

Review Article

## REVIEW AND EXPERIMENTAL STUDY OF MACRO ALGAE SPECIES AND THEIR NATIVE HABITAT

Sulaiman O Olanrewaju<sup>1,\*</sup>, Amagee A<sup>1,2</sup>, Kader ASA<sup>3</sup>

<sup>1</sup>Marine Technology Center, University Technology Malaysia, 21030 UTM, Skudai, Johor, Malaysia

<sup>2</sup>Technip, Jalan Tun Razak, Kuala Lumpur, Malaysia

<sup>3</sup>Bureau Veritas, Jalan Sulatan Hishamuddin, Kuala Lumpur, Malaysia

Received: 09.06.2015 / Accepted: 16.06.2015 / Published online: 19.06.2015

**Abstract:**

Environmental considerations will increasingly determine use of macro algae product and improve process acceptability that drive the next generation of economic opportunity. Some countries including Japan are actively promoting a macro algae 'green' technology that is many growing demand worldwide in the coming decades. In this context, biomass refer to any source of heat energy that is produced from non-fossils biological materials. Different macro algae survive in different habitat. This paper describe review of macroalgae species as well as qualitative and quantitative experimental analysis of the types of macro algae which are suitable cultivation in Malaysia water. This approach would identify the oceanic parameters that are most suitable for the macro algae and conduct species matching.

**Keywords:** Algae species, Macroalgae, Water sampling.

---

\*Correspondence to:

**ASulaiman O.Olanrewaju**, Marine Technology Center, University Technology Malaysia, 21030 UTM, Skudai, Johor, Malaysia

E-mail: [oozulaiman@gmail.com](mailto:oozulaiman@gmail.com) Tel:+609668-3697 Fax: +609-6683193

## Background and Issues with Biofuel Energy Source

The use of algae include food production of useful compounds for food supplement, as bio filters to remove nutrients and other pollutant from wastewaters, to record water quality, as indicators of environmental change, in space technology, and as laboratory research systems. Algae can also be use to make biodiesel and biobutanol can produces vastly superior amounts of vegetable oil, it is prefer to compared terrestrial crops grown for same purpose. It also can be used to produce hydrogen. Marine macro algae are receiving increasing attention as an attractive renewable source for producing fuels and chemicals. Marine biomass energy sources although heavily subsidy as renewable energy sources. Macro algae species are very abundant in earth and they have high caloric energy value compare to other biomass sources. In addition to this, the biomass can also be use for carbon capture. The carbon capture is an approach to mitigate the global warming by capturing the carbon dioxide from the large point sources such as fossil fuel power plants and storing it instead of releasing it into atmosphere like technology for large scale capture of CO<sub>2</sub> is already commercially available and fairly well developed. This study focuses on matching the macro algae species with the habitat in Malaysia water and identified the most suitable types of macro algae that can be for marine biomass energy source.

## Material and Methods

The work access the species of biomass in Malaysia and geographical location of where to find the macro algae species. The assessment is conducted by analyzing the sea water in certain habitat of seaweed in Malaysia. The study focused on element which is sea water analysis, energy value and carbon sink test for power and emission from biomass species.

- i. Sea water analysis: The water analysis was involved mapping the biomass species and identifies the location of their growth. Water samples were collected during the same month from different location that is Bidong Island, Setiu Wetland and Perhentian Island. Since several places are involved, each water sample analysis is taken at different time. The water samples are stored in dark plastic bottles and kept at the sampling not longer that six hours before filtered by hand operated vacuum pump.
- ii. Caloric energy value and carbon sink: Biomass energy extracts carbon to reduce the carbon stocks. The carbon sinks remove carbon dioxide from the atmosphere. The main natural sinks are absorption of carbon dioxide by the oceans via physicochemical and biological processes and also photosynthesis by terrestrial plants.
- iii. Calculate for power efficient and emission from biomass species: The power efficient is identify by testing biomass oil in the engine. Biomass energy reduction in the emission of atmospheric pollutants compared to conventional power sources would be investigated.

## Water sample and case study area

The state of Terengganu is located on the east coast in Peninsular facing the South China Sea. Three location of sea water in Terengganu are taken as sampling site in order to identify the habitat species of algae which is Setiu Wetland, Bidong Island and Perhentian Island. Setiu Wetland is the part of Setiu River Basin and the larger Setiu-Chalok-Bari-Merang basin wetland complex lies in Terengganu. It is located at 05° 40'N and 102° 43' E.

