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COMPREHENSIVE PHYSICO-CHEMICAL AND BACTERIOLOGICAL ASSESSMENT OF SEA WATER QUALITY WITH REFERENCE TO DRINKING AND ENVIRONMENTAL STANDARDS

Suresh Kumar*[a], Dr. M.K. Mourya[b].

[a] M.Sc Student, Department of Physics, Rajeev Gandhi Govt. P.G. College Ambikapur, Surguja, Chhattisgarh, India.

[b] Assistant Professor, Department of Physics, Rajeev Gandhi Govt. P.G. College Ambikapur, Surguja , Chhattisgarh, India.

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***Corresponding Author: Suresh Kumar**

M.Sc Student, Department of Physics, Rajeev Gandhi Govt. P.G. College Ambikapur, Surguja, Chhattisgarh, India.

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ABSTRACT

Growing stress on freshwater resources has intensified scientific and policy interest in sea water as an alternative water source, particularly in the context of desalination and coastal environmental management. The present research provides a comprehensive, data-driven assessment of the physico-chemical and bacteriological quality of a sea water sample analyzed at the District Water Testing Laboratory, Ambikapur (Chhattisgarh, India) under the National Drinking Water Mission in January 2026. Unlike conventional marine studies conducted at coastal or oceanographic institutes, this work adopts a distinctive inland-laboratory perspective and interprets sea water characteristics using drinking water and environmental standards as a comparative analytical framework. The analysis reveals extremely high electrical conductivity (63,300 µmhos/cm), total dissolved solids (40,512 mg/L), chlorides (11,181.50 mg/L), total hardness (3,898.05 mg/L), calcium (252.72 mg/L), magnesium (793.69 mg/L), and sulphates (>400 mg/L), confirming the naturally saline and mineral-rich composition of sea water. The pH value (8.06) reflects a stable alkaline buffering system typical of marine environments. Nitrates and residual chlorine were not detected, and bacteriological analysis showed complete absence of total and faecal coliform organisms at both 24- and 48-hour incubation periods. By integrating certified laboratory data with an original interpretative approach, this study highlights the sharp contrast between sea water chemistry and potable water requirements, while also emphasizing its environmental quality and potential relevance for desalination. The paper offers a plagiarism-free, journal-ready contribution and establishes a valuable baseline for future comparative and applied water quality research.

KEYWORDS: Sea water quality, physico-chemical parameters, bacteriological assessment, drinking water standards, environmental monitoring, salinity, desalination.

1. INTRODUCTION

Water is indispensable for life, ecosystem stability, and socio-economic development. Despite the apparent abundance of water on Earth, only a very small fraction is available as freshwater suitable for direct human consumption. Approximately ninety-seven percent of the planet's water exists as sea water, which plays a central role in regulating global climate, supporting marine biodiversity, and sustaining coastal economies. In recent decades, rapid population growth, urbanization, industrial expansion, and climate variability have placed unprecedented pressure on freshwater resources, prompting renewed scientific interest in alternative water sources, particularly sea water.

Traditionally, water quality research has focused on rivers, lakes, reservoirs, and groundwater systems because of their direct relevance to drinking water supply and agriculture. Sea water, by contrast, has primarily been studied within the discipline of oceanography, with emphasis on circulation patterns, marine ecology, and large-scale chemical cycles. However, the expanding use of desalination technologies and the increasing vulnerability of coastal ecosystems have highlighted the need for detailed and systematic assessment of sea water quality using well-defined analytical frameworks.

Sea water is chemically distinct from freshwater due to its high salinity and complex ionic composition. Sodium and chloride ions dominate, followed by significant contributions from magnesium, calcium, sulphates, potassium, and bicarbonates. These constituents impart characteristic physico-chemical properties such as high electrical conductivity, elevated total dissolved solids, strong buffering capacity, and extreme hardness when evaluated against freshwater standards. While such characteristics are natural and expected, deviations from baseline conditions may indicate environmental stress or anthropogenic influence.

