International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 12, Issue 7-2025

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2025.12.07.005

Analysis of Physio-chemical Parameters of Water Samples from the Mangrove Wetlands near Mumbra, District Thane, Maharashtra

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Abstract

Water samples were collected from three selected stations of mangrove ecosystems of Mumbra for a period of 15 months from June 2022 to August 2023 and analyzed for various hydrographic parameters. The present work would give the baseline information on the hydrographic condition of the mangrove ecosystem of Mumbra. The surface water temperature fluctuated from 20 to 22 °C, the turbidity from 2 to 83 NTU, the oil and grease from 0.58 to 13 mg/l, the dissolved oxygen from 0.45 to 7.32 mg/l and the suspended solids from 0.6 to 67 mg/l. The observed variation in the inorganic constituents were: Phosphates in mg/l (<0.5 to 21.2), Nitrates in mg/l (<0.2 to 3.7) and Silicate in µg/l (62.5 to 250), Variations were also observed in heavy metals such as lead in mg/l (<0.010 to 3.76) and chromium in mg/l (<0.005 to 0.04), However arsenic was reported below detection level (<0.02 mg/l). Hydrographical conditions were moderately diverse throughout the year and were higher in the monsoon season of 2023.

Keywords: Mumbra, Mangroves, Hydrographic parameters, Wetlands.

Introduction

Wetlands are described as lands transitional between terrestrial and aquatic eco-systems where the water table is typically at or near the surface or the land is covered by shallow water (Mitsch and Gossilink 1986). Wetlands cover about 4 to 6% of the world's land (Demissie and Addis, 2015) and are important for ecosystem services, nutrient cycles, soil formation, water treatment. But due to urbanization, industrialization, and anthropogenic activities of almost half of the world's wetlands disappeared in the last century (Phukan and Saikia, 2014). Mumbai has lost

around 40% of all its mangroves, mostly to reclamation for housing, slums, sewage treatment and garbage dumps.

These areas are being polluted by growing industrial areas at the coastlines as well as the discharge of domestic and industrial sewage (Sarkar, 2017). The prominent mangroves observed presently in Mumbai can be found at Vasai creek, Thane creek, Manori, Malad, Mahim-Bandra, Versova, Sewri and Mumbra-Diva. Destruction of wetlands has enhanced property damage from floods and droughts, caused nutrient runoff and water pollution, resulted in shore erosion, and triggered declines in wildlife populations. Hence it is important to conserve these wetlands.

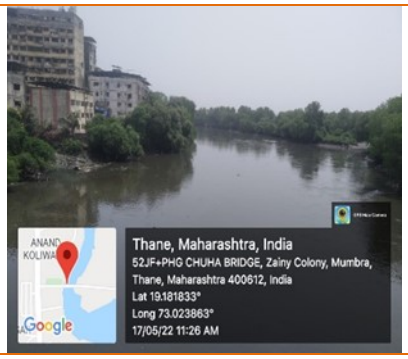
The physicochemical analysis of water in mangrove wetland ecosystems is crucial for understanding their health, productivity, and resilience. This analysis provides insights into the interactions between terrestrial and marine environments, the impact of anthropogenic activities, and the overall biogeochemical processes that sustain these ecosystems. Effective water quality monitoring is essential for sustainable management practices in mangrove ecosystems, ensuring their long-term viability. Many ecological and biodiversity studies have been carried out on Thane creek but there is dearth of studies on mangrove wetlands near Mumbra. The present work will serve as baseline study of Mumbra wetlands. As reclamation of land and construction activity in Mumbra are steadily increasing along with the open sewage disposal problem, hence it is important to study the effects of anthropogenic activities on their mangrove ecology and envision protection measures.

