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Research Article
Carbon Sink Profile in Cultured Seaweed, *Gracilaria changii* for Mitigation of Global Warming Phenomenon

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Abstract

Background and Objective: Concern of environment due to global warming is one of the reasons for this study to be conducted. However, there are lacked of studies to mitigate this global problem. Therefore, this study was aimed to determine the carbon sink in seaweed, water and sediment from seaweed, *Glacillaria changii* culture. **Materials and Methods:** The study was conducted in grow-out pond at Southern (Johor State) and Northern (Kedah State) of Peninsular Malaysia. The carbon content in water was determined using total organic carbon (TOC) analyzer, while combustion method using solid sample module (SSM) machine was used for sediment and *G. changii* samples. **Results:** The results showed that total carbon (TC), total organic carbon (TOC) and total inorganic carbon (TIC) in seaweed sample were higher in northern region as compared to southern region. This indicates that seaweed has high potential value in sequestering carbon dioxide (CO_2) in environment which further can be used to mitigate the global warming effect phenomenon. **Conclusion:** Thus, *G. changii* are not only showed high economic value to the industry but also potentially play an important role as carbon sink which they can store carbon.

Key words: Carbon sink, *Glacillaria changii*, seaweed, carbon sequester, climate change

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Now-a-days, the release of carbon to the atmosphere due to discharge from aquaculture industry become the most important environmental issue. Additionally, the recent and continuing increase of atmospheric carbon dioxide (CO_2) content is caused by anthropogenic CO_2 emissions from fossil fuel burning[1]. Thus, it can cause the global warming phenomenon and increase the average temperature in the atmosphere, ocean and land. The increasing concentration of CO_2 in the atmosphere can proportionally increase the concentration of CO_2 in the ocean as they act as reservoir of carbon. The global warming problem can also may impact to fisheries and aquaculture industry. For instance, the fish body temperature would be affected by water temperature where increasing temperature can affect important metabolic process of fishes including growth, reproduction, swimming ability and behavior. If this problem is not resolved, then it is not only affected the fisheries industry, but it can also affect the aquaculture productivity when the global warming keep occurs continuously.

Oceans are estimated to accumulate approximately 30% of CO_2 emissions arising from fossil-fuel and tropical deforestation between 1980 and 1989, thereby slowing down the rate of greenhouse effect globally[2]. Biological processes in marine environment potentially to sequester CO_2 and thus removing carbon from surface waters to the ocean floor through organic particle sedimentation. This biological pumping process aimed to reduce the total carbon content of the surface layer and increased in ocean depth[3,4]. The climatically forced ecological changes that have been documented over the past century was likely pale in comparison to changes in the coming decades because greenhouse gas emission rates continue to accelerate[5,6]. However, this problem might be solved by developing seaweed cultivation which potentially act as carbon fixation. Growth performance of seaweed stimulated by increased CO_2 concentration should lead to greater biological productivity with an expected increase in the photosynthetic storage of carbon[7]. Thus, absorbed carbons by seaweed cultivation pond can be removed by harvesting procedures.

Total carbon (TC) are all carbon species in the sample, including both inorganic and organic carbon. In particular, total organic carbon (TOC) or also known as soil organic carbon (SOC) was decomposition of animal and plant which occurs in dissolved and undissolved organic substances in water. The TOC play an important roles to maintain fertility, water storage and production of plant in terrestrial ecosystem[8,9]. Organic carbon in water is made up of thousands of components including macroscopic particles, colloids, dissolved macromolecules and specific compounds. Hence, TOC was commonly used as a non-specific indicator of water quality in order to measure and to identify the presence of any organic contaminants in the water[10]. In fact, the quantity of carbon is higher in soil than atmosphere, thus the quantity of carbon in atmosphere can be reduced by increasing the carbon in the soils. If carbon was removed be reduced. Therefore, the issue of global warming can be solved.

As we are moving towards green technology, therefore the aim of this study was to determine the carbon sink profile in seaweed, *Glacillaria changii* cultured using different culture technique and to compare the carbon sink from southern region (Johor State) and northern region (Kedah State) of Peninsular Malaysia. The analysis of carbon content was conducted in order to measure the TC, TOC and TIC in sediment, water and *G. changii* samples that accumulated in aquaculture pond. Subsequently, the information obtained from this study will help in mitigation program for global warming problem.

