

Biofuel potential of some seaweed species from the Coast of South Andaman

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Abstract

Fossil fuels have been the major source of energy since industrial revolution began and has become the driving force of global economy. But these fuel resources are in the process of rapid depletion and become a concern in recent years. The CO₂ load due to fossil fuel consumption on the environment and its influence on greenhouse gases brings the disorders which becomes source for climate change. With a view to protect environment, the idea of generating sustainable, cost effective and environment friendly fuels has taken the centre stage and the best source for substituting these fossil fuels is to look into a sustainable source of renewable biofuels. The attention is thus being given towards the marine resources, and seaweeds considered the base for biofuel production, being the most abundant plant with high biomass present in the oceans. The present study, biofuel potential of some seaweeds from the coast of South Andaman is examined. The study was conducted by extracting lipid and converting it to biofuel from 12 species of seaweeds *Acetabularia cranulata*, *Dictyosphaeria versluisii*, *Halimeda gracilis*, *Halimeda opuntia*, *Padina gymnospora*, *Padina pavonica*, *Sargassum weightii*, *Turbinaria conoides*, *Galaxaura rugosa*, *Portieria hornemanni*, *Trichogloeopsis pedicellata*, *Trichogloea equienii* representing Chlorophyta, Phaeophyta, and Rhodophyta. The comparative data suggested that seaweeds from South Andaman coast have the potential for use for biofuel production in future.

Keywords: Seaweed, Biofuel, Energy, Potential, Tropical island

Introduction

Fossil fuels have been the major source of energy as on date. But it is in the process of exhaustion due to increasing demand and limited stock in the nature. Simultaneously, release of CO₂ due to burning these fossil fuel increases greenhouse gases in the environment and brings lot of environmental disorders and become instrumental in influencing climate change. It is thus essential to look into a sustainable, cost effective and environment friendly fuels. The best alternative is to produce biofuel as source of renewable energy from marine algae as these are most promising bioresources from the marine environment with high biomass and species abundance.

Recent years, attempts are being made to develop suitable technology for extracting biofuel from biological sources (Antizer and Turrion, 2008). The biomass is said to be the largest energy resources available in the world and seaweeds may be considered as one of the most important components in this regard. Also, these biofuels are mainly renewable, sustainable, biodegradable and carbon neutral

source of energy, so that, it encourages green industries, agricultural and automobile trade (Xu and Li, 2016; Su et al., 2015). The production of biofuel has undergone several stages of development and in recent times, the production of biofuel includes extraction from marine algae (Aitken and Ladislao, 2012). The conversion of brown macroalgae *Padina tetrastrum* biomass to liquid biofuel through trans-esterification method was reported by Ashok et al., (2017). The idea of biofuel from macroalgae is due to its biochemical constituents to produce energy generating fuel, which can replace the current trend of fossil fuel-based powers (Hughes et al., 2012).

Many algae constitute several types of lipids that can substitute petroleum derived fuels (Lee and Lee, 2012). Apart from its high lipid content, seaweeds also possess carbohydrate that can also be converted to different form of biofuel. Again, the algal cellulose content is heavier with less lignin content signifying that the biomass can pave way for the biofuel production. Different processes are

used to achieve different type of biofuel such as biodiesel, bioethanol (Wargacki et al., 2012), bio-hydrogen, biogas, methane (Ghosh et al., 1981; Chynoweth et al., 2001). The most significant aspect of algal biofuel is that it directly converts the biomass into biofuel and it can be cultivated with any less desirable source of water; in saline, brackish, polluted waters (Knothe, 2006; Meher et al., 2006).

The seaweeds comprise largest biomass in the marine environment, so, it is the most suitable candidate for biofuel extraction. The Andaman Sea exhibit a high seaweed resource with estimated representation of about 300 species (Palanisamy, 2012) and have the potential for commercial use (Gopinathan and Panigrahy, 1983; Banu et al., 2018; Banu and Mishra, 2019). Also, along the coast of South Andaman, the species diversity is very high and all these species can be assessed for their potential towards commercial use including biofuel, food, manure and medicinal value, etc. With this backdrop, present study was attempted to assess the biofuel potential of some seaweeds from the coast of South Andaman, Andaman and Nicobar Islands. The basic objective of this study has to examine the lipid content of some of the abundant seaweed species and convert them to biofuel, along with their analysis towards the production of biofuel.