Materials and Methods

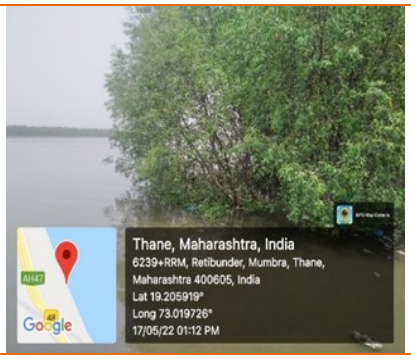
Study Area

Physico-chemical parameters of Mumbra Mangrove Ecosystem were studied by observing three different stations like Visarjan Ghat, Retibunder Ghat and Chuha Bridge. Water samples were collected in every month from these three distinct sampling locations typically 10 to 15 cm below the water's surface for the period of 15 months (June 2022 to August 2023), between the timing 9:00 to 10:00 a.m., in sterile, clear plastic bottles of one-litre capacity. The manganous sulphate and alkali iodide reagents were added immediately at the collection site to fix the samples for dissolved oxygen. All the samples were immediately taken to the lab for water analysis. Collected water samples were examined for physio-chemicals parameters such as temperature, turbidity, oil and grease, suspended solids, dissolved oxygen, and nutrients like phosphates, nitrates, silicate, as well as heavy metals like lead, chromium, and arsenic using the standard procedures (American Public Health Association 1998) (R. K. Trivedy and P. K. Goel, 1984) .

Heavy metals like Lead, Chromium, Arsenic were analyzed by atomic absorption spectroscopy in the Thane Municipal Corporation lab.



Site 1: Visarjan Ghat (V)
Latitude: 19.214317°
Longitude: 73.012526°



Site 2: Retibunder (R)
Latitude: 19.205919°
Longitude: 73.019726°

Site 3: Chuha Bridge (C)
Latitude: 19.181833°
Longitude: 73.023863°

Fig.1: Geographical locations of all three sites (study areas) - Visarjan Ghat (V), Retibunder (R) and Chuha Bridge (C)

Results and Discussion

Temperature: Surface water temperature is affected by various factors viz. solar radiation, evaporation, freshwater influx, and cooling processes, as well as the flow of adjacent neritic waters. Temperature has a considerable impact on an organism's metabolic activity (Sirajudeen and Mubashir, 2013). Temperature recorded at all three sites ranges between 20°C and 22°C with slight monthly temperature variations. (Fig.2).

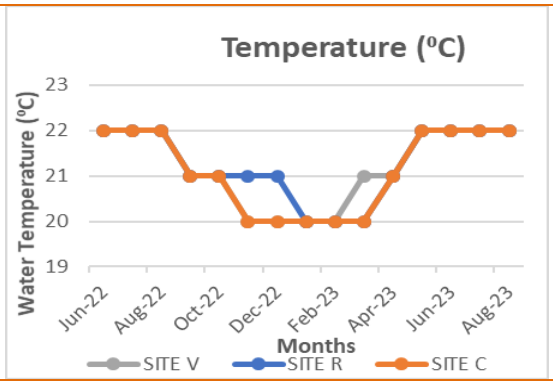


Fig.2: Monthly variation of water temperature (ºC) in all study stations of Mumbra mangrove wetland

Turbidity:

Turbidity is a metric used to quantify how much the presence of suspended particles cause water to lose its clarity. Turbidity can be used to test the quality of water; the higher the turbidity, the murkier the water appears to be due to the presence of total suspended solids (TSS). Direct discharge of sewage introduces organic matter and pathogens, contributing to higher turbidity levels (Kawalekar, S., 2015). Likewise dredging can resuspend sediments, increasing turbidity in nearby waters (Cussioli, et. al., 2019). Site C has the lowest and greatest turbidity values of 2 and 53 NTU respectively, as detected in June 2022 and June 2023, whereas site 'R' has the lowest and highest turbidity values of 3 and 83 NTU, which were also found in June 2022 and June 2023. The minimum and maximum turbidity values at Site 'V' were 2 and 54 NTU respectively, as observed in June 2022 and June 2023 (Fig.3). The higher turbidity values observed in the mangrove ecosystem of Mumbra can be attributed to various anthropogenic activities like idol immersion, sand dredging, sewage and garbage dumping.