MATERIALS AND METHODS

Sampling location: This study was carried out at the seaweed cultivation pond in the coastal area of the southern region, Kedah, Malaysia (5°38'43"N; 100°21'18'E) and northern, Johor, Malaysia (1°27'46.99"N; 100°33'57.02'E), respectively (Fig. 1). The ponds size of 0.25 ha for southern region and 2 ha for northern region of Peninsular Malaysia were prepared for cultivation of seaweed culture. Both ponds were drain with water prior drying process to eliminate the unwanted organism. After that, natural seawater was pump into the ponds which ranged between 15-25 ppt.

The seaweed cultivation ponds were firstly prepared by stocking with a seedling of seaweed for southern region (100 g/basket) and northern region (2 kg/quadrats) ranged between 400 g m^{-2} until 500 g m^{-2}, respectively. The cultivation of seaweed were carried out with two different culture methods which were known as longline method where the seedling were placed in the basket (southern region), while random broadcast method were applied by spreading the seaweed seedling (northern region). The culture period to complete the grow-out cycle was estimated within 2 months.

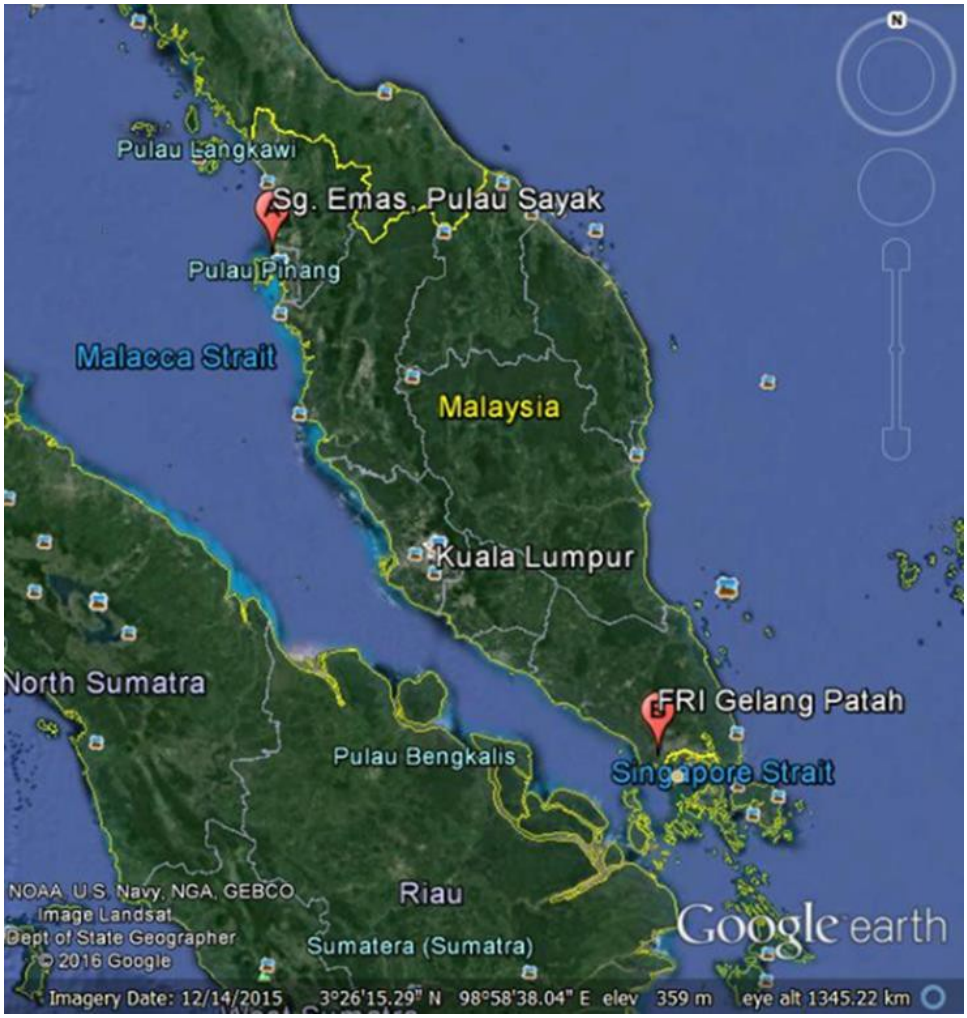

Fig. 1: Study location of carbon sink profile in seaweed, *G. changii* cultured pond at southern region (Johor State) and northern region (Kedah State) of Peninsular Malaysia (http://www.earth.google.com)

