Clean Technologies and Recycling

Clean Technologies and Recycling, 3(4): 257–266.
DOI: 10.3934/ctr.2023016
Received: 04 July 2023
Revised: 09 October 2023
Accepted: 15 October 2023
Published: 07 November 2023

http://www.aimspress.com/journal/ctr

Research article

Identification of marine micro algae in correlation with water quality assessment of coastal region of Maharashtra, India

Smita M. Pore and Vinayak P. Dhulap*

Department of Environmental Science, School of Earth Sciences, Punyashlok Ahilyadevi Holkar Solapur University, Solapur (MH), 413255, India

* **Correspondence:** Email: vpdhulap@sus.ac.in.

Abstract: The recent marine algae study was carried out in the coastal region of Maharashtra, which is a district of Ratnagiri, Sindhudurg between 2021 and 2022. Water and algae samples were collected between September to October, mainly because to availability of algae is maximum in this period. The sampling locations were decided based on both previous work performed by researchers and on a literature review. The sampling sites were fixed based on the size of study area, sampling site accessibility, availability of algae on surface and substratum of the rock or wall. The microalgae were collected and preserved in plastic jar containing 3% to 4% formalin. The water samples were collected and specific physical and chemical parameters such as pH with pH meter, dissolved oxygen (mg/L) by DO meter, and temperature (Celsius) by digital thermometer were analyzed in situ. The remaining physical and chemical parameters were analyzed in the departmental research laboratory using standard methods outlined by the American Public Health Association (APHA). The collected micro algae were identified by a standard microscopy method using key references and with the help of algae experts. The main objective of the present research was to conduct extensive research on the collection and identification of diverse algal species in a coastal region to determine algal diversity, to determine the water quality standard and to measure the occurrence of algae in water.

Keywords: micro algae; water analysis; algae identification; algal diversity

1. Introduction

Algae can occupy a diverse ecosystem, such as fresh water and marine water (ocean, ponds, lakes, rivers and stream), due to its adaptability in extreme conditions. Due to its quick responses towards pollutants, algae are often used as an indicator of water pollution [1]. The type and effect of pollutants are indicated by various types of bioindicator present in the ecosystem. Certain species of algae such as *Euglena*, *diatoms*, and *Chlamydomonas* can be grown the range of low to high nutrient content water [2]. In a water quality assessment, micro algae species of *Chlorella vulgaris* and *Pseudo kirchneriella subcapitata* can be used in a bioassay test to check water toxicity [3]. In the treatment of wastewater, biofuel generation and for other biological applications, desirable genes should be isolated and their characterization is essential [4]. Temperature measurement of polluted water is an important parameter because temperature can affect the concentration of DO (dissolved oxygen) and BOD (biological oxygen demand) of water, which display harmful effects on both aquatic life and on algal growth [5]. Algae produces the maximum amount of dissolved oxygen in water during daytime through the process of photosynthesis, and the amount of dissolved oxygen is lower during night due to respiration [6]. Contaminants or pollutants present in the water can affect the water quality and human health. Anthropogenic activities such as mining, industrial effluent discharge, water treatment plants and agricultural activities cause surface and ground water pollution because the polluted water is rich in phosphate nitrate and organic content, which promotes the growth of micro algae [7]. The application of geospatial technology includes remote sensing and the geographic information system (GIS), which can help identify the availability of chlorophyll within plants and algae through satellite imagery. The application of these advanced techniques is useful to identify algal diversity and the water quality of area certain region [8]. The application of different numerical models such as water quality model and remote sensing based models are used to continuous monitoring of water ecosystem and growth of harmful algal blooms [9].

Algae are present in the form of biofilms alongside different species of bacteria, fungi and invertebrates. Along with a periphyton community, benthic algae form thick biofilms in high light intensity. Algal biofilms grow along side tall plants or other organisms and are easy to harvest from water bodies [10]. The growth of algal blooms depends on the characteristics of fresh water and coastal water. In fresh water, the type of soil reservoir, the pattern of drainage within the area and the type of vegetation cover are important for algal growth. In costal water, the temperature, pH, light intensity, water salinity and nutrient availability are essential for algal growth [11]. Microalgae assay technique is used for the study of eco-toxicology of water samples and the effect of environmental factors on the growth of algae .The algal growth is important to maintain the food chain of aquatic ecosystem, because micro algae are producer in the trophic level [12] Micro algae are identified on the basis of their morphology and physiological features as a scientific method. At present research world the advanced technique such as molecular markers are used for identification of different types of algae [8].

