International Journal of Science and Research Archive
eISSN: 2582-8185
Cross Ref DOI: 10.30574/ijsra
Journal homepage: https://ijsra.net/

(RESEARCH ARTICLE)

Optimization of growth conditions of isolated algae from Coastal areas of Andhra Pradesh

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International Journal of Science and Research Archive, 2025, 14(03), 477-485

Publication history: Received on 27 January 2025; revised on 06 March 2025; accepted on 08 March 2025

Article DOI: https://doi.org/10.30574/ijsra.2025.14.3.0680

Abstract

Algae are significant members of aquatic ecosystems, with roles in carbon sequestration, nutrient cycling, and other biotechnology applications. The current research involves the isolation, culture, and optimization of the growth of algae collected from three ecologically diverse locations in India—Chirala, Nellore, and Machilipatnam. Water samples were collected and cultured in the laboratory under controlled conditions in different culture media, nutrient compositions, temperatures, PH levels, light intensities, and aeration types. The results indicated significant differences in algal diversity and growth response to environmental factors. Coastal regions (Chirala and Machilipatnam) were found to be richer in species composition than the inland freshwater site (Nellore). The optimal growth was observed at 32°C, PH 7.5, and indirect sunlight, with some species-specific variations. Algal strains cultured in nutrient-rich media exhibited higher biomass accumulation, suggesting their application in biofuel generation and environmental remediation. The research provides significant insights into algal culture optimization for industrial and ecological applications, promoting sustainable biotechnology solutions.

Keywords: Algae Cultivation; Growth Optimization; Environmental Parameters; Carbon Sequestration; Biofuel Production; Bioremediation

1. Introduction

Algae are the main components in the water ecosystems where they act as primary producers to facilitate carbon and nutrient cycling. As algae are able to fix atmospheric CO_2 through Photosynthesis, algae are crucial to climate change mitigation and ecosystem balance. (1) Algal species are diverse, both in morphology, Physiology, and habitat. This diversity makes them capable of colonizing various water environments, from freshwater to marine environments, and tolerating fluctuating environmental conditions. (2)

Identification and separation of algae from the diverse environments are important to determine their adaptability and potential utilization. Parameters such as salinity, temperature, pH, and nutrient availability are the ones that possess strong controlling influences upon the productivity and distribution of algae. (3) Such interactions are important to study to guarantee maximum algal growth to be employed to sequester carbon, produce bio fuels, and bioremediate. (4)

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This study deals with the isolation and distributional diversity of algae from the three stations of India: Chirala, Nellore, and Machilipatnam with varying ecological conditions. Chirala and Machilipatnam are coastal stations under the salinity influence of sea water, whereas Nellore is an inland freshwater station under the influence of agricultural runoff and man made interventions. (5) By means of species diversity and the capability to fix CO_2, this research will find the best conditions to derive the maximum productivity from algae.

A large array of algal species was isolated from the water samples obtained from the three stations. The coastal stations (Chirala and Machilipatnam) showed higher species richness of marine and brackish water algae but freshwater samples from Nellore included species that belonged to the richer nutrient environments. The growth of algae was varied based on the parameters of the habitat where salinity and nutritional content played a crucial role in the distribution of the species. (6) A few of the isolated species had high CO_2 fixation potential and were amenable to carbon sequestration. (7)

Maximizing the light intensity, pH, and nutrient availability improved the biomass productivity to reflect the viability of the culture under control to be employed industrially. The research recommends the use of site-adapted algae strains to produce fuel and to execute the cleanup of the environment and supports the creation of sustainable algae culture technology that can be employed in biotechnology and the control of the environment. (8)

2. Methods

2.1. Sample collection

Samples were obtained through the collection of water samples from the Nellore coastal regions, Machilipatnam coastal regions, and the coastal regions of Chirala. The water was sampled in sterilized and clean containers to preserve the purity of the samples to ensure that the water does not get contaminated during collection. The water was poured slowly into the air-tight dark containers to ensure that there was no chemical alteration in the constitution of the water during the time the water was transported. The samples were preserved under the respective conditions upon receiving the samples in the laboratory under 4°c until analysis. (9)

