Comparative Assessment of Physico-Chemical and Microbiological Characteristics of Water Sources in Kanyakumari, Thoothoor and Trivandrum

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Abstract
Coastal ecosystems serve as productive ecosystems with numerous services both ecologically and socio-economically. However, anthropogenic activities have led to degradation in the quality of seawater. The objective of this paper is to compare the physicochemical and microbiological qualities of seawater from Trivandrum (Kerala), Kanyakumari, and Thoothoor (Tamil Nadu), India. Physicochemical and microbiological analysis was carried out on the selected parameters using the APHA standards for seawater. It has been observed that there were some significant spatial differences among these three coastal zones. Kanyakumari showed high levels of total hardness and fluoride levels, whereas Kerala had high levels of phosphate and sulphate concentrations, and Thoothoor had high levels of potassium concentration. Escherichia coli, coliform bacteria, sulphite reducing anaerobes, Pseudomonas aeruginosa and yeasts/moulds proved the presence of microbial contamination due to anthropogenic activities.

Keywords: Anthropogenic activities, coastal ecosystems, microbiological analysis, seawater quality, socio-economic services

1. Introduction

Water is one of the most critical natural resources that have an integral contribution towards life-sustenance and balancing of ecological systems. Marine and coastal habitats are amongst the most productive and biologically diverse ecosystems in the world which support various ecological processes, offer many economic and social benefits (Ayyam et al., 2019). Such ecosystems help immensely in supporting various processes such as fishery production, nutrient recycling, biodiversity preservation, transportation and tourism activities among others. Ecological sustainability of marine and coastal ecosystems is highly dependent upon the quality of the water in the surrounding environment. Apart from supporting ecological sustainability, the quality of coastal waters has an immense impact on the well-being of the human population living in the area.. The marine environment provides an essential role in fisheries, recreational and tourism endeavors, while the presence of microorganisms in the water can be potentially hazardous for the health of humans, either through their direct contact or by means of consuming marine resources. Hence, it is vital to monitor seawater quality on a constant basis.

Coastal water bodies form dynamic systems that are affected by the interplay of various factors. The fast pace of urbanization, industrialization, population increase, tourism infrastructure development, and greater usage of coastal areas has resulted in increasing stress on the marine ecosystem in the last few decades (Maheriya and Patel, 2025). The coastal water has become increasingly polluted through sewage pollution, industrial effluents, agricultural run-off, port activities, tourism pollution, and solid waste pollution. Such pollution can have an impact on the character of the aquatic ecosystem. As a result, the knowledge of the condition of coastal water quality becomes relevant in the context of managing marine ecosystems sustainably.

Physical and chemical parameters offer important details related to the state of the environment and ecology of aquatic ecosystems. Parameters such as pH, chloride, alkalinity, sulphate, nitrate, dissolved oxygen, and salinity are commonly used for evaluating the state of water and detecting any changes in the environment (Nayar, 2020). These parameters represent the chemistry of water and affect various biological and geochemical processes taking place in the marine ecosystem. Variations in the physical and chemical properties can be caused by both natural reasons, such as tidal movements, fresh water discharge, seasons, and oceanography, as well as by human activities.

Besides physicochemical properties, the microbiological quality is another indicator of environmental safety. The microbes form an inherent component of the aquatic environment that takes part in the nutrient cycle, decomposes organic matter, and supports ecosystem functioning. On the contrary, some types of microorganisms can be considered indicators of environmental pollution due to human activities. For this reason, microbiological investigation is commonly applied as a technique for determining the state of aquatic environments, as well as sources of possible contamination. Faecal contamination of waters can be determined based on analysis of indicator microbes, including E. coli and coliform bacteria, while sulphite-reducing anaerobic bacteria, P. aeruginosa, and yeast-mould group can also reveal information concerning microbial contamination.