2. Material and methods

2.1. Study area

The present research was carried out in the coastal and fresh water region of the Maharashtra state of India. The coastal region of Maharashtra state is popularly known as Kankan, which extends throughout the western coasts of Maharashtra, Goa and Karnataka. Algae collection was performed on different beaches of two districts: Ratnagiri (latitude 16 °59' 39.9984" N and thelongitude 73 °18' 0.0108" E) and Sindhudurg (latitude: 16 ° 10' 53.8356" and longitude: 73 ° 44' 52.0296"). Fresh water algae samples were collected from the Bhima (Chandrabhaga) river of Pandharpur and from freshwater lakes of the Solapur district (latitude 17 °39' 35.7120" N and longitude 75 °54' 22.9932" E).

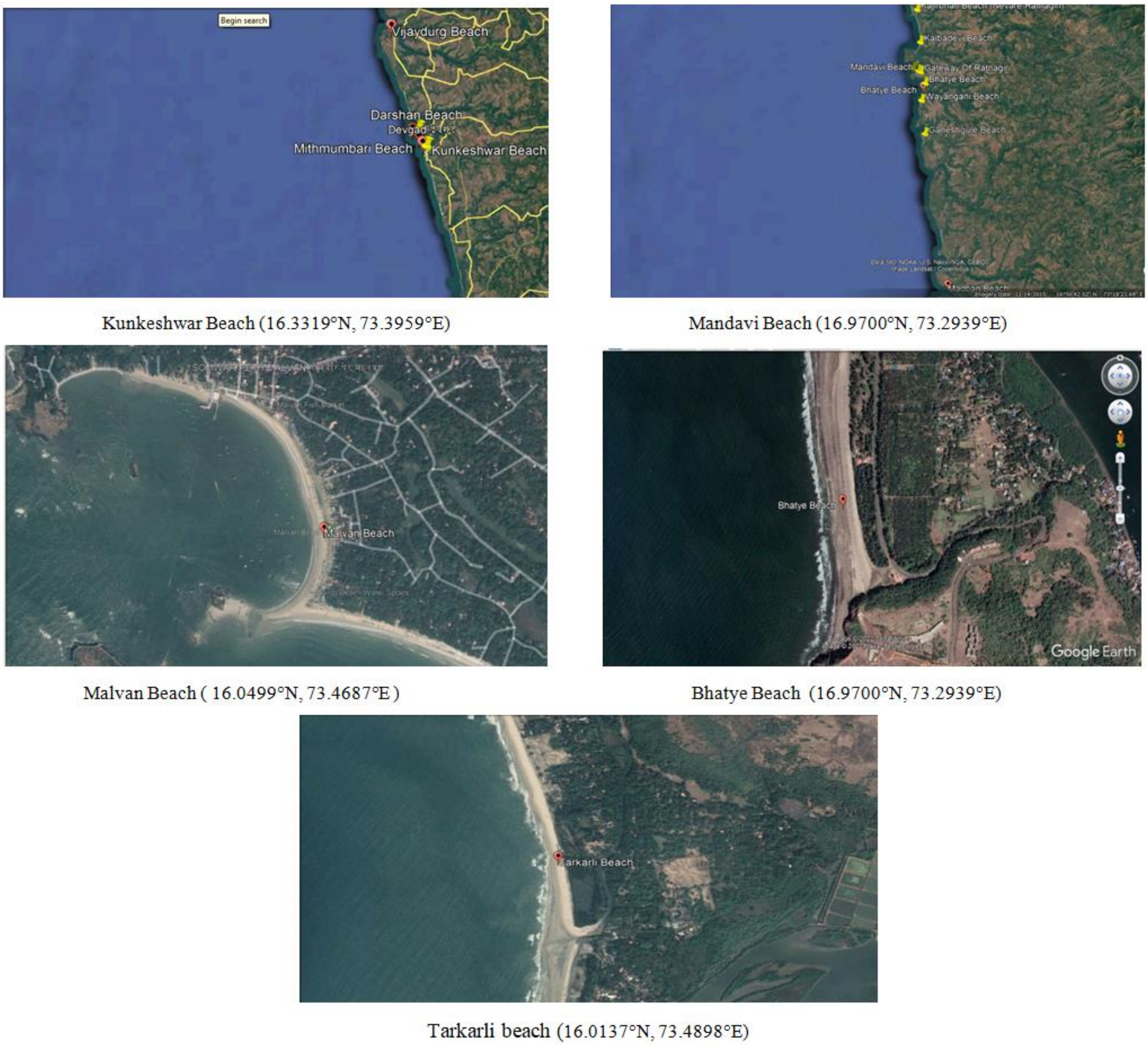

Figure 1. Sample locations of coastal beaches from Sindhudurg and Ratnagiri districts (Source—Google Earth image).

2.2. Algae collection

In the present study, algae and water samples collection were collected in both 2021 and 2022 during the period between 30 September and 3 October from the coastal area of Sindhudurg and Ratnagiri district, Maharashtra (Figure 1). This duration of algae collection was ideal due to the increased abundance and availability of fresh algae. The equipment required for algae collection is minimal as compared to other biomass collections. For the qualitative collection of algae, either plastic, glass bottles or containers were used. A 10 ml pipette was used to collect samples of soft substrate, and a knife was used for to scrape the algae attached to hard structures such as rock or wood. These algae, also called epilithic algae, were collected in separated sampling jars.

After the collection of algae samples, the jars were labeled with the area of collection, the time and the latitude and longitude of an area/site. Any floating algae were manually collected by hand and any submerged algae were collected through plankton net. The lengths of filamentous algae were measured by scale within the field. After