## Water sampling

The water samples were takes in Setiu Wetland, Bidong Island and Perhentian Island. The 200 meter depth is marks on the rope at the vandorn water sampler. The latitude and longitude at the location was identified using the Global Positioning System (GPS). The GPS was set up assuming 500 meter distance from the shore. The water samples are transfer into immediately bottles after takes using vandorn water sampler to prevent the distrupcion of surrounding. the most suitable for macro algae survive is about 29-32°C.

## Setiu wetland

Two different times are taken which is at 11.00am and 3.00pm. So, four different of water samples are taken. The location of Setiu wetland are N 05° 40.540' E 102° 43.080' and N 05° 40.313 E 102° 43.934'. Temperature of water samples was taken a moment after exchange the samples into the bottles. The water temperature is 32°C. This figure show the location of Setiu Wetland where the water samples are taken (Table 1 and Figure 1).

## Bidong island

Bidong Island is one square kilometer in area and accessible from the coastal town of Merang. It is located at 05° 36' N and 103° 03' E. At the Bidong island also takes two times samples, in 11.00am and 3.00 pm. Four collected of water samples taken and the temperature were identified. It is located 05° 36.828' N and 103° 03.262' E. The water temperature is 31°C. This figure show the location of Bidong island where the water samples are taken (Figure 2).

## Perhentian island



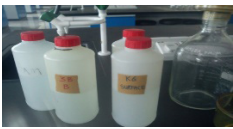




Perhentian Island is divided by two which is Perhentian Kecil and Perhentian Besar. The sampling site is at Perhentian Kecil with located at 05° 51' N and 102° 44' E. Two different times are taken which is at 3.00pm and 10.00 am on the next day. The location of Perhentian Island is 05° 21.26' N and 102° 44.2' E and the water temperature is 29°C. This figure show the location of Bidong island where the water samples are taken (Figure 3).

## Critical Review of Previous Study on Macro Algae Species

### Types of algae

Macro algae have four different types, which is Rhodophyta, Chlorophyta, Phaeophyta and CarpoCirus. Rhodophyta is the red algae that include various forms of crustose calcareous algae

**Table 1.** Equipment of water analysis.

Equipments	Function/pictures
Vandorn water sampler	 Use to take water samples
Ice chest	 Use to keep the water samples at temperature 1-4°C
Bottles sample	 Use to keep water samples
Thermometer	 Use to determine the sea water temperature
Global Positioning System (GPS)	 Use to set the latitude and longitude of the location
GF/C filter paper	 Use to filter the dirt in water samples
Vacuum Pump	 Use to filter and pump the water samples

CCA which are abundant on offshore reefs of the Great Barrier Reef. The red algae or Rhodophyta shown in Figure 4, are one of the oldest groups of eukaryotic algae and also one of the largest with about 5000-6000 species of mostly multicellular marine algae. The red algae form a distinct group characterized by these attributes which is eukaryotic without flagella and centriols, using floridean polysaccharide as food reserves with phycobiliprotein as accessory pigments and chloroplasts lacking external endoplasmic reticulum and containing unstacked thylakoids. Most of red algae are also multicellular, macroscopic, marine and have sexual reproduction. They often have alternation of generations and may have three generation rather than two. Many of the corraline algae, which secrete calcium carbonate and play a major role in buiding coral reefs belong here. Red algae such as Palmanari palmate and nori are a traditional part of European and Asian cuisines and are used to make other products such as agar, caarageans and other food additives. Most of the Rhodopytes are found in freshwater that generally prefer clean and in running water.

Chlorophyta species is a division of green algae, informally called chloropytes. In order to classification systems, it refers to a highly paraphytetic group of all the green within the green plants and thus includes about 7000 species of mostly aquatic

photosynthetic eukaryotic organisms. Like the land plants, green algae contain chlorophyllsa and b and store food as starch in their plastids. Species of Chlorophyta are common inhabitants of marine, freshwater and terrestrial environment. Several species have adapted to specialized and extreme environments such as deserts, arctic environments, hypersaline habitats, marine deep waters and deep sea hydrothermal vents. Some groups such as the Trentepohiliales are exclusively found on land. Several species of Chlorophyta live in symbiosis with a diverse range eukaryote, including fungi to form lichens, ciliates, Foraminifera, Cnidaria and mollucs. Some species of chlorophyta (Figure 5) are heterotrophic, either free-living or parasitic. The heterotrophic green alga Prototheca can cause infections in humans and animals known as protothecosis.