Physicochemical and microbiological analyses provide more insights into the quality of water than any other single parameter. While chemical parameters indicate alterations in the environment as well as the nutrition of the area, the microbiological analysis determines any contaminants present and stress on the ecosystem.
The southern coastal zone of India, especially that of the coastal area of Trivandrum (Kerala), Kanyakumari, and Thoothoor, offers a distinct marine ecosystem that is distinguished by heavy fishing activity, human settlements, tourism, and growing human impact. These regions lie in an ecologically significant portion of the Indian coastline where various oceanographic processes like tides, currents, and monsoons affect water quality variables. Such changes may affect both the physicochemical characteristics and microbial communities present in seawater, thus being significant regions for ecological studies.
Various studies have assessed the quality of coastal water in selected areas in India. Nevertheless, the majority of these studies have addressed various individual components such as physico-chemical properties, heavy metals, nutrients, or sediment quality. There are very few researches conducted taking into account both the physical-chemical and microbiological properties of water. There is also very limited information available about the quality of seawater in relation to Trivandrum, Kanyakumari, and Thoothoor, which are important from an ecological and economical perspective. The current research has therefore been designed in such a way that the physicochemical and microbiological properties of seawater samples collected from the three coastal regions can be compared in order to know the impact of human interference on the marine ecosystem.

2. Materials And Methods

2.1. Study area

Present work was performed in the southern coastal region of India in three distinct coastal regions, namely Trivandrum (Kerala), Kanyakumari, and Thoothoor (Tamil Nadu). These coastal regions have been reported to witness heavy fishing, tourism, presence of people, and anthropogenic stress..

2.2. Sample Collection

Water samples were collected from the sea in the coastal region of the selected three locations. Prior to collecting the samples, all the bottles were washed using laboratory detergent followed by distillation with distilled water and final washing using seawater from the particular sampling location.
Samples for physicochemical analysis were collected using polyethylene bottles whereas microbiological analysis samples were collected in sterile glass bottles. Samples of dissolved oxygen were collected in 300ml BOD bottles devoid of any air bubbles. After collection, samples were labelled and transported in ice boxes to the lab where analysis was done using the standard procedures recommended by the American Public Health Association. (APHA, 2017).

2.3. Physicochemical Analysis

Physicochemical analysis of seawater was carried out following the methodologies provided in APHA (2017). The parameters that were analysed were pH, dissolved oxygen, salinity, chloride, alkalinity, sulphate, and nitrate.

2.3.1 Determination of pH

The pH value of the seawater samples was measured using an electric pH meter through the method of electrometry (APHA, 2017). Buffers of pH values 4.0, 7.0, and 9.0 were used to calibrate the meter..

2.3.2 Determination of Total Alkalinity

The determination of total alkalinity was done using the acid titration method. A 100 mL seawater sample was measured using a conical flask and 2-3 drops of phenolphthalein indicator were added. In case of a pink colour development, the seawater sample was titrated with standard sulphuric acid till the disappearance of colour. After this process, methyl orange indicator was added, followed by the titration until there was a change in colour from purple to orange. This marked the endpoint, and total alkalinity was determined and reported as mg L-1 as CaCO3.

2.3.3 Determination of Chloride

Determination of chloride concentration was done using argentometric titration method, standard silver nitrate solution with potassium chromate as the indicator, as per APHA (2017). The endpoint was defined as the development of brick-red precipitate. The chloride concentration was reported as mg L-1.

2.3.4 Sulphate Determination

Determination of sulphate concentration was done using the gravimetric method, as per APHA (2017). The sulphate ions in seawater samples were precipitated as barium sulphate, filtered, dried and weighted.

2.3.5 Determination of Nitrate

The nitrate level was quantified using the spectrophotometric analysis method stated in APHA (2017). The absorbance values for the prepared solutions were taken using a UV-VIS spectrophotometer at the specified wavelength, and the nitrate level was obtained using the calibration graph.

2.4. Microbiological Analysis

Isolation of Total Coliform, Escherichia coli, Anaerobic Sulphite Reducing Bacteria, Pseudomonas aeruginosa and Yeasts & Molds was performed using appropriate media and methods. Organisms were allowed to grow in favourable conditions and growth was determined by counting the number of colonies formed or Most Probable Number, depending on the microbe being studied. Counts were reported in CFU mL-1 or MPN 100 mL-1.