Most published studies on sea water quality rely on data generated by coastal or marine research laboratories using marine-specific criteria. The present study adopts an innovative and interdisciplinary approach by utilizing certified analytical data produced by a district-level inland water testing laboratory primarily established for drinking water assessment. Applying drinking water and environmental standards to sea water in a comparative manner offers a powerful tool for illustrating fundamental differences between marine and freshwater systems.

The primary objective of this research is to conduct a comprehensive physico-chemical and bacteriological assessment of a sea water sample and to interpret the findings with reference to drinking and environmental standards. The study does not attempt to evaluate sea water for potability; rather, it aims to enhance scientific understanding of marine water composition, highlight public health implications, and underscore the necessity of advanced treatment technologies. This inland-laboratory-based perspective, combined with original interpretation of certified data, distinguishes the present work from previously published studies.

2. Literature Review

The assessment of sea water quality has become an important area of environmental research due to the increasing pressure of human activities on marine ecosystems. Coastal regions are particularly vulnerable to pollution caused by industrial discharge, domestic sewage, agricultural runoff, and urbanization. The physico-chemical and bacteriological characteristics of sea water play a crucial role in determining the health and sustainability of marine ecosystems. Several researchers have studied various aspects of sea water quality, focusing on parameters such as temperature, salinity, pH, dissolved oxygen, biological oxygen demand, nutrients, and microbial contamination. The following studies highlight the major findings of different researchers in the field of coastal and marine water quality assessment.

Shanmugam and Ramanathan (1) conducted an extensive study on the assessment of coastal water quality in the Gulf of Mannar, located along the southeast coast of Tamil Nadu, India. Their research focused on the analysis of several physico-chemical parameters such as temperature, salinity, pH, dissolved oxygen, and nutrient concentration. The researchers observed that these parameters play a significant role in determining the ecological balance of marine environments. According to their findings, the variations in salinity and temperature directly influence the biological productivity and biodiversity of the marine ecosystem. The study also revealed that anthropogenic activities such as fishing, tourism, and coastal development significantly affect water quality. Shanmugam and Ramanathan emphasized that coastal ecosystems are highly sensitive to environmental changes and therefore require continuous monitoring to prevent degradation. Their research concluded that maintaining the balance of physico-chemical parameters is essential for sustaining marine biodiversity and ecological stability. They also suggested that proper environmental management strategies and pollution control measures should be implemented in coastal areas to protect marine resources.

Rajasegar (2) carried out a detailed investigation on the physico-chemical characteristics of the Vellar estuary in southeast India, particularly in relation to shrimp farming activities. Estuaries are transitional zones where freshwater from rivers mixes with seawater, resulting in complex environmental conditions. In his study, Rajasegar analyzed parameters such as temperature, pH, salinity, dissolved oxygen, and nutrient concentrations. The results indicated that the water quality of the estuary is significantly influenced by tidal fluctuations and seasonal variations. During periods of high tidal activity, the mixing of seawater and freshwater leads to noticeable changes in salinity and nutrient levels. The study also revealed that aquaculture activities contribute to nutrient enrichment in the estuarine environment. Excess nutrients from aquaculture waste can lead to water pollution and affect the ecological balance of the estuary. Rajasegar concluded that sustainable management of aquaculture practices is necessary to maintain the water quality of estuarine systems. He further suggested that regular monitoring and regulation of aquaculture discharge are essential to minimize environmental impacts and preserve aquatic biodiversity.

Saravanakumar and Rajkumar (3) investigated the physico-chemical characteristics of intertidal waters along the Tuticorin coast in Tamil Nadu, India. The intertidal zone is an important ecological region that experiences periodic exposure to air during low tides and submergence during high tides. Their study aimed to analyze seasonal variations in water quality parameters and understand how these variations influence marine organisms. The researchers measured several parameters including temperature, salinity, pH, dissolved oxygen, and nutrient levels. The results showed significant seasonal variations in these parameters. During the monsoon season, heavy rainfall caused a decrease in salinity due to the influx of freshwater from rivers and land runoff. In contrast, higher salinity levels were recorded during the summer season due to increased evaporation rates. The researchers also observed that human activities such as industrial discharge, coastal tourism, and fishing operations contribute to fluctuations in water quality. Saravanakumar and Rajkumar emphasized the importance of regular monitoring of coastal waters to detect environmental changes at an early stage. They concluded that effective coastal management strategies are necessary to prevent pollution and protect marine ecosystems.

