Application of Interpolation technique of GIS for assessment of water quality index in freshwater of Solapur District Maharashtra, India

Smita M. Pore[1], Vaishali J. Palkar[2], Vinayak P. Dhulap[3]
[1]*Department of Environmental Science, School of Earth Sciences, Punyasholk Ahilyadevi Holkar Solapur University, Solapur, Maharashtra, India – 413255*
[2] *Department of Geography, Vivekanand College, Kolhapur, Maharashtra. India- 416003*

***Abstract*—For the production of ethanol from micro and macro algae, the selected species of algae are chosen to increase the efficiency of the manufacturing process and to decrease the cost of manufacturing ethanol. The present research was carried out in the freshwater region of Solapur district, Maharashtra, from 2021 to 2023. The algae and water samples were collected from the lakes and rivers of Solapur district to study the effect of water quality parameters on the growth and diversity of freshwater microalgae. During the study period, the algae were collected in September, due to the favourable season and availability of algae. The collected micro algae were identified by a standard microscopy method using key references and with the help of a taxonomist. The physical and chemical parameters of water were analysed by the standard method of APHA. 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.**

***Index Terms*—Micro algae; water analysis; algae identification; algal diversity**

INTRODUCTION

On a global scale, fossil fuels can be replaced by sustainable biofuels with the help of the application of genetic engineering in the manufacture of the enzymes (Khan et al., 2017). Germany and Sweden are the only two countries that utilize biofuel (ethanol produced from sugarcane) consumption over fossil fuel, which results in a reduction of greenhouse gases (Janda et al., 2012). The seaweeds marine is used for biofuel generation due to their large growth rate and resilience in the harsh environmental weather (Meiron et al., 2019). Nowadays, algae are the best biomass instead of edible seeds because algae are harvested and cultivated throughout the year and resist extreme weather circumstances (Natalia et al., 2017). In the biomass algae, the percentage of lipids is approximately about the 30%, whereas in engineered genetically modified microbes, the lipid content can reach up to 80% (Patel et al., 2012). Algae are autotrophic organisms capable of assimilating inorganic carbon from the atmospheric CO_2 and converting solar energy into chemical energy through the process of photosynthesis ($6CO_2 + 6H_2O + \text{light} \rightarrow C_6H_{12}O_6 + 6O_2$). During photosynthetic activity, microalgae can sequester more than 1 kg of CO_2 per kilogram of biomass produced, while also exhibiting high growth rates, highlighting their potential for effective carbon capture (Shahid et al., 2020). As the highest-yielding biodiesel feedstock, microalgae offer a promising solution for meeting large-scale automotive fuel demands and could potentially replace conventional petroleum diesel. The species such as Scenedesmus dimorphus, Nannochloropsis, and Chlorella vulgaris produce large quantities of lipids, hydrocarbons, and different oils complex that are suitable for the manufacture of biodiesel. Algae can be grown in the harsh environmental conditions, including elevated salinity levels, low nutrient availability, and observed maximum growth in the absence of another competitor microorganism in an unsterile environment (Zafar et al., 2021). Micro algae were highly diversified organisms with 3,00,000 different species, among them a few species had 80% of oil content, which was used for oil production through different techniques (Ubaid Rasool et.al., 2016). Microalgae are taxonomically categorized into ten major groups, including diatoms (Bacillariophyceae), green algae (Chlorophyceae), golden algae (Chrysophyceae), yellow–green algae (Xanthophyceae), red algae (Rhodophyceae), cyanobacteria (commonly referred to as blue–green algae), brown algae (Phaeophyceae), dinoflagellates (Dinophyceae), Prasinophyceae, and Eustigmatophyceae. Nearly all species of algae are used for the manufacture of the value-added biomass, which is used to improve the immunity of the aquatic animals and also replace aquaculture feed (Pei et al., 2019). The species of Spirulina, Schizochytrium, and Porphyridium cruentum are important sources of protein, lipid, and carbohydrate (Rodionova et al., 2017). The freshwater algae Chlamydomonas reinhardtii require low salt content and show a high growth rate in diluted water (Rahman et al., 2020). Microalgal cultures typically exhibit optimal growth at temperatures ranging from 20°C to 24°C; however, the exact optimum may vary depending on the species and composition of the culture medium. Temperature can affect the growth as well as the phytochemical properties of algae, such as carbohydrate and lipid content (Jeffrey et al., 2014). Nitrates and phosphates are the key nutrients that cause the algae growth, and these inorganic substances are derived from the decomposed organic materials, which increases the growth of algae in fresh water (Steffii et al., 2003).

The significant advantage of remote sensing over conventional water quality monitoring methods is its ability to provide both spatial and temporal insights into surface water characteristic. Remote sensing has become an essential tool for monitoring water quality in both coastal and inland lake environments. This technology enables the detection of large-scale environmental changes, establishes connections between offshore and near- shore dynamics, and offers long-term, near-daily observations facilitating the analysis of seasonal patterns and interannual variability in aquatic systems (Koponen et al., 2002).

II. REVIEW OF LITERATURE

Rhayany et al (2025), said that, algae are the natural and essential phototrophic producer components of all kinds of wet ecosystems on the earth, especially the oceans, which constitute 2/3rd of the earth's surface. As primary producers, they are the major sources of the biomass of all aquatic systems. In aquatic systems, algae form the essential component of the aquatic food chain. Voloshin et al (2016), state that microalgae can withstand adverse environments, such as high salt concentration and polluted water, where plants are not grown. Thus, the use of microalgae is being explored as a promising feedstock for the manufacture of biofuels. Minhas et al (2023), said that the large populations of green algae can be found on land and in nutrient-rich standing waters, where a large number of flagellated Chlorophyta are dominant. Li et al (2017), investigated the key factors influencing algal reproduction, identifying nutrient levels in the water, light availability, water temperature, and other physical and chemical parameters as major contributors to their growth. Nitrogen, a structural component of algal cells, and phosphorus, which plays the crucial role in photosynthesis, respiration, enzyme activation, and energy transfer, are both vital for algal growth and the expansion of algal blooms. P. Singh et al (2015), state that the growth of microalgae was influenced by the duration of light, intensity of light, and available temperature. For the growth of microalgae, the optimum temperature required was in the range of 20 °C to 30 °C, depending on the type of algae, and light irradiance was between 33 µmol m2 s1 and 400 µmol m^2 /s. Razzak et al (2024), highlighted that carbon dioxide (CO_2) is a vital substrate for photosynthesis, with its availability directly influencing microalgal growth rates. Elevated CO_2 concentrations can improve photosynthetic efficiency and, consequently, enhance biomass productivity. The rate of growth kinetics was affected if the temperature dropped below 15°C and the salinity was 15 gm/L (Ning et al., 2017). The lakes are a natural habitat for many algae, where they get optimum growth factors and withstand extreme conditions. Some algae are transferred through human activities and through polluted water (Udayashankara et al., 2013).

