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ANALYZING THE POTENTIAL FOR *Padina gymnospora* CULTIVATION IN THE COASTAL WATERS OF ST. MARTIN'S ISLAND, BAY OF BENGAL, BANGLADESH: DETERMINING THE FLUCTUATIONS OF PHYSICOCHEMICAL PROPERTY ACROSS SEASONS AND LOCATIONS

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Abstract

Cultivating seaweed presents an opportunity to enhance the livelihoods of the inhabitants of St. Martin's Island inhabitants. This research investigates the suitability of the island's coastal waters for seaweed cultivation, taking into account variations in physicochemical factors in different seasons. The water temperature and salinity at various locations ranged from 24.22ºC to 27.64ºC and 23.8 to 33.76 psu, respectively. pH remained relatively constant throughout the year, fluctuating between 7.71 and 8.22. Dissolved oxygen levels were highest during the dry, cooler winter season (6.47±0.21 ppm) and lowest during the monsoon season (4.96±0.09 ppm). Electrical conductivity (EC) ranged from 39.00 mS/cm to 53.46 mS/cm, while total dissolved solids (TDS) varied between 20.35 and 27.90 g/l. Water clarity was at its peak during the dry, cooler winter season, averaging 4.14 meters. This investigation confirms the feasibility of year-round seaweed cultivation in the coastal waters around St. Martin's Island. In our study comparing cultivation methods for *Padina gymnospora* during the dry, cool winter season, the long-line approach resulted in a higher daily weight gain compared to the floating net method. This trend extended to growth rates by length, with the long-line method demonstrating a 5.09% daily growth and the floating net method showing 4.46%. However, net biomass production was 289.32 g/m² for the long-line method and 381.28 g/m² for the floating net method. Furthermore, the Cost-Benefit Ratio values for the long-line and floating net methods were 2.57 and 3.27, respectively. These findings affirm the viability of cultivating *Padina gymnospora* in coastal waters using the floating net method.

***Key words*:** Seaweed culture; Seasonal variation; Spatial variation; St. Martin's Island; Bay of Bengal.

INTRODUCTION

Seaweed cultivation has experienced global recognition in recent times owing to its extensive array of applications, encompassing the production of biochemicals (such as agar, agarose, algin, carrageenan), colors, food products, animal feed, enzymes, and pharmaceuticals (Athithan 2014). The resultant compounds exhibit biological functionality, such as anti-inflammatory, anticoagulant, antibacterial, antioxidant, antitumor, cytotoxic, and antiviral properties (Islam *et al*. 2022b, Biswas *et al.* 2023). Additionally, seaweeds have the potential to aid in the CO_2 sequestration and removal of harmful substances from wastewater (Islam *et al.* 2021). Consequently, it has evolved into a firmly established industry (Buschmann *et al*. 2017). Seaweed cultivation serves as a means to generate foreign currency and offers impoverished populations an alternative source of income. This venture's exceptional profitability can be attributed to the short culture cycle and the utilization of cost-effective farming methods of seaweeds (García-Poza *et al.* 2020). Recently, the seaweed industry has been recognized as a pivotal sector in the Okinawa prefecture, Japan, with an estimated production value of approximately 2.6 billion yen (Islam *et al.* 2023). Hence, in an effort to mitigate poverty, international development agencies are actively advocating for the implementation of seaweed cultivation among coastal rural populations (Campbell *et al.* 2019, Rimmer *et al.* 2021).

The culture of seaweed relies on a combination of environmental factors, including flow patterns of current, temperature, salinity, nitrate and phosphate concentrations, and exposure to sunlight (Trono Jr 1992). Thus, the selection of appropriate locations for seaweed farming necessitates a comprehensive physical and chemical characteristics of coastal waters. Furthermore, exploring suitable seaweed varieties and advancing commercial cultivation techniques could prove to be advantageous for Bangladesh, aligning with its new aspiration of fostering a 'Blue Economy'.

Bangladesh is blessed with a remarkable coastal zone that spans approximately 710 kilometers and is dotted with numerous islands. The country consists of a vast number of islands, including St. Martin's Island, Hatiya Island, and Bhola Island, each offering unique natural beauty and cultural heritage (Islam *et al.* 2016, Hasan *et al.* 2021). This coastal region, along with its islands, holds immense economic significance for Bangladesh (Islam *et al.* 2022a). The country has, so far, explored only a few Blue Economy sectors, such as fisheries, shipbuilding, shipbreaking, salt generation, and port facilities. Besides, most of these sectors follow traditional methods. Therefore, ample opportunities and challenges remain for exploring many other blue economy sectors.

It has been reported that both the southeastern part of Bangladesh and St. Martin's Island have an optimum environmental condition that encourage the natural growth of seaweeds (Islam *et al.* 2017). Bangladesh's coastal and estuarine waters harbor an estimated 200 species and 77 genera of seaweeds, while the red seaweed biomass surrounding St. Martin's Island is 1500 metric tons (Aziz 2015). St. Martin's Island is the sole coral-bearing island in the Bay of Bengal part of Bangladesh (Tajwar *et al.* 2022). It is also one of the most biodiversified regions in terms of marine biota. The water around the island is also an ideal fishing zone as it is home to a variety of marine fish species. The island is home to a diverse array of marine life, including 66 species of coral, of which 36 are currently living, 234 species of fish, 14 species of algae, and 187 species of crabs (Hossain and Islam 2006). Approximately, nine species of echinoderms, four species of Bryozoans, 61 species of molluscs, and four species of Zoanthids build up the macro-invertebrate communities of the island (Tomascik 1997). The island is a prominent location for the natural availability of seaweed due to the presence of rocky substrates. Even though there is an abundance of seaweed in the area, it is not enough to meet the rising demands. Moreover, there are nearly 7,000 people in St. Martin's Island area, with a slightly larger male population than a female population (Tania 2022). The majority of St. Martin's Island's residents are fishermen with an average daily wage of 500 Bangladeshi Taka (Tania 2022). Hence, the coastal waters surrounding the island hold the potential to serve as a viable area for seaweed cultivation. This not only has the capacity to uplift the local population from poverty but also has the capability to cater to both national and global demands for seaweed.