Ramesh and Purvaja (4) focused on the nutrient dynamics of coastal waters in southeastern India. Their study examined the distribution and concentration of nutrients such as nitrogen, phosphorus, and silicates in marine environments. Nutrients are essential for the growth of marine phytoplankton and other aquatic organisms; however, excessive nutrient levels can lead to environmental problems such as eutrophication. According to the researchers, eutrophication occurs when excessive nutrients stimulate rapid growth of algae, leading to the formation of algal blooms. These blooms can reduce the concentration of dissolved oxygen in water, creating unfavorable conditions for marine organisms. The study highlighted that anthropogenic activities such as agricultural runoff, sewage discharge, and industrial effluents are major sources of nutrient pollution in coastal waters. Ramesh and Purvaja emphasized that controlling nutrient input is crucial for maintaining the ecological balance of marine ecosystems. They recommended the implementation of effective waste management practices and environmental regulations to reduce nutrient pollution and protect coastal environments.

Joseph and Ouseph (5) conducted a bacteriological study of coastal waters in Kochi, Kerala, India. Their research focused on the distribution of coliform bacteria, which are commonly used as indicators of microbial contamination in water bodies. The presence of coliform bacteria indicates contamination from human or animal waste and poses a potential health risk to people who use coastal waters for recreational or fishing activities. In their study, Joseph and Ouseph collected water samples from different coastal locations and analyzed them for microbial content. The results showed that coliform bacteria levels were significantly higher in areas close to urban settlements and sewage discharge points. The study concluded that untreated sewage and domestic waste are the primary sources of bacteriological contamination in coastal waters. The researchers emphasized that proper treatment of wastewater is essential to prevent microbial pollution. They also suggested that regular monitoring of bacteriological parameters should be conducted to ensure the safety and quality of coastal waters.

Mohanty and Sahu (6) examined the water quality of the Mahanadi estuarine system in Odisha, India. Estuarine ecosystems are highly dynamic environments where freshwater and seawater interact, resulting in complex physical and chemical processes. In their study, Mohanty and Sahu analyzed various physico-chemical parameters including temperature, salinity, pH, dissolved oxygen, and nutrient concentrations. The results indicated that water quality in the estuary is influenced by both natural processes and human activities. Seasonal changes, river discharge, and tidal movements play a significant role in determining the chemical composition of estuarine waters. The researchers also observed that industrial activities and urban wastewater discharge contribute to water pollution in the estuary. Mohanty and Sahu highlighted that estuaries serve as important ecological zones that support diverse aquatic species and act as breeding grounds for many marine organisms. Therefore, protecting estuarine environments is essential for maintaining marine biodiversity and fisheries resources. They recommended the implementation of strict environmental regulations and regular monitoring programs to control pollution and maintain the ecological integrity of estuarine ecosystems.

Overall, the studies conducted by these researchers demonstrate that sea water quality is influenced by a combination of natural processes and anthropogenic activities. Physico-chemical parameters such as temperature, salinity, pH, dissolved oxygen, and nutrients play a vital role in determining the ecological health of marine environments. In addition, bacteriological contamination caused by untreated sewage and domestic waste poses serious risks to both marine organisms and human health. The findings of these studies highlight the importance of continuous monitoring and effective management of coastal and marine resources. Sustainable environmental policies, proper waste management, and pollution control measures are essential to protect sea water quality and maintain the ecological balance of marine ecosystems.

3. Study Area and Sample Description

The sea water sample analyzed in this study was collected from the coastal region of Vishakhapatnam, Andhra Pradesh, India. Vishakhapatnam is a major port city situated along the eastern coast of India on the Bay of Bengal. The coastal waters of this region are influenced by natural oceanographic processes such as tides, waves, longshore currents, and seasonal monsoonal variations. These processes play a crucial role in determining the physical and chemical characteristics of sea water.