III. MATERIALS AND METHODS

- Study area

Solapur District

Geographically, Solapur district is situated between 17.10° and 18.32° N latitude and 74.42° and 76.15° E longitude, on the southeastern fringe of Maharashtra. The major rivers flowing through the district are the Bhima and Sina Rivers, with the Nira, Mann, and Bhogawati Rivers serving as their tributaries.

Ekrukh Lake (a)

Sambhaji Lake (b)


Siddheshwar Lake (c)

Chandrabhaga/Bhima River (d)

Figure 1: Google Earth images of fresh water bodies of Solapur District, Ekrukh Lake (a), Sambhaji Lake (b), Siddheshwar Lake (c), and Chandrabhaga/Bhima River (d), Maharashtra, India

- Water and algae collection

The algae and water samples were collected from the freshwater region of Solapur district of Maharashtra in April and September (pre-monsoon and post-monsoon, respectively) during the 2021 to 2023 study period. This duration was favourable for algae collection due to the post-monsoon season, where all the environmental factors were suitable for algal growth and their reproduction phase. When macroalgae (seaweed) species reach maturity, they are harvested by removing the entire thallus and cutting it into smaller fragments for subsequent cultivation. Both manual and mechanical harvesting methods are employed to collect large quantities of wild macroalgal biomass.

Table 1- The list of equipment required for the analysis of the physical and chemical parameters of water

Sr. No.	Parameter	Equipment Required for Analysis
1.	Temperature	Thermometer and Water Analysis Kit
2.	Colour	Visual and colour kit
3.	Odor	Physiological Sense
4.	Electrical Conductivity/ (TDS)	Conductivity Meter and Water Analysis Kit
5.	pH	pH Meter and Water Analysis Kit
6.	Dissolved Oxygen	Titration and Water Analysis Kit
7.	Nitrate	U. V. Visible Spectrophotometer
8.	Phosphate	U. V. Visible Spectrophotometer
9.	Biochemical Oxygen Demand	Incubation followed by titration
10.	Chemical Oxygen Demand	C.O.D. digester

- Algae identification

The collected freshwater algae samples were observed under microscope with 10×, 20×, and 40× magnification lenses. The algal samples were microscopically examined and identified on the basis of morphological and microscopic examination using the Algal Botanical Survey of India, the Algae Indian Biodiversity Portal at the genus level.

- Water analysis

The physical parameters of water, such as temperature, turbidity, electrical conductivity, Total Dissolved

Solids (TDS), Total Suspended Solids (TSS), and Total Solids (TS), and chemical parameters, viz., pH, Dissolved oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Nitrate and Phosphate, were analyzed by standard method of APHA.

- Application of GIS in water analysis through the interpolation technique

The interpolation was a mathematical technique used to estimate unknown values of a parameter within the range of measured data points. It helps in obtaining intermediate values where direct measurement was not available. Interpolation was used to estimate the value of a variable (such as pH, dissolved oxygen, TDS, BOD, COD, etc.) at a point between two known data points.

IV. RESULTS

Table 2- Analysis of fresh water from Solapur District, Maharashtra, during April 2021

Name of sampling location	Location Lat/Long	Odor	Turbidity NTU	Temp °C	pH	EC µS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosphate mg/L	Nitrate mg/L
Sambhaji lake	17°38'49"N 75°54'04"E	odor	30	39.9	6.8	524	1417	990	427	5.1	36.5	374	5.6	14.2
Ekrukh lake	17°44'42"N 75°55'01"E	odorless	25	39.7	7.1	445	1214	895	319	5.6	26.8	255	5	10.9
Siddheshwar lake	17°40'16"N 75°54'11"E	odorless	25	39.7	7.1	412	1310	888	422	5.3	25.7	300	4.9	10.1
Chandrabhaga River	17°41'08"N 75°20'23"E	odor	30	38.2	6.8	580	1488	992	496	4.82	39.2	398	5.7	16.1
Maximum value		odorless	30	39.9	7.1	580	1488	992	496	5.6	39.2	398	5.7	16.1
Minimum value		odorless	25	38.2	6.8	412	1310	895	319	4.8	25.7	255	4.9	10.9
Mean		odorless	27.5	39.4	7	490	1357	941	416	5.2	32	331	5.3	12.8
Standard deviation		odorless	2.4	0.68	0.16	65.8	1004	50	63	0.28	5.9	57	0.23	2.4

Table 3- Analysis of fresh water from Solapur District, Maharashtra, during September 2021

Name of sampling location	Location Lat/Long	Odor	Turbidity NTU	Temp °C	pH	EC µS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosphate mg/L	Nitrate mg/L
Sambhaji lake	17°38'49N 75°54'04"E	odor	25	33.1	7.1	501	1397	912	435	5.8	34.9	350	5.8	16.2
Ekrukh lake	17°44'42N 75°55'01"E	odorless	20	33.6	7.3	410	1200	874	296	6.1	24.8	212	5.04	12.8
Siddheshwar lake	17°40'16N	odorless	20	33.6	7.2	392	1290	894	406	5.6	22.7	259	5.1	11.9

	75°54'11"E													
Chandrabhaga River	17°41'08N 75°20'23"E	odor	30	32.2	7.4	520	1458	982	446	5.2	36.1	368	6.2	18.5
Maximum value		odorless	30	33.6	7.4	520	1458	982	446	6.1	36.1	368	6.2	18.5
Minimum value		odorless	20	32.2	7.2	501	1200	894	296	5.2	22.7	212	5.1	11.9
Mean		odorless	23.8	33.1	7.25	455	1336	915	396	5.7	30	297	5.5	14.9
Standard deviation		odorless	4.1	0.57	0.11	55.5	99	40	59	0.32	5.9	64	0.49	2.6

Table 4-Analysis of fresh water from Solapur District, Maharashtra, during April 2022