Padina gymnospora stands out as one of the most prevalent types of seaweed found in the waters around St. Martin's Island. This particular brown algae species holds substantial promise due to its noteworthy attributes in terms of antimicrobial properties, cytotoxic effects, and antioxidant capabilities (Hossain *et al.* 2021). Furthermore, it is noteworthy that *Padina gymnospora* finds application not only as a dietary component in certain regions globally but also as a constituent in skin care products, as well as, fertilizers and soil enhancers. As a result, there has been a noticeable escalation in the demand for *Padina gymnospora* in recognition of its diverse array of applications and its potential to contribute significantly in various sectors.

The study aims to examine the physicochemical properties, compare the seasonal variation of these properties, and determine the feasibility and potential of *Padina gymnospora* cultivation in the coastal waters of St. Martin's Island.

MATERIAL AND METHODS

Study area

The island of St. Martin's, also locally known as "Narikel Jinjira," (Fig. 1) is situated in the north-eastern region of the Bay of Bengal between the latitudes of 20°34' and 20°39' N, and the longitudes of 92°18' and 92°2' E. It is a part of the Teknaf Upazila, which is within the Cox's Bazar district of Bangladesh (Tajwar *et al.* 2022). The island is relatively close to the border of Myanmar's Arakan coastal plain, being only 4.5 kilometres to the east, and is bordered by the Bay of Bengal on its west and southwest. The current research focuses on the coastal waters surrounding the island.

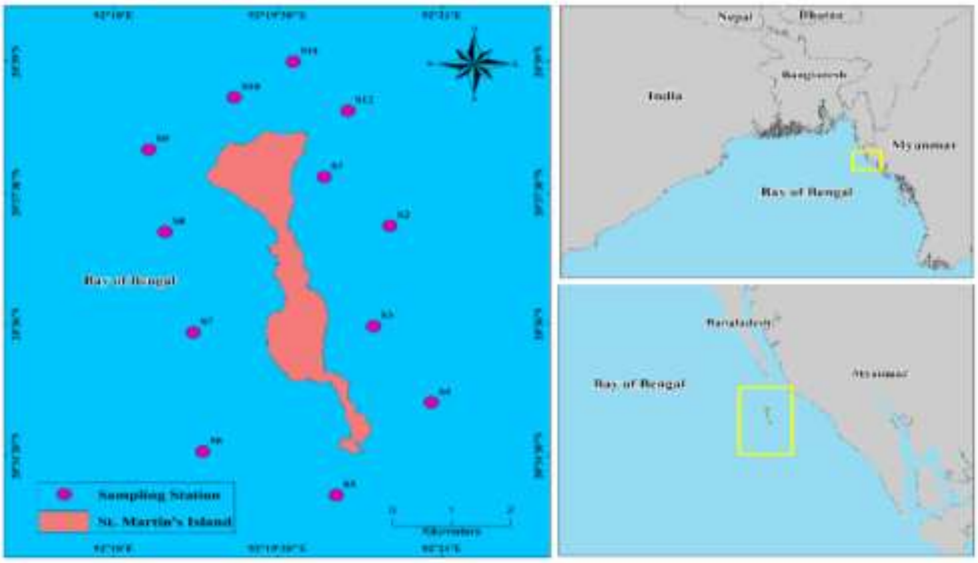

Fig. 1. Map of the study region.

Water sample collection

St. Martin's Island was visited in the different seasons of the year 2021. The parameters of water samples were measured in three distinct seasons: the pre-monsoon hot season, the rainy monsoon season, and the cool dry winter season following Ahmed and Kim (2003).

Seven essential parameters were chosen for Physico-chemical water quality analysis; these were: temperature, salinity, pH, DO, total dissolved solids, electrical conductivity, and transparency. In the study a mercury centigrade thermometer was used to measure the temperature of the coastal waters. The pH and dissolved oxygen levels were determined using a portable digital pH meter and DO meter from HANNA (Romania) and HACH (USA), respectively. The salinity and clarity of the water were determined using a refractometer (Agriculture Solutions, WL0020-ATC) and a Secchi disk. Electric conductivity and total dissolved solids were measured with a multiparameter waterproof meter from HANNA (HI98194, Romania). In addition, the concentrations of nitrate (NO_3^-) and phosphate (PO_4^-) were determined using established spectrophotometric techniques with a Shimadzu UV–Visible 1800 double-beam spectrophotometer, as described in the protocol published by Grasshoff *et al.* (1999). The research adhered to the established standard operating procedure (SOP) for laboratory operations, including chemical handling and safety protocols. Furthermore, the blanks were prepared, and the glassware was washed and rinsed meticulously.

Seedling's collection, culture, and daily growth rate evaluation

The seaweed selected for cultivation in this study is *Padina gymnospora* (brown algae). This species was selected based on their ability to grow effectively under the local physicochemical conditions. The seedlings of this seaweed were collected from reju khal, Cox's Bazar. The species found in the water around St. Martin's Island are also found in reju khal. Furthermore, it is easier to collect the seedlings from this location as tidal flow makes the collection impossible from the coastal water of the island. After the collection, the seeds were preserved in an aquarium where a continuous flow of seawater was ensured at the Bangladesh Oceanographic Research Institute. Later, these seeds were transferred to St. Martin's Island in an icebox for cultivation.

The seaweed was cultured using both the long-line method and the floating net method. Six long lines were set up to cultivate these seaweeds using the long line method. Each line consisted of a 40-foot nylon rope (8mm) with a 2-foot gap in between, resulting in a total width of 12 feet. A total of 2100 grams of *Padina gymnospora* seaweed seedlings were planted on these ropes, with each seedling securely attached using a bobbin thread. The supporting bamboo poles stood at approximately six feet in height. In the floating net culture approach, Lakkha fish nets measuring 40 feet in length and 12 feet in width were employed. The mesh size was approximately 20 centimeters, and the net was constructed using either nylon rope or stranded polyethylene wires with a test strength ranging from 110 to 150 lbs. The net's meshwork comprised lines with a test strength ranging from 30 to 100 lbs, and it was positioned horizontally. Bobbin thread was used to interconnect all the *Padina gymnospora* seedlings within this net, totaling around 3000 grams of seedlings. The net was suspended 2.0 feet above ground level, supported by a total of fifteen fishing buoys to ensure buoyancy.

After 30 days daily growth rate (DGR) %/day for both the length and weight were evaluated using the formula provided by Hung *et al.* (2009):

$$DGR = \{\left(\frac{W_t}{W_o}\right)^{\frac{1}{t}} - 1\} \times 100\ \%/day \qquad (1)$$

The seaweed biomass (Y) was computed using the formula given by Doty (1986):

$$Y = \frac{W_t - W_o}{A} \qquad (2)$$

In equations 1 and 2, W_t is the final fresh weight, W_o is the initial fresh weight, t is the day of the culture, and A is the total culture area.