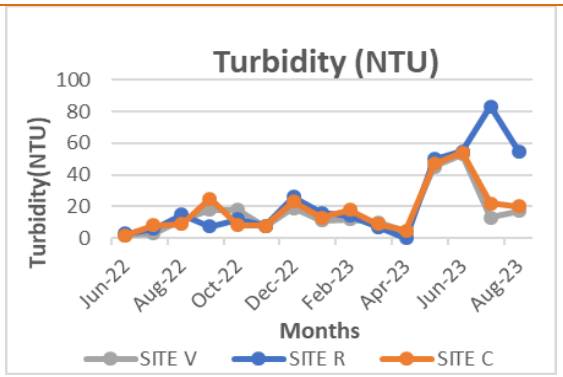


Fig. 3: Monthly variation of Turbidity (NTU) in all study stations of Mumbra mangrove wetland

Total Suspended Solids (TSS):

Direct discharge of sewage and solid waste into mangrove areas leads to increased TSS levels, as seen in various studies highlighting the correlation between urbanization and litter accumulation (Cavalcante, D. R., et al., 2024). Total Suspended Solids content at all three sites ranged between 0.6 to 67 mg/l Site 'V' has the lowest and greatest suspended solids values of 1 and 67mg/l respectively, as detected in January 2023 and June 2023, whereas site 'R' has the lowest and highest suspended solids values of 2 and 45 mg/l, which were also found in January 2022 and June 2023. The minimum and maximum suspended solids values at Site C were 0.6 and 52 mg/l respectively, as observed in February 2023 and November 2022 (Fig. 4).

Higher levels of suspended solids observed in the mangrove wetlands of Mumbra, are significantly influenced by anthropogenic activities such as sewage and garbage dumping. These activities contribute to the accumulation of total suspended solids (TSS), which can adversely affect water quality and ecosystem health.

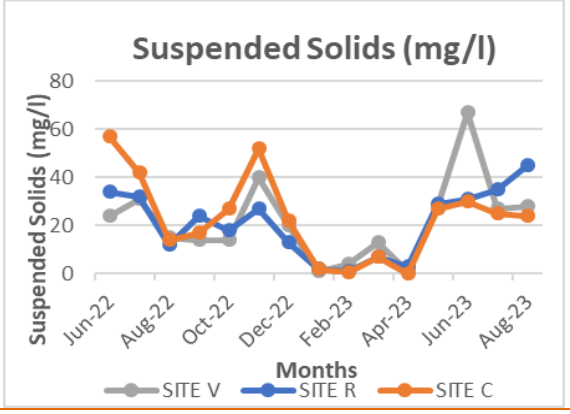


Fig. 4: Monthly variation of Suspended Solids (mg/l) in all study stations of Mumbra mangrove wetland

Oil and grease:

Oil spills and leaks from vehicles during maintenance and operation lead to the introduction of hydrocarbons into nearby water bodies (Martins and Joselia, 2022). The practice of immersing idols in water bodies often involves the use of paints and materials that contain oils and chemicals, further contaminating the water (Jezequel, et al., 2017). Indiscriminate disposal of household waste, including cooking oils and greases, contributes to the rising concentrations of oil and grease in wastewater streams.

The oil and grease values ranged between 0.58 to 13 mg/l at all the three sites. Site 'V' has the lowest and highest oil and grease values of 1 and 12 mg/l, respectively, as identified in December

2022 and January 2023, while site 'R' has the lowest and highest oil and grease values of 1 and 12 mg/l, which were likewise discovered in December 2022 and January 2023. As of December 2022 and January 2023, the lowest and highest oil and grease values at Site 'C' were 1 and 13 mg/l (Fig. 5). The presence of oil and grease in the water of the Mumbra mangrove ecosystem can be attributed to several anthropogenic activities, particularly from the automobile industry, domestic waste, idol immersion and sand dredging activities.