Material and Methods

Study Area

The seaweed samples were collected from six locations along the coast of South Andaman namely, Brookshabad Quarry (Lat. 11°38'N, Long. 92°44'E), Burmanallah (Lat. 11°34'N, Long. 92°44'E), Chatham (Lat. 11°68'N, Long. 92°72'E), Kodyaghat (Lat. 11°35'N, Long. 92°42'E), Marina Park (Lat. 11°40'N, Long. 92°45'E) and Mazhar Pahar (Lat. 11°45'N, Long. 92°44'E). All these locations were endowed with luxuriantly growing seaweed species. The sampling duration was from December, 2018 to March, 2019, i.e., during non-rainy season of Andaman.

Collection of Seaweeds

The present study, 12 seaweed species belonging to three Phyla with four representative species from each such as Chlorophyta (*Acetabularia cranulata*, *Dictyosphaeria versluysii*, *Halimeda gracilis* and *Halimeda opuntia*); Phaeophyta (*Padina gymnospora*, *Padina pavonica*, *Sargassum weightii* and *Turbinaria conoides*); Rhodophyta (*Galaxaura rugosa*, *Portieria hornemanni*, *Trichogloeopsis pedicellata* and *Trichogloea requienii*) were selected randomly (Plate - 1).



Acetabularia cranulata Dictyosphaeria versluysii Halimeda gracilis Halimeda opuntia



Padina gymnospora

Padina pavonica Sargassum weightii

Turbinaria conoides

**Galaxaura rugosa****Portieriahornemanni****Trichogloeopsispedicellata**

Plate - 1. Seaweed species from Chlorophyta; Phaeophyta and Rhodophyta in the present study

The seaweed samples of the respective species were collected by hand picking from the sampling areas and washed with seawater at the sampling site to remove debris and sand. Samples were brought to the laboratory in an ice box and washed thoroughly under tap water to remove any associated epiphytes. The cleaned seaweed samples were shade dried for a week and then powdered using electronic blender. The powdered samples were packed in air tight container respectively and stored at 4°C for further analysis.

The lipid was extracted by taking 10gm of seaweed powder in a 250 ml conical flask and 100ml of chloroform methanol solution (2:1) was added to this. The flask with sample mixture was shaken vigorously for two minutes and then kept at ambient temperature for 24 hours in sealed condition. Latter, the mixture was filtered (Whatman No.1 filter paper) and the filtrate was mixed with 0.8% Sodium Chloride (NaCl) solution. At this, the solution mixture got separated into two different layers i.e. the upper hydrophilic layer with water and methanol, where bottom hydrophobic layer was of lipid and chloroform. This solution was then transferred to a separating flask and kept undisturbed for five minutes to allow the two phases to separate properly. The lower bottom phase containing lipid was eluted out carefully into a pre-weighed empty beaker and the lipid from the chloroform was collected by evaporating the chloroform. The weight of the total lipid (gm) was calculated by subtracting the weight of the pre-weighed empty beaker from the beaker with the lipid [Total Lipid (gm) = Weight of beaker with lipid content – Weight of empty beaker].

Conversion of Lipid to Biodiesel

For conversion of lipid to biodiesel (biofuel), 10 ml of 0.5% Sodium methoxide (CH_3NaO) solution was added to the beaker with extracted lipid and the solution was kept in the water bath at 60°C for 4 to 5 hours with frequent shaking for trans-esterification. Then 8ml of hexane was added to the beaker with sample and allowed to stand for 20 minutes. After formation of two distinct layers, the upper layer was identified as a biodiesel with hexane and bottom layer was glycerine. The upper layer was separated with micropipette and transferred into a pre-weighed blank test tube and biodiesel was collected by evaporating the hexane. The biodiesel concentration was calculated by subtracting the pre-weighed blank test tube weight from the test tube with biodiesel and total conversion rate (%) from lipid to biofuel was estimated.