Cost-benefit analysis

A thorough cost-benefit analysis was undertaken to evaluate the economic feasibility of seaweed mariculture completely. Based on the implementation of both the long-line and floating net methods, the expenses related to the long-line approach are 1050 BDT and the expenditures associated with the floating net method amount to 1100 BDT. The prices involved in this project include necessary materials, such as bamboo poles, nylon ropes, bobbin thread, lakkha fish nets, and various additional fees.

The assessment of the seaweed mariculture's economic viability extends to the examination of the benefits derived from the endeavor. Key among these benefits is the harvested biomass yield of *Padina gymnospora*. The per unit price of this yield is determined to be 180 BDT per kilogram. By evaluating the gross returns generated from the cultivated biomass, the cost-benefit ratio was calculated following the formula.

$$BCR = \frac{Gross\ Return\ (GR)}{Total\ Cost\ (TC)}$$

The assessment of the cost-benefit ratio is of utmost importance in ascertaining economic viability. When the ratio is larger than 1.0, it indicates a positive net present value, suggesting that the project is anticipated to yield returns that surpass the expenses incurred. This particular instance demonstrates a promising outlook.

Sample processing and analysis

All the parameters were measured immediately after collecting the water sample using respective instruments. The required computer-based analyses were conducted using MS Excel 2019. For graphical and data visualization, Graph Pad Prism and ArcGIS were used, respectively.

RESULTS AND DISCUSSION

Seasonal and spatial variation of physicochemical properties

During the study, temperature, salinity, power of hydrogen (pH), Electric Conductivity (EC), Total Dissolved Solids (TDS), Dissolved Oxygen (DO), and Transparency were monitored at 12 different stations in three seasons.

Table 1. Mean values and standard deviation of physicochemical properties of water samples collected from sampling sites around St. Martin's island.

Season	Temperature	Salinity	pH	DO	EC	TDS	Transparency
Pre-Monsoon hot season	26.83±0.21	32.91±0.51	8.18±0.02	5.95±0.06	52.06±0.90	27.51±0.23	2.68±0.02
Rainy Monsoon Season	27.06±0.22	24.43±0.38	7.80±0.06	4.96±0.09	40.07±0.76	20.98±0.35	1.45±0.03
Dry cool winter season	24.55±0.39	30.53±0.28	8.13±0.02	6.47±0.21	46.61±0.72	26.33±0.25	4.14±0.02

Temperature influences the chemical and biological activities of marine organisms. Moreover, the growth rate of seaweeds is dependent on the temperature of the coastal waters. The temperature of coastal water was observed over 14 stations in three different seasons. The average temperature recorded from the stations ranged from 24.22ºC to 27.64ºC (Fig. 2A). Mean seasonal temperature for the pre-monsoon, monsoon, and dry cool winter seasons are 26.83±0.21ºC, 27.06±0.22ºC and 24.55±0.39ºC, respectively (Table 1). The maximum temperature during the pre-monsoon and rainy monsoon season was observed in the western region of the island while in the dry cool winter season, the maximum temperature was measured in the northern waters of the island (Fig. 2B).

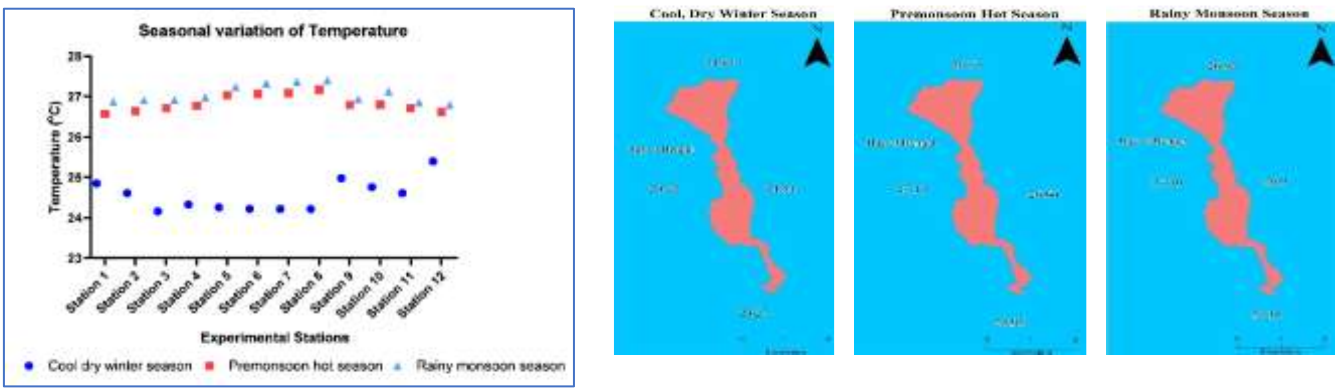

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Fig. 2. Temperature variation (A) seasonal and (B) spatial in the coastal waters of St. Martin's Island.

Seawater salinity is a highly valuable factor in the production of seaweed because it is one of the primary determinants of osmotic equilibrium. It is also a key component that greatly affects the abundance and distribution of organisms in marine environments. The salinity of the coastal water around St. Martin's Island ranged from 23.8 psu to 33.76 psu (Fig. 3A). The highest seasonal salinity value was 32.91±0.51 psu in the premonsoon season, and the lowest in the monsoon season 24.43±0.38 (Table 1). The maximum salinity during the premonsoon and monsoon season was observed in the southern waters while in the dry cool winter season northern waters of the island. The minimum salinity was recorded in the waters east of the island while during the dry cool winter season waters in the south of the island had the minimum salinity (Fig. 3B).