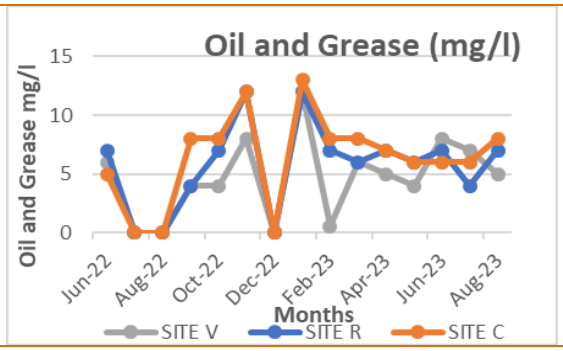


Fig. 5: Monthly variation of oil and grease (mg/l) in all study stations of Mumbra mangrove wetland

Dissolved Oxygen (DO):

The amount of gaseous oxygen in water that is essential to aquatic life's survival is known as dissolved oxygen (DO). Because it shows how well the water can support aquatic life, it is an essential indication of water quality. DO ranging from 2.4 to 5.0 mg/l was observed in case of Pichavaram mangroves (Prabu, Rajkumar and Perumal, 2008). DO ranging from 3.92 to 5.22 mg/l and 3.97 to 5.33 mg/l were observed at Point Calimere, and Muthupettai mangroves respectively (Srilatha et al., 2013). DO ranging from 5.5 to 6.4 mg/l was observed while working on Vedaranyam mangroves (Srinivasan, Natesan and Parthasarathy, 2013). Dissolved Oxygen content at the three sites varied between 0.45 mg/l to 7.32 mg/l, during the study period. Site 'V' has the lowest and highest dissolved oxygen values of 1.13 and 7.32 mg/l, respectively, as identified in January 2023 and June 2023, whereas site 'R' has the lowest and highest dissolved oxygen values of 1.28 and 5.93 mg/l, which were likewise detected in January 2023 and July 2023. Site 'C' had minimum and maximum dissolved oxygen readings of 0.45 and 6.92 mg/l respectively, in November 2022 and June 2023 (Fig. 6). In the present investigation low value of do observed from October 2022 to August 2023 could be attributed to high levels of oil and grease recorded during the same period. Because oil and grease prevent atmospheric oxygen from combining with water, therefore amount of do in the water dropped (Alade et al., 2011). However, during the monsoon season, all sites showed higher levels of dissolved oxygen. The increase in dissolved oxygen concentrations seen during the monsoon season could be attributed to the cumulative effect of increasing wind velocity combined with significant rainfall, resulting in freshwater mixing.

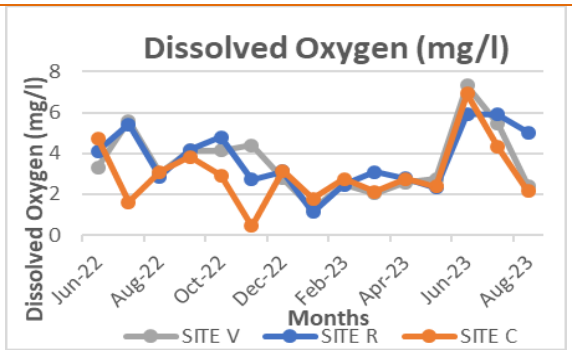


Fig. 6: Monthly variation of Dissolved Oxygen (mg/l) in all study stations of Mumbra mangrove wetland

Nitrates:

High concentrations of nitrates in water can be harmful to health, especially for young children causing methemoglobinemia also referred to as "blue baby syndrome". Nitrate levels in drinking water should not exceed 10 mg/l). Monsoon rains enhances terrestrial runoff, contributing to higher dissolved inorganic nitrate concentrations in mangrove ecosystems (Priya et al., 2017). The influx of rainwater enhances runoff, which carries nutrients from agricultural and urban areas into water bodies, leading to elevated nitrate levels.

The nitrate values ranged between <0.2 to 3.7 mg/l at all the three sites during the study period. Site 'V' has the lowest and greatest nitrate values of <0.2 and 3.7 mg/l respectively, as detected in November 2022 and June 2023, whereas site 'R' has the lowest and highest nitrate values of <0.2 and 2.2 mg/l which were also found in November 2022 and June 2023. The minimum and maximum nitrate values at Site 'C' were <0.2 and 2.5mg/l respectively, as observed in November 2022 and June 2023 (Fig.7). Higher values of Nitrate were recorded during monsoon months in all the sites. This may primarily due to terrestrial runoff, atmospheric deposition and anthropogenic influence.