2.5. Quality Assurance and Quality Control

Reagents employed in the study were of analytical purity level while solutions were prepared by employing distilled or de-ionized water. All glassware and bottles used were adequately washed and sterilized. Finally, instruments like the pH meter and spectrophotometer were appropriately calibrated using standard materials.

2.6. Statistical Analysis

The experimental results were analysed using IBM SPSS Statistics software package. Descriptive statistics were calculated as mean ± SD. Difference between the three sampling points was determined using one-way analysis of variance (ANOVA). Correlation between the variables was determined using Pearson's correlation, while multiple regression analysis was used to find out the important variables for total hardness.

3. Result And Discussion

Reagents employed in the study were of analytical purity level while solutions were prepared by employing distilled or de-ionized water. All glassware and bottles used were adequately washed and sterilized. Finally, instruments like the pH meter and spectrophotometer were appropriately calibrated using standard materials..

3.1 Physicochemical Properties of Seawater

Physicochemical analysis results showed the difference in the quality of the water at all three sampling points. The pH value of the seawater ranged between 6.40-8.20 with an average value of 7.39 ± 0.58 indicating the neutrality or slight alkalinity of the water. Such readings of the pH value of the seawater are characteristic of a healthy ecosystem and are typical of the seawater itself due to its buffer capacity. Conductivity of the water samples had the values ranging between 116.0-215.0 µS/cm with an average of 158.66 ± 25.42 µS/cm, implying moderate variation in the composition of ions in the water. Turbidity of water samples varied from 1.0 to 6.8 NTU with an average value of 3.43 ± 1.54 NTU (Table 3.1). Relatively high values of turbidity in certain regions might be caused by the presence of sediments, tides, coastal erosion and anthropogenic influence such as fishing and tourism. Saravanakumar et al., (2008) mentioned such trends in the values of turbidity and pH in the coastal waters of southern India.

Table 3.1. Physicochemical properties of seawater across three regions

Parameters	Minimum	Maximum	Mean	Std. Deviation
pH Value	6.4	8.2	7.393	0.5842
Electrical Conductivity (µS/cm)	116.0	215.0	158.657	25.4226
Turbidity (NTU)	1.0	6.8	3.430	1.5376
Total Hardness (mg/L as CaCO3)	32.87	386.43	222.6633	133.77394
Total Dissolved Solids (mg/L)	79.5	150.8	108.277	21.0463
Total Alkalinity (mg/L)	4.1	4.8	4.420	.2091
Calcium (mg/L)	14.17	80.43	49.4043	23.61612
Magnesium (mg/L)	7.80	46.32	27.3733	13.25125
Potassium (mg/L)	4.02	9.85	6.5697	1.54671
Chloride (mg/L)	18.41	24.27	21.8037	1.56854
Phosphate (mg/L)	0.131	0.695	0.34340	0.171720
Fecal Coliform Presence (0=Absent, 1=Present)	0	1	.27	.450
Sulphate (mg/L)	0.74	0.95	0.8350	0.05264
Fluoride (mg/L)	0.158	0.578	0.36103	0.136465
Nitrate (mg/L)	0.15	0.38	0.2590	0.06707
Iron (mg/L)	0.046	0.454	0.25247	0.124176
Sodium (mg/L)	19.22	48.23	35.3653	7.45268