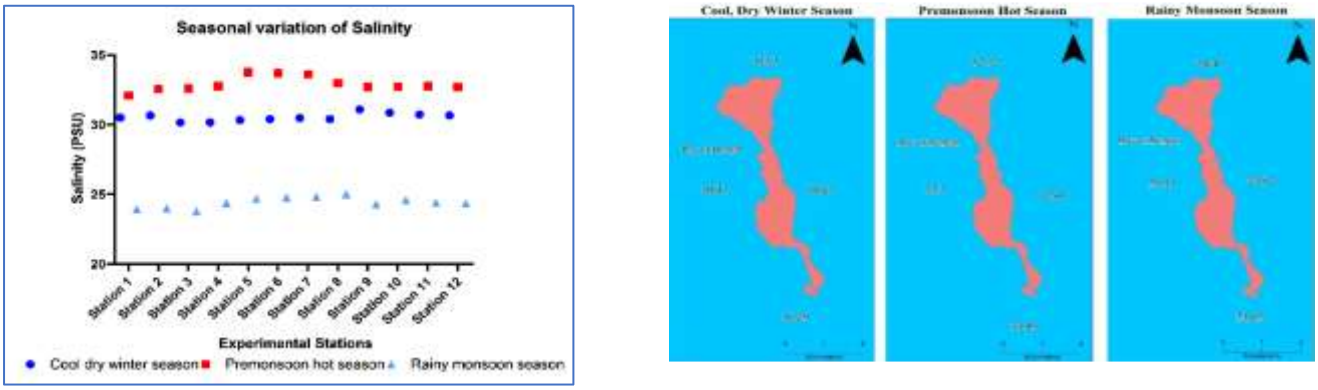

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Fig. 3. Salinity variation (A) seasonal and (B) spatial in the coastal waters of St. Martin's Island.

The value of pH measures the concentration of hydrogen ions in a solution and indicates the intensity of acidity or alkalinity. Almost all metabolic activities of aquatic organisms are pH-dependent. The pH value of seawater ranged from 7.71 to 8.22 (Fig. 4A). The maximum pH was measured at St-6 in pre-monsoon season and the minimum pH was found at St-3 in monsoon season. The mean seasonal pH for pre-monsoon, monsoon, and dry cool winter seasons are 8.18±0.02, 7.80±0.06, 8.13±0.024, respectively (Table 1). The value of pH is almost equal on every side of the island in different seasons (Fig. 4B).

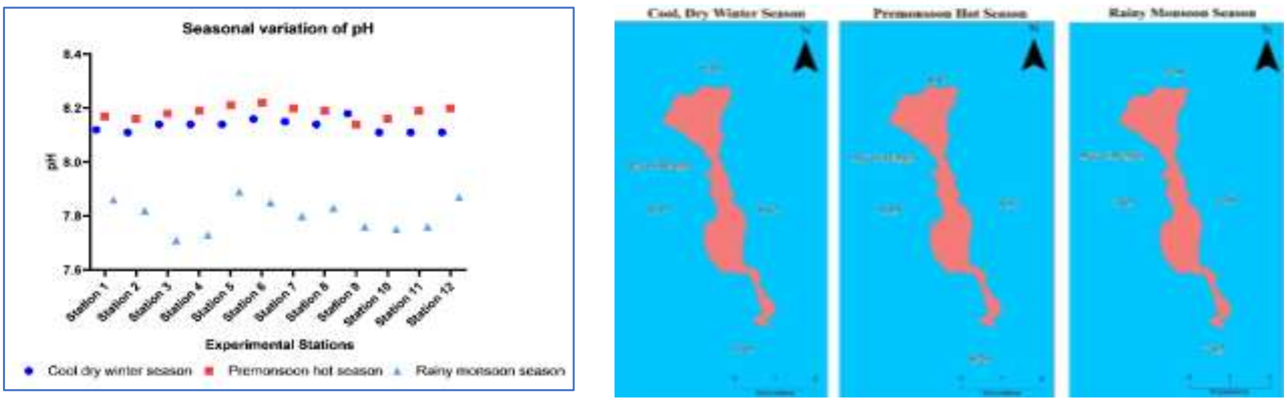

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Fig. 4. pH variation (A) seasonal and (B) spatial in the coastal waters of St. Martin's Island.

The concentration of dissolved oxygen dictates whether the biological changes in the marine environment are the result of aerobic or anaerobic organisms. The two sources of oxygen in water are the atmosphere and photosynthetic organisms. The reduction of oxygen generally occurs due to the respiration of marine organisms, decomposition of organic matter, increase in temperature, and discharge of oxygen-demanding wastes (Singh *et al.* 2012). During the study, a higher concentration of dissolved oxygen is observed during the winter season with respect to the other two seasons. This concentration of oxygen could be lower due to the higher salinity and temperature of the water during the pre-monsoon season. The concentration of oxygen in the study area ranged from 4.82 ppm to 6.74 ppm (Fig. 5A). The mean seasonal values of DO for the three seasons are 5.95±0.06 ppm, 4.96±0.09 ppm and 6.47±0.21 ppm, respectively (Table 1). During the study, the highest concentration of DO was measured in the western, eastern, and southern waters around the island during the pre-monsoon hot season, rainy monsoon season, and dry cool winter season, respectively (Fig. 5B).

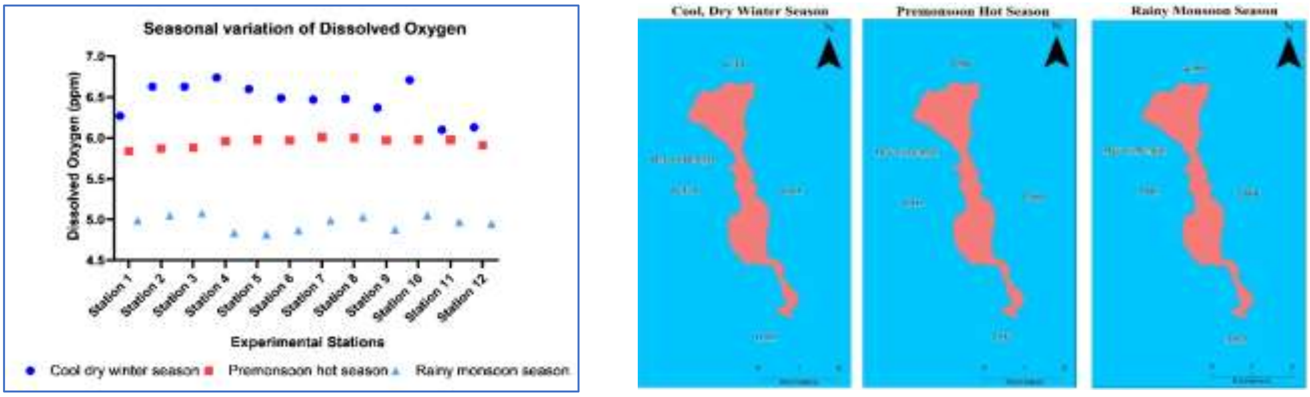

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Fig. 5. DO variation A. seasonal and B. spatial in the coastal waters of St. Martin's Island.

