



Carbon Content In Macroalgae Species Against Temperature Regime

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ABSTRACT

Temperature rise due to climate change has created environmental impacts on various ecosystems, including coastal areas. Temperature rise also affects plant metabolism, such as carbon uptake, where Macroalgae are the dominant community in the intertidal zone, and thus, potential to absorb carbon. A series of experiments on several dominant macroalgae species from the southern coastal area in West Java have been conducted to see the effect of temperature regime on their carbon content. The treatment of temperatures at 24, 27, 30, and 33 °C was carried out for 72 hours against 6 macroalgae species representing Chlorophyceae, Phaeophyceae and Rhodophyceae in order to investigate the carbon content. The results showed that the macroalgae of Phaeophyceae division absorbed higher carbon content in comparison to the macroalgae of the other divisions. The temperature significantly affecting chlorophyll was measured at testing temperature of 33 °C against the tested species.

Keywords: carbon, intertidal zone, macroalgae, temperature

ABSTRAK

Kenaikan suhu karena perubahan iklim global berdampak pada berbagai ekosistem, tanpa terkecuali daerah pesisir. Kenaikan suhu juga mempengaruhi metabolisme tumbuhan, sebagai contoh adalah penyerapan karbon seperti pada makroalga yang merupakan komunitas dominan pada zona intertidal. Serangkaian eksperimen terhadap makroalga yang dominan tumbuh di pesisir selatan Jawa Barat telah dilakukan untuk melihat efek dari perbedaan suhu terhadap kandungan karbon. Perlakuan suhu 24, 27, 30, dan 33 °C terhadap 6 spesies makroalga yang mewakili divisi chlorophyceae, phaeophyceae, dan rhodophyceae dalam durasi 72 jam, untuk mengetahui kandungan karbon dari masing-masing spesies yang diuji. Hasil yang diperoleh menunjukkan bahwa Phaeophyceae memiliki kandungan karbon yang lebih tinggi dibandingkan dengan dua divisi lainnya setelah perlakuan. Suhu 33 °C terbukti secara signifikan mempengaruhi kandungan klorofil pada semua spesies makroalga yang dicobakan.

Kata kunci: carbon, intertidal zone, macroalgae, temperature

1. Introduction

The CO₂ in atmosphere is significantly increasing from 280 ppm to 404,96 ppm in the past few decades, triggered by the industrial revolution (Eakin *et al.*, 2008; NOAA, 2016). The Green House Effect has caused global temperature rise in seawater by 0.7°C in the ocean surface (Eakin *et al.*, 2008) and may also affect the organisms, with no exception to macroalgae.

Macroalgae, in a positive way, contribute in reducing CO₂ production released to the atmosphere and can significantly reduce global warming (Kaladharan *et al.*, 2009). However, continuous global warming in seawater column will also affect macroalgal carbon uptake. Furthermore, almost every biological function (photosynthesis, respiration rate, growth, calcification level, nitrogen fixation, and reproduction) will be affected by chemical changes (Eakin *et al.*, 2008), including the effect of Ocean Acidification (Porzio *et al.*, 2017). Moreover, one of the consequences will also lead to the lost of biodiversity.

Macroalgae are distributed as cosmopolite in coastal areas and they play significant role in the primary production in mangrove ecosystem, seagrass beds, and coral reefs (Mineur *et al.*, 2015). Along with seagrasses and mangroves, macroalgae contribute 50 per cent of the whole primary production on Earth (Beardall and Raven, 2004), and they also absorb carbon (Chung *et al.*, 2011). Macroalgae contribute to up to 50% of the carbon fixation in this planet and cover as much as 71% carbon storage in the sea sediment. As the primary producer in the ocean, macroalgae have potential contribution in the carbon uptake and storage (Chung *et al.*, 2011).

Less frequently work is also focusing on the species of macroalgae where they possess better ability in absorbing carbon than the other species in terms of temperature rise. This study attempts to fill the information gap concerning the carbon content and chlorophyll in macroalgal species as metabolism product due to the temperature rise.

