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Assessment of Water Quality Parameters in Mangrove Ecosystems: Implications for Conservation and Management in Thane District, India

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Abstract

The mangrove ecosystem is a vital coastal habitat that supports diverse flora and fauna while providing essential ecosystem services. Understanding and monitoring water quality parameters are crucial for assessing the health and functioning of mangrove ecosystems. In this study, a comprehensive assessment of water quality parameters in a mangrove ecosystem, including temperature, pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), alkalinity, hardness, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO) were estimated. Present investigating reveals that significant variability in above parameters, indicating that the dynamic nature of the mangrove environment. While temperature and pH levels exhibited moderate fluctuations within acceptable ranges for mangrove ecosystems of Palghar, elevated levels of suspended and dissolved solids, along with the presence of organic pollutants, suggest potential anthropogenic impacts on water quality. Despite these challenges, relatively stable levels of alkalinity and hardness reflect the ecosystem's resilience to natural processes and its ability to maintain nutrient availability. Furthermore, the presence of organic pollutants highlights the need for proactive conservation and management strategies to mitigate water quality degradation and safeguard the health of mangrove ecosystems. Continued monitoring and collaborative efforts among scientists, policymakers, and local communities are essential to ensure the long-term sustainability of mangrove ecosystems and the ecosystem services they provide.

***Key words*:** Mangrove ecosystem, Water, Temperature, pH, Solids, Hardness, BOD, COD, Conservation

Mangrove ecosystems, characterised by their unique intertidal location where terrestrial and marine environments converge, play a vital role in supporting biodiversity and serving as natural buffers against coastal hazards [1]. The physicochemical parameters of the water within these ecosystems are integral to understanding their ecological dynamics and resilience [2]. As climate change and anthropogenic activities continue to impact coastal environments, comprehending the intricate relationships between mangrove water quality and ecosystem health becomes increasingly imperative. Physicochemical characteristics of mangrove water encompass a diverse range of factors, including temperature, salinity, pH, dissolved oxygen, nutrient concentrations, and pollutants [3]. These parameters collectively influence the biological and chemical processes within the ecosystem, influencing the growth and survival of flora and fauna uniquely adapted to this dynamic interface.

Present investigation aims to delve into the detailed examination of physicochemical parameters within mangrove ecosystem waters. By systematically analyzing these parameters, we seek to unravel the intricate dynamics that govern water quality, nutrient cycling, and overall ecosystem health in mangrove environments. Such insights are critical not only for advancing our understanding of these ecosystems but also for informing effective conservation and management strategies to ensure the long-term sustainability of mangrove habitats amid changing environmental conditions [4]. Through a comprehensive exploration of physicochemical parameters, this research endeavors to contribute valuable knowledge to the broader field of coastal ecology and management practices.

MATERIALS AND METHODS

Study area

Dombivli Reti Bunder Creek, Dombivli, Thane district, Maharashtra State, India was considered as the site of sample to be collected. Reti Bunder Creek is located in the city of Dombivli, which is situated in the Thane district of Maharashtra, India. Dombivli is a suburb of Mumbai, and it lies approximately 48 kilometers northeast of the city Centre. Reti Bunder Creek is one of the prominent water bodies in the region, serving as a tributary of the Ulhas River. The creek runs through the heart of Dombivli and is surrounded by residential areas, commercial establishments, and industrial zones.

Sample collection

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Water Samples were collected from the site in water bottles. Samples were transported to the Research laboratory for further analysis. The samples were stored in the laboratory according to standard procedure until the analysis was completed.

Water analysis

A) *Water analysis will be done by using standard measure*

Temperature and pH are the physical factors to consider. This research will look at chemical factors including Total Suspended Solids (TSS), alkalinity, biological oxygen demand, chemical oxygen demand, dissolved oxygen and total organic content [5].

Laboratory analysis

The primary principles methods utilized in determining the chemical features of the samples are titrimetric and spectrophotometric procedures.