Water quality is reflected in the EC value, which indicates the concentration of ions and nutrients in the water (DeZuane 1997). It depends on the concentration of ions and its nutrient. In the study, the value of EC of seawater ranged from 39.00 mS/cm to 53.46 mS/cm (Fig. 6A). The mean seasonal EC for pre-monsoon, monsoon, and dry cool winter are respectively 52.06±0.90 mS/cm, 40.07±0.76 mS/cm, 46.61±0.72 mS/cm (Table 1). The maximum EC was observed on the western side of the island during the pre-monsoon hot season while the minimum value of EC was found on the east side in the rainy monsoon season (Fig. 6B).

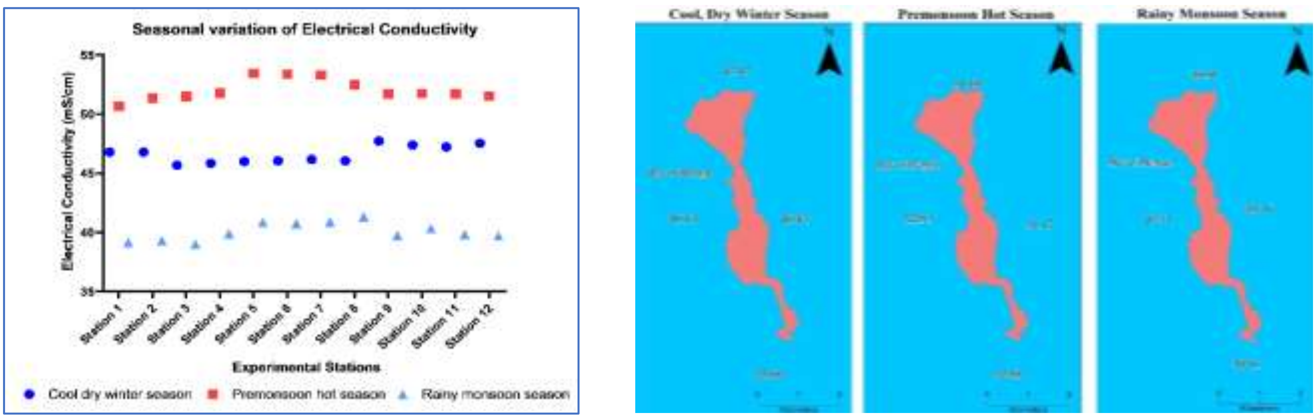

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Fig. 6. EC variation A. seasonal and B. spatial in the coastal waters of St. Martin's Island.

The values of TDS signify the quantity of inorganic chemicals present in a water sample (Kumar and Prabhahar 2012). The value of TDS ranged from 20.35 grams per liter (g/l) to 27.90 g/l (Fig. 7A). The maximum value of TDS was found at St-11 in pre-monsoon season and the minimum TDS is found at St-9 in monsoon season. The average seasonal variation of TDS for the pre-monsoon hot season, rainy monsoon season, and dry cool winter season are 27.51±0.23 g/l, 20.98±0.35 g/l, and 26.33±0.25 g/l, respectively (Table 1). The maximum value of TDS during the pre-monsoon and monsoon season was observed in the western and southern waters while in the dry cool winter season northern waters of the island (Fig. 7B).

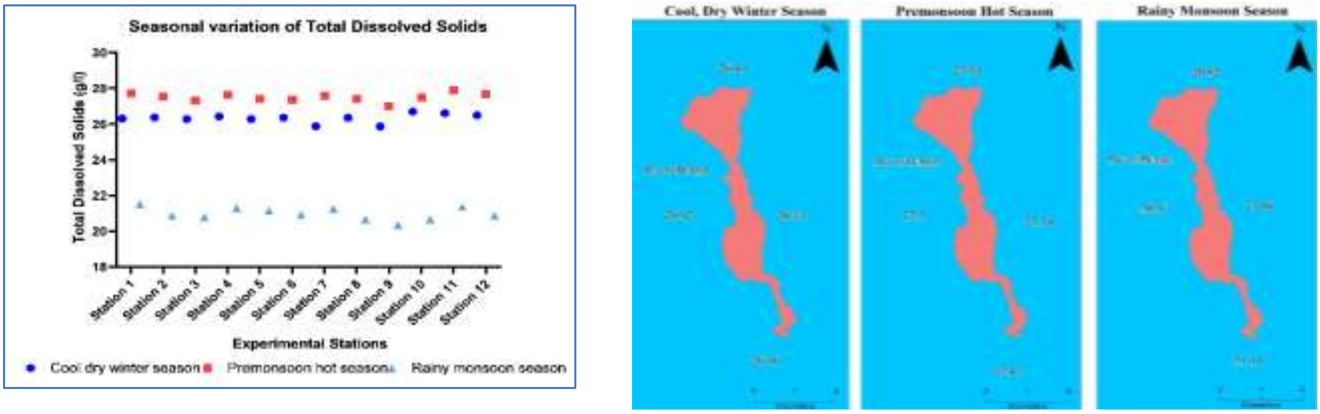

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Fig. 7. TDS variation A. seasonal and B. spatial in the coastal waters of St. Martin's Island.

The transparency of water is a measure of its clarity. It is important to quantify this parameter as it indicates the depth of sunlight penetration and sunlight is essential for photosynthesis. Transparency of the water around St. Martin's Island ranged from 1.40 m to 4.16 m (Fig. 8A). The transparency of the water was observed to be higher during the dry cool winter season due to the calm environment than in other seasons. The mean seasonal variation of transparency for pre-monsoon, monsoon and dry cool winter are 2.68±0.02m, 1.45±0.03m and 4.14±0.02m, respectively (Table 1).