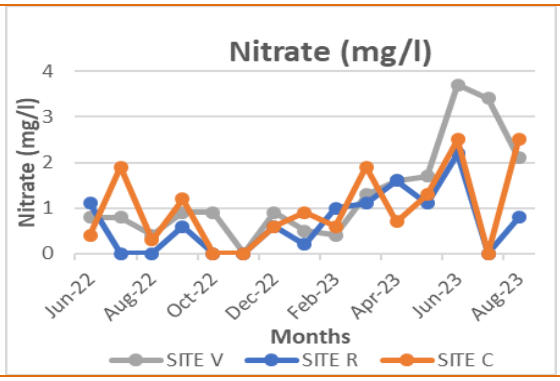


Fig. 7: Monthly variation of Nitrate (mg/l) in all study stations of Mumbra mangrove wetland

Phosphates:

Phosphorous is considered to be the most significant component among the nutrients responsible for eutrophication of a water body, as it is the primary initiating factor. Elevated levels of phosphates may signify pollution and are mostly accountable for eutrophic conditions (Dubey and Ujjania, 2016).

The runoff from household activities, which includes detergents containing alkyl phosphates, could be responsible for the high values recorded during the monsoon season. Furthermore, turbulence and mixing during this season may potentially be the cause of the phosphate being released from the bottom dirt into the water column. Idol immersion, particularly during festivals, introduces various pollutants, including phosphates, into water bodies. Idols made from non-biodegradable materials like Plaster of Paris and painted with toxic substances release harmful chemicals upon decomposition (Warsi et al., 2024). After idol immersion, significant increases in turbidity and nutrient levels, including phosphates, were observed, leading to adverse effects on aquatic life (Roy, S. et al., 2022). The monsoon season facilitates runoff from agricultural fields and urban areas, which often contains fertilizers and waste, contributing to higher nutrient loads in water bodies.

Throughout the study period, the phosphate levels at all three locations varied from 0.5 to 21.2 mg/l. At all the three sites minimum value of phosphates observed was 0.5mg/l (June 2022 to May 2023). Maximum values of phosphates at sites V, R, C were 21.2mg/l, 2.5mg/l, 12.3mg/l respectively. Highest values of phosphates were observed at sites 'V' and 'C' in the month of

August 2023, highest value of phosphate at site 'R' observed during July 2023 (Fig.8). During this monsoon, higher phosphorus levels were observed, increased runoff from nearby land areas, accelerated organic matter decomposition, and increased sewage discharge could all be contributing factors to the observed high value during the monsoon season. Changes in redox conditions brought on by the monsoon may have an effect on phosphate mobility in sediments.

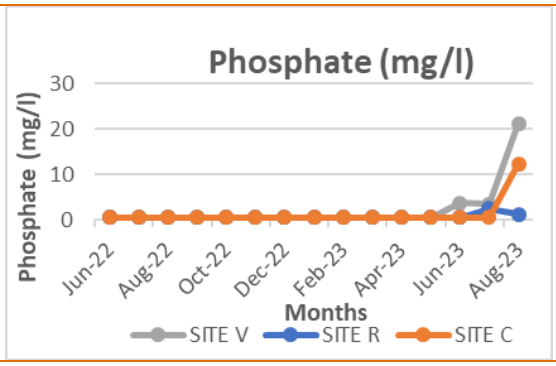


Fig.8: Monthly variation of phosphates (mg/l) in all study stations of Mumbra mangrove wetland

Silicates:

Compounds with silicon and oxygen that are frequently mixed with metals like calcium, potassium, or sodium are known as silicates in water. They exist in a variety of forms, such as suspended solids, colloidal particles, and dissolved ions. Certain silicates are good for water systems, but others can harm them by accumulating deposits and scales.

The silicates values ranged between 62.5 to 250 µg/l at all the three sites during the study period. Site 'V' has the lowest and highest silicates values of 119.047 and 250 µg/l, respectively, as identified in August 2022 and September 2022, while site 'R' had the lowest and highest silicates values of 62.5 and 238.1µg/l, which were detected in September 2022 and November 2022. Site 'C' had minimum and maximum silicates values of 59.52 and 200 µg/l respectively, which is found in August 2022 and November 2022 (Fig.9).