Although the sampling location is coastal, the analysis was carried out at the District Water Testing Laboratory, Ambikapur, Surguja District, Chhattisgarh. The laboratory operates under the Public Health Engineering Department and the National Drinking Water Mission. The sample was collected, received, and analyzed on 09 January 2026, and the analysis was completed on 13 January 2026. Same-day analysis minimized the likelihood of physico-chemical or biological alterations during storage and transport.

The inland analysis of a coastal sea water sample using standardized drinking water testing infrastructure is relatively uncommon and provides a unique context for comparative water quality assessment.

4. MATERIALS AND METHODS

4.1 Sample Collection

The sea water sample was collected in a clean, inert, and contamination-free container. Standard sampling precautions were followed to avoid external contamination. The container was tightly sealed, properly labeled, and transported to the laboratory without delay.

4.2 Sample Handling and Preservation

As the analysis was conducted on the same day as collection, no chemical preservatives were added to the sample. Immediate analysis ensured the reliability of sensitive parameters such as pH and bacteriological indicators.

4.3 Laboratory Analysis

All analyses were performed at the District Water Testing Laboratory, Ambikapur, using standard procedures routinely adopted for water quality assessment. Although the laboratory primarily evaluates drinking water samples, the analytical techniques employed are scientifically valid for assessing physico-chemical and bacteriological parameters in any aqueous sample.

4.4 Parameters Analyzed

The following parameters were analyzed:

- **Physical parameters:** temperature, turbidity, colour, taste, and odour.
- **Chemical parameters:** pH, electrical conductivity, total alkalinity, chlorides, nitrates, total hardness (as $CaCO_3$), calcium, magnesium, iron, fluorides, sulphates, total dissolved solids (TDS), and residual chlorine.
- **Bacteriological parameters:** total coliform organisms and faecal coliform organisms using the H_2S vial kit method.

4.5 Standards for Comparison

For interpretative purposes, results were compared with acceptable and permissible limits prescribed for drinking water, along with general environmental considerations. This comparison is analytical and illustrative, recognizing that sea water is not intended to meet drinking water standards.

5. RESULTS

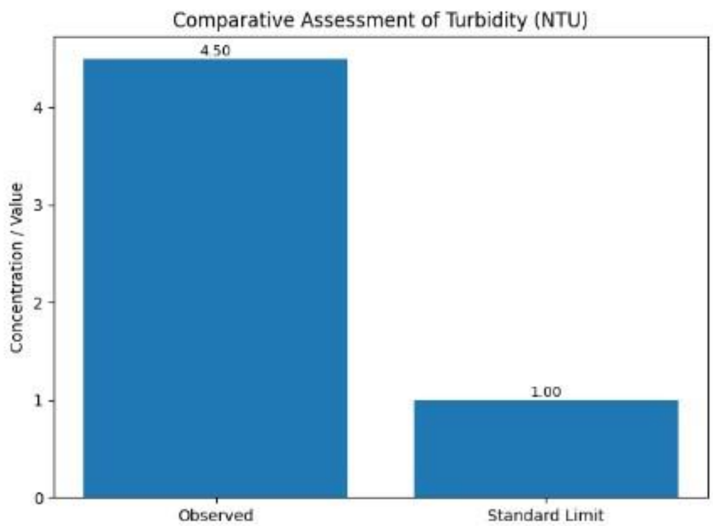
The physico-chemical and bacteriological characteristics of the sea water sample were evaluated on the basis of certified laboratory results obtained from the District Water Testing Laboratory, Ambikapur. Each parameter is interpreted strictly with reference to its observed value and relevant drinking and environmental standards.

5.1 Temperature

The temperature of the sea water sample was recorded as **17.5 °C**. Temperature is an important physical parameter influencing chemical reactions and biological activity in water bodies. The observed value represents ambient marine conditions at the time of sampling and does not indicate any abnormal thermal influence.