Temperature

Digital thermometers were used to check the temperature of the samples and environment [5].

pH

In-situ pH measurements were taken. For standardization of the equipment, known buffer solutions of pH 4, pH 7, and pH 10 will be made and utilized, and the pH values of the water samples were obtained [5].

Total suspended solid

Total suspended solids was determined using Whatman's filter paper that will be washed in double distilled water and dried for exactly one hour at 105° C before being cooled in desiccators. A digital balance is used to calculate the residual weight (W1). A 100mL sample of water was filtered through the resin paper and then evaporated for one hour at 105°C. TSS was computed using (W2- W1) × 100 mg/L and is weight, which are represented W2 of the filter paper holding the residue [5].

Alkalinity

Titration techniques will be used to calculate alkalinity. In a clean 150 mL conical flask, 50 mL of the water samples will be placed, along with three drops of the phenolphthalein indicator. It will then be titrated with 0.05 M H2SO4 until the colour has vanished. Three drops of methyl orange indicator will be added to the colourless solution and titrated until the colour changes from yellow to permanent reddish or orange red, at which point the titre values will be recorded and the alkalinity calculated [5].

BOD

The biochemical oxygen demand was calculated using Winkler's technique with an Azide adjustment. The BOD bottle will be constructed and incubated in the dark for 5 days at 20°C. After five days, the incubated BOD container was filled with 2 mL orthophosphoric acid, gently shaken, and titrated with sodium thiosulphate until there was a change in color. On day five, the titre value signifies soluble oxygen. The difference between dissolved oxygen on day one and day five was used to compute BOD [5].

COD

The COD was calculated using the approach specified in standard procedures. In a reflux flask, 50 mL of water is mixed well with 10 mL of potassium dichromate solution and 1 g mercuric sulphate. Anti-Bumping beads are to be used to keep the solution from boiling over. 10 mL concentrated sulphuric acid containing silver sulphate is to be cautiously introduced via the open end of the condenser and swirled together. The reflux equipment is turned on for about an hour and then turned off. The contents of the flask will be diluted to 150 mL with distilled water. Three drops of Ferro in indicator are to be added to the resultant solution, and the sample is titrated with standard ferrous ammonium sulphate [5].

Dissolved oxygen

The Azide variation of Winkler's technique was used to measure dissolved oxygen. 200mL of the water sample will be placed into a 300 mL BOD container with care. The alkaline alkali-iodide-azide reagent is added after 1 mL of manganese sulphate solution. The resultant mixture will be titrated against 0.025 N sodium thiosulphate until a colour shift occurs, at which time the titre value is recorded as DO [5].

Total organic carbon (TOC)

It is measured using the technique outlined in standard procedures. The dried Sediment samples are to be coarsely crushed, and 0.2 grams is weighed into 500 mL conical flasks, followed by 10 mL of 0.5 M K2Cr2O7, which is gently stirred. H2SO4 (concentrated) (20 mL) will be carefully added to the suspension. The mixture is gently stirred and set aside for about 40 minutes. 200 mL distilled water is added, followed by 10 mL pure H3PO4 carefully added. After allowing the mixture to cool, three drops of ferroin indicator will be added. The content is then titrated to the wine-red end point with 0.25 M FAS. TOC of the water sample will be calculated as per the following formula:

$$(\%)\ TOC = (Vb - Vs) \times M \times 1.38 = R/W$$

where Vb = volume of FAS for blank; Vs = volume of FAS for the sample; M= morality of FAS; and W = weight of the sample in grams [5].

Heavy metals – Cadmium, Chromium, Lead, Mercury. The heavy metals (Cr, Cu, Cd, Hg, Pb, and Zn) accumulation in acid digested triplicate samples will be measured using an Atomic Absorption Spectrophotometer, and the amounts will be given in parts per million (ppm) [6].