Name of sampling location	Location Lat/Long	Odor	Turbidity NTU	Temp °C	pH	EC µS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosphate mg/L	Nitrate mg/L
Sambhaji lake	17°38'4N 75°54'0E	odor	35	41.8	7	586	1478	996	482	4.9	38.2	387	5.9	16.6
Ekrukh lake	17°44'4N 75°55'0E	odorless	30	41.8	6.8	468	1245	886	359	5.2	30	273	5.2	14.3
Siddheshwar lake	17°40'1N 75°54'1E	odorless	30	41.7	6.7	455	1328	912	416	5.1	28.1	316	5.2	14.2
Chandrabhaga river	17°41'0N 75°20'2E	odor	40	40	6.9	602	1502	986	516	4.52	40.9	420	6.1	19.6
Maximum value		odorless	40	41.8	7	602	1502	996	498	5.2	40.9	420	6.1	19.6
Minimum value		odorless	30	40	6.8	455	1245	912	329	4.9	28.1	293	5.2	14.2
Mean		odorless	33.8	41.3	6.9	528	1388	945	443	4.9	34.3	349	5.6	16.2
Standard deviation		odorless	4.1	0.76	0.13	66.7	106	47	60	0.26	5.4	58	0.41	2.2

Table 5- Analysis of fresh water from Solapur District, Maharashtra, during September 2022

Name of sampling location	Location Lat/Long	Odor	Turbidity NTU	Temp °C	pH	EC µS/cm	TS mg/L	TDS mg/L	TSS mg/L	DO mg/L	BOD mg/L	COD mg/L	Phosphate mg/L	Nitrate mg/L
Sambhaji lake	17°38'4N 75°54'0E	odor	25	33.1	7.4	568	1447	926	421	6.2	36.9	336	5.62	14.6
Ekrukh lake	17°44'4N 75°55'0E	odorless	20	33.6	7.5	401	1220	924	241	6.3	22.8	242	5	11.5
Siddheshwar lake	17°40'1N	odorless	20	33.6	7.5	432	1305	956	368	5.9	24.2	295	4.9	11.1

	75°54' 1E													
Chandrabhaga river	17°41' 0N 75°20' 2E	odor	30	32.2	7.9	576	1478	1011	443	5.6	36.9	398	6	16.3
Maximum value		odorless	30	33.6	7.9	576	1498	1011	443	6.3	36.9	398	6	16.3
Minimum value		odorless	20	32.2	7.5	401	1290	924	241	5.6	22.8	242	4.9	11.1
Mean		odorless	23.7	33.1	7.6	494	1362	954	368	6	30.2	317	5.4	13.4
Standard deviation		odorless	4.1	0.77	2	78	104	35	78	0.28	6.7	57	0.45	2.2

Table 6- Analysis of fresh water from Solapur District, Maharashtra, during April 2023

Name of sampling location	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	Phosphate mg/L	Nitrate mg/L
Sambhaji Lake	17°38' 4N 75°54' 0E	odor	41.8	43	6.9	602	1530	1009	521	4.8	43.9	421	6.2	19.1
Ekrukh Lake	17°44' 4N 75°55' 0E	odorless	41.8	43	6.6	500	1270	964	306	5.2	33.5	342	5.5	16.9
Siddheshwar Lake	17°40' 1N 75°54' 1E	odorless	41.7	43	6.5	492	1346	986	360	5	31.2	368	5.6	15.8
Chandrabhaga River	17°41' 0N 75°20' 2E	odor	40	42	6.7	665	1586	1030	556	4.9	45.6	495	6.5	21
Maximum value		odorless	40	43	6.7	665	1586	1030	521	5.2	45.6	495	6.5	21
Minimum value		odorless	30	42	6.5	492	1346	964	306	4.8	31.2	342	6.2	15.8
Mean		odorless	33.8	42.7	6.7	564	1433	997	435	5	38.5	406	6	18.2
Standard deviation		odorless	4.1	0.65	0.15	72	129	24	105	0.15	6.3	58.5	0.42	2

Table 7- Analysis of fresh water from Solapur District, Maharashtra, during September 2023

Name of sampling location	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	Phosphate mg/L	Nitrate mg/L
Sambhaji lake	17°38' 4N	odor	25	32	7.45	496	1495	1062	433	5.2	41.5	445	6.2	17

	75°54' 0E												
Ekrukh lake	17°44' 4N 75°55' 0E	odorless	20	32	7.7	421	1224	965	259	5.42	31.5	302	5.9	15.2
Siddheshwar lake	17°40' 1N 75°54' 1E	odorless	20	32	7.5	387	1316	944	372	5.2	29.6	342	6.1	14
Chandrabhaga river	17°41' 0N 75°20' 2E	odor	30	31	8.1	559	1526	993	533	5.25	43.6	466	6.4	19.5
Maximum value		odorless	30	32	8.1	559	1635	1062	533	5.42	43.6	466	6.41	19.5
Minimum value		odorless	20	31	7.5	387	1316	993	259	5.2	29.6	302	5.9	14
Mean		odorless	23.8	31.8	7.7	465	1450	991	399	6.6	36.5	388	6.1	16.4
Standard deviation		odorless	4.1	0.43	0.25	68	138	44.5	99	1.33	6.08	72	0.19	1.83