The presence of silicates in the water of the Mumbra mangrove ecosystem, particularly amidst ongoing construction, can be attributed to several interrelated factors. These include the natural biogeochemical processes of mangroves, the impact of anthropogenic activities, and the unique properties of silicon in enhancing plant resilience. The increase in silicate levels is due to sand dredging activities is a complex interaction influenced by sediment dynamics and nutrient cycling. Dredging can resuspend sediments, altering the nutrient composition and potentially increasing dissolved silicate (DSi). Dredging activities disturb sediment layers, leading to the resuspension of finer particles, which are rich in nutrients, including silicates (Nayar, et al., 2007).

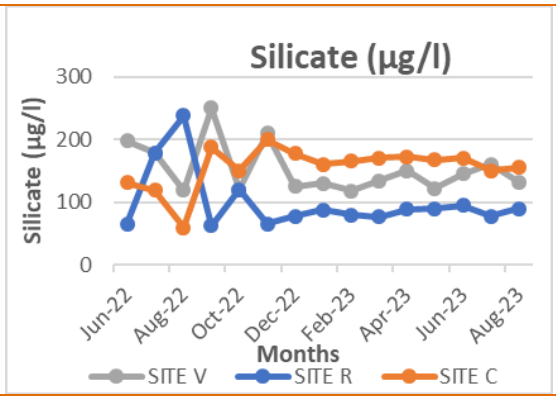


Fig.9: Monthly variation of silicates (µg/l) in all study stations of Mumbra mangrove wetland

Lead:

Because of its toxicity and longevity, lead pollution in mangrove water is a problem. The presence of lead in mangrove sediments can be impacted by a number of causes, including both natural and human-induced processes. Rainwater can wash lead from urban surfaces into mangrove areas, exacerbating contamination levels (Szafranski and Granek, 2023). Construction activities disturb soil, leading to increased erosion and the leaching of lead into water systems (Day et al., 2024). These activities disturb sediments, releasing previously trapped heavy metals into the water column. This process can lead to increased bioavailability of lead, as observed in various mangrove ecosystems. Raw sewage often contains heavy metals such as Zn, Cd, Pb, and Ni, which can accumulate in mangrove soils and sediments (Kamau et al., 2015).

Throughout the study period, the Lead content at all three sites varied from <0.010 to 3.76 mg/l. At all the three sites minimum value of lead is same which is 0.010 mg/l which were observed from June 2022 to October 2022. Maximum values of lead at sites V, R, C were 3.76 mg/l, 2.4 mg/l, 3.43 mg/l respectively. All highest values of lead observed in the month of March 2023 at all the three sites (Fig.10). Lead contamination in the water of mangrove ecosystems in the Mumbra region primarily arises from anthropogenic activities, particularly construction and industrial processes. These activities introduce heavy metals, including lead, into the environment, which can accumulate in the mangrove ecosystem and subsequently affect local water quality.

In the present study areas, we observed an increase in oil and grease in the water between October 2022 to August 2023 as a result of sand-dragging activities and the nearby automotive industry. Because grease includes lead, which leaches into the water as the amount of oil and grease in the water grows, we end up with lead in the water. Lead levels have also increased as a result of other human activities like idol immersion, sewage, and sand-dragging pipe corrosion (Hossain et al., 2024).

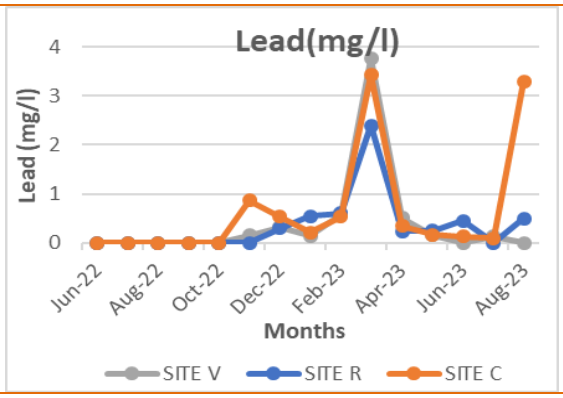


Fig. 10: Monthly variation of lead (mg/l) in all study stations of Mumbra mangrove wetland

Chromium:

Chromium is usually present in trace amounts in natural water sources, but industrial operations can add more. Heavy rainfall leads to increased surface runoff, which carries sediments and contaminants, including chromium, into the mangrove ecosystem (Roy, D. et al., 2018).