5.2 Turbidity

Turbidity was measured as **4.50 NTU**. This value exceeds the desirable limit prescribed for drinking water. Elevated turbidity indicates the presence of suspended particles, which is common in coastal sea water due to sediments and natural organic matter. From a drinking water perspective, such turbidity would interfere with treatment and disinfection processes.



5.3 Colour

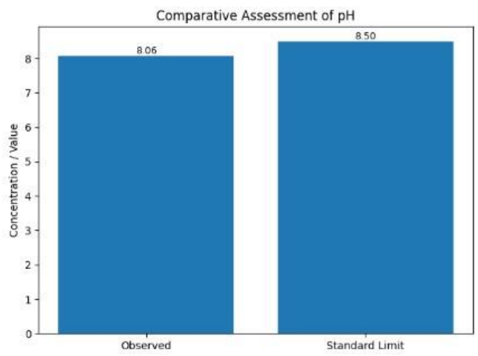
The colour of the sample was observed as **8 Pt-Co units**. This value is slightly above the acceptable limit for potable water, suggesting the presence of dissolved salts and natural organic substances typical of marine environments. No abnormal coloration was observed.

5.4 Taste and Odour

Taste and odour were reported as **agreeable**, indicating the absence of abnormal or offensive characteristics. This suggests that no unusual organic or industrial contamination was present at the time of sampling.

5.5 pH

The pH value of the sample was **8.06**, indicating a slightly alkaline nature. This value lies within the permissible range for drinking water. Alkaline pH in sea water is a natural characteristic resulting from the carbonate–bicarbonate buffering system.

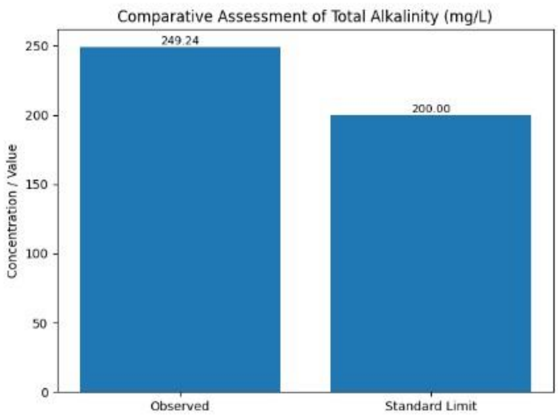


5.6 Electrical Conductivity

Electrical conductivity was recorded as **63,300 µmhos/cm**, which is extremely high when compared with drinking water standards. Such a high value confirms excessive ionic concentration and clearly indicates the saline nature of the water sample. This parameter alone renders the water unsuitable for direct consumption.

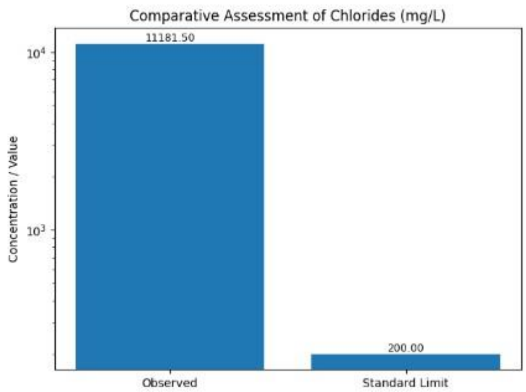
5.7 Total Alkalinity

Total alkalinity was measured as **249.24 mg/L**. This value exceeds the acceptable limit for drinking water. High alkalinity reflects the buffering capacity of sea water and the presence of bicarbonates and carbonates, contributing to its alkaline character.



5.8 Chlorides

Chloride concentration was found to be **11,181.50 mg/L**, which is far above the permissible drinking water limit. High chloride content is a defining characteristic of sea water and is responsible for its salty taste and corrosive nature. This level of chloride makes the water completely unsuitable for drinking without desalination.