Collection of water, sediment and seaweed, *G. changii* samples: Sample was collected weekly from September, 2016 until January, 2017 for southern region, August, 2016 until January, 2017 for Northern region, respectively. Samples of water was collected using Van Dorn water sampler and sediment samples was collect using PVC sediment core with 7.5 cm (≈3 inch) diameter size. Whereas, for seaweed, the samples was collected using hand-pick technique up to 0.3 kg for southern region and 2 kg for northern region. For sediment and seaweed, the samples were dried first prior analysis of TC, TOC and TIC.

Analysis of carbon in water sample: Water sample was filtered using 0.45 µm Whatman filter paper to remove plankton biomass. Concurrently, standard solution of carbon was prepared with accurately measured. Then, the measured amounts of standard solution were transferred into 1 L volumetric flask and deionized water was added up to 1 L. The filtered water sample was then filled in arranged sample vials for TC, TOC and TIC measurement following procedure by ultra-high sensitive TOC-VWP analyzers, Shimadzu. Each of the samples was analyzed in triplicates.

Analysis of carbon in sediment and seaweed, *G. changii* sample: The sediment and seaweed, *G. changii* samples were air-dried and powdered using mortar and pestle. The samples were then sieved to obtain powdered particle size using 450 µm mesh sieve. Then, 30 mg of the sieved sediment and *G. changii* samples were transferred into ceramic boat for TC, TOC and TIC measurement following procedure by solid sample combustion unit, Solid Sample Module (SSM-5000A), Shimadzu. Each of the samples was prepared in triplicates.

Statistical analysis: Statistical analysis was conducted using one-way analysis of variance (ANOVA) and *post-hoc* test in order to determine the difference between concentration of TC, TOC and TIC with the date of culture. Significant differences between samples were determined at 0.05 level of probability. Statistical analyses were conducted using SPSS version 22 computer package.

RESULTS

Carbon content at northern region (Kedah state) of Peninsular Malaysia: The concentration of TC, TOC and TIC in the water of seaweed pond at northern region of Peninsular Malaysia showed similar trends which was fluctuated from week 1-10 (Fig. 2). The concentration of TC was highest on week 1 with 5.68% and the lowest on week 10 with 3.61%. The concentration of TOC was highest on week 1 with 4.61% and lowest was on week 10 with 2.25%. On the other hand, TIC concentration was highest on week 10 with value 1.15% and lowest on week 3 with 0.31%.

The concentration of TC, TOC and TIC in sediment sample of seaweed pond from northern region from week 1-10 showed stable trends but with minor depreciation on each week (Fig. 3). The concentration of TC was ranged between 3.18 and 3.52%, while the concentration of TOC ranged between 3.44 and 14%, respectively. The lowest concentration

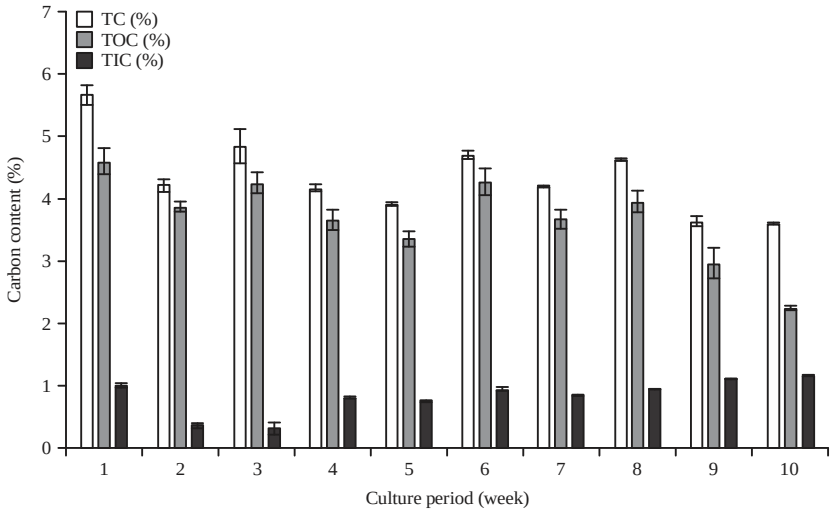

Fig. 2: TC, TOC and TIC in water samples collected from week 1-10 from northern region (Kedah state) of Peninsular Malaysia