2. Materials and Methods

Material of macroalgae taken from the southern part of West Java (7.6408 °S – 7.6689 °S and 107.6839 °E – 107.6967 °E), includes *Ulva fasciata*, *U. lactuca* (Chlorophyceae), *Sargassum binderi*, *Turbinaria conoides* (Phaeophyceae), *Gracilaria coronopifolia*,

Acanthophora spicifera (Rhodophyceae). The collected species were dominant species from each division found in the sampling location. The material was taken from the intertidal zone during low tide, cleaned up from epiphyte, and then stored in plastic jars to be kept in a cool storage prior to experiments. Acclimatisation was done in two steps. First step of acclimatisation was done in a fibre pond filled with seawater (filtered, 0.45 µ) with aeration for 3 days under natural lighting in room temperature. The second step of acclimatisation for the temperature regime was done 48 hours with the same conditions of the initial acclimatisation, except for the temperatures. Each temperature treatment is done in different aquarium with mixed macroalgae.

Material used for the experiments was 1 g macroalgae and each of 6 species. They were placed in a 250-ml beaker filled with filtered seawater (0.45 µ). Experiments were run for 72 hours under natural lighting with the materials exposed to temperature regimes of 24, 27, 30, and 33 °C with the same procedure for each of the 3 replicates. Experiments were done without nutrient addition in order to explore the carbon content affected by different temperatures. Samples were taken after 24, 48, and 72 hours of experimental periods for the Carbon and pigments analyses (chlorophyll). The percentage of Carbon changes was defined using the formula below:

$$(C_{\text{initial}} - C_{\text{Final}})$$

Chlorophyll quantity is calculated using the formula by Arnon (1949).

Measurement of a sample (A=absorbance)

$$\text{Chlorophyll-a (mg.g}^{-1} \text{ FW)} = 0.0127A_{663} - 0.00269A_{645}$$

Results were then statistically analysed using software IBM SPSS version 2.2 to measure the significant values.

3. Results and Discussion

In general, carbon content found during the 72-hour experimental period showed general pattern of a slight decrease, except for *Turbinaria conoides*. Macroalgae from Phaeophyceae, *S. binderi* and *T. conoides*, showed higher initial carbon content in comparison to other tested species in this study. In comparison to other

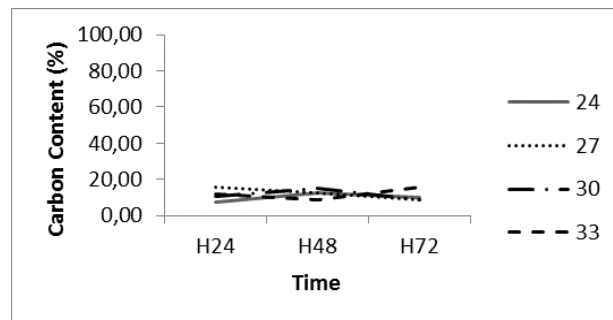
species (Fig. 1), the highlight results were showed by Phaeophyceae, with no significant difference ($F = 0.06$; $p = 0.1$) in its carbon content for all temperature treatments.

Phaeophyceae showed better performance in absorbing carbon content at testing temperatures of 30 and 33 °C, especially for *T. conoides* (Fig.1d). Results of *T. conoides* and *S. binderi* showed a surge of carbon content in day 48 and 72, while the others showed a decrease. This result was also in line with the final carbon content, which showed a high difference between initial and final results (Fig. 2).