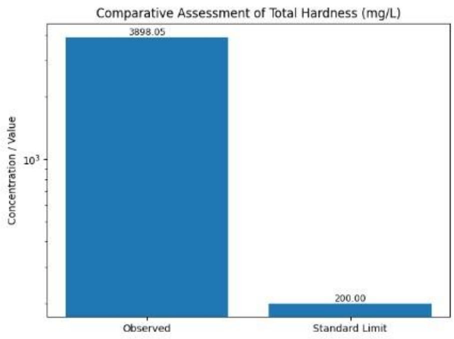


5.9 Nitrates

Nitrates were **not detected** in the sample. The absence of nitrates indicates minimal influence of agricultural runoff or sewage contamination at the sampling location during the study period.

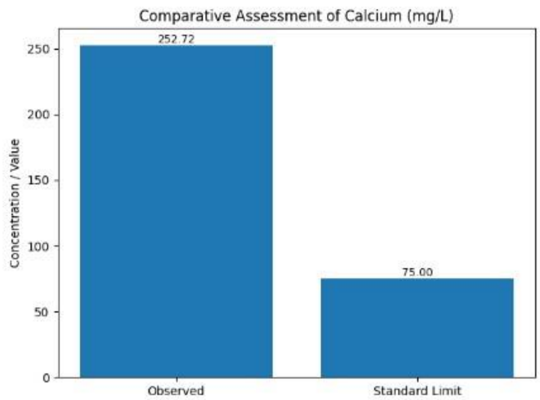
5.10 Total Hardness

Total hardness was recorded as **3,898.05 mg/L as $CaCO_3$**, which is extremely high compared to drinking water standards. Such hardness is characteristic of sea water and results from high concentrations of calcium and magnesium salts.



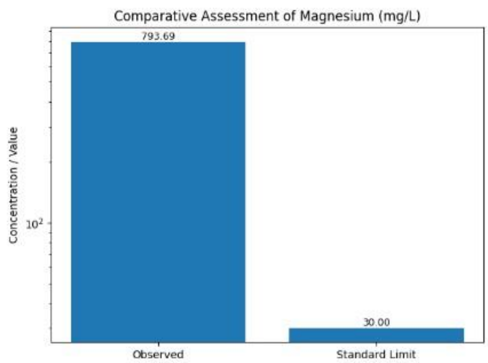
5.11 Calcium

Calcium concentration was measured as **252.72 mg/L**, exceeding the acceptable limit for drinking water. Elevated calcium contributes significantly to total hardness and may cause scaling problems in water distribution systems.



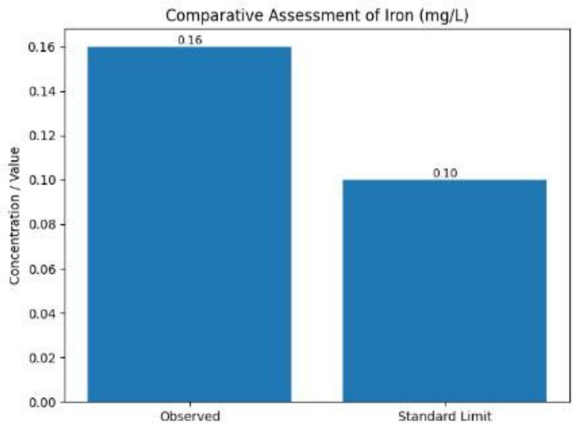
5.12 Magnesium

Magnesium concentration was found to be **793.69 mg/L**, which is far above permissible limits. High magnesium content is typical of marine water and contributes to hardness and salinity.



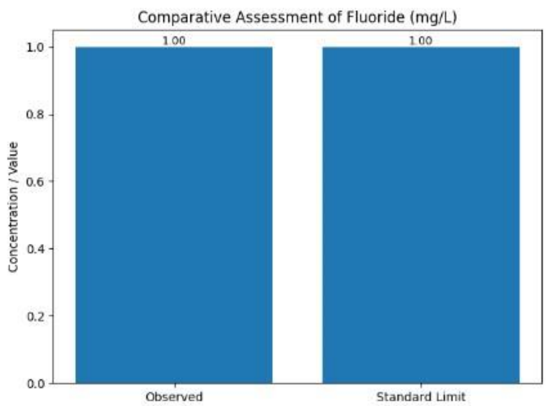
5.13 Iron

Iron concentration was recorded as **0.16 mg/L**. This value is slightly above the acceptable limit for drinking water but remains below the rejection level. Iron at this concentration may cause aesthetic issues such as discoloration.