collection of different types of microalgae, all specimens were placed a solution of formalin (formaldehyde, 3% to 5%) to preserve the algae for further study. Color is a taxonomic characteristic of most algae, especially green algae. The colors of the microalgae included the following: green, light green, blue green, dark brown, light brown to greenish brown. The preservation of microalgae in formalin can maintain the natural color of algae for longer duration even kept in dark condition.

2.3. Water collection

The water sample containers were rinsed and pre-washed with distilled water and washed again with the same water sample. For nitrate and phosphate determinations, water samples were stored in 500 ml polyethylene bottles, and sulfuric (H_2SO_4) acid was added to reach a pH < 2. The amount of phosphate and nitrate were estimated using a spectrophotometer. For the analysis of hardness, total dissolved solids (TDS), and salinity determination, water samples were separately collected in 500 ml plastic bottles. Then, all samples were immediately stored in ice boxes and filtered through 0.2 mm membrane filters.

2.4. Algae identification

The collected algal samples were brought to a departmental laboratory for microscopic examination. The representative macroalgae filaments were picked up with forceps and placed on a glass slide, drops of distilled water and denitrified algae were added, samples were covered with a cover slip, and the slide was observed in a microscope under 10×, 20×, and 40× magnification. The identification of non-filamentous algae followed the same procedure. During this identification, algal species were identified at the genus level with digital microscopy and a microscopic camera (Figure 2). Photo plates of algal samples were microscopically examined and identified on the basis of morphological and molecular identification using the Algal Botanical Survey of India, the Algae Indian Biodiversity Portal and by taxonomist with the research Institute of the Solapur District.