The Phaeophyta or brown algae is a large group of mostly marine multicellular algae, including many seaweeds of colder Northern Hemisphere waters. They play an important role in marine environments, both as food and for the habitats they form. For instance *Macrocystis*, a kelp of the order Laminariales, may reach 60m in length, and forms prominent underwater forest. Another example is sargassum, which creates unique habitats in the tropical waters of the Sargasso

Sea. Many brown algae shown in Figure 6, such as kelp are used as food for humans. Brown algae exist in a wide range of sizes and forms. The smallest members of the group grow as tiny, feathery tufts of threadlike cells no more than a few cm long. Some species even have a stage in their life cycle that consists of only a few cells, making the entire alga microscopic. Other groups of brown algae grow too much larger sizes. Kelps can range in size from two-foot-tall sea palm *Postelsia* to the



Figure 4: Species of red algae.



Figure 5: Species of green algae.

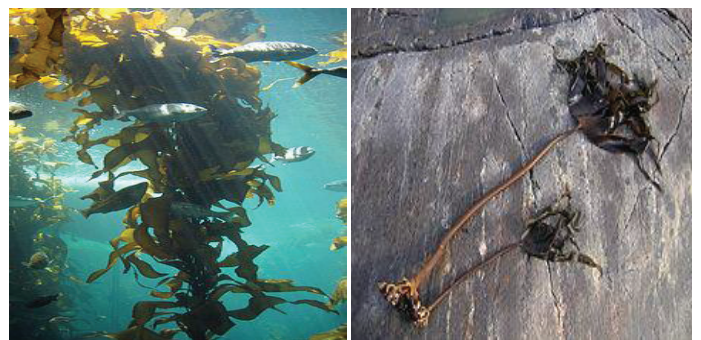


Figure 6: Species of brown algae.

giant kelp *Macrocystispyrifera* which grows to over 45m long and is the largest of all the algae.

Brown algae have adapted to a wide variety of marine ecological niches including the tidal splash zone, rock pools, the whole intertidal zone and relatively deep near shore waters. They are important constituent of some brackish water ecosystem and four species are restricted to life in fresh water. A large number of predominantly cool and cold water organisms that benefit from nutrients in up welling cold water currents and inflows from land, *Sargasum* being a prominent exception to this generalization.

### Producing marine macro algae

As world energy demand continues to rise and fossil fuel resources are depleting, marine macroalgae (i.e., seaweed) is receiving increasing attention as an attractive renewable source for producing fuels and biochemical. Product marine plant biomass has many advantages over terrestrial plant biomass for example they are use as a feedstock. Recent breakthroughs in converting diverse carbohydrates from seaweed biomass into liquid biofuels

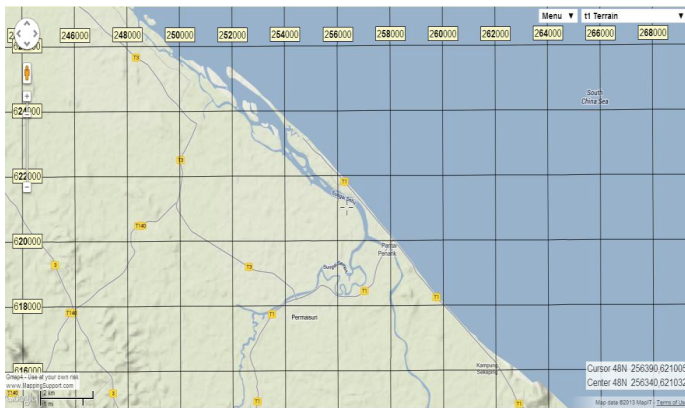


Figure 1: Setiu Wetland.

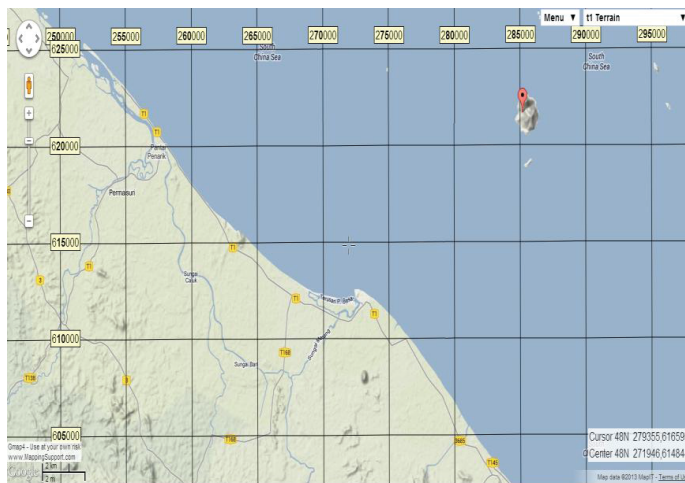


Figure 2: Bidong Island.