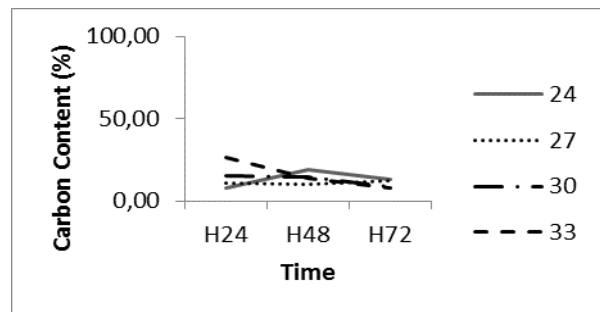
In general, Carbon content of macroalgae showed a decrease in most species, except for *T. conoides* at a temperature of 30 °C and *G. coronopifolia* at a temperature of 24 °C. Generally, *T. conoides* and *S. binderi* (Phaeophyceae) had lower decrease in carbon content. Division wise, the highest decrease in carbon content was shown by Chlorophyceae (*U. lactuca* and *U. fasciata*), Rhodophyceae (*G. coronopifolia* and *A. spicifera*), and Phaeophyceae (*S. binderi* and *T. conoides*), each respectively (Fig. 2).

Generally, chlorophyll content in the final results showed a decreasing pattern in all species being tested ($F = 0.00$, $p = 0.00$) for the individual macroalgae exposed at a temperature of 33 °C (Fig. 3). Different results however were shown by individuals exposed at lower temperatures of 24, 27 and 30 °C in each species. The chlorophyll content significantly affected by all temperature treatments were *U. lactuca* ($F = 0.01$, $p \leq 0.05$) and *U. fasciata* ($F = 0.01$, $p \leq 0.02$) (Chlorophyceae).

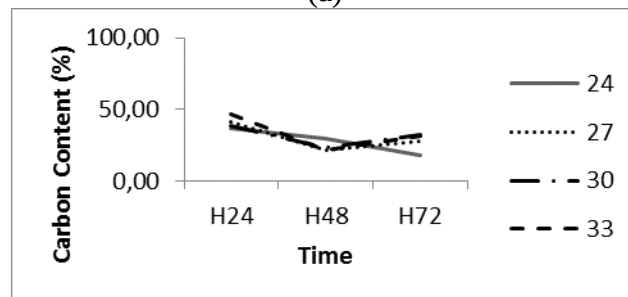
Final chlorophyll content showed similar results in all species of individuals exposed at a temperature of 33 °C (Fig. 4). Individuals of all macroalgae species exposed at a temperature of 33 °C showed lower chlorophyll content in comparison to other individuals exposed at lower temperatures (24, 27, and 30 °C). Final chlorophyll content of the species Rhodophyceae (*G. coronopifolia* and *A. spicifera*) relatively remained the same in individuals exposed at a lower temperature range after a 72-hour experimental period, while other species showed slight fluctuation among temperature treatment.



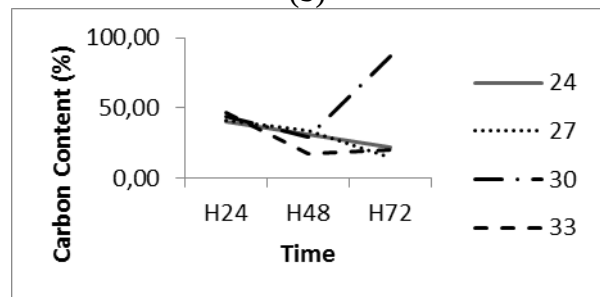
(a)



(b)



(c)



(d)