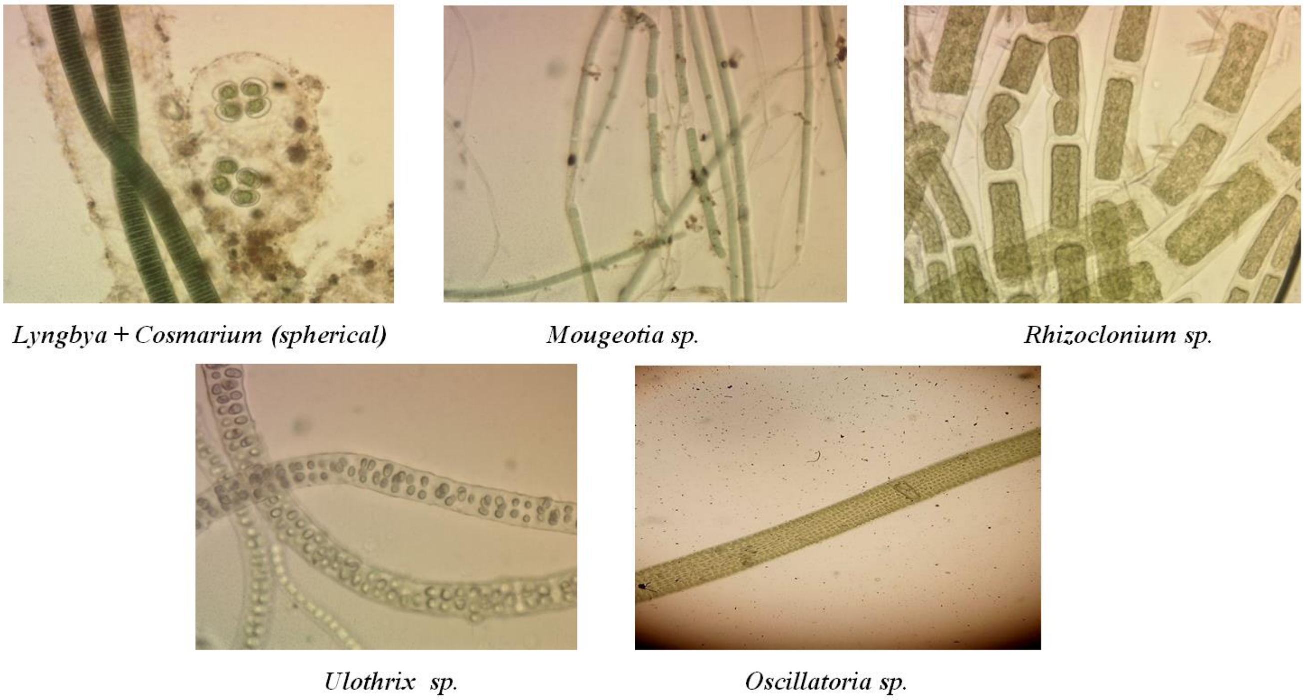

Figure 2. Photo-plates of microscopic algal species from the marine water samples.

2.5. Water analysis

2.5.1. Physicochemical analysis

Various physical parameters such as pH, temperature and DO were analyzed on site using standard methods. The EC (Electrical conductivity), TDS (Total dissolved solids), TS (Total solids), TSS (Total suspended solids), BOD (Biological oxygen demand), COD (Chemical oxygen demand), total hardness, acidity and alkalinity are determined by standard methods (APHA, 2005).

3. Results and discussion

The study was performed during the months of September–October 2021 in the years 2021 and 2022 in coastal region of Maharashtra, India to uncover the seasonal variation of water quality and algal diversity (Figure 2). The physical and chemical parameters of various water samples (year 2021 and 2022) were studied by standard analytical methods (Figure 3).

Water temperature can affect the growth of micro algae and aquatic life within a marine ecosystem. Within the study region, the surface temperature of the water ranged from 29 to 34 ℃. The variation of temperature fluctuations was observed in the year minimum (from 28–28.3 ℃), maximum (from 30–32 ℃) and mean (from 29–32.9 ℃). The fluctuation of temperature in both years was due to climatic change. During marine heat waves, the lives of various marine species are threatened. These temperatures can be sustained by algae because they can survive in conditions of high environmental temperatures. pH is another important parameter which determines the quality of water. The acidic pH affected the aquatic life by altering their food web, as well as affecting the behavior of all marine organisms. In the present research, the pH values were at neutral range in both years, which is favorable for aquatic life.

Electrical conductivity indicates the total number of ions present in the water; additionally, it measures the ability of water to transmit an electrical current over a certain distance. In the present research, the average increase in the water's EC was from 555 to 680 μS/cm. Many factors were responsible for the change in the EC, such as temperature, and salinity (i.e. the concentration of dissolve salts of water (32 to 33 gm/L)). The dissolved oxygen of marine water ranged from 5.4 to 5.22 mg/L in the year 2021 and 2022, respectively (Tables 1 and 2). The amount of dissolved oxygen of the water was depleted due to an increase in temperature and salinity. An increased amount of BOD affects the availability of dissolved oxygen to the aquatic fauna. The available oxygen is utilized by aerobic microorganisms to decompose the organic waste present in the water. During the study period, the average range of BOD was from 27.8 to 40 mg/L; the average range of COD was from 243 to 290 mg/L. These figures indicate the presence of a high concentration of organic matter in the water due to water pollution. One cause of water pollution in the year 2022 is the increased number of tourists within the coastal area. In 2021, severe restrictions were placed on travelling and human mobility, which reduced pollution in and around the coastal area. The effect of water pollution was also observed in the concentration of nitrate (16 to 30 mg/L) and phosphate (5 to 6.18 mg/L). The TDS and TSS values of the water were increased during the monsoon period due to higher number of floating particles and dissolved solids.