2.2. Cultivation of algae

The algae were grown in the laboratory using culture medium like the algal broth (ab), autoclaved to be free from contamination. Small water samples taken containing various algae species were added to the autoclaved glass containers. The culture was then subjected to regulated conditions using the 12-hour light-dark cycle. The temperature was kept regulated to 16°c to 32°c under constant air supply of carbon dioxide and oxygen. The growth was monitored using the measurement of the optical density (OD) 660, aside from visual observation and measurement of the chlorophyll. Regular sub culturing was conducted to prevent overcrowding and the depletion of the nutrients to ensure the right growth. (9)

2.3. Optimization of culture conditions

The control of the various parameters over the algae growth rate was based upon a fully randomized experimental design where one parameter was varied and the other parameters held constant. The parameters that were controlled during the algae growth were the nutrients, the illumination, the temperature, the pH, and continuous aeration or stirring. (10)

2.4. Culture medium/nutrients

Two mediums, AB medium and distilled water, were used to culture the algae. The highest growth rate was achieved after some time. The measurement was done on the 7th day initially, and the growth rate was approximated based on the fresh weight gain of the biomass. The measurement of the biomass was done by filtering the alga separately and then weighing it once the surplus water was drained using blotting.

Table 1 Effect of medium on growth of collected algae

Growth medium	**Distilled water**		**AB medium**
Machilipatnam algae (fresh weight in g)/ 100ml	Week 1	0.0217 ± 0.0099	0.045 ± 0.0120
	Week 2	0.038 ± 0.0102	0.065 ± 0.0135
	Week 3	0.050 ± 0.0125	0.085 ± 0.0145
	Week 4	0.070 ± 0.0150	0.120 ± 0.0185
Nellore algae (fresh weight in g)/ 100ml	Week 1	: 0.0067 ± 0.0052	: 0.015 ± 0.0065
	Week 2	0.010 ± 0.0045	0.022 ± 0.0081
	Week 3	0.015 ± 0.0052	0.030 ± 0.0095
	Week 4	0.020 ± 0.0059	0.045 ± 0.0123
	Week 1	: 0.0117 ± 0.0097	: 0.028 ± 0.0112
Chirala algae (fresh weight in g)/ 100ml			
	Week 2	0.022 ± 0.0078	0.045 ± 0.0100
	Week 3	0.031 ± 0.0085	0.060 ± 0.0125
	Week 4	0.045 ± 0.0115	0.075 ± 0.0156

2.4.1. Temperature

The cultures were kept at different temperatures. The temperature was measured at intervals using a thermometer, and growth rates were determined by measuring the fresh weight of algae at each temperature.

2.4.2. pH

Both distilled water & culture medium AB were adjusted to different PH ranges (6.5, 7, 7.5, 8, 8.5, and 9). Algae were cultured in these PH ranges, and their growth was influenced and noted by measuring the fresh weight of samples after the prescribed time.

2.4.3. Light

Algal cultures were exposed to different light conditions: outdoor open sunlight, in the laboratory near a window, and under artificial fluorescent light. Algal growth was measured in terms of biomass of the cultures under each light condition.

2.4.4. Aeration/mixing

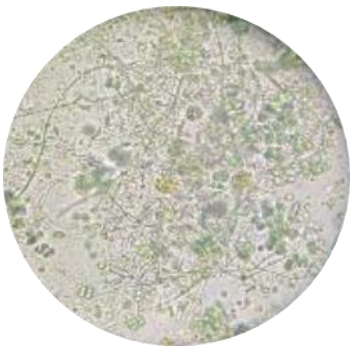
For aeration and mixing, an orbital shaker was used, and flasks were placed on the shaker at 300 rpm. Aeration was given using aerating pumps. These cultures were kept indoors where they got continuous sunlight. Growth results were compared under different conditions of aeration and mixing, and the cultures with the highest growth rates were selected for further research.