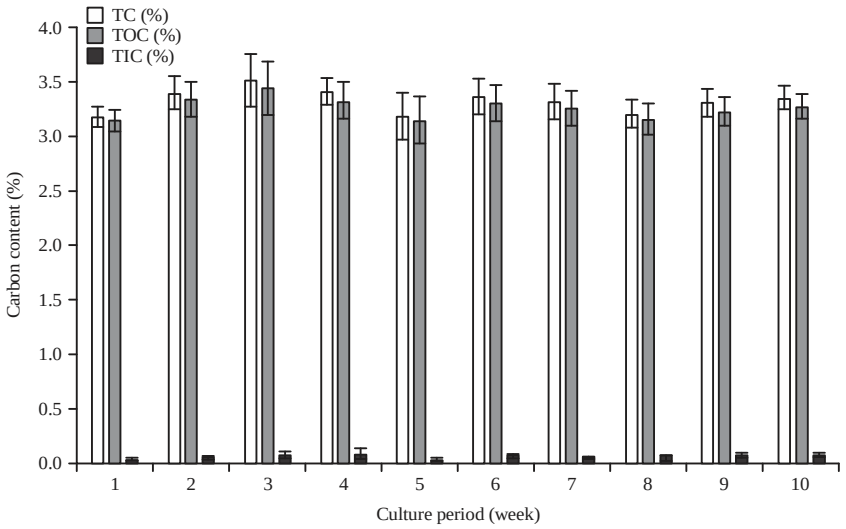

Fig. 3: TC, TOC and TIC of sediment samples collected from week 1-10 from northern region (Kedah state) of Peninsular Malaysia

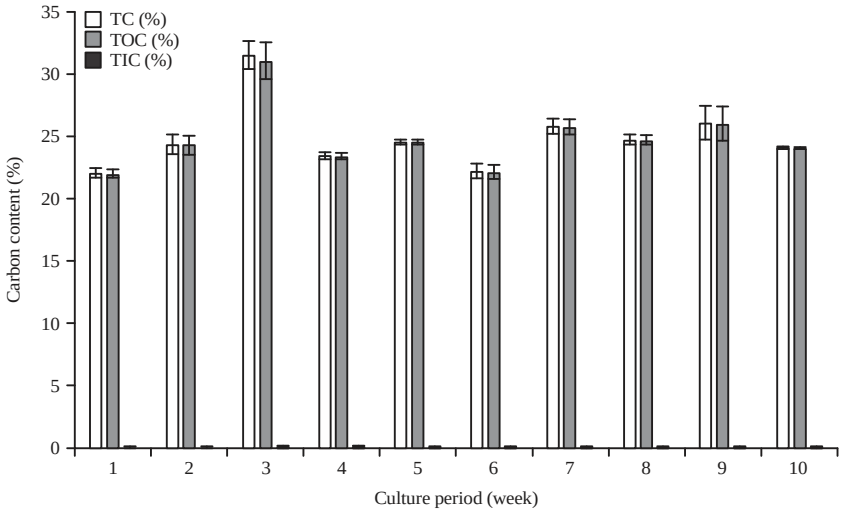

Fig. 4: TC, TOC and TIC of seaweed, *G. changii* collected from week 1-10 from northern region (Kedah state) of Peninsular Malaysia