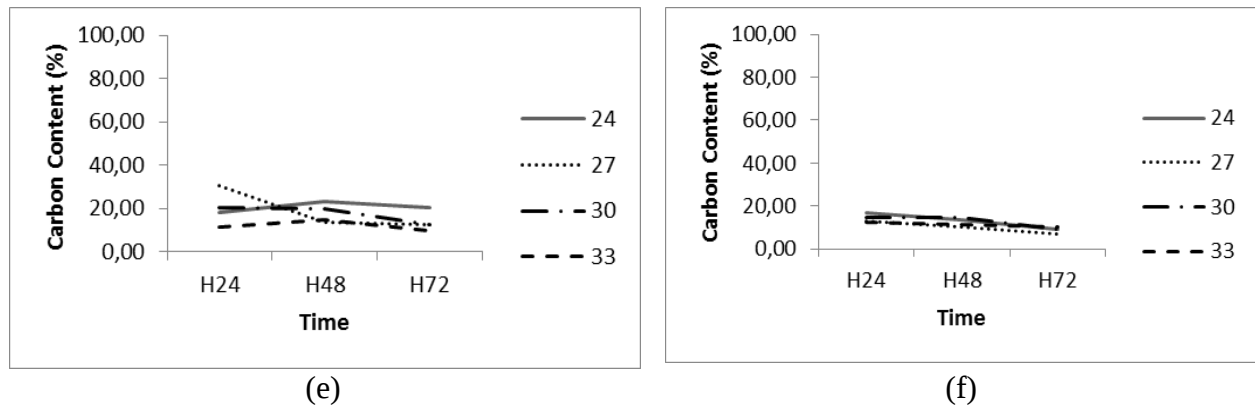


Figure 1. Content of Carbon (%) from 6 macroalgae species: (a) *U. lactuca*; (b) *U. fasciata*; (c) *S. binderi*; (d) *T. conoides*; (e) *G. coronopifolia*; (f) *A. spicifera*, at testing temperatures of 24, 27, 30, 33 °C during the 72-hour experimental period.

In this study, results generally showed that species of macroalgae from Chlorophyceae and Rhodophyceae performed lower absorbance of carbon content after being exposed at high temperatures. On the contrary, the carbon content of Phaeophyceae (*S. binderi* and *T. conoides*) showed a slight decrease after a 72-hour temperature treatment. This finding may indicate that macroalgae from Phaeophyceae can tolerate a wider temperature range.

The results of carbon content in this study was in line with Hurd et al. (2014), where the main factor of photosynthetic process was determined by nutrients and temperatures, thus

would affect the carbon uptake and storage in macroalgae. Macroalgae need inorganic carbon, ionic mineral, and light for their growth, so the limitation on one of these factors will inhibit its metabolism, including carbon uptake. The amount of carbon decrease in most species indicated a disturbance caused by a temperature rise, with the exception of *T. conoides* that showed different results. The high carbon content in *T. conoides*, primarily in the treatment at testing temperatures of 30 and 33 °C indicated that this species has the ability to uptake carbon in high temperature, even with no additional nutrient in the media.

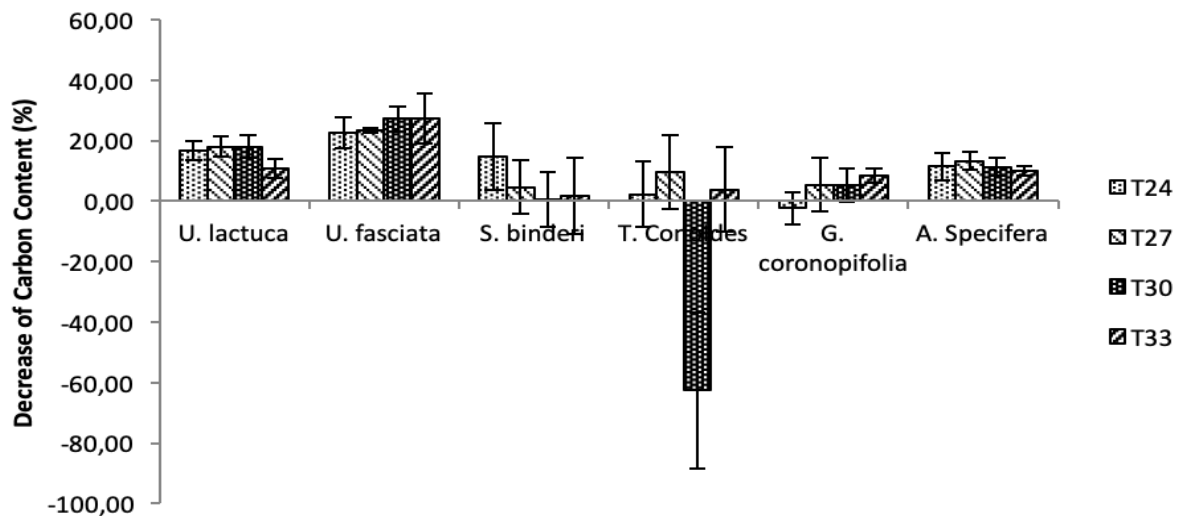


Figure 2. Decrease of Carbon content changes shown in percentage (%) from 6 macroalgae species at testing temperatures of 24, 27, 30, 33 °C after a 72-hour experimental period.