3. Results

3.1. Microscopic examination of marine algae collected from various places

Microscopic analysis of the marine algal samples from Chirala, Machilipatnam, and Nellore reveals typical differences in algal composition and structure. The Chirala sample is a compact group of diatom-like structures with chain or cluster-forming cells, indicating a productive bloom due to favorable nutrient status (fig 1). The Machilipatnam sample, on the other hand, has complex, branched, and filamentous structures, possibly cyanobacteria or filamentous green algae, and crystalline structures indicating mineral precipitation (fig 2). The sample predominantly has a green field with profuse chlorophyll containing micro-algae and scattered dark filaments probably cyanobacteria. A bright pink or red spot is prominent and could be pigment-containing algae or contaminants. The observations reflect the diversity

and distribution of marine micro-algae along the Andhra Pradesh coast, indicating environmental effects on algal composition and growth (fig 3).

		
Figure 1 microscopic observation of Nellore	**Figure 2** microscopic observation of Chirala	**Figure 3** microscopic observation of Machilipatnam

3.2. Effect of temperature on the growth of collected algae

The effect of temperature on algae growth was ascertained by growing the algae at five different temperatures: 16°c, 20°c, 24°c, 28°c, and 32°c. The growth rate of all the three algae was greatly influenced by temperature. At 16°c, Machilipatnam algae showed the lowest fresh weight of 0.9 ± 0.0072 g, Nellore algae 0.02 ± 0.0052 g, and Chirala algae 0.01 ± 0.0524 g. As the temperature increased, the algae showed improved growth. At 20°c, Machilipatnam algae showed 0.1029 ± 0.0072 g, Nellore algae 0.0357 ± 0.0052 g, and Chirala algae 0.3743 ± 0.0524 g. All the algae showed maximum growth at 32°c, with Machilipatnam algae showing 0.250 ± 0.0150 g, Nellore algae 0.110 ± 0.0102 g, and Chirala algae 0.560 ± 0.0854 g. The findings show that temperature is a significant factor in algae growth and that elevated temperatures favor better growth, particularly of Chirala algae (Table 1).

Table 2 effect of temperature on growth of collected algae

Temperature		**16°c**	**20°c**	**24°c**	**28°c**	**32°c**
Machilipatnam algae (fresh weight in g)/ 100ml	Week 1	0.9 ± 0.0072	0.1029 ± 0.0072	0.135 ± 0.0095	0.180 ± 0.0123	0.250 ± 0.0150
	Week 2	1.3 ± 0.0095	0.15 ± 0.0103	0.18 ± 0.0105	0.25 ± 0.0145	0.32 ± 0.0167
	Week 3	1.7 ± 0.0103	0.18 ± 0.0114	0.23 ± 0.0115	0.30 ± 0.0155	0.38 ± 0.0173
	Week 4	2.0 ± 0.0125	0.22 ± 0.0121	0.28 ± 0.0123	0.35 ± 0.0167	0.45 ± 0.0189
Nellore algae (fresh weight in g)/ 100ml	Week 1	0.02 ± 0.0052	0.0357 ± 0.0052	0.050 ± 0.0068	0.075 ± 0.0085	0.110 ± 0.0102
	Week 2	0.05 ± 0.0045	0.065 ± 0.0071	0.075 ± 0.0083	0.10 ± 0.0095	0.15 ± 0.0120
	Week 3	0.08 ± 0.0057	0.09 ± 0.0083	0.10 ± 0.0091	0.12 ± 0.0102	0.20 ± 0.0145
	Week 4	0.10 ± 0.0065	0.12 ± 0.0091	0.12 ± 0.0099	0.14 ± 0.0113	0.22 ± 0.0160
Chirala algae (fresh weight in g)/ 100ml	Week 1	0.01 ± 0.0524	0.3743 ± 0.0524	0.420 ± 0.0612	0.480 ± 0.0721	0.560 ± 0.0854
	Week 2	0.05 ± 0.0563	0.45 ± 0.0600	0.51 ± 0.0635	0.58 ± 0.0753	0.68 ± 0.0900