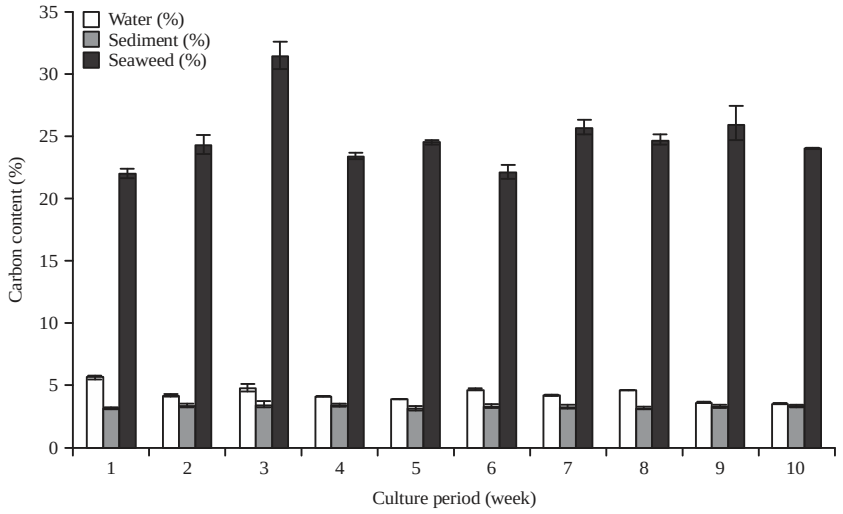

Fig. 5: Comparison of TC content in water, sediment and seaweed collected from week 1-10 from northern region (Kedah state) of Peninsular Malaysia

of TIC was determined which ranged between 0.03 and 0.09%. Figure 4 showed the concentration of TC, TOC and TIC in *G. changii* sample of seaweed pond at northern region of Peninsular Malaysia. The concentration of TC and TOC was increased gradually from 22.06-31.53% and 21.98-31.06%, respectively. The concentration of TIC was under limited values of 0.019711±0.0051. In general, the concentration of TC was highest in seaweed as compared to water and sediment samples for northern region (Fig. 5).

Figure 6 showed the concentration of TC, TOC and TIC in water sample of seaweed pond at northern region of Peninsular Malaysia. From the whole samples, it was found that the highest concentration of TC in the water sample was 1 on week 6 with 4.59% and the lowest concentration of TC was on week 2 with 2.75%. While, the highest concentration TOC in the water sample is on week 10 with 3.84% and the lowest was on week 2 with 2.12%. The highest concentration of TIC in the water sample was on week 3 with 1.01% and the lowest concentration was on week 9 with 0.01%.

Figure 7 showed the concentration of TC, TOC and TIC in sediment sample of seaweed pond at southern region of Peninsular Malaysia. The graph showed fluctuated trend as there were no significant different between sampling weeks. From the whole samples, it was found that the highest

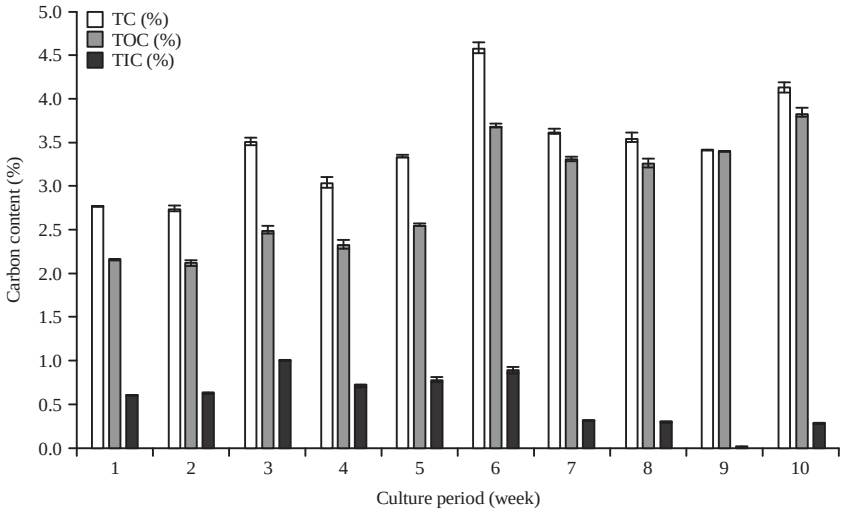

Fig. 6: TC, TOC and TIC of water collected from week 1-10 from southern region (Johor state) of Peninsular Malaysia