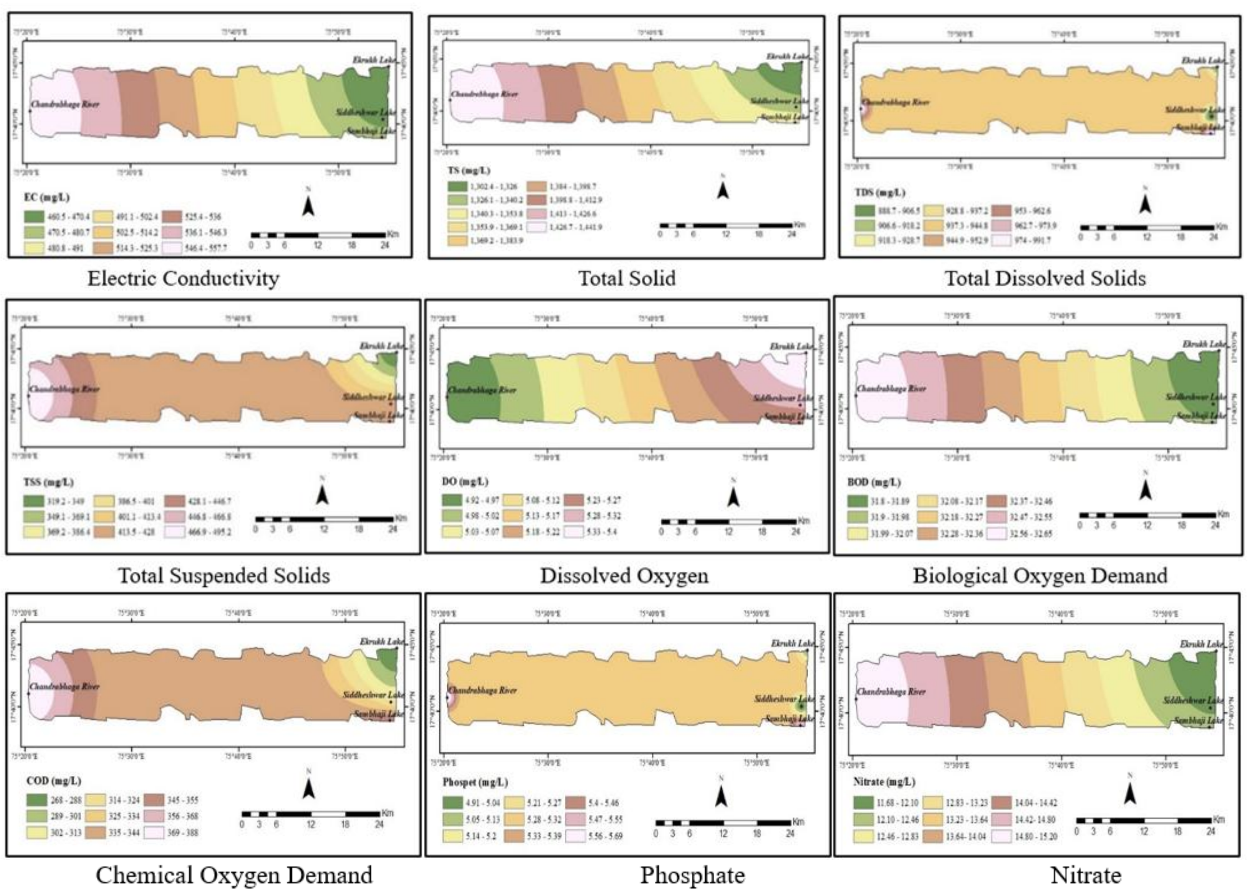
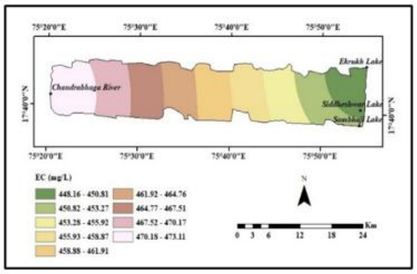
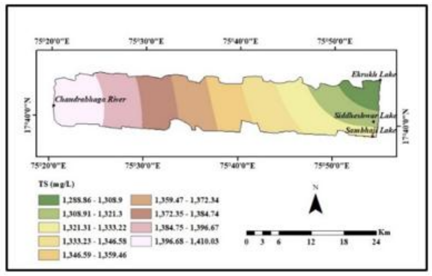
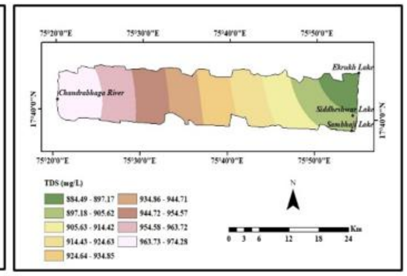
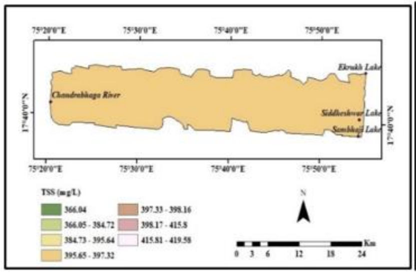


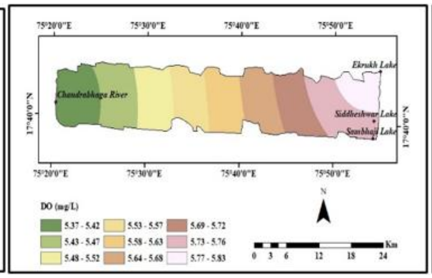
Figure 2- Interpolation of the fresh water parameter of Solapur District during April 2021

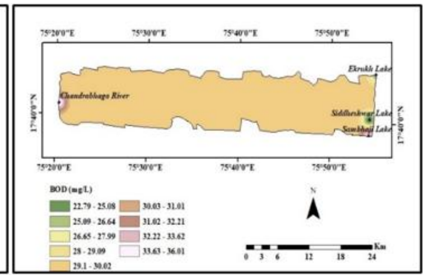

Electric Conductivity

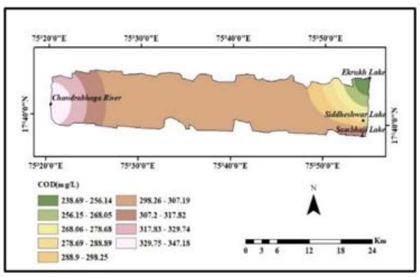

Total Solid

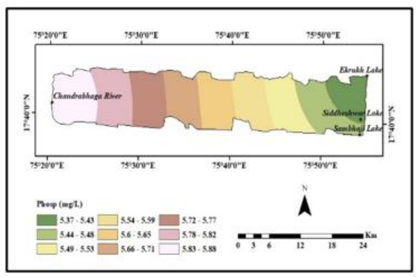

Total Dissolved Solids


Total Suspended Solids


Dissolved Oxygen


Biological Oxygen Demand


Chemical Oxygen Demand


Phosphate

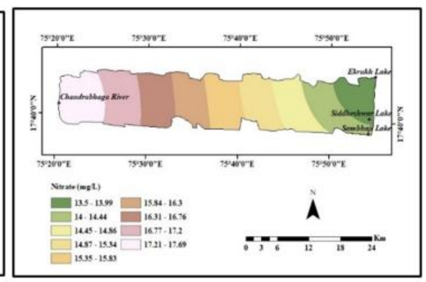
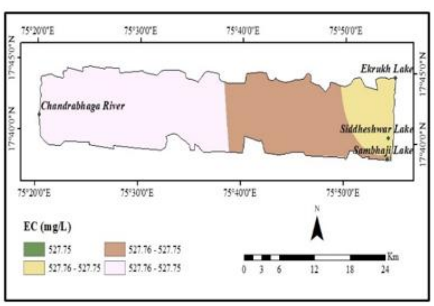
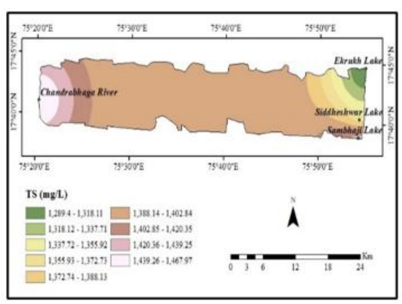
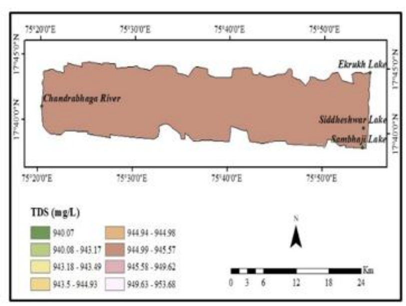
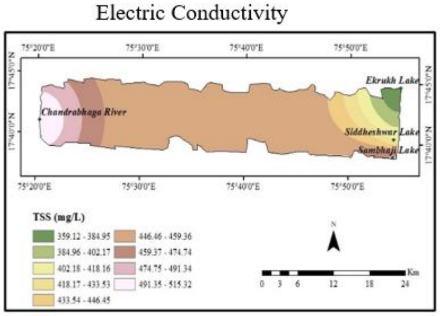