Results

Lipid Profile

The lipid content of all the twelve studied species was estimated per 100 gm of dry seaweed biomass. As depicted in Fig. 1, the lipid content was found to be highest in the red seaweed *Trichogloeopsis pedicellata* with a concentration of 2.67gm followed by brown seaweed *Turbinaria conoides* (2.5gm). But other brown seaweed *Padina gymnospora*, *Padina pavonica* and *Sargassum weightii* also had lipid concentration of 1.52, 1.43 and 1.15 gm, respectively. Similarly, lowest concentration (0.34 gm) was obtained in the case of green seaweed *Halimeda gracilis*.

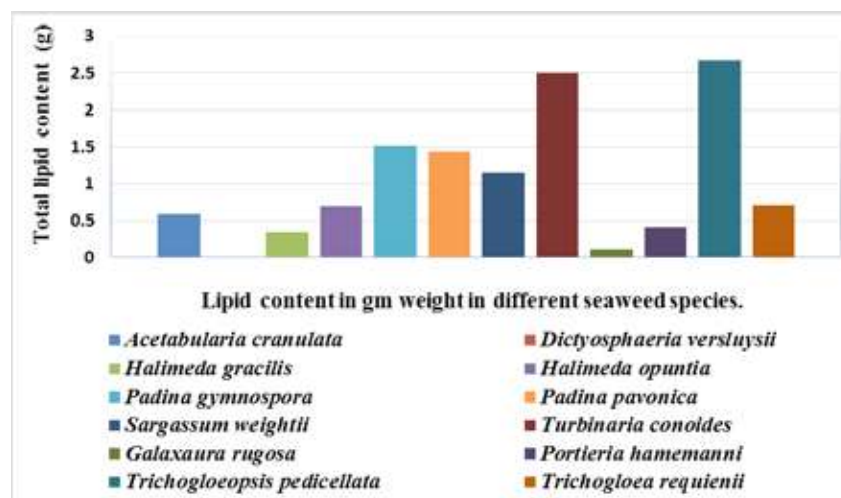


Fig. 1. Total Lipid content (g) in twelve seaweed species from South Andaman coast

However, overall lipid content of all twelve species studied in the present investigation suggested that the brown seaweed species had higher concentration followed by red seaweed and the least is green seaweed species (Fig.2).

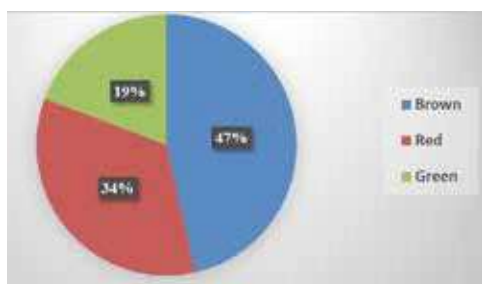


Fig. 2. Lipid content (%) of seaweed species under different Phylum from the Coast of South Andaman

Biofuel (Biodiesel) Production

The conversion percentage of biofuel (biodiesel) production from lipid of twelve different species of seaweeds is given in Table - 1. As depicted in Fig.3, it is revealed that the maximum yield of biofuel was produced from *Turbinaria conoides* with 0.69/100g of biodiesel followed by *Halimeda opuntia* and *Trichogloea requienii* with 0.52 gm and 0.46 gm, respectively. The minimum amount was recorded in *Portieria hornemanni* with 0.09gm. Whereas, amount of biofuel production capacity is same (0.34g) in case of *Acetabularia cranulata* and *Padina pavonica*.

Table - 1. Lipid and Biofuel production rate from different seaweed species from the coast of South Andaman

Species	Lipid/100g	Biofuel /100g	Conversion Rate (%)
<i>Acetabulariacranulata</i>	0.58	0.34	58.62
<i>Dictyosphaeriaversluisii</i>	1.12	0.20	17.85
<i>Halimedagracilis</i>	0.34	0.27	79.41
<i>Halimedaopuntia</i>	0.69	0.52	75.36
<i>Padinagymnospora</i>	1.52	0.19	12.50
<i>Padinapavonica</i>	1.43	0.34	23.77
<i>Sargassum weightii</i>	1.15	0.21	18.26
<i>Turbinariaconoides</i>	2.50	0.69	27.60
<i>Galaxaurarugosa</i>	1.10	0.30	27.27
<i>Portieriahornemanni</i>	0.41	0.09	21.95
<i>Trichogloeopsispedicellata</i>	2.67	0.12	4.49
<i>Trichogloea requienii</i>	0.70	0.46	65.71