	Week 3	0.09 ± 0.0624	0.49 ± 0.0625	0.57 ± 0.0702	0.63 ± 0.0795	0.75 ± 0.0920
	Week 4	0.11 ± 0.0652	0.52 ± 0.0657	0.61 ± 0.0735	0.70 ± 0.0840	0.82 ± 0.0945

3.3. Effect of PH on the growth of collected algae

The culture medium PH also influenced algal growth. Algae were grown in media with varying PH levels, ranging from 6.5 to 9.0. At the lowest PH examined (6.5), there was minimal growth in all the algae species. Machilipatnam algae weighed 0.115 ± 0.015 g fresh weight, Nellore algae 0.035 ± 0.0048 g, and Chirala algae 0.490 ± 0.0500 g. The growth improved with increasing PH levels, with optimum growth at PH 7.5, where Machilipatnam algae weighed 0.141 ± 0.017 g, Nellore algae 0.043 ± 0.0055 g, and Chirala algae 0.553 ± 0.0562 g. At higher PH levels (8.0, 8.5, and 9.0), the growth began to reduce. The poorest growth was at PH 9.0, where Machilipatnam algae weighed 0.090 ± 0.015 g, Nellore algae 0.032 ± 0.0045 g, and Chirala algae 0.420 ± 0.0445 g. The findings suggest that PH is a key factor in algal growth, and the optimum range for optimum growth lies between PH 7.0 and 7.5 (Table 2).

Table 3 effect of PH on growth of collected algae

PH		**PH 6.5**	**PH 7.0**	**PH 7.5**	**PH 8.0**	**PH 8.5**	**PH 9.0**
Machilipatnam algae (fresh weight in g)/100ml	Week 1	0.115 ± 0.015	0.130 ± 0.016	0.141 ± 0.017	0.125 ± 0.018	0.100 ± 0.016	0.090 ± 0.015
	Week 2	0.150 ± 0.018	0.165 ± 0.018	0.175 ± 0.019	0.160 ± 0.020	0.130 ± 0.018	0.110 ± 0.017
	Week 3	0.180 ± 0.020	0.200 ± 0.021	0.210 ± 0.022	0.195 ± 0.022	0.160 ± 0.020	0.135 ± 0.019
	Week 4	0.200 ± 0.022	0.220 ± 0.023	0.230 ± 0.024	0.210 ± 0.024	0.180 ± 0.021	0.150 ± 0.020
Nellore algae (fresh weight in g)/ 100ml	Week 1	0.035 ± 0.0048	0.040 ± 0.0052	0.043 ± 0.0055	0.041 ± 0.0053	0.036 ± 0.0048	0.032 ± 0.0045
	Week 2	0.050 ± 0.0062	0.055 ± 0.0068	0.060 ± 0.0072	0.055 ± 0.0068	0.050 ± 0.0060	0.045 ± 0.0058
	Week 3	0.065 ± 0.0075	0.070 ± 0.0078	0.080 ± 0.0085	0.070 ± 0.0080	0.065 ± 0.0072	0.055 ± 0.0068
	Week 4	0.075 ± 0.0081	0.080 ± 0.0085	0.090 ± 0.0092	0.080 ± 0.0090	0.070 ± 0.0080	0.065 ± 0.0075
Chirala algae (fresh weight in g)/ 100ml	Week 1	0.490 ± 0.0500	0.520 ± 0.0528	0.553 ± 0.0562	0.540 ± 0.0547	0.470 ± 0.0485	0.420 ± 0.0445
	Week 2	0.530 ± 0.0525	0.570 ± 0.0550	0.600 ± 0.0590	0.580 ± 0.0580	0.500 ± 0.0510	0.460 ± 0.0480
	Week 3	0.560 ± 0.0558	0.600 ± 0.0585	0.630 ± 0.0624	0.610 ± 0.0605	0.530 ± 0.0540	0.480 ± 0.0505
	Week 4	0.590 ± 0.0580	0.630 ± 0.0612	0.660 ± 0.0650	0.640 ± 0.0640	0.550 ± 0.0562	0.500 ± 0.0530