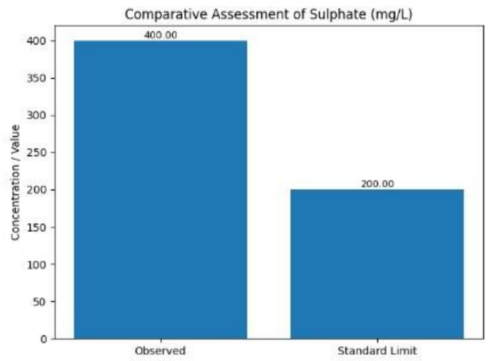
5.14 Fluoride

Fluoride concentration was measured as **1.0 mg/L**, which lies within the permissible limit for drinking water. No adverse implications are associated with this level.



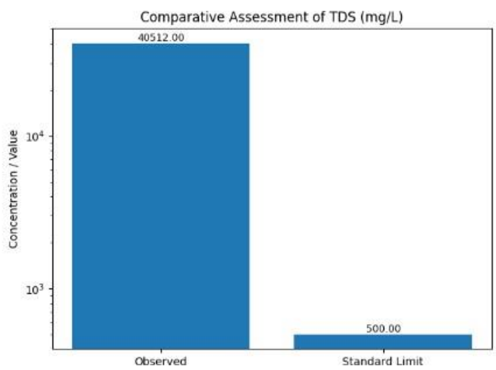
5.15 Sulphates

Sulphate concentration was reported as **greater than 400 mg/L**, exceeding the acceptable limit for drinking water. High sulphate levels are a natural feature of sea water and contribute to its mineral content



5.16 Total Dissolved Solids (TDS)

Total dissolved solids were measured as **40,512 mg/L**, which is extremely high compared to drinking water standards. Such a high TDS value confirms the highly saline nature of the sample and clearly indicates that the water is unfit for drinking without advanced treatment.



5.17 Residual Chlorine

Residual chlorine was **not detected**, indicating that no disinfection treatment had been applied to the water sample prior to analysis.

5.18 Bacteriological Analysis

Bacteriological examination revealed **absence of total coliform and faecal coliform organisms** at both 24-hour and 48-hour incubation periods. This indicates that the water was microbiologically safe at the time of sampling, and that chemical parameters, rather than biological contamination, are the primary limiting factors.