3.1.1 Mineral Properties

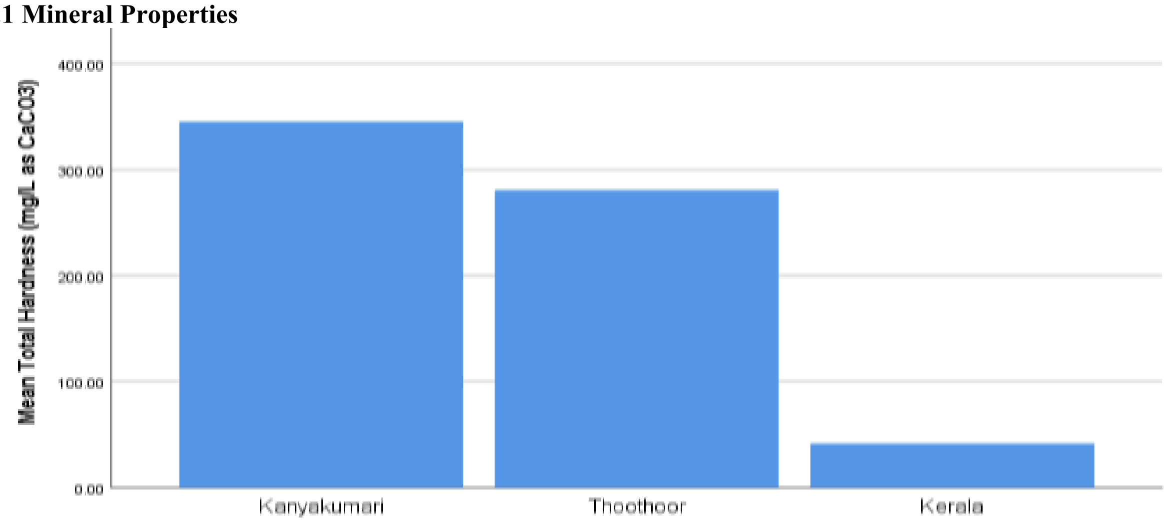

Figure 3.1. Comparative study of total hardness across three regions.

Total hardness was found to vary the most amongst all the analysed parameters, as its range was between 32.87 mg/L and 386.43 mg/L as CaCO3, while the average was 222.66 ± 133.77 mg/L. According to the comparative analysis, the highest level of hardness was observed in Kanyakumari, after which follows Thoothoor, while relatively low hardness levels were recorded in Kerala (Fig 3.1). This can be attributed to the reason that the level of dissolved ions of calcium and magnesium in the region of Kanyakumari was more because of mineral weathering and continuous interaction between the seawater and geological composition. Same conclusions have been reached by WHO (2017), who states that calcium and magnesium are the primary minerals contributing to water hardness.

The TDS values ranged from 79.5 to 150.8 mg/L, the mean value being 108.28 ± 21.05 mg/L, indicating that there is moderate amount of minerals in seawater samples. Calcium values ranged from 14.17 to 80.43 mg/L, while magnesium from 7.80 to 46.32 mg/L. Their average concentration values were 49.40 ± 23.62 mg/L and 27.37 ± 13.25 mg/L, respectively. These minerals are naturally found in seawater and contribute to the major portion of total hardness.. Variations in their concentration in the three regions may be due to geological differences in those regions and circulation of seawater and flow of fresh water in those regions. Generally, the mineral content of seawater at Kanyakumari is comparatively high than Kerala, whereas Thoothoor shows intermediate properties.

3.1.2 Major Ions and Nutrient Characteristics

There were variations in the amounts of the selected major ions and nutrients in different sites in the coastal areas. Sodium ion was in the amount of 24.81 to 47.79 mg/L with an average value of 35.37±7.45 mg/L while potassium was in the range of 4.02 to 9.85 mg/L with an average value of 6.57±1.55 mg/L (Table 3.1). Analysis revealed that there was more potassium in Thoothoor, then in Kanyakumari and Kerala.

The amount of chloride ions was relatively constant within the range of 18.41 to 24.27 mg/L with an average of 21.80±1.57 mg/L showing marine characteristics of the samples. Chlorides have low variation in seawater due to their conservative nature. The content of the nutrients and the trace elements was also varied among the three coastal regions. The concentration of phosphate was 0.08 - 0.64 mg/L, averaging at 0.343 ± 0.172 mg/L, and relatively high in Kerala (Figure 3.2.). Sulphate concentration was within 0.73 - 0.92 mg/L range, and its average concentration was 0.835 ± 0.053 mg/L, while fluoride concentration was between 0.16-0.62 mg/L, and average concentration was 0.361 ± 0.136 mg/L (Fig 3.3 and Fig 3.4).