Nitrate

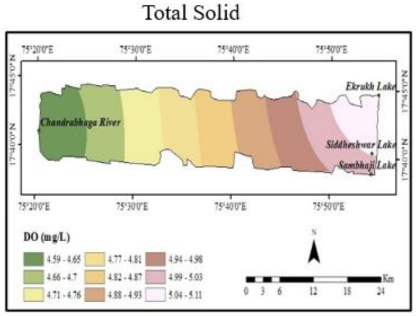
Figure 3- Interpolation of the freshwater parameter of Solapur District during September 2021

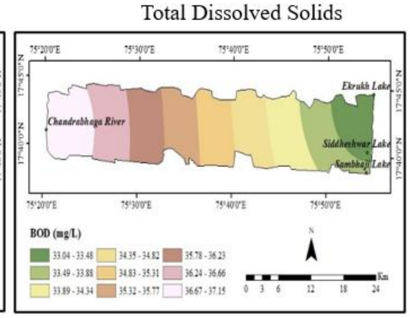

Electric Conductivity

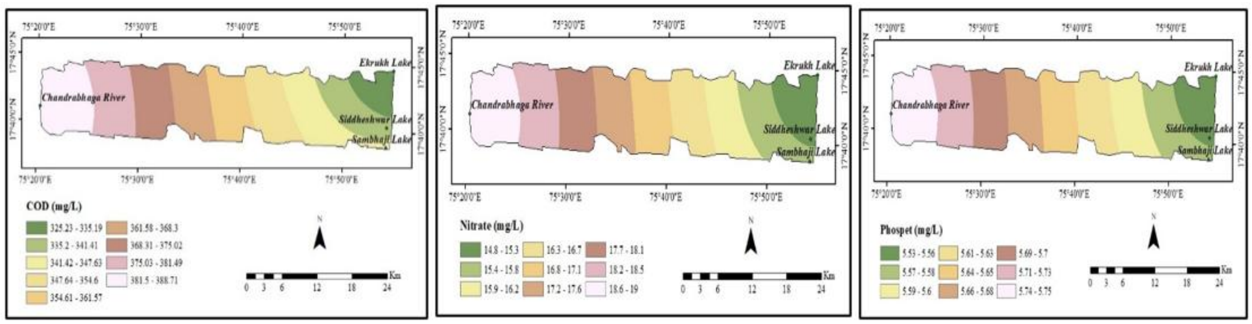

Total Solid


Total Dissolved Solids


Total Suspended Solids

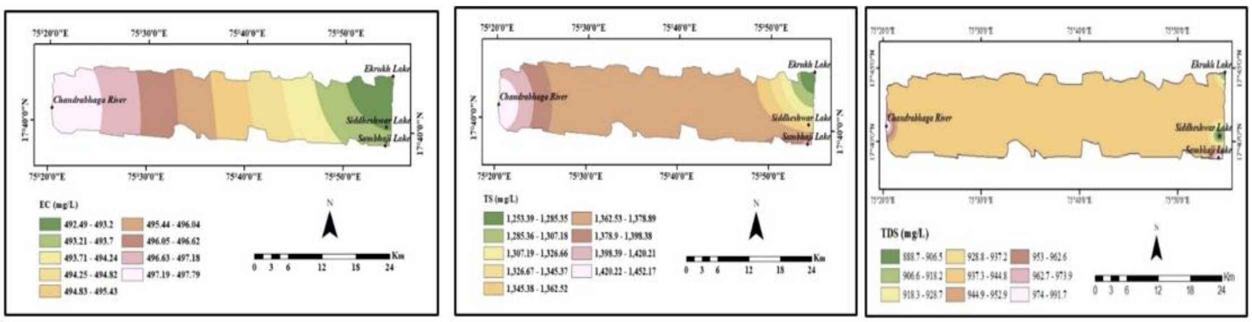

Dissolved Oxygen


Biological Oxygen Demand

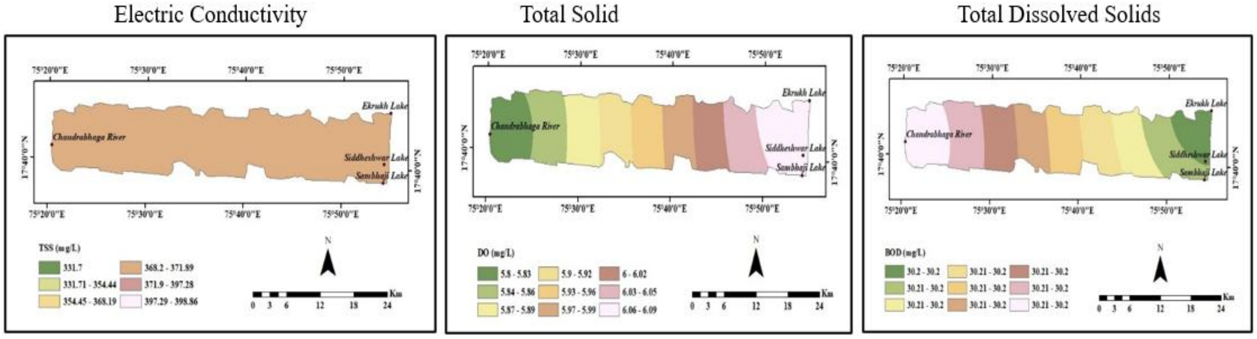


Chemical Oxygen Demand | Phosphate | Nitrate

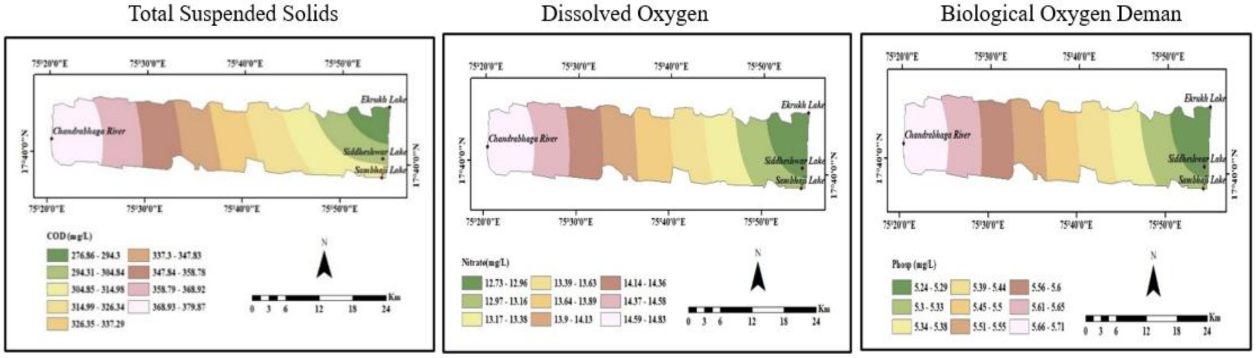