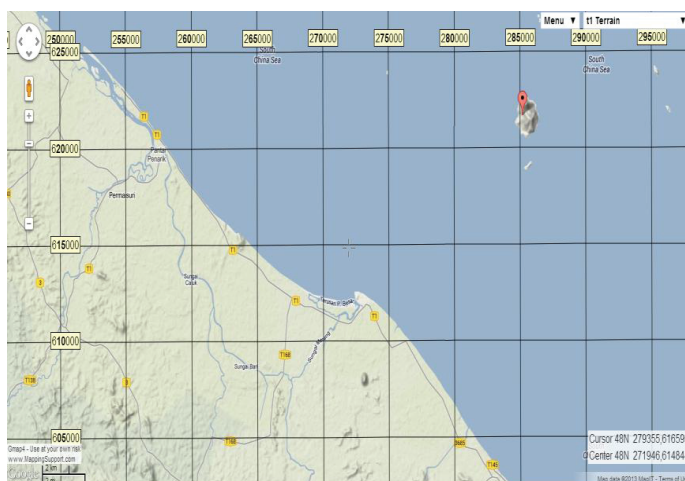


Figure 3: Water Sampling.

for example bioethanol through metabolic engineering have demonstrated potential for seaweed biomass as a promising, although relatively unexplored according to biofuels (Na Wei, 2013). Marine biomass energy system in Japan was proposed consisting of seaweed cultivation (*Laminariajaponica*) at offshore marine farms, biogas production via methane fermentation of the seaweeds, and fuel cell power generation driven by the generated biogas. The estimated CO<sub>2</sub> mitigation is equivalent to about 0.9% of the required CO<sub>2</sub> mitigation for Japan per annum under the Kyoto Protocol framework (Shinya Yokohama, 2008).

Brown macro-algae that commonly found around the British coasts are mainly used as a source of many useful industrial chemicals such as phycocolloids (e.g. alginates). Conversion of macro-algae into biofuel has largely focused on the production of biogas by anaerobic digestion (Hanssen et al., 1987; Hansson, 1983; Matsui and Koike, 2010). Some recent studies have focused on the utilization of the sugars present in seaweed (mannitol and laminarin for brown algae) in order to produce bio-ethanol by fermentation (Adams et al., 2009; Choi et al., 2009; Horn et al., 2000). Marine macro algae are one such source of aquatic biomass and potentially represent a significant source of renewable energy. The average photosynthetic efficiency of aquatic biomass is 6–8% (Renewable biological systems for alternative sustainable energy production, 1997) which is much higher than that of terrestrial biomass (1.8–2.2%). Either microalgae or marine macro algae (kelp or seaweed) could be used for solar energy conversion and biofuel production. (A.B. Ross, 2007).

Brown macro algae that commonly found around the British coasts are mainly used as a source of many useful industrial chemicals such as phycocolloids (eg alginates). Conversion of macro algae into biofuel has largely focused on the production of biogas by anaerobic digestion (Hanssen et al, 1987; Hansson, 1983; Matsui and Koike, 2010). Some recent studies have focused on the utilization of the sugars present in seaweed (mannitol and laminarin for brown algae) in order to produce bioethanol by fermentation (Adams et al., 2009; Choi et al.; Horn et al., 2000).