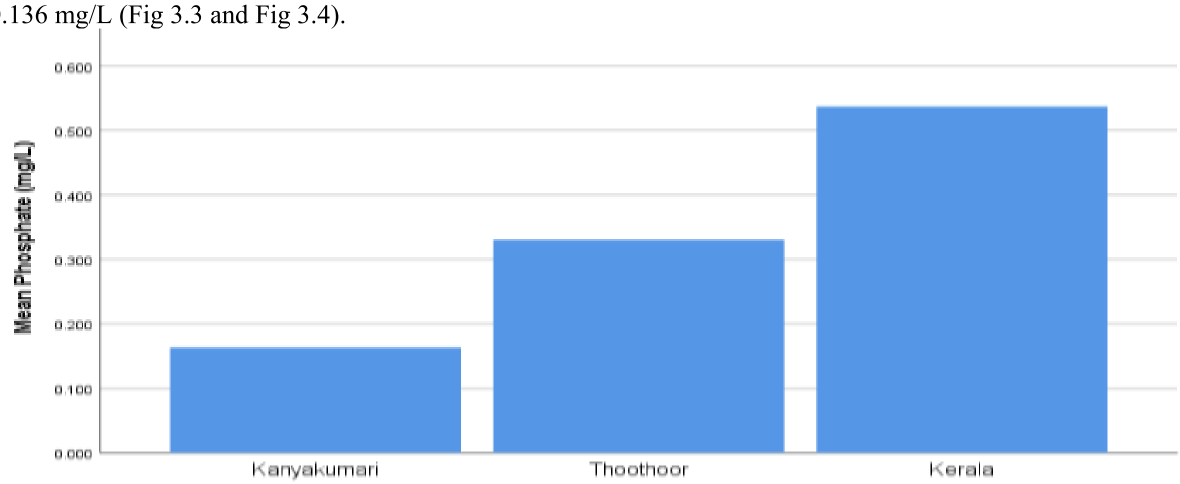

Figure 3.2. "Comparative study of phosphate across three study sites"