Figure 4- Interpolation of the freshwater parameter of Solapur District during April 2022



Electric Conductivity | Total Solid | Total Dissolved Solids

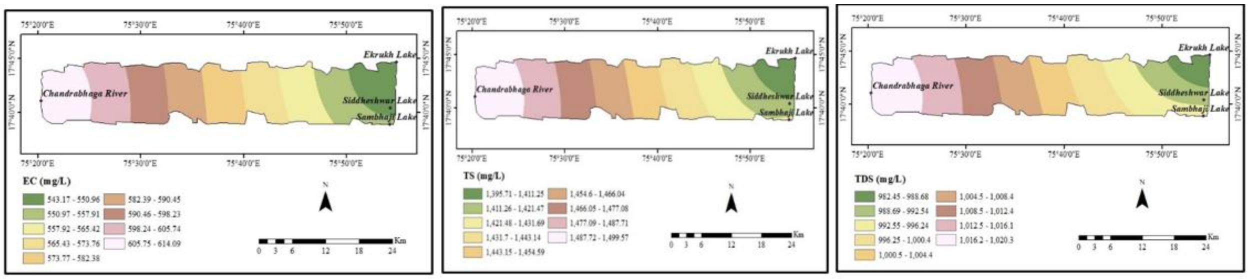


Total Suspended Solids | Dissolved Oxygen | Biological Oxygen Deman

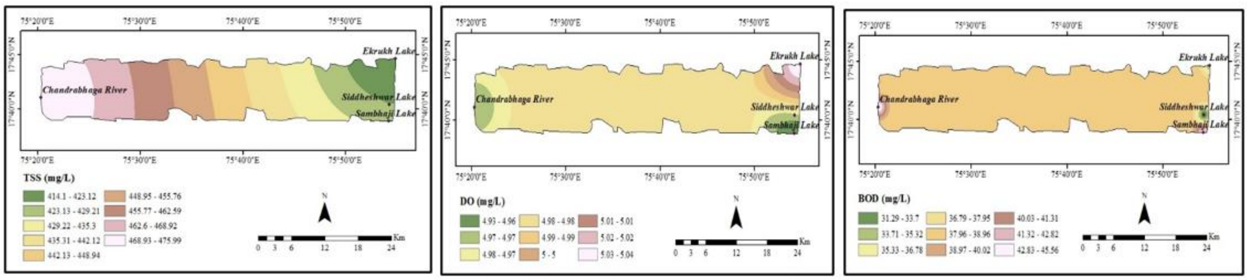


Chemical Oxygen Demand | Phosphate | Nitrate

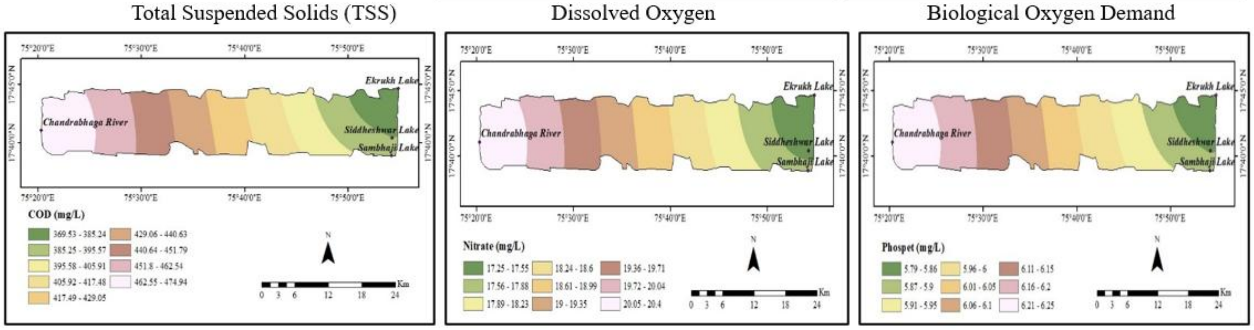
Figure 5- Interpolation of the freshwater parameter of Solapur District during September 2022