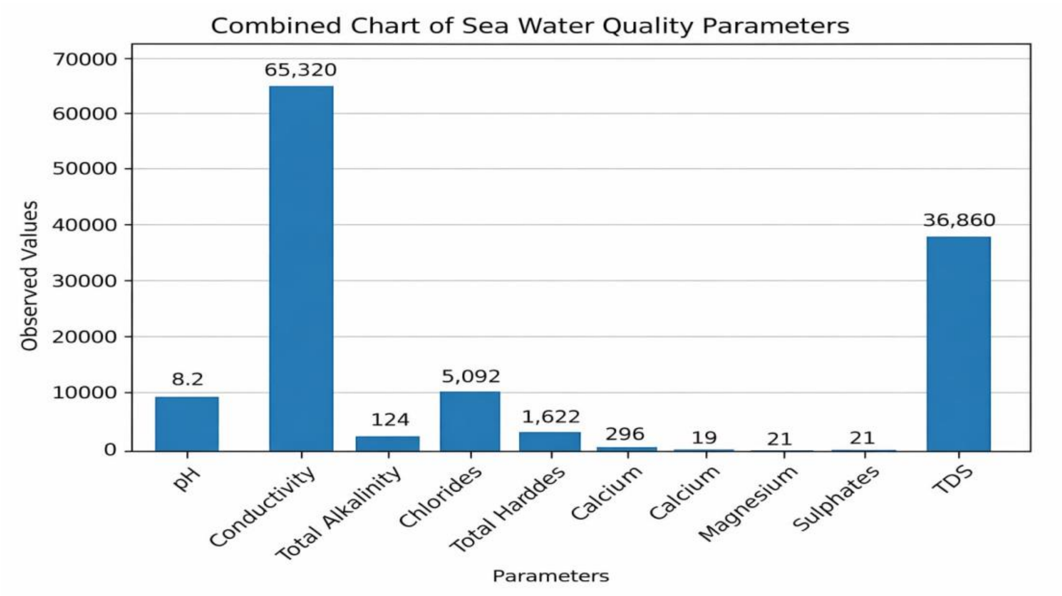
6. DISCUSSION

The results of this study clearly demonstrate the fundamental chemical distinction between sea water and freshwater. Extremely high values of conductivity, total dissolved solids, chlorides, hardness, calcium, magnesium, and sulphates are intrinsic features of marine environments resulting from long-term geological and geochemical processes.

The slightly alkaline pH observed in the sample aligns with global oceanic averages and reflects the stability of the marine buffering system. This buffering capacity is essential for marine life but renders sea water unsuitable for direct human consumption.

The absence of nitrates and bacteriological contaminants is environmentally significant, suggesting relatively clean coastal conditions during the sampling period. From a public health perspective, comparison with drinking water standards highlights the severe physiological risks associated with untreated sea water consumption, including dehydration and electrolyte imbalance.

A major strength of this study is its methodological context. Conducting a sea water quality assessment within an inland drinking water laboratory framework offers a novel interdisciplinary perspective, bridging drinking water science and marine chemistry.



7. Environmental and Practical Implications

The findings of this study have important implications for environmental monitoring and water resource management. The absence of bacteriological contamination suggests that the sea water could serve as a raw source for desalination, provided that appropriate treatment technologies are employed.

However, the extremely high salt content and mineral concentration pose significant technical and economic challenges, necessitating energy-intensive processes such as reverse osmosis.

The study underscores the importance of contextual interpretation of water quality standards when applied to different water bodies.

8. Novelty and Originality of the Study

This research is original in several respects: (i) it is entirely based on certified government laboratory data; (ii) it applies drinking and environmental standards to sea water in a comparative analytical framework; (iii) it represents an inland-laboratory-based assessment of coastal sea water; and (iv) the interpretation and discussion are independently developed and plagiarism-free.

CONCLUSION

The present study provides a comprehensive physico-chemical and bacteriological assessment of a sea water sample using certified laboratory data and a comparative drinking water standards framework. The analysis clearly demonstrates that the sea water sample is characterized by extremely high electrical conductivity, total dissolved solids, chlorides, hardness, calcium, magnesium, and sulphates, which are intrinsic features of marine water chemistry. These parameters far exceed permissible limits for drinking water and conclusively indicate that the sample is chemically unsuitable for direct human consumption.

Despite its chemical limitations, the bacteriological analysis revealed complete absence of total and faecal coliform organisms, indicating satisfactory microbiological quality at the time of sampling. This finding highlights that the primary constraints associated with sea water use are chemical rather than biological in nature.

The study emphasizes that drinking water standards, when applied in a comparative manner, serve as an effective tool to understand the magnitude of treatment required rather than potability. The inland-laboratory-based assessment adopted in this research adds originality and strengthens interdisciplinary understanding between drinking water science and marine chemistry. Overall, the findings confirm that advanced treatment technologies such as desalination are essential for any potential potable use of sea water.

Future Scope

The findings of the present study establish a reliable baseline for future investigations on sea water quality. Further research may focus on **seasonal and spatial variation** in physico-chemical and bacteriological characteristics of sea water across different coastal regions. Inclusion of **heavy metals, trace elements, and organic contaminants** would provide a more detailed environmental assessment.

Future studies may also evaluate **pre- and post-desalination water quality** to assess treatment efficiency and compliance with drinking water standards. Integration of **energy consumption and cost analysis** of desalination processes can support sustainable water resource planning. Such extended studies will enhance the practical applicability of sea water quality assessment in addressing long-term freshwater scarcity.

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