Eight different species of marine algae were isolated and identified from coastal areas. The isolated species included *Lyngbya, Mougeotia sp, Rhizoclonium, Cosmarium, Oscillatoria sp.* and *Ulothrix*. Among all the species, the *Ulothrix, Oscillatoria sp.* and *Lyngbya* were the dominant species among all the samples collected from the coastal water (Figure 2). In the Kunkeshwar coastal area, a very low abundance of microalgae were observed due to the low enrichment of nutrients compared to other sites. The Tarkarli and Malvan coastal sites observed a maximal amount of substratum algae (*Cyanophaceae*). The turbidity and total solids affected the number of algae species present. The result shows that the physicochemical parameters of marine water are correlated to the diversity and abundance of microalgae within the various sampling stations. In the present paper, the important parameters of marine water were analyzed to study the water quality indices in correlation with algal diversity.

Table 1. Water Analysis of marine water samples (2021).

Sr. No.	Parameter	Location Lat/long	Odor	Turbidity NTU	Temp ℃	pH	EC μS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosp. mg/L	Nitrate mg/L	Salinity gm/L
1	Tarkarli beach	16.0137 °N, 73.4898 °E	odorless	20	29	6.9	564	1460	845	615	5.04	22	300	5.04	15	36
2	Malvan beach	16.0499 °N, 73.4687 °E	odorless	20	29	6.8	614	1490	860	630	5.19	28	250	6	22	37.2
3	Sadanand beach	22.8298 °N, 69.3261 °E	odorless	25	30	6.5	600	1510	960	550	5.42	32	264	5.48	16	34.8
4	Mandavi beach	16.9700 °N, 73.2939 °E	odorless	25	29	7.3	555	1150	849	301	5.45	28	244	4.94	26	36
5	Bhatye beach	16.9700 °N, 73.2939 °E	odorless	25	28	7	564	1488	900	588	5.01	36	255	5.78	25	34.7
6	Kunkeshwar beach	16.3319 °N, 73.3959 °E	odorless	10	29	6.5	503	1360	910	450	6.12	21	144	4.88	12	33
Maximum value			odorless	25	30	7.3	600	1488	910	615	6.12	36	264	6	26	36
Minimum value			odorless	10	28	6.5	503	1150	845	301	5.01	21	144	4.88	12	33
Mean			odorless	20.8	29	6.8	566	1409	887	522	5.4	27.8	243	5.35	19.3	35.3
Standard deviation				5.32	0.70	0.28	35.5	126	57.7	111.3	0.375	5.28	47.75	0.43	5.52	1.322

Table 2. Water Analysis of marine water samples (2022).

Sr. No.	Parameter	Location Lat/long	Odor	Turbidity NTU	Temp ℃	pH	EC μS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosp. mg/L	Nitrate mg/L	Salinity gm/L
1	Tarkarli beach	16.0137 °N, 73.4898 °E	odorless	20	32	7	646	1660	800	860	5.2	38	288	6.04	19	33
2	Malvan beach	16.0499 °N, 73.4687 °E	odorless	20	34	7.4	680	1590	980	610	5.8	48	350	6.8	26	36
3	Sadanand beach	22.8298 °N, 69.3261 °E	odorless	30	33	7.2	569	1710	940	770	5.43	39	322	6.8	21	34
4	Mandavi beach	22.8298 °N, 69.3261 °E	odorless	40	33	7.6	701	1450	1000	450	5	42	300	5.98	26	36
5	Bhatye beach	16.9700 °N, 73.2939 °E	odorless	25	32	7	640	1688	980	708	4.92	38	255	6.28	30	34
6	Kunkeshwar beach	16.3319 °N, 73.3959 °E	odorless	25	33	7.2	502	1200	604	596	5	34	222	4.18	12	33
Maximum value			odorless	40	32	7.6	702	1710	1000	860	5.8	48	350	6.8	30	36
Minimum value			odorless	20	23	7	502	1200	604	450	4.92	34	222	4.18	12	33
Mean			odorless	28.3	32.9	7.2	623	1549	884	666	5.22	40	290	6.01	22.3	34.3
Standard deviation				6.2	0.69	0.22	67.6	179	244	132	0.306	4.34	41.97	0.88	5.82	1.247