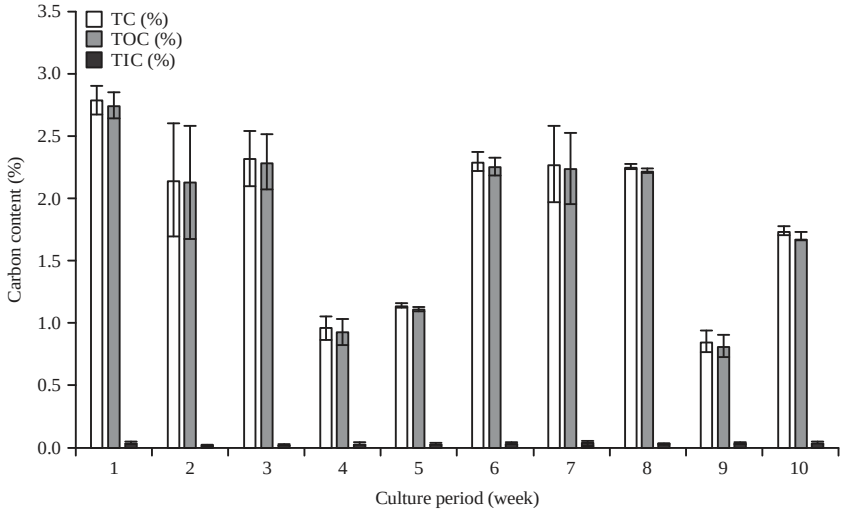

Fig. 7: TC, TOC and TIC of sediment collected from week 1-10 from Southern region (Johor state) of Peninsular Malaysia

concentration of TC in the sediment sample was on week 1 with 2.79% and the lowest concentration of TC was on week 9 with 0.86%. While, the highest concentration TOC in the sediment sample was on week 1 with 2.75% and the lowest was on week 9 with 0.82%. The concentration of TIC in the sediment sample was shown no significance difference between week 1 until week 10 which ranged between 0.02 and 0.04%.

Figure 8 showed the concentration of TC, TOC and TIC in seaweed, *G. changii* sample at southern region of Peninsular Malaysia. From the whole samples, it was found that the highest concentration of TC in the *G. changii* sample was on week 6 with 28.88% and the lowest concentration of TC was on week 1 with 18.42% and the graph show there are significant different between week 1 and 10. While, the highest concentration of TOC in the *G. changii* sample was on week 6 with 28.86% and the lowest was on week 1 with 18.27% and the graph also showed there were the *G. changii* sample was on week 9 and 10 with 0.50% and the lowest concentration was on week 5 and 6 with 0.02%.

Similarly to northern region, the concentration of TC in Southern region was highest in seaweed, *G. changii* samples as compared to the water and sediment (Fig. 9). For sediment sample, the graph showed no significant different within weeks where the highest concentration of TC in sediment sample was on week 1 with 2.79% and the lowest concentration was on week 9 with 0.86%. For water sample, there was also showed significant different among weeks which ranged between 2.75% 1 and 4.59%.

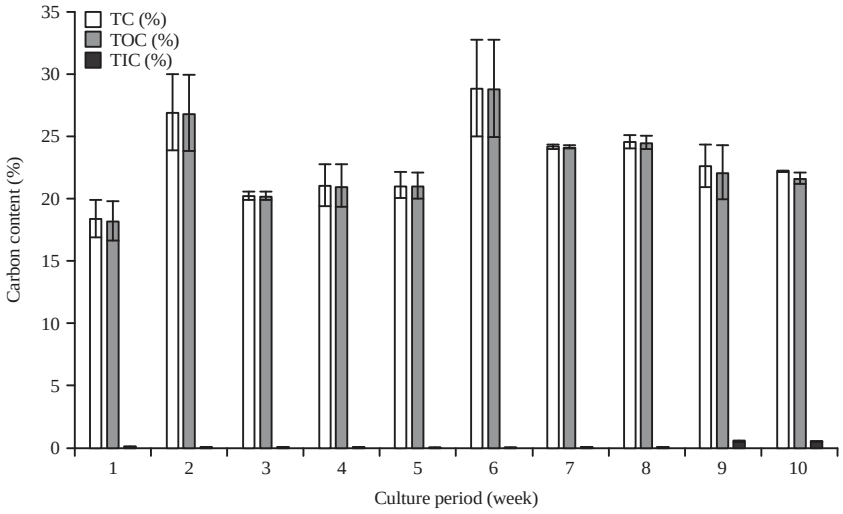

Fig. 8: TC, TOC and TIC of seaweed, *G. changii* collected from week 1-10 from southern region (Johor state) of Peninsular Malaysia

