Microbial Contaminants

Microbial contamination is generally caused by bacteria, viruses, and protozoa that enter water

sources through fecal matter or waste discharge. Common pathogens include:

- ***Escherichia coli (E. coli)***: Indicates fecal contamination and causes diarrhea and urinary infections.
- ***Vibrio cholerae***: Causes cholera, a severe waterborne disease common in contaminated surface water.
- ***Salmonella typhi***: Leads to typhoid fever and gastrointestinal distress.
- ***Giardia* and *Cryptosporidium***: Protozoan parasites responsible for prolonged diarrhea and dehydration.
- ***Noroviruses* and *Hepatitis A virus***: Viral pathogens transmitted through contaminated drinking water (WHO, 2022).

The presence of any of these organisms indicates unsafe water and requires immediate disinfection and source correction.

Health Risks

Microbial contamination in drinking water poses severe health threats. Consumption of such water can result in acute diseases like diarrhea,



dysentery, cholera, and jaundice. Infants, elderly individuals, and immunocompromised people are at higher risk. According to WHO (2022), around 485,000 deaths occur each year globally due to diarrheal diseases caused by contaminated drinking water. In Sambalpur, the high BOD and COD values observed in certain sites raise concerns about potential microbial contamination. If consumed without treatment, such water can lead to gastrointestinal disorders, dehydration, and long-term health complications. Prolonged exposure to contaminated water also increases vulnerability to chronic diseases due to secondary infections. Hence, the water from non-treated sources like ponds and borewells should always undergo filtration and disinfection before use.

DISCUSSION

The overall findings show that while Sambalpur's treated municipal water meets most international standards, localized contamination in untreated sources persists. The results highlighted that groundwater and surface water in Indian towns often exceed safe biological limits due to inadequate sanitation and old infrastructure. High BOD and COD levels in some samples indicate direct sewage intrusion and insufficient treatment of wastewater. Such contamination not only affects water safety but also damages the city's distribution pipelines through corrosion and microbial biofilm formation. The slightly high pH values in a few samples may be due to the presence of carbonate and bicarbonate ions derived from limestone and cement pipes. Similarly, moderate TDS values indicate the dissolution of natural minerals, which does not pose a health risk but may influence water taste. The DO values within the 4–6 mg/L range suggest that the municipal treatment system provides adequate aeration. However, the water quality downstream of residential areas shows oxygen depletion,

confirming organic pollution from domestic discharge. These findings suggest that periodic cleaning of storage tanks, chlorination of distribution pipelines, and maintenance of water treatment plants are essential. Moreover, public awareness on household-level purification (boiling, filtration, or chlorination) is necessary to minimize health risks.

Summary

The results of this study show that:

- The pH and TDS levels of drinking water in Sambalpur are within acceptable limits.
- High BOD and COD values in some sources indicate organic pollution and microbial activity.
- Dissolved oxygen levels are moderate, reflecting partial oxygen depletion in polluted sites.
- Untreated water sources like ponds and borewells are not safe for direct consumption.
- Treated municipal and RO water meet the WHO and BIS standards and are suitable for drinking.

Therefore, regular monitoring, efficient treatment, and public awareness are crucial to maintaining safe water quality in Sambalpur Municipality.

CONCLUSION

This study evaluated the physicochemical and microbiological quality of drinking water in the Sambalpur Municipality area of Odisha, India. The analysis incorporated key parameters such as pH, total dissolved solids (TDS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and dissolved oxygen (DO), in accordance with



the guidelines of the World Health Organization (WHO) and the Bureau of Indian Standards (BIS).

The findings indicate that most treated water sources, particularly the municipal supply and RO-treated samples, meet national and international standards for potable water. However, untreated sources especially ponds and borewells showed elevated levels of BOD and COD, reflecting organic pollution and potential microbial contamination. These deviations can be attributed to sewage infiltration, industrial discharge, and runoff from urban and agricultural zones.

The observed pH and TDS values remained within acceptable limits, suggesting chemical stability and suitability for consumption. Nevertheless, the presence of organic and microbial pollutants in certain areas highlights the vulnerability of the water distribution system, particularly due to aging pipelines, leakages, and inadequate chlorination. Seasonal factors such as monsoon-induced turbidity further exacerbate the problem by introducing suspended solids and nutrients that promote microbial growth.

To ensure sustained water safety in Sambalpur, the following measures are recommended:

1. **Regular Monitoring:** Continuous testing of physicochemical and microbial parameters at multiple points in the supply network to detect contamination early.
2. **Infrastructure Upgradation:** Replacement of old and corroded pipelines, installation of smart meters, and reduction of non-revenue water to improve efficiency.
3. **Treatment Enhancement:** Optimization of chlorination and filtration processes, particularly during monsoon seasons when turbidity increases.

4. **Public Awareness:** Promotion of safe water-handling practices, household filtration, and conservation awareness under initiatives such as *Jal Jeevan Mission* and *Swachh Bharat Abhiyan*.

5. **Policy and Institutional Support:** Strengthening coordination between municipal authorities, PHED, and pollution control agencies for integrated water resource management.

Overall, Sambalpur's treated municipal water can be considered safe for consumption; however, periodic quality checks, infrastructure modernization, and community engagement are crucial to achieving the long-term goal of universal access to clean and safe drinking water.

Author Contributions

PMB Collection of Sample; PKS laboratory work, figure, table preparation, manuscript writing, review and correspondence.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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