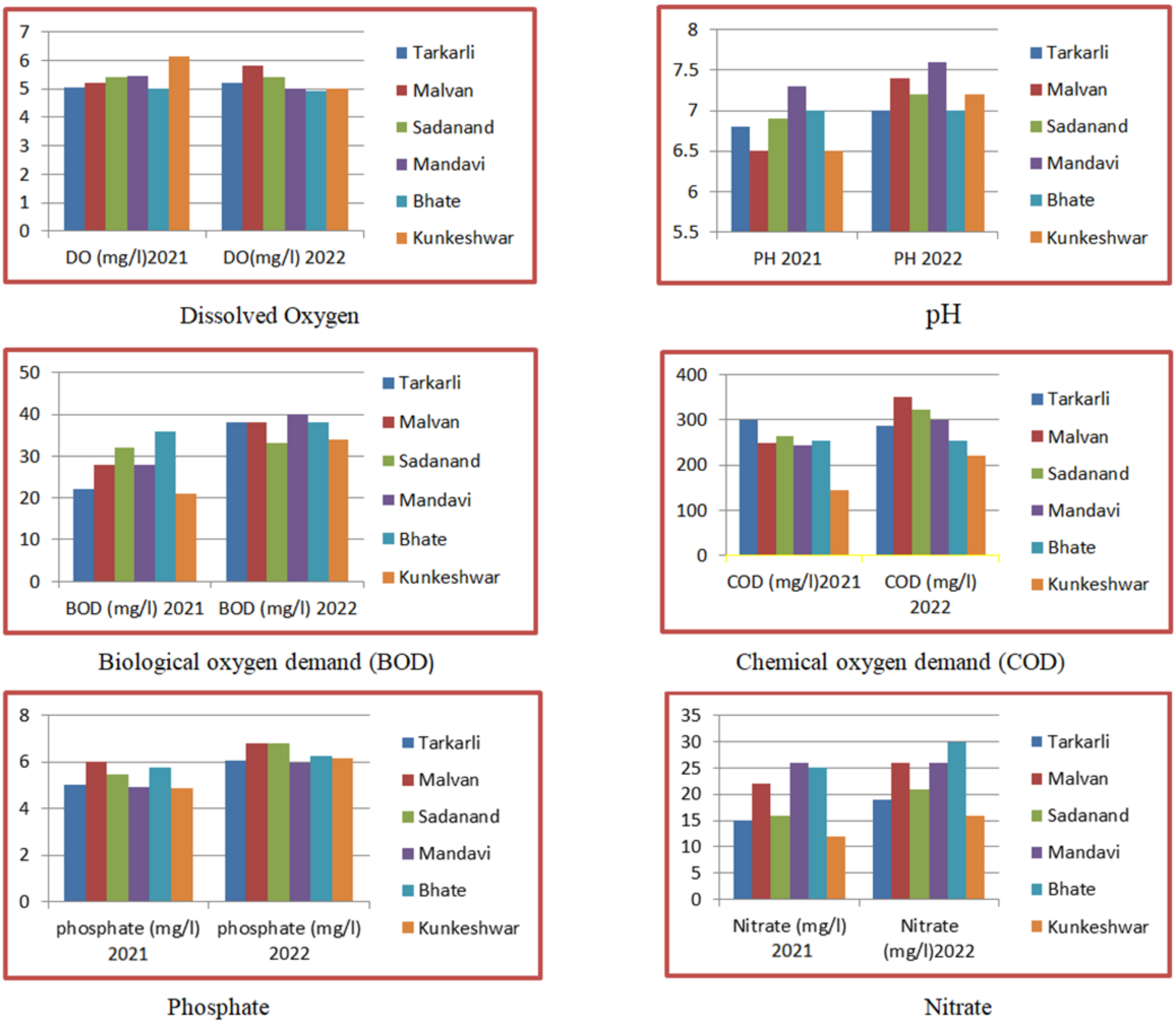

Figure 3. Physicochemical analysis of DO, pH, BOD, COD, Phosphate, and Nitrate from marine water.