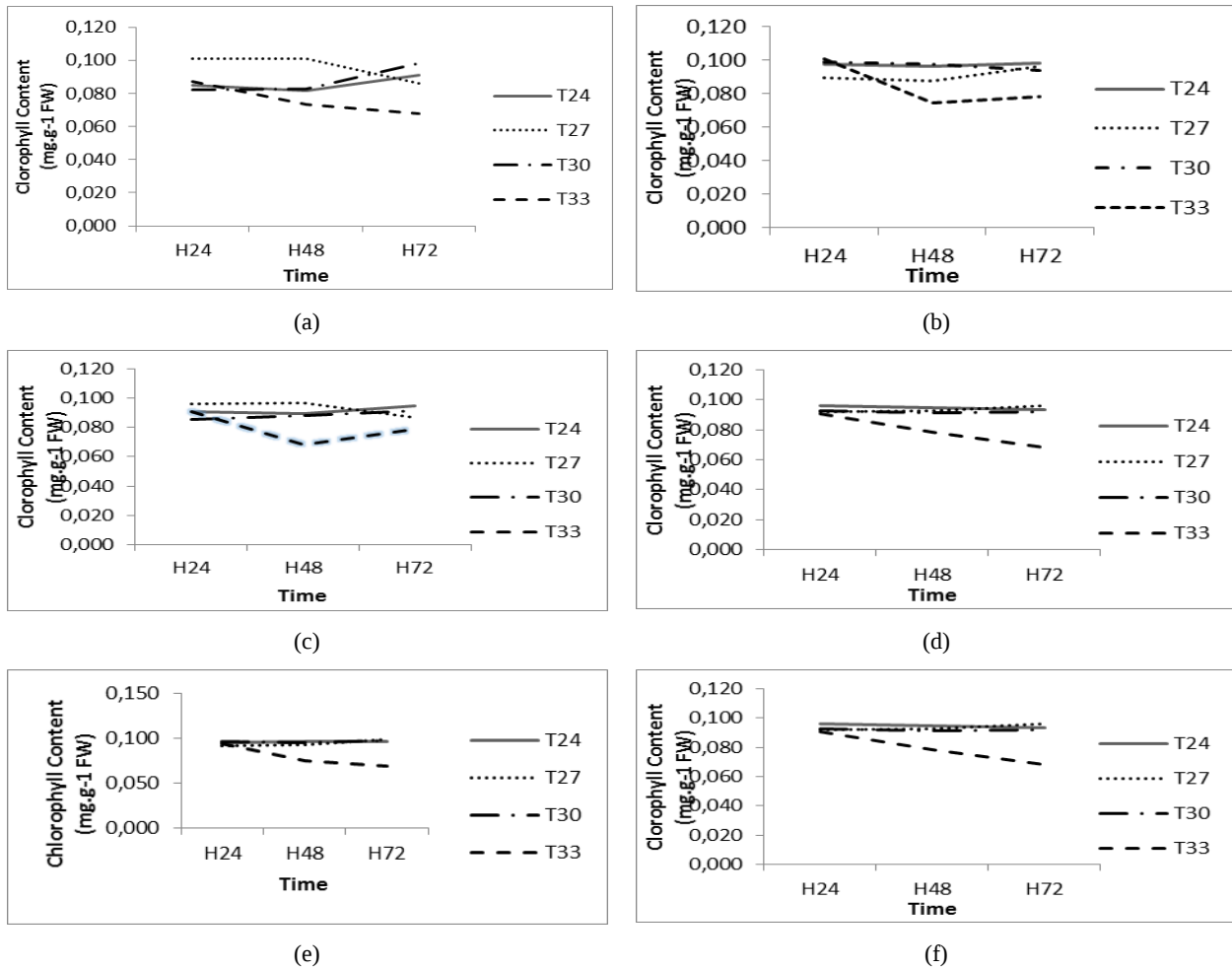


Figure 3. Content of chlorophyll (mg.g⁻¹ FW) in 6 macroalgae species: (a) *U. lactuca*; (b) *U. fasciata*; (c) *S. binderi*; (d) *T. conoides*; (e) *G. coronopifolia*; (f) *A. spicifera*, at testing temperatures of 24, 27, 30, 33 °C during a 72-hour experimental period.