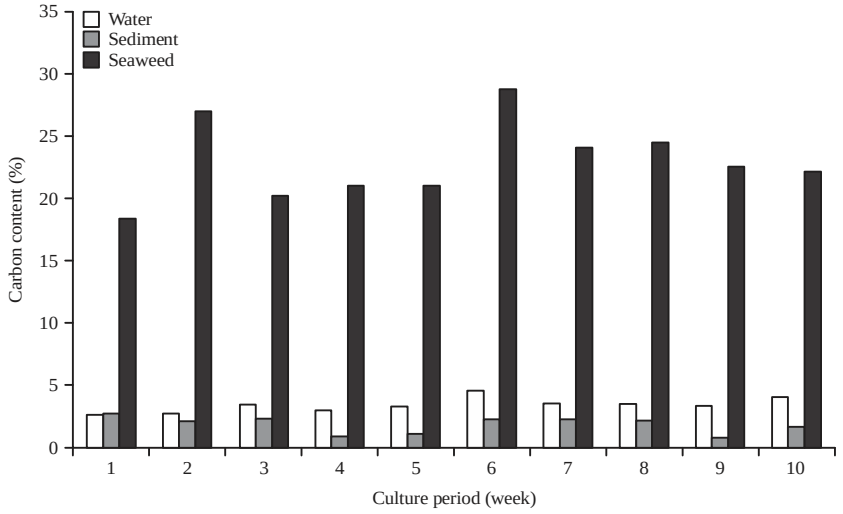

Fig. 9: Comparison of TC content in water, sediment and seaweed collected from week 1-10 from southern region (Johor state) of Peninsular Malaysia

DISCUSSION

Global warming or climate change was considered as one of the global problems that occurred in the world nowadays due to increasing carbon levels in the atmosphere. Increasing CO_2 concentrations in the atmosphere and in the sea was driving a number of physical and chemical changes[6,9]. These problems occurred because of human activities such as deforestation and burning of fossil fuel.

This study showed that the concentration of TC between three type of samples which were water, sediment and seaweed from northern and southern region of Malaysia had a significant effect toward mitigation of global warning phenomenon, where seaweed has the highest TC content as compared to water and sediment sample (Fig. 5, 9). This indicated that seaweed production can act as good carbon sinker in the aquaculture environment. The main producers of coastal and marine regions such as microalgae, seaweed and seagrass are the best sequestering agents from their terrestrial counterparts[11]. Seaweed are also highly productive species that can contribute to the accumulation of annual biological production of CO_2 and the global carbon cycle[12]. Similarly to seagrass and mangroves plants, seaweed is a macroalgae which perform photosynthesis. Therefore, seaweed can utilized and stored carbon in their structure and used it to produce food.

Apart from that, sediment also showed a good indicator that it can also retained carbon as organic carbon which can contribute to reduce the amount of carbon in atmosphere. If the amount of carbon was stored in soil as organic carbon, hence, it will reduced the amount of carbon in atmosphere and therefore the problem of global warming and climate change will be solved[8,12]. Water sample showed the lowest content of TC, TOC and TIC as compared with seaweed and sediment sample.

Photosynthesis process by seaweeds can decreased the CO_2 in water by transform dissolved inorganic carbon into organic carbon[12]. Moreover, TC content in the sample was depends on the type of sample, temperature, organisms surrounding the watercourse as well as time of the sample was collected. The concentration of organic carbon depends on geographical area, source of pollutants that entering the rivers, precipitate depth of tested sediments and also the content of the sediment was difference for flowing of waters and lakes[10].

The technique used to culture the seaweed was different between these two regions which were random broadcast by spreading the seaweed seedlings in the pond (Northern region), while longline method by placing in the basket (Southern region). The results showed that sample of water, sediment and seaweed in the northern region had higher values as compared to Southern region. This might be due to different technique was applied in culturing seaweed for Southern region that does not attach to substrate. The elimination of carbon in this unique producer community is a function of biomass production capacity, which in turn depends on the interaction between edaphic, climatic and topographic factors of an area[12]. Hence, the results obtained from these two region might be various to each other. Further study need to be conducted in order to estimate the potential of carbon storage and sequestration in different type of region or their land substratum.