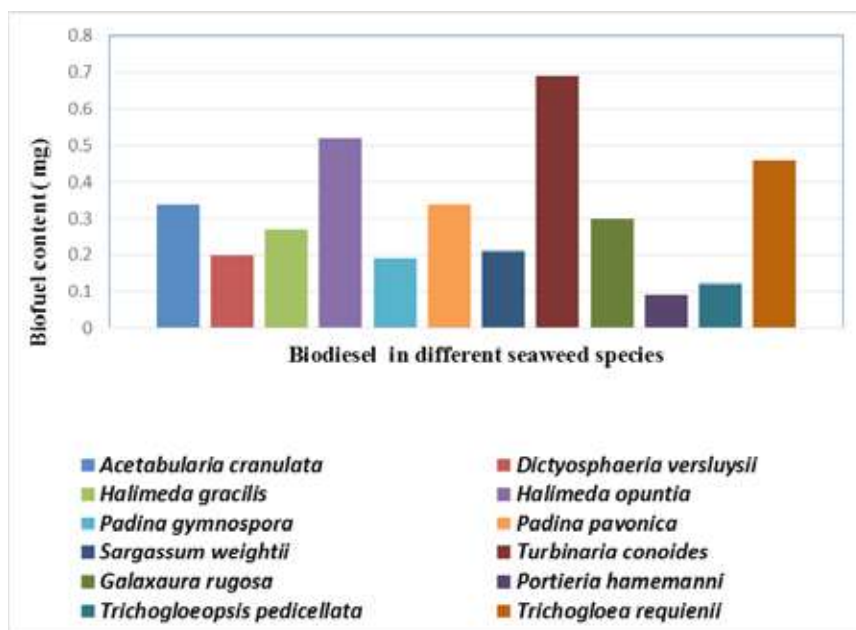


Fig. 3. Biofuel concentrations in different seaweeds

The comparative production capability among the three Phyla of seaweeds suggests that brown algae had the highest production value of 38% followed by green algae with 36% and the least is red algae with 26% in terms of biofuel production rate (Fig. 4).

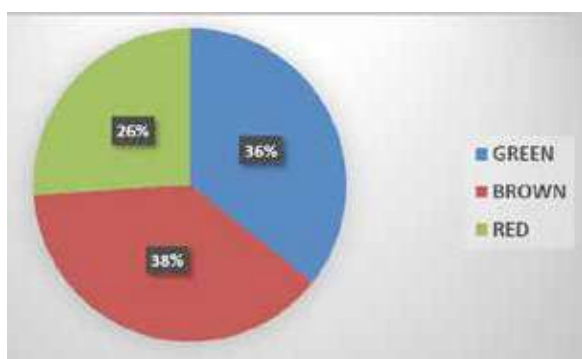


Fig. 4. Percentage of biofuel content in the seaweeds under three Phyla from South Andaman coast

Biofuel Conversion

The conversion of lipid to biofuel in all 12 seaweed species in the present study resulted in varying degree of biofuel production (Table - 1). In terms of percentage conversion maximum biofuel production rate was obtained in *Halimeda gracilis* (79.41%) followed by *Halimeda opuntia* (75.36%) and *Trichogloea requienii* (65.71%) respectively and minimum percentage of

conversion was recorded in *Trichogloeopsis pedicellata* i.e. 4.49% (Fig. 5).