Electric Conductivity | Total Solid | Total Dissolved Solids

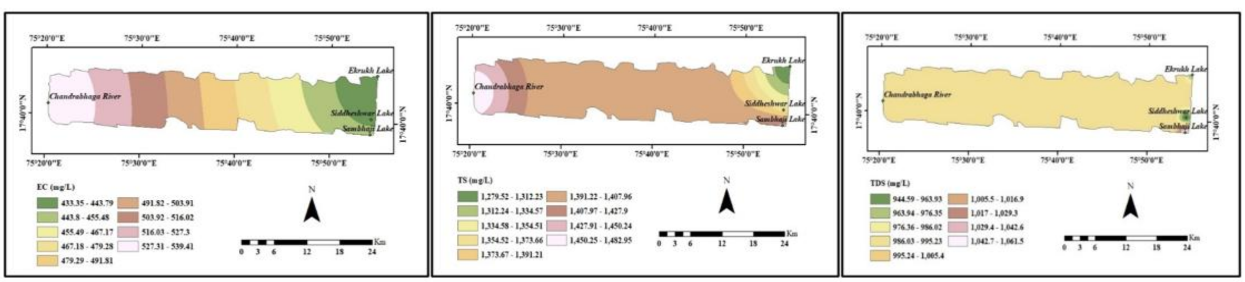


Total Suspended Solids (TSS) | Dissolved Oxygen | Biological Oxygen Demand

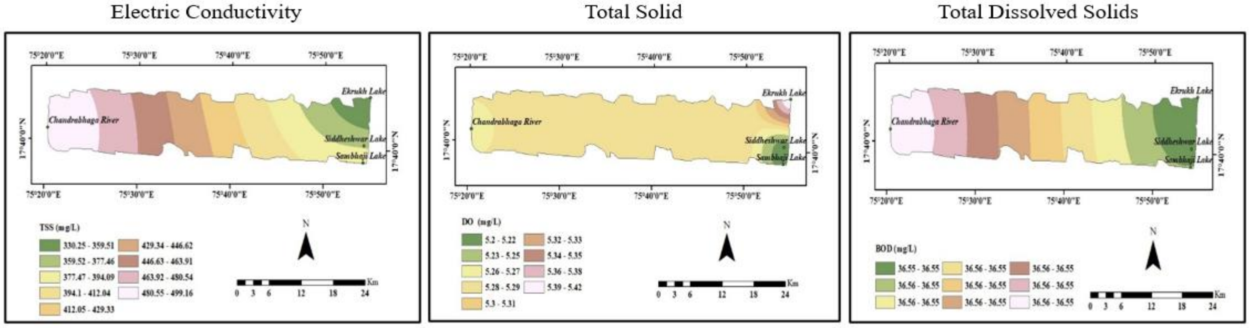


Chemical Oxygen Demand | Phosphate | Nitrate

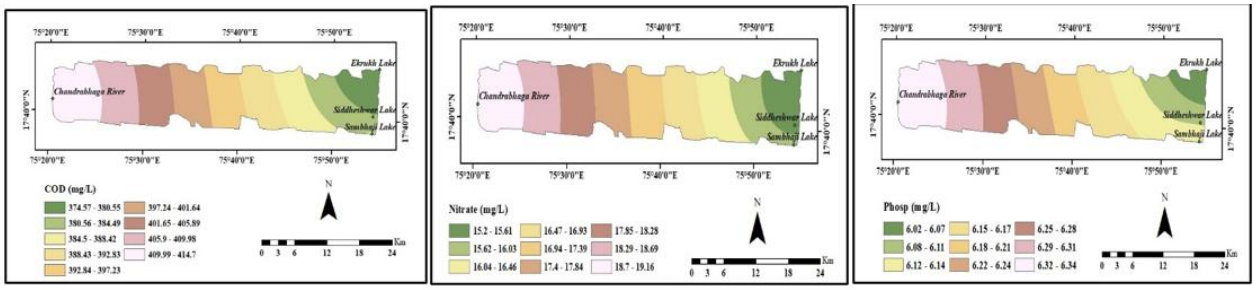
Figure 6- Interpolation of the freshwater parameter of Solapur District during April 2023



Electric Conductivity | Total Solid | Total Dissolved Solids



Total Suspended Solids (TSS) | Dissolved Oxygen | Biological Oxygen Demand



Chemical Oxygen Demand Phosphate Nitrate

Figure 7- Interpolation of the freshwater parameter of Solapur District during September 2023

The research was conducted during April and September from the year 2021 to 2023 in the fresh water of (Solapur) regions of Maharashtra, India, from Sambhaji lake, Ekrukh lake (Hipparaga lake), Siddheshwar Lake, and Chandrabhaga River Maharashtra, India, to study the seasonal difference in the water quality and availability of algal diversity. For the study, water samples were analysed and collected by standard analytical methods during the post- and pre monsoon season to study the change detection of water quality.

The water pH was in the range of 6.8 to 7.1 in April and 7.1 to 7.4 in September. A fluctuation in pH was experienced in the sampling location due to temperature changes. The temperature varied from 38.2 °C to 39.2 °C in April and 32.2 °C to 33 °C in September, depending on the environmental conditions. The fluctuation in temperature affects the DO of the water reservoir, because as the temperature increases, the oxygen level in the water body decreases. The content of DO was lower in April as compared to September, ranging from 4.5 mg/L to 5.8 mg/L and 5.2 mg/L to 6.1 mg/L. This range of DO favours the growth of phytoplankton in the freshwater. The findings indicated that elevated water temperatures corresponded with reduced dissolved oxygen levels. Factors such as photosynthesis, organic matter decomposition, re-aeration, and the water's physicochemical properties collectively influence the oxygenation of aquatic environments.

BOD values ranged from 25.7 mg/L to 39.2 mg/L in April and 22.7 mg/L to 36.1 mg/L in September. The BOD was increased in April due to high temperatures that favour the development of microorganisms and indicate inputs of organic waste through river runoff. The value of COD also increased in April in the range of 295 mg/L to 398 mg/L and 212 mg/L to 368 mg/L in the month of September. The range of TS was in the range of 1214 mg/L to 1488 mg/L in April and 1200 mg/L to 1458 mg / L in September. The range of TS was high in April due to high temperature and deposition of nutrients and organic matter in the water. Nitrate and phosphate levels exhibited a notable rise in September compared to April, reaching approximately twice their earlier concentrations in this transect, suggesting possible changes in nutrient dynamics and ecological functioning.

In the entire study period, the temperature was observed in the range of 28°C –28.3°C, a maximum of 30°C to 34°C, and a mean of 29°C –33.3°C. The fluctuation of temperature in all years is due to climate change and environmental factors. The change in water temperature during the study period affected the growth of macro and aquatic life and microalgae within the freshwater ecosystems. These temperature fluctuations were sustained by some thermostable algae, which survived in large temperature fluctuations.

pH is a critical parameter for assessing the quality of freshwater ecosystems, as well as for understanding algal biodiversity. Acidic pH levels can disrupt aquatic life by affecting food webs, reproductive cycles, and the behaviour of marine organisms. In this study, pH values remained near neutral throughout the observation period, providing a favourable environment for aquatic organisms in both freshwater habitats. EC reflects the total concentration of ions in water and indicates its ability to conduct electricity. During the study, EC increased on average from 555 µS/cm to 680 µS/cm, influenced by factors such as temperature and salinity, which ranged from 32 g/L to 34.5 g/L. The DO levels in marine water ranged from 5.4 mg/L in 2021 to 5.3 mg/L in 2023, highlighting minor variations over the study period.

The levels of DO in the water during 2022 and 2023 decreased, primarily due to rising temperature.

Elevated BOD further reduced the availability of oxygen for aquatic organisms, impacting both their population size and species diversity. Over the study period, BOD values ranged from 27.8 to 40.2 mg/L, showing a yearly increase that corresponded with a higher number of visitors to the coastal areas.