3.4. Effect of light on the growth of gathered algae

The effect of light on the growth of algae was determined by exposing the algae to different light conditions: direct sunlight, indirect sunlight, and fluorescent light. The result showed that light is an essential factor for the growth of algae. In direct sunlight, Chirala algae grew the most, weighing 0.672 ± 0.0435 g, followed by Machilipatnam algae at 0.196 ± 0.0198 g and Nellore algae at 0.056 ± 0.0052 g. Algae exposed to indirect sunlight also grew but at a reduced rate. Machilipatnam algae weighed 0.145 ± 0.0165 g, Nellore algae 0.040 ± 0.0042 g, and Chirala algae 0.450 ± 0.0345 g.

Algae grown under fluorescent light showed consistent growth, with Machilipatnam algae at 0.185 ± 0.0180 g, Nellore algae 0.050 ± 0.0048 g, and Chirala algae 0.620 ± 0.0400 g. The results show that the intensity of light has an effect on the growth of algae, with direct sunlight favoring maximum growth in Chirala algae and fluorescent light providing the best condition for Machilipatnam and Nellore algae (Table 3).

Table 4 effect of light on growth of collected algae

Light		**Direct sunlight**	**Indirect sunlight**	**Fluorescent light**
Machilipatnam algae (fresh weight in g)/ 100ml	Week 1	0.196 ± 0.0198	0.145 ± 0.0165	0.185 ± 0.0180
	Week 2	0.225 ± 0.0215	0.170 ± 0.0180	0.210 ± 0.0202
	Week 3	0.255 ± 0.0240	0.190 ± 0.0195	0.235 ± 0.0220
	Week 4	0.280 ± 0.0260	0.210 ± 0.0210	0.260 ± 0.0240
Nellore algae (fresh weight in g)/ 100ml	Week 1	0.056 ± 0.0052	0.040 ± 0.0042	0.050 ± 0.0048
	Week 2	0.075 ± 0.0065	0.055 ± 0.0050	0.065 ± 0.0058
	Week 3	0.095 ± 0.0078	0.070 ± 0.0062	0.080 ± 0.0065
	Week 4	0.110 ± 0.0085	0.080 ± 0.0070	0.090 ± 0.0072
Chirala algae (fresh weight in g)/ 100ml	Week 1	0.672 ± 0.0435	0.450 ± 0.0345	0.620 ± 0.0400
	Week 2	0.710 ± 0.0462	0.480 ± 0.0370	0.660 ± 0.0430
	Week 3	0.750 ± 0.0490	0.510 ± 0.0395	0.690 ± 0.0460
	Week 4	0.780 ± 0.0518	0.530 ± 0.0420	0.720 ± 0.0490

3.5. Effect of aeration on the growth of collected algae

Aeration was provided to one group of algal cultures using an aeration pump, and the other group was maintained static. Algal growth was measured by optical density (OD) at 600 nm. The findings revealed that aeration significantly enhanced the growth of all three species of algae. Under the influence of aeration, Machilipatnam algae had an OD of 0.455 ± 0.571, Nellore algae 0.12 ± 0.082, and Chirala algae 0.966 ± 0.379. Without aeration, the OD readings were lower: Machilipatnam algae measured 0.365 ± 0.485, Nellore algae 0.09 ± 0.070, and Chirala algae 0.755 ± 0.312. The findings reveal that aeration plays an important role in the growth promotion of algae, with Chirala algae recording the highest optical density values under aeration (Table 4).

Table 5 Effect of aeration on growth of collected algae

Areation		**With aeration pump**	**Without pump**
Machilipatnam (od 600 nm)	Week 1	0.455 ± 0.0571	0.365 ± 0.0485
	Week 2	0.525 ± 0.0610	0.420 ± 0.0520
	Week 3	0.590 ± 0.0650	0.475 ± 0.0555
	Week 4	0.655 ± 0.0702	0.530 ± 0.0590
Nellore (od 600 nm)	Week 1	0.120 ± 0.0082	0.090 ± 0.0070
	Week 2	0.150 ± 0.0095	0.115 ± 0.0082
	Week 3	0.175 ± 0.0105	0.135 ± 0.0090
	Week 4	0.200 ± 0.0120	0.155 ± 0.0102
Chirala (od 600 nm)	Week 1	0.966 ± 0.0379	0.755 ± 0.0312
	Week 2	1.050 ± 0.0415	0.820 ± 0.0340
	Week 3	1.120 ± 0.0450	0.880 ± 0.0375
	Week 4	1.185 ± 0.0485	0.940 ± 0.0405