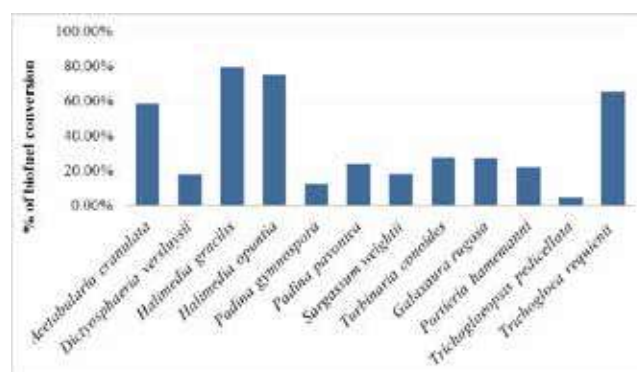


Fig. 5. Conversion percentage of lipid to biofuel in different seaweeds

Discussion

The biofuel potential of some seaweed, from the coast of South Andaman was investigated and potential seaweed species like *Turbinaria conoides*, *Halimeda opuntia* and *Trichogloea requienii* were recorded from the coast of South Andaman. There is no earlier report pertaining to biofuel potential of sea weeds from Andaman Sea, India. The present study was an attempt to assess the potential and probable utilisation of the sea weed resources in this respect.

Some studies estimated that red seaweed *Gracilaria verrucosa* could provide highest biofuel yield (Mohapatra and Padhi, 2018). But in the present investigation biofuel potential in terms of lipid content and yield percentage was found to be high in brown sea weed *Turbinaria conoides* followed by green seaweed *Halimeda opuntia* and red seaweed *Trichogloea requienii*, respectively. Also, the brown seaweeds had overall high yield percentage in comparison to red seaweeds. Ashok et al. (2017) reported about 7.8% biofuel production from *Padina tetrasporomatica*. Whereas, in the case of *P. gymnospora* and *P. pavonica*, rate of biofuel production was found to be 0.19% and 0.34%, respectively, in the present study. However, the present study suggested that the biofuel production in four brown seaweeds within a range of 0.19-0.69%, which is in agreement with earlier study by Xu et al. (2014).

Lipid profiling of seaweeds suggested that this will be a source for biofuel production (Anuradha et al., 2015). Sivaramakrishnan et al., (2017) reported that lipid content of four seaweeds *Halimeda macroloba*, *Halimeda tuna*, *Enteromorpha* sp. and *Acetabularia acetabulum* from Andaman Sea lies in the range of 0.69 - 3.22% with a maximum in *A. acetabulum* and minimum in *H. tuna*. This study showed that lipid content in 12 species was found within a range of 0.34 - 2.67% with maximum in red seaweed *Trichogloeaopsis pedicellata* and minimum in green seaweed *H. gracilis*. The earlier study, the total lipid content in *Sargassum weightii* from the coast of Mandapam (SE Bay of Bengal) was reported to be 2.33% (Manivannan et al., 2008), which is higher in comparison to the present study from the coast of South Andaman Sea, where it was 1.15%. This variation may be attributed to local conditions. Similarly, in case of *Galaxaura urarugosa* lipid content was 1.46 g (Nunes et al., 2017). Whereas, in this species, lipid content was 1.10g with 27.27% conversion rate to biofuel found in the present study. On the basis of the percentage of lipid content it was presumed that the conversion rate to biofuel for the two red seaweed species *Trichogloeaopsis pedicellata* and *Portieria hornemanni* will be highest and lowest, respectively. But the higher conversion rate was recorded in green seaweeds in biofuel content (58.62 – 79.41%), though they had lowest lipid content (0.34 – 1.12%). But in overall, brown

seaweeds had the highest biofuel content (0.19 – 0.69%). The variation in the lipid and biofuel can differ even in same species seasonally, location wise and temperature of seaweed growth (Renaud and Luong-Van, 2006; Nelson et al., 2002). As per the study though biofuel production was higher in brown seaweed *Turbinaria conoides*, the conversion of lipid to biodiesel was found to be higher in green seaweed *H. gracilis*, *H. opuntia* and red seaweed *Trichogloea requienii* suggesting that these species have significant potential for biodiesel production. Again, the benefits offered by seaweed based biofuel are numerous without any negative environmental impact and it can be obtained from the biomass, which is available in plenty and can be produced in Andaman Sea. The study suggested that seaweeds of Andaman Sea can be an instrumental for possible biofuel production. Emphasis may thus be given to explore potential seaweeds from the Andaman Sea. Also, with the emphasis given by development of blue economy algal fuel production especially from seaweeds will be highly beneficial.

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