The COD ranged from 243 to 313 mg/L, indicating a high concentration of organic matter in the water, likely resulting from pollution. A contributing factor to water pollution in 2022 and 2023 was the increased influx of tourists to the Lake and following the COVID-19 pandemic. In contrast, 2021 saw strict travel and mobility restrictions, which helped reduce pollution in the freshwater. Elevated pollution levels were also reflected in the concentrations of nitrate (19.3–25.3 mg/L) and phosphate (5.25–6.23 mg/L). Additionally, TDS and TSS increased during the monsoon period due to a greater presence of floating particles and dissolved matter. During the analysis, it was observed that the water quality in the month of September was good in comparison to April, due to low temperature, neutral pH, low BOD, and COD. This condition was favourable to algae growth and their reproduction.

V. CONCLUSION

The environmental factors, such as temperature, pH, salinity, EC, BOD, COD, TS, TDS, and TSS, play an important role in the growth rate of freshwater algae during the entire study period. The month of September (post-monsoon season) was favourable for the growth of marine micro and macro algae compared to April, due to neutral pH, low temperature, BOD, COD, and low salinity. Interpolation was used to estimate the value of a variable (such as pH, dissolved oxygen, TDS, BOD, COD, etc.) at a point between two known data points.

This study contributes to scientific understanding by providing valuable data on the quality and ecosystem dynamics of freshwater environments, which can support further research, modelling, and predictive analyses. Such information enhances our comprehension of natural processes and their interactions with human activities. The findings underscore the growing impact of anthropogenic activities on freshwater ecosystems, highlighting the importance of establishing comprehensive databases and monitoring strategies.

REFERENCES

[1] A. Rahman, S. Agrawal, T. Nawaz, S. Pan, and T. Selvaratnam, "A review of algae-based produced water treatment for biomass and biofuel production," Water, vol. 12, no. 9, pp. 1–27, 2020.

[2] J. W. Moody, C. M. McGinty, and J. C. Quinn, "Global evaluation of biofuel potential from microalgae," Proceedings of the National Academy of Sciences, vol. 111, no. 23, pp. 8691–8696, 2014.

[3] S. Fried, B. Mackie, and E. Nothwehr, "Nitrate and phosphate levels positively affect the growth of algae species found in Perry Pond," Tillers, no. 4, pp. 21–24, 2003.

[4] R. A. Voloshin, M. V. Rodionova, S. K. Zharmukhamedov, T. N. Veziroglu, and S. I. Allakhverdiev, "Review: Biofuel production from plant and algal biomass," International Journal of Hydrogen Energy, vol. 41, pp. 17257–17273, 2016.

[5] L. A. Minhas, M. S. Mumtaz, M. Kaleem, R. Waqar, and J. Annum, "A prospective study on morphological identification and characterization of freshwater green algae based on the microscopic technique in District Rawalpindi," Pakistan Journal of Agricultural Research, vol. 36, no. 1, pp. 20–35, 2023.

[6] L. Wang, X. Wang, X. Jin, J. Xu, H. Zhang, J. Yu, Q. Sun, C. Gao, and L. Wang, "Analysis of algae growth mechanism and water bloom prediction under the effect of multi-affecting factor," Saudi Journal of Biological Sciences, vol. 24, pp. 556–562, 2017.

[7] S. P. Singh and P. Singh, "Effect of temperature and light on the growth of algae species: A review," Renewable and Sustainable Energy Reviews, vol. 50, pp. 431–444, 2015.

[8] S. A. Razzak, K. Bahar, K. M. O. Islam, A. K. Haniffa, M. O. Faruque, S. M. Z. Hossain, and M. M. Hossain, "Microalgae cultivation in photobioreactors: Sustainable solutions for a greener future," Green Chemical Engineering, vol. 5, no. 4, pp. 418–439, 2024.

[9] N. Xu, B. Huang, Z. Hu, Y. Tang, S. Duan, and C. Zhang, "Effects of temperature, salinity, and irradiance on the growth of harmful algal bloom species Phaeocystis globosa Scherffel

(Prymnesiophyceae) isolated from the South China Sea," Journal of Oceanology and Limnology, vol. 35, pp. 557–565, 2017.

[10] T. H. Udayashankara, K. G. Anitha, S. Rao, A. Shifa, and M. Shuheb, "Study of water quality and dynamic analysis of phytoplanktons in four freshwater lakes of Mysore, India," International Journal of Innovative Research in Science, Engineering and Technology, vol. 2, no. 7, pp. 2600–2609, 2013.

[11] K. Janda, L. Kristoufek, and D. Zilberman, "Biofuels: policies and impacts," Agricultural Economics Czech, vol. 58, no. 8, pp. 372–386, 2012.

[12] S. Khan, R. Siddique, W. Sajjad, G. Nabi, K. M. Hayat, P. Duan, and L. Yao, "Biodiesel production from algae to overcome the energy crisis," HAYATI Journal of Biosciences, vol. 24, no. 4, pp. 163–167, 2017.

[13] M. Zollmann, A. Robin, M. Prabhu, M. Polikovsky, A. Gillis, S. Greiserman, and A. Golberg, "Green technology in green macroalgal biorefineries," Phycologia, vol. 58, no. 5, pp. 516–534, 2019.

[14] N. Głowacka, J. Gaduš, and J. Slobodník, "Biomass of microalgae as a source of renewable energy," Acta Regionalia et Environmentalica, no. 1, pp. 24–29, 2017.

[15] B. Patel, B. Tamburic, F. W. Zemichael, P. Dechatiwongse, and K. Hellgardt, "Algal biofuels: A credible prospective?" International Scholarly Research Network, pp. 1–14, 2012.

[16] P. Han, Q. Lu, L. Fan, and W. Zhou, "A review on the use of microalgae for sustainable aquaculture," Applied Sciences, vol. 9, pp. 1–20, 2019.

[17] M. V. Rodionova, R. S. Poudyal, R. Voloshin, and S. K. Zharmukhamedov, "Biofuel production: Challenges and opportunities," International Journal of Hydrogen Energy, vol. 42, no. 12, pp. 1–12, 2017.

[18] A. Shahid, S. Malik, H. Zhu, J. Xu, M. Z. Nawaz, S. Nawaz, M. A. Alam, and M. A. Mehmood, "Cultivating microalgae in wastewater for biomass production, pollutant removal, and atmospheric carbon mitigation: A review," Science of the Total Environment, vol. 704, pp. 135–148, 2020.

[19] U. Rasool and S. Hemalatha, "A review on bioenergy and biofuels: Sources and their production," Brazilian Journal of Biological Sciences, vol. 3, no. 5, pp. 3–21, 2016.