4. Discussion

The present study aimed to optimize the conditions for algae growth from different water samples of Chirala, Nellore, and Machilipatnam by investigating the effects of temperature, PH, light, aeration, and nutrient availability. The results show that environmental factors significantly affect the growth of algae and biomass buildup, with variation among the places. The findings agree with literature emphasizing the role of algae in aquatic ecosystems as primary producers of global carbon fixation and oxygen evolution. (11) (12)

Temperature had a marked effect on algae growth, with higher temperatures favoring higher biomass productivity. The optimal growth rates for the three algae species were at 32°c, showing their potential in warm climates. This supports earlier findings that micro-algae optimally grow at 25°c to 35°c due to heightened metabolic and photosynthetic processes. (13) However, exposure to extreme temperatures for protracted periods may lead to cellular stress, thus affecting enzymatic processes and growth efficiency. Temperature variability in marine and freshwater ecosystems has been shown to impact microbial dynamics and community structures, which in turn affect algal populations. (14) (15)

PH was another factor that was causing the algae growth. The findings showed the best range 7.0 to 7.5 PH where lower growth was seen at lower and higher values. At the PH 6.5, the algae showed lower biomass accumulation that can be explained through the lower availability of the nutrients and the enzyme activity, whereas the growth was limited at the PH 9.0 that can be explained through the greater cellular stress along with the changed availability of the ions. The findings are consistent with the microbial population findings within the estuary that reflect the sensitivity of the microbial and algae to the change of the PH, especially within the rich medium of the nutrients. (16)(17). Considering the impact of PH on algal metabolism, optimal conditions must be maintained in large-scale cultivation systems to obtain maximum biomass yield for industrial applications such as bio-fuel production and waste water treatment. (18)

Availability of light played a direct role in the growth of the three algae species. The highest growth was exhibited by the culture under direct sunlight exposure, the highest being that of the Chirala algae, indicating the former's high-light preference. Fluorescent illumination also facilitated steady growth, indicating the viability of indoor culture under partial natural sunlight. The role played by the intensity and quality of the spectrum of the light to the control of Photosynthetic activity and accumulation of biomass has been indicated in the case of marine phyto-plankton through earlier work. (19)(20). This underlines the necessity of specific illumination regimes within industrial culture systems of algae particularly to be used in biotechnological applications and the production of bio-fuels. (21)

Aeration has shown to enhance dramatically the growth of algae, where the aerated culture has higher values of the optical density (od 600 nm) than the non-aerated culture. This enhancement can be attributed to higher gas exchange, higher uptake of the nutrients, and the prevention of sedimentation, which are the criteria for maximum photosynthesis efficiency. The strong positive response of the algae from Chirala to aeration shows the prospect of the production of high-biomass yields through the use of the aerated systems. The same trends are seen under marine microbial research where microbial respiration and the cycling of the nutrients are the problem of aeration. (22)(23) Such evidence supports the necessity of aeration during large-scale culture production of algae, particularly for the industries that are focusing on carbon sequestration, bio-fuel, and bio-remediation.

Availability of nutrients was another factor that determined the growth of algae, where medium bb supported greater accumulation of biomass than distilled water. This indicates that the use of nutrient supplements improves the productivity of algae through the availability of essential macro nutrients and micro nutrients to be used during metabolic functions. The growth of algae in distilled water was lower, an indication that natural water bodies lack the essential nutrients to produce maximum biomass. Studies on microbial compositions within coastal waters and estuaries have further highlighted the availability of nutrients to be a factor that determines the productivity and diversity of algae. (23)(24) These findings emphasize the necessity to properly choose culture media to guarantee maximum yields of algae to be employed in industrial applications such as sustainable aquaculture and biotechnological applications.