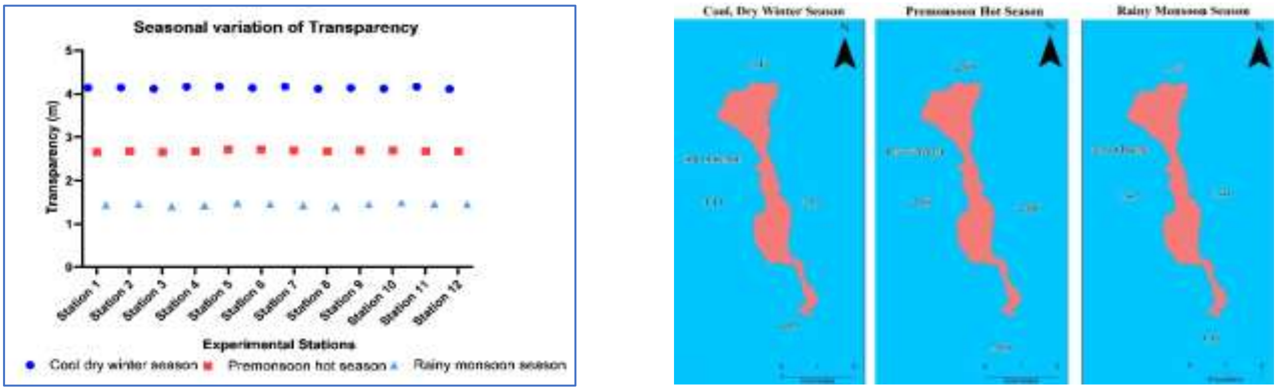

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Fig. 8. Transparency variation A. seasonal and B. spatial in the coastal waters of St. Martin's Island.

The highest value of transparency during the pre-monsoon and monsoon seasons was measured in the seawater on the south and north sides of the island while in the winter season the water was more transparent in the south side of the island (Fig. 8B). During the study, the physicochemical properties of the coastal waters around the island (north, south, east and west) were observed.

However, from this study no single factor could be identified that is accountable for the difference in values of physicochemical properties around the island.

Seaweed culture prospect in the coastal water of St. Martin's Island

Season and site selection for seaweed culture: For a successful seaweed farm, it is essential to select a suitable site. This can be accomplished by monitoring various physicochemical properties such as temperature, pH, salinity, DO and transparency.

Table 2. Criteria for the suitability of seaweed culture.

	Criteria*		Mean values		
Parameters	**Suitable**	**Strongly suitable**	**Pre-monsoon hot season**	**Rainy monsoon season**	**Dry, cool winter season**
Temperature (^{o}C)	20-24	24-28	26.83	27.06	24.55
pH	6.5-<7.5	7.5-8.5	8.18	7.80	8.13
Salinity (PSU)	24-37	28-34	32.91	24.43	30.53
DO (mg/L)	6.1-7	4-6	5.95	4.96	6.47
Transparency (m)	0.3 - 1	>1	2.68	1.45	4.14

*(Zafar 2005, 2007)

Table 2 shows the water quality parameters that are acceptable for seaweed culture along with the mean values of those parameters measured during the pre-monsoon hot season, rainy monsoon season, and dry, cool winter season. The seasons can be divided in to either suitable or strongly suitable for seaweed culture. For a season to be suitable for seaweed culture the temperature of the water needs to be between 20ºC and 24ºC, the salinity should range from 24 psu to 37 psu, the value of pH should be greater than 6.5 but less than 7.5, the concentration of dissolved oxygen should be between 6.1 and 7 ppm, and the transparency of the water should be between 0.3 and 1 meter.

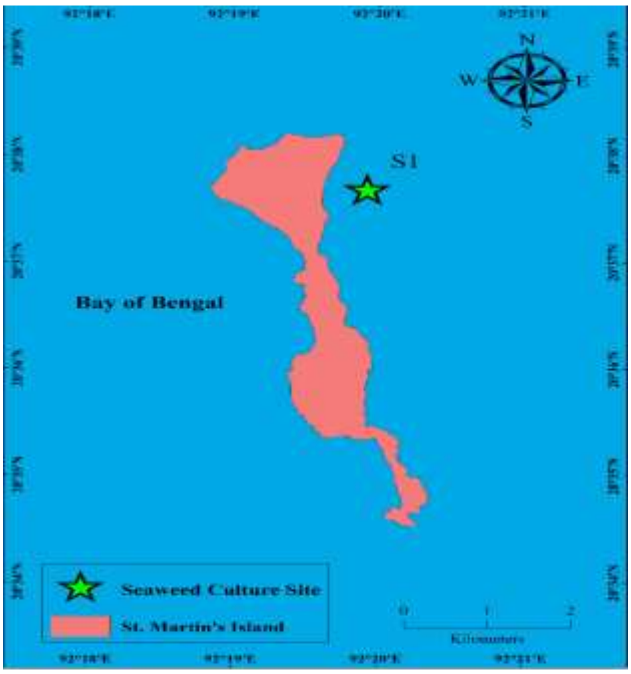

Fig. 9. Seaweed culture site in the coastal water of St. Martin's Island.

Furthermore, water strongly suitable for seaweed culture has temperatures ranging from 24ºC to 28ºC, salinity between 28 psu and 34 psu, pH value between 7.5 and 8.5, and DO concentration between 4 and 6 ppm, and transparency of the water should be higher than 1 meter. Moreover, the alkalinity of the water should be between 100-130 ppm (Zafar 2005, 2007), and the current speed between 0.2 m/s and 1 m/s. Based on the values of these properties, it can be established that seaweed can be cultured around the island throughout the year. However, for this study, the cool, dry winter season was selected for the cultivation of seaweed. This is because the concentration of both nitrogen and phosphorus was higher in the cool, dry winter season. Furthermore, the concentration of heavy metal was also lower during the cool, dry winter season (Alam *et al.* 2023). So, it can safely be said that seaweed can be cultured profitably in the coastal water of St. Martin's Island during the cool, dry winter season. Furthermore, in this study, the north-eastern section of the island was selected as the focal area for assessing the viability of cultivating *Padina gymnospora*.

Growth rate evaluation, biomass and economic analysis of *Padina gymnospora*: This study thoroughly investigated the growth rates and economic feasibility of *Padina gymnospora*, a prominent species of Brown Algae, using two independent cultivation methods: the long line and the floating net methods. The study examined the daily rates of growth in weight and length, along with the corresponding cost-benefit ratios (CBRs), in order to determine the most effective and financially viable method for cultivating *Padina gymnospora.*

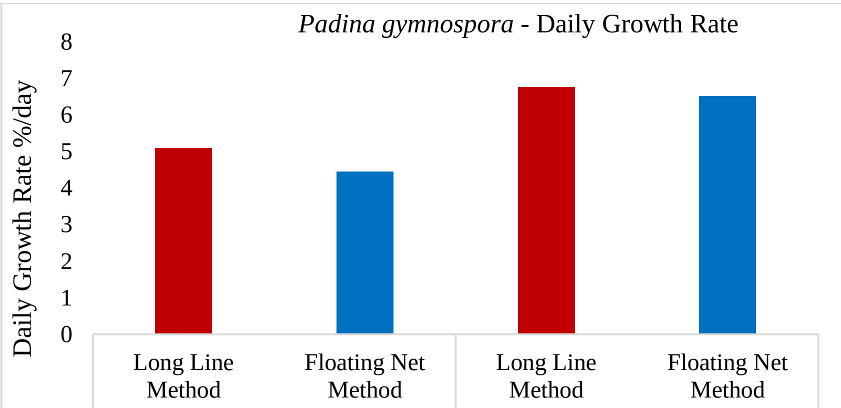

Fig. 10. Comparison of daily growth rate of *Padina gymnospora* based on culture methods.