CONCLUSION

These findings showed that content of TC, TOC and TIC in seaweed, *G. changii* samples were higher than that TC, TOC and TIC content in both water and sediment. This indicated that *G. changii* are not only contribute to high economic value to the world but also potentially play an important role as carbon sequester which they can store carbon and perform photosynthesis to produce food as their end product. Besides, *G. changii* can significantly absorb waste nutrients, control eutrophication and consequently improve the health and stability of marine ecosystems which further promote a sustainable development of aquaculture industry. The results also showed that the content of TC, TOC and TIC were higher in seaweed sample of northern region as compared to southern region of Malaysia. The different technique in culturing the seaweeds also give an adverse effect in accumulation of carbon in the seaweed samples where seaweed at northern region was attach at substrates as compared to southern region which suspended in water column. In addition, sediment also can store the carbon as organic carbon and help to reduce the amount of carbon in atmosphere. If the amount of the carbon can be stored in soil, thus it will help to reduce the amount of carbon in surrounding environment and consequently the problem of global warming can be solved.

SIGNIFICANCE STATEMENT

The main objective of this study was to determine the carbon sink profile in seaweed, water and sediment from seaweed, *Glacillaria changii* aquaculture pond as potential carbon sinker for mitigation of global warming effect. Even though numbers of studies on mitigation of global warming effects were conducted in recent years, the optimum usage of seaweed culture as carbon sinker is remains largely unknown. There are gaps that could be studied further in order to understand on other various factors; such as the effect of culture methods, location at different region and substrate used. Knowledge of biological properties of seaweed, *G. changii* which are not only contribute to high economic value to the world, but also potentially play an important role as carbon sequester which they can store carbon and perform photosynthesis to produce food as their end product. We hope that, with this novel finding could be a breakthrough in the area of seaweed aquaculture production and any similar research.

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REFERENCES

1. Farquhar, G.D., J. Lloyd, J.A. Taylor, L.B. Flanagan and J.P. Syvertsen *et al*., 1993. Vegetation effects on the isotope composition of oxygen in atmospheric CO_2. Nature, 363: 439-443.
2. Kawahata, H. and Y.A. Awaya, 2006. Global Climate Change and Response of Carbon Cycle in the Equatorial Pacific and Indian Oceans and Adjacent Landmasses. Elsevier Oceanography Series, Vol. 73, Elsevier B.V., The Netherlands, pp: 1-470.
3. Nogia, P., G.K. Sidhu, R. Mehrotra and S. Mehrotra, 2016. Capturing atmospheric carbon: Biological and nonbiological methods. Int. J. Low-Carbon Technol., 11: 266-274.
4. Parmesan, C. and G. Yohe, 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature, 421: 37-42.
5. Wootton, J.T., C.A. Pfister and J.D. Forester, 2008. Dynamic patterns and ecological impacts of declining ocean pH in a high-resolution multi-year dataset. Proc. Natl. Acad. Sci., 105: 18848-18853.
6. Harley, C.D.G., K.M. Anderson, K.W. Demes, J.P. Jorve, R.L. Kordas, T.A. Coyle and M.H. Graham, 2012. Effects of climate change on global seaweed communities. J. Phycol., 48: 1064-1078.
7. Muraoka, D., 2004. Seaweed resources as a source of carbon fixation. Bull. Fish. Res. Agen. Suppl., 1: 59-63.
8. Hoegh-Guldberg, O. and J.F. Bruno, 2010. The impact of climate change on the world's marine ecosystems. Science, 328: 1523-1528.
9. Robinson, A.B., N.E. Robinson and W. Soon, 2007. Environmental effects of increased atmospheric carbon dioxide. J. Am. Phys. Surg., 12: 79-90.
10. Niemirycz, E., J. Gozdek and D. Koszka-Maron, 2006. Variability of organic carbon in water and sediments of the odra river and its tributaries. Pol. J. Environ. Stud., 15: 557-563.
11. Kaladharan, P., S. Veena and E. Vivekanandan, 2009. Carbon sequestration by a few marine algae: Observation and projection. J. Mar. Biol. Assoc. India, 51: 107-110.
12. Turan, G. and A. Neori, 2010. Intensive Sea Weed Aquaculture: A Potent Solution Against Global Warming. In: Seaweeds and their Role in Globally Changing Environments, Seckbach, J., R. Einav and A. Israel (Eds.). Cellular Origin, Life in Extreme Habitats and Astrobiology, Vol. 15. Springer, Dordrecht, pp: 357-372.