The findings of the research are important to determine the adaptability of algae to water bodies. The coastal algae from the areas of Chirala and Machilipatnam showed greater tolerance to the environmental fluctuation compared to the freshwater algae from Nellore that showed reduced biomass growth under stressed conditions. This means that the coastal algae are likely to be used on a large scale to generate bio fuels, to purify waste water, and to capture carbon. Research findings based on microbial dynamics along the Indian coast suggest that the distribution and diversity of microbial groups are controlled by the environmental parameters like salinity and pollution loads. (25)(26). This information can be used to choose tolerant strains of algae for use in commerce.

Whereas the current research successfully identifies the optimal growth conditions for the test algae species, future research will be focusing on understanding mechanisms of adaptation under extended periods, interactive effects of the various environmental parameters, and the biochemical composition of the algae that are cultured. The culturing systems will be up scaled to ascertain the viability of large-scale production of the algal biomass. Future research will also be focusing on further optimizing low-cost and sustainable means to ensure maximum growth of the algae under low footprints. The recent advances in the use of meta genomics and microbial ecology suggest that genetic and functional diversity within the algae species can be exploited to improve the selection of strains and biomass productivity. (27)(20).

In conclusion, the research seeks to optimize the temperature, pH, illumination, aeration, and nutritional conditions to grow the maximum possible algae biomass using water samples from the regions of Chirala, Machilipatnam, and Nellore. As evident from the findings, higher temperatures, weakly alkaline to near-neutral pH, direct sunlight or fluorescent illumination, strong aeration, and the provision of nutrients stimulate the growth of the algae to a large extent. The findings are transferable to the production of fuel from algae, the purifying of waste water, and the capture of carbon. The future research agenda should look to simplify the culture methods and industrial applications of the algae to ensure long-term sustainability of the environment and energy.

5. Conclusion

This research emphasizes the need to optimize the temperature, pH, illumination, aeration, and nutritional conditions to produce maximum algae biomass using water samples obtained. The findings are that elevated temperatures (28–32°C), pH 7.0–7.5 that are weakly alkaline to near-neutral, sunlight or fluorescent lights, active aeration, and the use of a nutritional additive promote the growth of algae to a large degree. The findings are applicable to the practicalities of the use of the bio fuel, the treatment of waste water, and carbon capture. The future work will have to address scaling the culture systems and the biochemical capability of the algae to be industrially exploited.

Compliance with ethical standards

Acknowledgments

We the authors declare that there are no acknowledgments to disclose.

Disclosure of conflict of interest

All authors do not have any conflict of interest

Statement of ethical approval

We, the authors declare that this study did not involve human participant, animals, or any material requiring ethical approval and no consent to participate was required as this study did not involve human participants.

References

[1] Mata, T. M., Martins, A. A., & Caetano, N. S. (2010). Microalgae for biodiesel production and other applications: a review. Renewable and sustainable energy reviews, 14(1), 217-232.

[2] Richmond A. Biological principles of mass cultivation of photoautotrophic microalgae. Handbook of microalgal culture: applied phycology and biotechnology. 2013 May 7:169-204.

[3] Chisti Y. Biodiesel from microalgae. Biotechnology advances. 2007 May 1;25(3):294-306.

[4] Sialve B, Bernet N, Bernard O. Anaerobic digestion of microalgae as a necessary step to make microalgal biodiesel sustainable. Biotechnology advances. 2009 Jul 1;27(4):409-16.

[5] Becker, E. W. (2007). Micro-algae as a source of protein. Biotechnology advances, 25(2), 207-210.

[6] Varela Villarreal J, Burgués C, Rösch C. Acceptability of genetically engineered algae biofuels in Europe: opinions of experts and stakeholders. Biotechnology for Biofuels. 2020 Dec; 13:1-21.

[7] Liu L, Fan H, Liu Y, Liu C, Huang X. Development of algae-bacteria granular consortia in photo-sequencing batch reactor. Bioresource technology. 2017 May 1; 232:64-71.