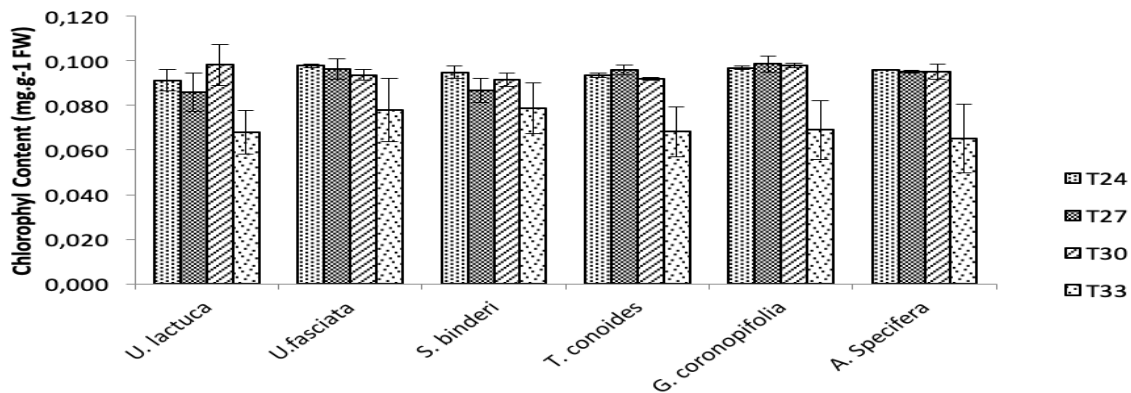


Figure 4. Final content of chlorophyll (mg.g⁻¹ FW) in 6 macroalgae species at testing temperatures of 24, 27, 30, 33 °C during the 72-hour experimental period.

Contrary to higher temperature treatments, different results were shown by *G. coronopifolia*, which experienced low carbon content decrease in the individuals exposed at a temperature of 24 °C, showing that the temperature of 24 °C did not even affect the carbon content in *G. coronopifolia*. This result differed from the finding stated by Esteves et al. (2004) where in the research, *Gracilaria* sp. showed the highest carbon content after being exposed at a temperature of 30 °C. These different results may presumably be due to the presence of nutrient addition. This assumption is also strengthened by the data source stating that the fast growing macroalgae like *Gracilaria* are positively affected by nutrient availability (Fernand et al., 2017; Monteiro, 2014). No nutrient supply during the experiments was estimated to be the cause of low carbon content.

The results of carbon content are consistent with the chlorophyll results. All species suffered from the high temperature in terms of chlorophyll content. The chlorophyll contents in all macroalgal species being tested were mostly affected at a temperature of 33 °C. At testing temperatures of 24, 27, and 30 °C, chlorophyll content of *G. coronopifolia* and *A. spicifera* remained high, while other species experienced a decrease. This presumably was due to other phycobiliprotein that provided support to metabolism process in Rhodophyceae, which also means that in terms of chlorophyll content, both species showed higher temperature tolerance than other species.

4. Conclusion

The most signifying results in this study showed that macroalgae from Phaeophyceae had the ability to undergo the test within a wider range of temperature exposure, while Chlorophyceae performed the worst. In terms of carbon content and chlorophyll, temperature regimes of 24, 27, 30, 33°C affect macroalgae from Chlorophyceae division more unequivocally than the species in other divisions. *T. conoides* seemed to be the most adaptive species with its ability to cope with the temperature higher than 27°C, about which a further investigation is required in terms of physiological process.

5. Acknowledgement

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