Table 1 Methods used in the present investigation

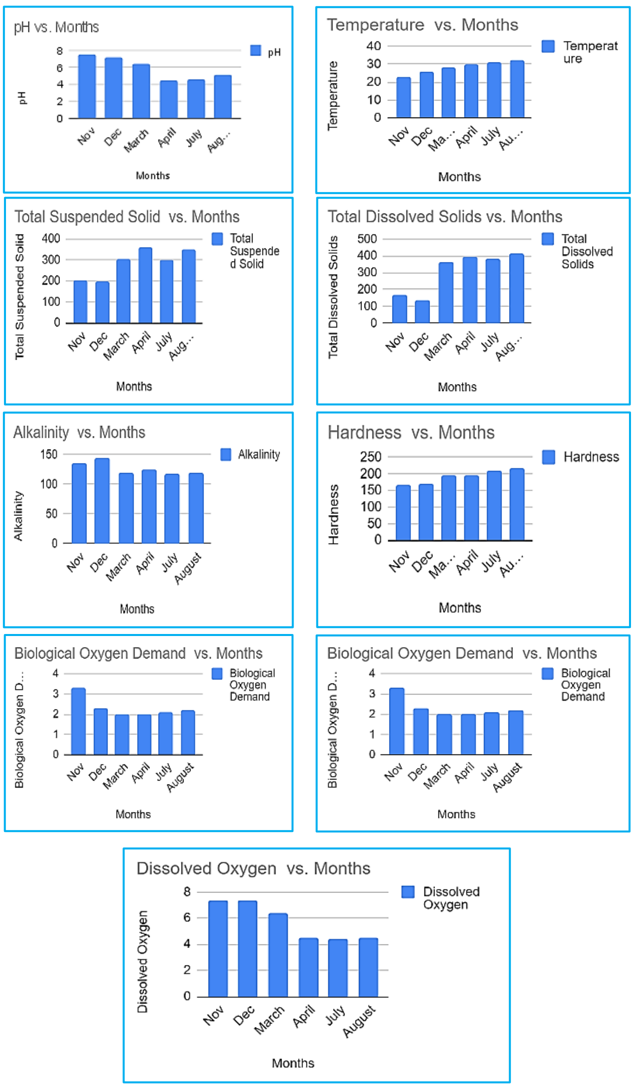
Water parameters	Methods
pH	pH Metre
Temperature	Thermometer
Colour	Visual /colour kit
Taste and odour	Physiological sense
Total suspended solid	Gravimetric method
Total dissolved solids	Gravimetric method
Acidity	acid-base titration
Alkalinity	Titration method
Hardness	EDTA titration method
Dissolved oxygen	Winkler's method
BOD	Winkler's method
COD	Winkler's method
Turbidity	Turbidimetric

RESULTS AND DISCUSSION

Water quality parameters in the mangrove ecosystem revealed significant variability and provided insights into the environmental conditions within the habitat. Temperature fluctuations exhibited a mean value of 28.15°C with a standard deviation of ± 2.85°C, suggesting moderate variability in temperature levels. This variability could be influenced by seasonal changes, tidal fluctuations, and localized environmental factors [7]. pH levels in the mangrove water displayed relative stability around a mean value of 5.5625, with a standard deviation of ±1.26. This slightly acidic pH is characteristic of mangrove ecosystems and is influenced by factors such as organic matter decomposition and vegetation dynamics [8].

Table 2 Water parameters of six months

S. No.	Water Parameters	November 2023	December 2023	March 23	April 23	July 23	August 23
1	pH	7.5	7.2	6.4	4.5	4.6	5.1
2	Temperature	23.2	26	28	30	31	32
3	Colour						
4	Taste and odour						
5	Total suspended solid	205	200	305	362	300	350
6	Total dissolved solids	168	135	361	395	380	410
7	Acidity						
8	Alkalinity	136	145	120	124	118	120
9	Hardness	166	170	195	197	210	216
10	Dissolved oxygen	7.4	7.4	6.4	4.5	4.4	4.5
11	BOD	3.3	2.3	2	2	2.1	2.2
12	COD	5.7	6.6	7.4	8	8	8.2
13	Turbidity	1	1	2	2	2.1	2.2



The assessment of water quality parameters in the mangrove ecosystem reveals significant implications for ecosystem health and management. Temperature fluctuations, pH stability, and concentrations of total suspended solids and total dissolved solids (TDS) were measured to understand the dynamic nature of the mangrove environment. Alkalinity, hardness, and levels of organic pollutants such as biological oxygen demand (BOD) and chemical oxygen demand (COD) were also analyzed to assess water quality. Additionally, dissolved oxygen (DO) concentrations were evaluated to understand oxygen dynamics within the ecosystem.