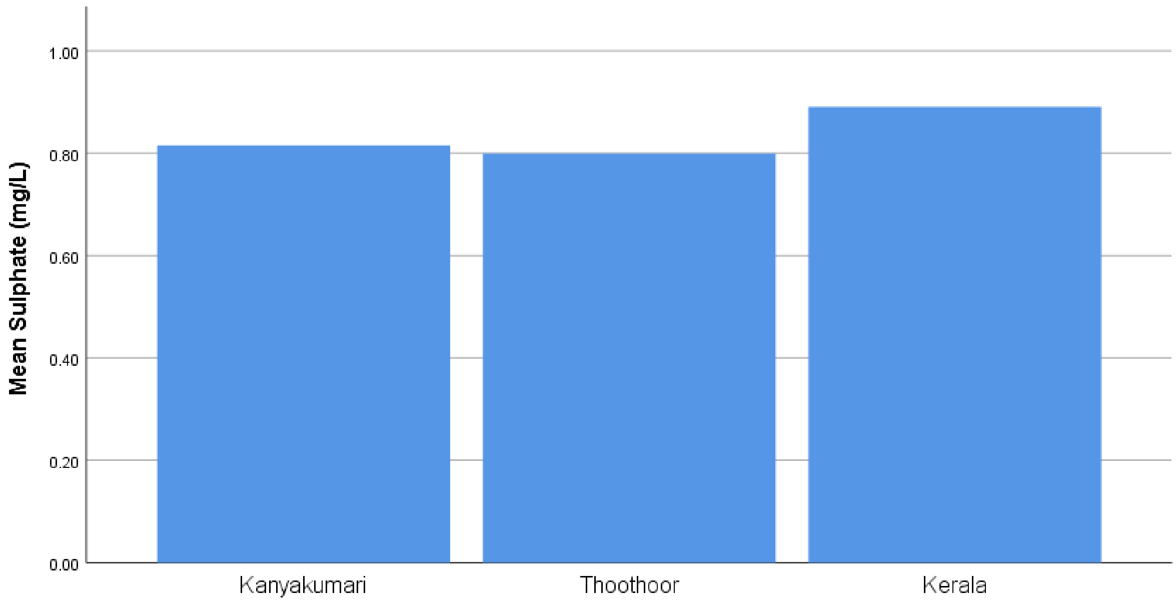

Figure 3.3. "Comparative study of sulphate across three study sites"

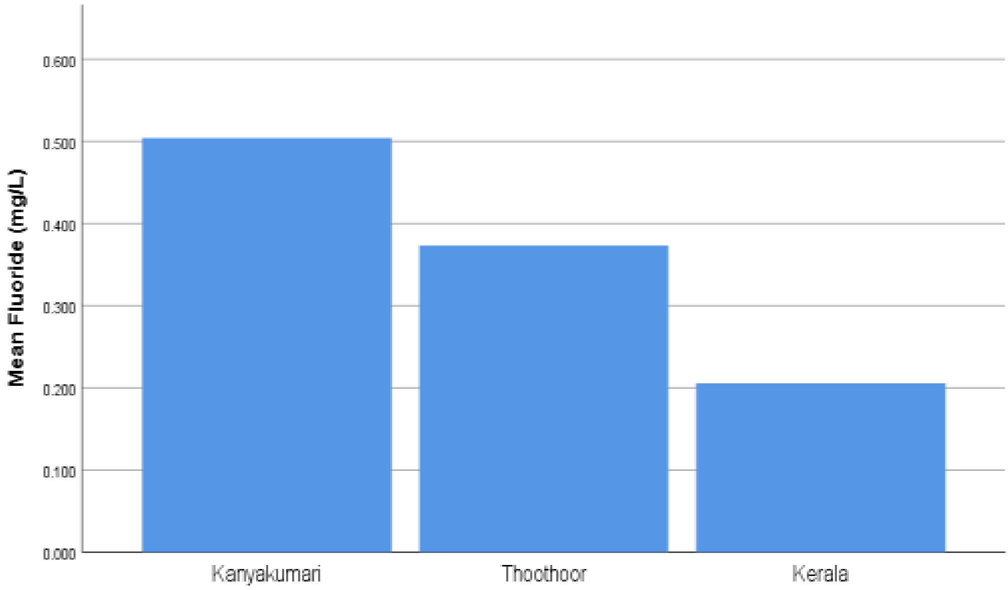

Figure 3.4. "Comparative study of fluoride across three study sites"

Maximum value of fluoride content was recorded in Kanyakumari. The concentration values of nitrate and iron were 0.259 ± 0.067 mg/L and 0.252 ± 0.124 mg/L, respectively. This means that there was the presence of moderate amount of nutrients and trace elements in the study site. Variability in phosphate and sulphate may be associated with the runoff of fresh water, decomposition of organic materials and anthropogenic activity. However, the variability in fluoride content is due to the geological conditions. (Sujitha et al., 2011).

3.2 Microbial Properties of Sea Water Table

Table 3.2. Microbial properties of sea water samples across three regions

Sl. No.	Parameter	Result
1	Escherichia coli	Present
2	Coliform	Present
3	Sulphite Reducing Anaerobes	Present
4	Pseudomonas aeruginosa	Present
5	Yeast and Mould	Present

Microbiological analysis of water samples obtained from the regions of Trivandrum, Kanyakumari, and Thoothoor indicated that all selected microbial indicators, such as E. coli, coliforms, sulphite-reducing anaerobes, P. aeruginosa, and yeasts/moulds were present (Table 3.2). The presence of these microorganisms indicates the contamination of coastal waters by microbial organisms. The contamination may be due to natural and anthropogenic factors..