In the long line cultivation method, *Padina gymnospora* exhibited an average daily weight increase of 6.77%. In contrast, the floating net method displayed a relatively lower growth rate, with an approximately 6.52% daily increase for the same species. This trend was similarly observed in terms of growth rate by length, with the long line approach demonstrating an average daily increase of 5.09%, while the floating net method exhibited a slightly lower figure of 4.46%.

In the cultivation of *Padina gymnospora* using the long line and floating net methods, an evaluation of net biomass production serves as a critical indicator of growth efficiency. In the long line method, a total of 2100 grams of *Padina gymnospora* seedlings were initially planted within the cultivation area, which measured 44.58 square meters. After a month, the final recorded weight of the seaweed reached 15000 grams. Calculating the net biomass production, we found that it amounted up to 289.32 grams per square meter of cultivation area. Similarly, in the floating net method, an initial planting of 3000 grams of *Padina gymnospora* seedlings occurred within an identical cultivation area. Following the cultivation period, the seaweed's weight increased to 20000 grams. The net biomass production for the floating net method, calculated under these circumstances, was 381.28 grams per square meter. This demonstrates the effectiveness of the floating net method in facilitating even higher biomass production compared to the long line method within the same area.

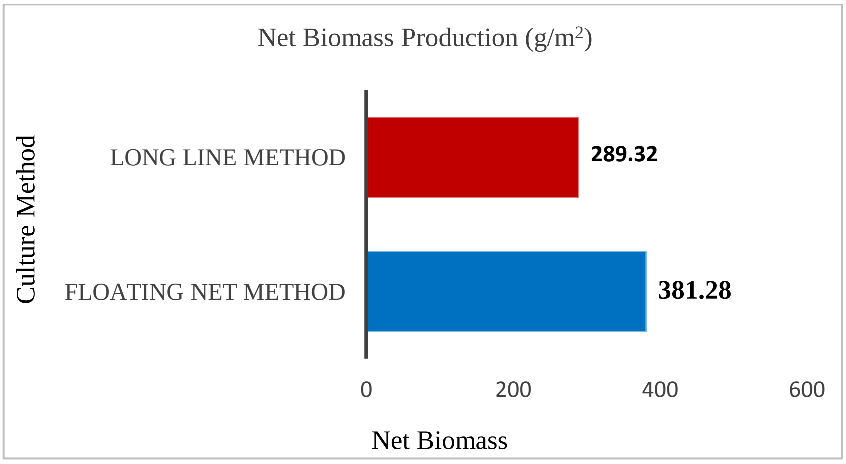

Fig. 11. Comparison of net biomass of *Padina gymnospora* among long line and floating net method.

The economic feasibility of the farming methods was evaluated by means of the computation of the cost benefit ratio (CBR). The CBR values obtained for *Padina gymnospora* in the coastal waters around St. Martin's Island were 2.57 and 3.27 using the long line method and the floating net method, respectively. These CBR values signify the economic viability of *Padina gymnospora* cultivation in this region. Notably, the significantly higher CBR value associated with the floating net method, at 3.27, suggests that it is the preferred and economically advantageous approach for sustainable seaweed cultivation in this coastal ecosystem.

This research was conducted in the coastal waters surrounding St. Martin's Island to evaluate how water quality varies throughout the year by quantifying various physicochemical parameters. Water quality in this region is influenced by agricultural activities, human settlements, unplanned infrastructure, and tourism. The study measured parameters, such as temperature, salinity, pH, dissolved oxygen (DO), electrical conductivity (EC), total dissolved solids (TDS), and water transparency across three different seasons.

Temperature in the study area fluctuated between 24.16ºC and 27.64ºC, with the highest readings occurring during the monsoon season. Salinity varied from 23.8 ppt to 33.76 ppt, peaking during the pre-monsoon hot season. pH levels remained relatively stable, ranging from 7.71 to 8.22 throughout the year. The highest dissolved oxygen levels were recorded during the dry, cool winter season (6.45±0.204 ppm), while the lowest levels were observed during the monsoon season (4.95±0.083 ppm). Electric conductivity values ranged from 39.00 mS/cm to 53.46 mS/cm, and total dissolved solids varied from 20.35 g/l to 27.90 g/l, with the highest TDS levels in the pre-monsoon hot season and the lowest during the rainy monsoon season. Water clarity was at its peak during the cool, dry winter season, with an average transparency of 4.14 meters, and it was least clear during the rainy monsoon season.

Based on the measured parameters, the findings suggest that the water surrounding St. Martin's Island is suitable for seaweed cultivation. Additionally, the long-line method yielded a higher daily growth rate for *Padina gymnospora*, whereas the floating net method produced a greater net biomass and demonstrated a more favorable cost-benefit ratio. Consequently, the most profitable cultivation of *Padina gymnospora* in the coastal waters of St. Martin's Island is achieved during the cool, dry winter season, with a preference for the floating net method.

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REFERENCES

Ahmed, R. and II-K. Kim. 2003. Patterns of daily rainfall in Bangladesh during the summer monsoon season: Case studies at three stations. *Phys. Geogr.* **24**: 295-318. https://doi.org/10.2747/0272-3646.24.4.295.

Alam, M. J., A. S. M. M. Kamal and M. K. Ahmed. 2023. Nutrient and heavy metal dynamics in the coastal waters of St. Martin’s island in the Bay of Bengal. *Heliyon*. **9**(10): e20458.

Athithan, S. 2014. Growth performance of a seaweed, *Kappaphycus alvarezii* under lined earthen pond condition in Tharuvaikulam of Thoothukudi coast, South East of India. *Res. J. Anim. Vet. Fish. Sci*. **2**: 6-10.