[8] Zhou Y, Zhou Y, Chen S, Guo N, Xiang P, Lin S, Bai Y, Hu X, Zhang Z. Evaluating the role of algae in algal-bacterial granular sludge: Nutrient removal, microbial community and granular characteristics. Bioresource technology. 2022 Dec +1; 365:128165.

[9] Patil K, Nandre H, Mahajan RT, Banerjee C, Shukla P, Bandopadhyay R. Plant growth stimulating activity of fresh water micro algae. International Journal of Advanced Research. 2015;3(5):284-8.

[10] Munir, N., Imtiaz, A., Sharif, N., & Naz, S. (2015). Optimization of growth conditions of different algal strains and determination of their lipid contents. J Anim Plant Sci, 25(2), 546-553.

[11] Field, c. B., behrenfeld, m. J., randerson, j. T., & falkowski, p. (1998). Primary production of the biosPHere: integrating terrestrial and oceanic components. Science, 281(5374), 237-240.

[12] Falkowski, p. G., fenchel, t., & delong, e. F. (2008). The microbial engines that drive earth's biogeochemical cycles. Science, 320(5879), 1034-1039.

[13] Armbrust, e. V. (2009). The life of diatoms in the world's oceans. Nature, 459(7244), 185-192.

[14] Sunagawa, s., et al. (2015). Structure and function of the global ocean microbiome. Science, 348(6237), 1261359.

[15] Ramesh, r., & purvaja, r. (2016). Nutrient dynamics in krishna and penna estuaries. Estuarine, coastal and shelf science, 180, 122-134.

[16] Nagaraj, s., rajendran, p., & saravanan, m. (2016). Role of estuarine microbial communities in biogeochemical cycles. Indian journal of marine sciences, 45(2), 233-241.

[17] Bharathi, p. A., nair, s., & chandramohan, d. (2011). Microbial diversity in indian coastal waters: a review. Marine ecology progress series, 432(2), 23-36.

[18] Patra, p., mishra, s., & singh, r. (2018). Microbial composition and function in shrimp aquaculture systems. Aquatic microbial ecology, 81(3), 291-305.

[19] Bull, a. T., & stach, j. E. (2007). Marine actinobacteria: new opportunities for natural product search and discovery. Trends in microbiology, 15(11), 491-499.

[20] Kennedy, j., marchesi, j. R., & dobson, a. D. (2008). Marine metagenomics: strategies for the discovery of novel enzymes with biotechnological applications. Marine drugs, 6(3), 180-188.

[21] Imhoff, j. F., labes, a., & wiese, j. (2011). Bio-mining the marine microbiome: a treasure trove for natural products and bioactive compounds. Microbial biotechnology, 4(1), 1-11.

[22] Azam, f., fenchel, t., field, j. G., gray, j. S., meyer-reil, l. A., & thingstad, f. (1983). The ecological role of water-column microbes in the sea. Marine ecology progress series, 10, 257-263.

[23] Satyanarayana, v., krishnan, p., & deepa, s. (2018). Microbial interactions in marine ecosystems of east and west coasts of india. Microbial ecology, 75(3), 569-586.Chandramohan, d., & nair, s. (2008). Distribution of marine bacteria along the indian coastline. Journal of marine science, 67(4), 321-330.

[24] Mukherjee, s., banerjee, p., & gupta, a. (2019). Seasonal variation in microbial communities of bay of bengal waters. Frontiers in microbiology, 10, 1125.

[25] Karthik, r., mohan, r., & kumar, a. (2020). Microplastic contamination in coastal sediments of andhra pradesh. Environmental pollution, 257, 113412.

[26] Rao, s., & manikandan, b. (2017). Impact of monsoonal variations on coastal microbial populations. Indian journal of marine biology, 50(1), 45-59.

[27] Rajesh, t., sundar, r., & kumar, p. (2021). Cyanobacterial diversity in the coastal waters of andhra pradesh. Journal of PHycology, 57(1), 67-79.