Detection of coliform bacteria and E. coli is known to be a sign of faecal contamination which implies that the sewage is not treated and the waste water enters the coastal zone. Intensive fishing industry, tourism, and numerous human settlements lead to greater probability of microbiological contamination because of continuous supply of sewage. Such results are consistent with Won et al., (2017) findings who claimed that anthropogenic activity plays a crucial role in determining the microbiological quality of the coastal waters.

Moreover, the presence of sulphite-reducing anaerobes is another evidence of organic pollution in the study area. Such microorganisms are usually found in the decomposition process of organic materials and have been found to exist for much longer than usual faecal indicator microorganisms, thus they can serve as good signs of past contamination.

In addition, the presence of P. aeruginosa is indicative of contamination of the environment from both natural and domestic sources. Such an opportunistic bacterium is commonly identified from water bodies which have received contaminated discharge and survives in various environmental conditions. The presence of yeasts and moulds is indicative of the continuous supply of organic material through runoff and decomposition of organic material and wastewater discharge. While such microorganisms occur naturally in the aquatic environment, their simultaneous occurrence with faecal indicator microorganisms is suggestive of anthropogenic activity.

Even though the physicochemical values are within limits, the microbial testing indicates the presence of microorganisms in the water sample taken from the coastal environment. In addition, microbial indicators can be used as proxies to assess the degree of environmental pollution of the aquatic ecosystems as noted by Savvichev et al. (2023). It is evident that there is an urgent need for regular monitoring of microbial content in water.

4. Conclusion

The physico-chemical and microbial properties of seawater were region-specific, influenced by natural environmental factors and human activity. The higher mineral concentration was observed in the Kanyakumari region, mainly total hardness and fluoride, while higher phosphate and sulphate concentration was observed in the Kerala region.

Intermediate physicochemical properties were seen in Thoothoor, with elevated amounts of potassium. The presence of "Escherichia coli, coliform bacteria, sulphite reducing anaerobes, Pseudomonas aeruginosa, and yeast and moulds" at all sampling points was indicative of microbial pollution owing to human interference. This emphasizes the significance of monitoring and managing the coasts effectively to maintain marine ecosystem health.

References

1. Ayyam, V., Palanivel, S., & Chandrakasan, S. (2019). Coastal ecosystems and services. In Coastal ecosystems of the Tropics-Adaptive management (pp. 21-47). Singapore: Springer Singapore.
2. Maheriya, R., & Patel, B. (2025). Long term changes of the major coastal wetlands of India using global surface water datasets. Environmental Research and Technology, 8(4), 843-855.
3. Nayar, R. (2020). Assessment of water quality index and monitoring of pollutants by physico-chemical analysis in water bodies: a review. International Journal of Engineering Research and Technology, 9(01), 178-185.
4. APHA. (2017). Standard methods for the examination of water and wastewater, 23rd edn. ISBN: 9780875532875.
5. Saravanakumar, A., Rajkumar, M., Serebiah, J. S., & Thivakaran, G. A. (2008). Seasonal variations in physico-chemical characteristics of water, sediment and soil texture in arid zone mangroves of Kachchh-Gujarat. J. Environ. Biol, 29(5), 725-732.
6. Sujitha, P. C., Dev, D. M., Sowmya, P. K., & Priya, R. M. (2011). Physico-chemical parameters of Karamana river water in Trivandrum district, Kerala, India. International journal of environmental sciences, 2(2), 472-490.
7. Savvichev, A. S., Demidenko, N. A., Kadnikov, V. V., Belenkova, V. V., Rusanov, I. I., & Gorlenko, V. M. (2023). Microbial community composition as an indicator of the state of basins located at the sea coast (exemplified by the Kanda Bay, Kandalaksha Gulf, White Sea). Microbiology, 92(6), 819-830.
8. Won, N. I., Kim, K. H., Kang, J. H., Park, S. R., & Lee, H. J. (2017). Exploring the impacts of anthropogenic disturbance on seawater and sediment microbial communities in Korean coastal waters using metagenomics analysis. International journal of environmental research and public health, 14(2), 130.