4. Conclusions

The present research was performed to study the water quality index in the coastal region of Maharashtra in correlation with algae identification. In the study region, eight dominant species of microalgae were isolated from the coastal region of Maharashtra between 2021 and 2022. There was variations in physiochemical parameters, seasons, and geographical parameters in both years and in different sampling locations. The results showed that there was no significant change in the pH value during study period; the observed values ranged from 7.2 to 8.5, which are standard values. The DO was higher in all the sampling site at the standard temperatures between 30 to 32 °C; this value of DO supports the marine diversity and algae occurrence. Temperature is a major influencing factor, which ultimately affects the marine diversity and growth of algae because the temperature is highest in summer season as compared to the monsoon and winter seasons. The turbidity, EC, BOD and COD were all higher in 2022 due to an increased number of tourists and visitors within the study region (Table 2). The concentration of phosphate and nitrate displayed variability's during both years, ranging from the 5 to 6.18 mg/L and 16 to 30 mg/L, respectively. The increased concentration of phosphate and nitrate indicate the presence of pollution in the present water samples, which favors the growth of micro algae.

Use of AI tools declaration

The authors declare they have not used artificial intelligence (AI) tool in the creation of this article.

Conflict of interest

The authors declare no conflict of interest in this paper.

References

1. Appavu A, Thangavelu S, Muthukannan S, et al. (2016) Study of water quality parameters of cauvery river water in Erode region. *J Global Biosci* 5: 4556–4567.
2. Sen B, Alp MT, Sonmez F, et al. (2013) Relationship of algae to water pollution and waste water treatment. *Water Treat* 14: 335–354. https://doi.org/10.5772/51927
3. EPA, Drinking Water Health Advisory for Manganese. U.S. Environmental Protection Agency, 2004. Available from: https://www.epa.gov/sites/default/files/2014-09/documents/support_cc1_magnese_dwreport_0.pdf.
4. EPA, Secondary Drinking Water Regulations. U.S. Environmental Protection Agency, 2023. Available from: https://www.epa.gov/sdwa/secondary-drinking-water-standards-guidance-nuisance-chemicals.
5. Ebrahimzadeh G, Alimohammadi M, Kahkah MRR, et al. (2021) Relationship between algae diversity and water quality-a case study: Chah Niemeh reservoir Southeast of Iran. *J Environ Health Sci Eng* 19: 437–443. https://doi.org/10.1007/s40201-021-00616-x
6. Abed IJ, Al-Hussieny AA, Kamel RF, et al. (2014) Environmental and identification study of algae present in three drinking water plants located on tigris river in Baghdad. *Int J Adv Res* 2: 895–900.
7. Rahmanian N, Ali SHB, Homayoonfard M, et al. (2015) Analysis of physiochemical parameters to evaluate the drinking water quality in the State of Perak, Malaysia. *J Chem* 2015: 1–10. https://doi.org/10.1155/2015/716125
8. Sarwa P, Verma SK (2017) Identification and characterization of green microalgae, Scenedesmus sp. MCC26 and Acutodesmus obliquus MCC33 isolated from industrial polluted site using morphological and molecular markers. *Int J Appl Sci Biotechnol* 5: 415–422. https://doi.org/10.3126/ijasbt.v5i4.18083
9. Tian Y, Huang M (2019) An integrated web-based system for the monitoring and forecasting of coastal harmful algae blooms: Application to Shenzhen city, China. *J Mar Sci Eng* 7: 314. https://doi.org/10.3390/jmse7090314
10. Narayanan RM, Sharmila KJ, Dharanirajan K (2016) Evaluation of marine water quality–a case study between cuddalore and pondicherry coast, India. *Indian J Mar Sci* 45: 517–532.

11. Khalil S, Mahnashi MH, Hussain M, et al. (2021) Exploration and determination of algal role as Bioindicator to evaluate water quality–Probing fresh water algae. *Saudi J Biol Sci* 28: 5728–5737. https://doi.org/10.1016/j.sjbs.2021.06.004
12. Rodrigues S, Pinto I, Formigo N, et al. (2021) Microalgae growth inhibition-based reservoirs water quality assessment to identify ecotoxicological risks. *Water* 13: 2605. https://doi.org/10.3390/w13192605

AIMS Press

© 2023 the Author(s), licensee AIMS Press. This is an open access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0)