The chromium values ranged between <0.005 to 0.04 mg/l at all the three sites during the study period. At all the three sites minimum value of chromium is same which is <0.005mg/l which were observed from June 2022 to May 2023. Maximum values of chromium at sites 'V', 'R', 'C' are 0.03mg/l, 0.01mg/l, 0.04 mg/l respectively. Highest values of chromium at sites 'V' and 'R' were observed in the month July 2023, highest value of chromium was observed at

site 'C' during June 2023 (Fig.11). Higher values of chromium mostly observed during monsoon season. The presence of chromium in the water of the mangrove ecosystem in Mumbra can be attributed to several interrelated factors, including industrial pollution, sedimentation processes, and the natural accumulation capabilities of mangrove plants. These elements contribute to the overall dynamics of chromium distribution in this unique ecosystem.

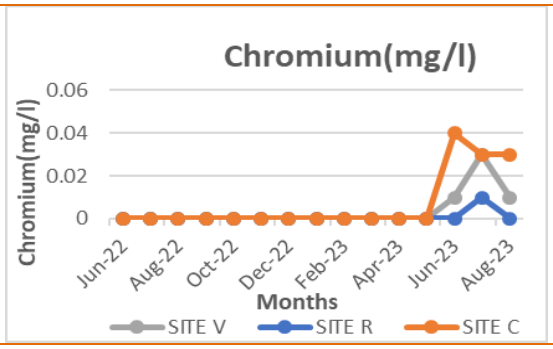


Fig. 11: Monthly variation of chromium (mg/l) in all study stations of Mumbra mangrove wetland

Arsenic:

For arsenic in drinking water, the World Health Organization (WHO) suggests a provisional recommendation value of 10 µg/L (micrograms per liter). In India, 0.05 mg/l (50 µg/l) is the acceptable level when no other sources are available. Elevated quantities of arsenic in drinking water can cause major health problems, such as heart disease and cancer.

The arsenic values were observed below detection level (<0.02mg/l) at all the three sites during the study period (Fig.12). No fluctuations were observed throughout the study period.

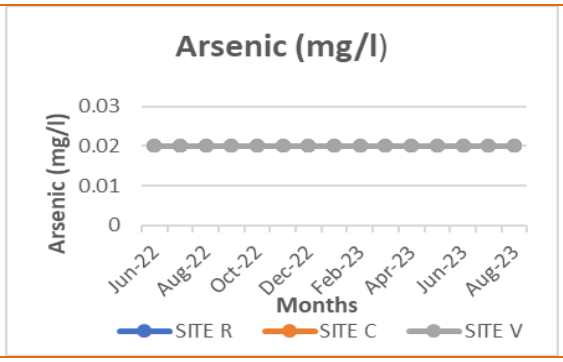


Fig. 12: Monthly variation of Arsenic (mg/l) in all study stations of Mumbra mangrove wetland

Conclusion

The physio-chemical parameters of water samples from Mumbra wetlands fluctuated moderately throughout the study period. As compared to monsoon 2022, in monsoon 2023 higher levels of turbidity, suspended solids, nitrate, silicates were observed, depicting deterioration in the water quality of the Mumbra wetlands. This may be due to the various anthropogenic activities like sand dredging, idol immersion, sewage and garbage dumping happening in and around the Mumbra wetlands having devastating effects on the Mumbra wetland ecosystem as a whole. Hence, it is strongly recommended that the concerned authorities should immediately take up the remedial measures to preserve and sustain the Mumbra wetland ecosystem.

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DOI:10.22192/ijarbs.2025.12.07.005	

How to cite this article:
Shaikh Nuzhat Farheen Abdul Kalam, Rupinder Kaur and Mangal Chavan. (2025). Analysis of Physio-chemical Parameters of Water Samples from the Mangrove Wetlands near Mumbra, District Thane, Maharashtra. Int. J. Adv. Res. Biol. Sci. 12(7): 35-46.
DOI: http://dx.doi.org/10.22192/ijarbs.2025.12.07.005