Aziz, A. 2015. Seaweeds, the future revenues of Bangladesh coastal waters. In: A. K. M. N. Alam, M. E. Hoq, M. Naser and K. A. Habib (eds.). *Proc. of the Marine Conservation and Blue Economy Symposium*. 58 pp.

Biswas, M. H., N. B. Bahar and N. Sharmin. 2023. Biological investigations of three marine algae *Enteromorpha intestinalis, Rhizoclonium riparium* and *Ceratophyllum demersum* collected from the Bay of Bengal. *Dhaka Univ. J. Pharm. Sci.* **22**: 81-87.

Buschmann, A. H., C. Camus and J. Infante. 2017. Seaweed production: overview of the global state of exploitation, farming and emerging research activity. *Eur. J. Phycol*. **52** (4): 391-406.

Campbell, I., A. Macleod, C. Sahlmann, L. Neves, J. Funderud, M. Overland, A. D. Hughes and M. Stanley. 2019. The environmental risks associated with the development of seaweed farming in Europe-prioritizing key knowledge gaps. *Front*. *Mar*. *Sci.* **6**: 1-22.

DeZuane, J. 1997. *Handbook of drinking water quality*. John Wiley & Sons. 592 pp.

Doty, M. S. 1986. Estimating returns from producing *Gracilaria* and *Eucheuma* on line farms. *Monogr*. *Biol*. **4**: 45-62.

García-Poza, S., A. Leandro and C. Cotas. 2020. The evolution road of seaweed aquaculture: cultivation technologies and the industry 4.0. *Int. J. Environ. Res. Public Health*. **17**: 6528

Grasshoff, K., K. Kremling and M. Ehrhardt. 1999. *Methods of Seawater Analysis*. WILEY-VCH Verlag GmbH, D-69469 Weinheim, Germany. 577 pp.

Hasan, M., M. Rahman and M. A. Islam. 2021. Assessment of toxic heavy metals in surface water of the Meghna river estuary: An integrated statistical approach. *Dhaka Univ. J. Earth Environ. Sci.* **2021**: 143-155.

Hossain, M. M. and M. H. Islam. 2006. Status of the biodiversity of St. Martin's Island, bay of Bengal, Bangladesh. *Pak. J. Mari. Sci*. **15**(2): 201-210.

Hossain, M. N., M. F. Rahman, M. A. Alim, T. Ahsan, T. Islam and M. M. Alam. 2021. Screening of potential bioactive compounds from *Padina Gymnospora* found in the coast of St. Martin Island of Bangladesh. *J. Marine Biol*. *Aquacult*. **6**(1): 1-7.

Hung, L. D., K. Hori and H. Q. Nang. 2009. Seasonal changes in growth rate, carrageenan yield and lectin content in the red algae *Kappaphycus alvarezii* cultivated in Camranh Bay, Vietnam. *J. Appl. Phycol.* **21**: 265-272.

Islam, M. A., M. Hasan and M. H. Peas. 2016. Shoreline vulnerability assessment in an offshore island (Sandwip). Bangladesh-an appraisal of geospatial techniques. *Dhaka Univ. J. Earth Environ. Sci*. **5**: 51-60.

Islam, M. K., M. Hasan and M. Rahman. 2022a. Shoreline dynamics assessment of Moheshkhali island of Bangladesh using integrated GIS-DSAS techniques. *Dhaka Univ. J. Earth Environ. Sci*. **11**: 1-14.

Islam, M. M., M. S. K. Khan and J. Hasan. 2017. Seaweed *Hypnea* sp. culture in Cox's Bazar coast, Bangladesh. *Bangladesh J. Zool*. **45**: 37-46. https://doi.org/10.3329/bjz.v45i1.34192

Islam, M. S., K. M. A. Kabir, J. Tanimoto and B. B. Saha. 2021. Study on *Spirulina platensis* growth employing non-linear analysis of biomass kinetic models. *Heliyon*. **7**(10): e08185.

Islam, M. S., I. Senaha, K. Nagamatsu, Y. Yoda and B. B. Saha. 2023. Green algae *Caulerpa lentillifera* cultivation technique utilising CO_2 and its social impact. *Int. J. Innov. Sustain. Dev.* **18**(1/2): 146-167.

Islam, M. S., I. Senaha and M. M. Rahman. 2022b. Mathematical modelling and statistical optimization of fast cultivation of *Agardhiella subulata*: response surface methodology. *Energy Nexus*. **7**: 1-9.

Kumar, M. P. and C. Prabhahar. 2012. Physico-chemical parameters of river water: a review. *Int. J. Pharm. Biol. Arch.* **3**: 1304-1312.

Rimmer, M. A., S. Larson, I. Lapong, A. H. Purnomo, P. R. Pong-Masak, L. Swanepoel and N. A. Paul. 2021. Seaweed aquaculture in Indonesia contributes to social and economic aspects of livelihoods and community wellbeing. *Sustainability*. **13**: 1-22.

Singh, J., R. K. Gangwara, P. Khare and A. P. Singh. 2012. Assessment of physico-chemical properties of water: River Ramganga at Bareilly. *J. Chem. Pharm. Res.* **4**: 4231-4234.

Tajwar, M., S. S. Shreya and M. Y. Gazi. 2022. Microplastic contamination in the sediments of the Saint Martin's Island, Bangladesh. *Reg. Stud. Mar. Sci*. **53**: 102401

Tania, T. C. 2022. Socio-economic culture and tourism: A case study on Saint Martin Island of Bangladesh. *J. Apl. Manajemen*. **6**: 84-93.

Tomascik, T. 1997. *Management plan for coral resources of Narikel Jinjira (St. Martin's Island)*. Final Report. Ministry of Environment and Forest, Government of Bangladesh, Bangladesh. 128 pp.

Trono Jr., G. C. 1992. *Eucheuma* and *Kappaphycus*: Taxonomy and cultivation, seaweed cultivation and marine Rancing. *Bull. Mar. Sci. Fish. Kochi Univ*. **12**: 51-65.

Zafar, M. 2007. *Seaweed culture* (*Hypnea* sp.) i*n Bangladesh: Seaweed Culture Manual-1*. Insttitute of Marine Science and Fisheries, University of Chittagong, Chittagong, Bangladesh. 14 pp.

Zafar, M. 2005. Seaweed culture in Bangladesh holds promise. *Infofish Int*. **1**: 8-10.

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