Total suspended solids (TSS) and total dissolved solids (TDS) concentrations were found to have mean values of 290.25 mg/L and 326.125 mg/L, respectively, with standard deviations of ±59.32 and ±109. These elevated levels of suspended and dissolved solids may indicate sedimentation and nutrient loading within the mangrove water; potentially impacting water clarity and ecosystem health [9]. Alkalinity and hardness exhibited relatively high mean values of 124.875 and 196.75 units, respectively, with standard deviations of ±10.13 and ±19.12. These parameters play vital roles in buffering pH fluctuations and influencing nutrient availability within the ecosystem, highlighting their importance for supporting mangrove vegetation and associated fauna [10]. Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) measurements indicated the presence of organic pollutants in the mangrove water, with mean values of 3.28 mg/L and 146.33 mg/L, respectively, and standard deviations of ±1.20 and ±19.69. These values exceed recommended thresholds, indicating potential pollution sources and risks to water quality and ecosystem health [11]. Dissolved Oxygen (DO) levels were measured at a mean value of 5.76 mg/L with a standard deviation of ±1.47, indicating relatively stable oxygen concentrations. However, fluctuations in DO levels can impact aquatic organisms and ecosystem processes, highlighting the importance of monitoring and maintaining adequate oxygen levels within the mangrove environment [12]. Overall, these findings underscore the dynamic nature of water quality parameters within the mangrove ecosystem and the importance of ongoing monitoring and conservation efforts to preserve ecosystem health and integrity (Table 1-3, Fig 1-3).

Table 3 Standard deviation values of analyzed parameters

Parameters	Standard deviation
Temperature	28.15 ± 2.85
pH	5.5625 ± 1.26
Total suspended solid	290. 25 ± 59.32
Total dissolved solid	326.125 ± 109
Alkalinity	124.875 ± 10.13
Hardness	196.75 ± 19.12
Biological oxygen demand	3.28 ± 1.20
Chemical oxygen demand	146. 33 ± 19.69
Dissolved oxygen	5.76 ± 1.47

CONCLUSION

In this research paper of water quality parameters in the mangrove ecosystem provides valuable insights into the environmental conditions and potential implications for ecosystem health. The observed variability in temperature, pH, suspended and dissolved solids, alkalinity, hardness, and oxygen levels highlights the dynamic nature of the mangrove environment and the complex interactions between various factors influencing water quality. The slightly acidic pH levels and elevated concentrations of suspended and dissolved solids indicate the influence of natural processes such as organic matter decomposition and sedimentation, as well as potential anthropogenic inputs such as runoff and pollution. While the alkalinity and hardness levels remain relatively stable, indicating buffering capacity and nutrient availability within the ecosystem, the presence of organic pollutants, as indicated by high biological oxygen demand (BOD) and chemical oxygen demand (COD) values, poses risks to water quality and ecosystem health. Despite these challenges, the relatively stable levels of dissolved oxygen (DO) suggest a resilient ecosystem capable of supporting aquatic life. However, fluctuations in dissolved oxygen (DO) concentrations underscore the importance of continued monitoring and management efforts to maintain optimal oxygen levels and ensure the health and integrity of the mangrove ecosystem. Overall, the findings highlight the need for proactive conservation and management strategies to address the underlying factors contributing to water quality degradation, including pollution, habitat loss, and climate change. Collaborative efforts among scientists, policymakers, and local communities are essential to mitigate the impacts of environmental stressors and safeguard the long-term sustainability of mangrove ecosystems worldwide. By prioritizing the protection and restoration of mangrove habitats and implementing sustainable practices, we can enhance resilience, biodiversity, and ecosystem services, benefiting both human communities and the natural environment.

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