Marine macro algae are one such source of aquatic biomass that potentially represent a significant source renewable energy. The average photosynthetic efficiency of aquatic biomass is 6-8% (Renewable biological systems for alternative sustainable energy production, 1997) which is much higher than that of terrestrial biomass is 1.8-2.2%. either microalgae or marine macro algae (kelp or seaweed) could be used for solar energy conversion and biofuel production (A.B.Ross, 2007)

Biomass, either terrestrial or aquatic, is considered a renewable energy source with quasi zero-emission. Among alternative energy sources, biomass represents the most ready to be implemented on a large scale without many environmental or economic penalty. The photosynthetic efficiency of aquatic biomass results to be much higher than 6–8%, average compare to that of terrestrial (1.8–2.2%, average). This makes the former more adapt for an enhanced CO<sub>2</sub> fixation to afford a high biomass production. Also, aquatic biomass presents an easy adaptability to grow in different conditions, either in fresh or marine waters, and in a wide enough

range of pH. The pond culture of algae presents the advantage of usage of carbon dioxide emitted by electric power plants, using of wastewater that may supply the amount of required nutrients. Micro-algae have received so far more attention with respect to macro algae as agents for enhanced CO<sub>2</sub> fixation due to their facile adaptability to grow in ponds or bioreactors and the extended knowledge on several strains used for fish feeding. Only recently they have been considered for energy production, and the potential of some Pacific Ocean strains has been preliminarily studied (M. Aresta et al., 2005).

## Application

While the general idea of using algae for energy production has been around for over 50 years, the concept of using lipids derived from algal cells to produce liquid fuels arose more recently. (Ayhan Demirbas, 2010). According to the Michele Aresta, (2005) macro-algae are extensively grown and used as food in Asiatic Countries, or as source of chemicals. They are usually collected from natural water basins where they are seasonally available. Only recently they have been considered for energy production, and the potential of some Pacific Ocean strains has been preliminarily studied. The Life Cycle Assessment (LCA) methodology has been applied to evaluate the energy production from macro-algal biomass. We have developed specific software (COMPUBIO) which can be used for an energetic, environmental or economic evaluation.

Needless to say, the world population is increasing at an alarming rate and so is the liquid fuel demand in the transport sector. Global warming, depletion of fossil fuels and increasing price of petroleum-based fuels are gaining great concern and the exigency of the situation has forced the search for alternative, sustainable, renewable, efficient and cost-effective energy sources with lesser green house gas emissions (Nigam and Singh, 2010). Biomass can serve as an excellent alternative source to meet the present and future fuel demands. The use of seaweeds for food and as medicines was recorded in China some thousands of years ago, and in parts of Asia seaweed products have for many years been widely used, if not staple, food items. In the western world seaweeds have traditionally been valued principally for their properties as animal feed and fertilizers and, during the eighteenth and nineteenth centuries, as a source of soda, iodine and other chemicals. (Darson, 1966).

The underlying physiological of algae antioxidant compounds is reviewed in the context of seaweed biological utilization. The application of seaweed antioxidants in foods, food supplements, nutraceutical and medicine is considered from the perspective of benefits to human health. We advocate that direct consumption of seaweed products for their antioxidant composition alone provides a useful alternative to non-natural substances, while simultaneously providing worthwhile nutritional benefits. Economic utilization of seaweed for their antioxidant properties remains in its infancy. This review examples ranging from laboratory studies through to clinical trials where antioxidants derived from seaweeds may provide major health benefits that warrant subsequent investigate studies and possible utilization (M. Lynn Cornish, 2010).

## Environmental Impact Consideration

The influence of salinity and temperature in the areas of planned wind farms will not vary extensively and will be similar at all locations while remaining at all times in the tolerance to optimum range of the culture candidate species (AlmadeVilella et al. 1982, Widdows and Donkin 1992, BSH 2003). The concentrations of pollutants (e.g. heavy metals, pesticides and near-surface agents) can be considered unperilous.

Besides geological and topographical variations, water temperature and currents have also caused differences in macro algae composition between the northern and southern parts of the Pescadores and Taiwan. The two main currents affecting the coastal areas of Taiwan are the Kuroshio Current and the Mainland Coastal Current. The Kuroshio Current brings water of higher

**Table 2.** Location of sampling site.

	Perhentian Island	Bidong Island	Setiu Wetland
Latitude (N°)	05°52.46	05°36.828	05°40.540
	52.46	36.828	40.54
Temperature (°C)	29	31	32

**Table 3.** Location of sampling site.

Bil	Parameter	Setiu wetland (11.00 am)	Setiu wetland (3.00pm)	Bidong (11.00am)	Bidong (3.00pm)
1	COD	110	188	68	100
2	Total nitrogen (N)	39	24	8	15
3	Total phosphate (P)	0.04	0.03	0.03	0.02
4	Total Phosphate (PO <sub>4</sub> <sup>3-</sup> )	0.14	0.09	0.09	0.06
5	Ammoniacal nitrogen (NH <sub>3</sub> -N)	1.03	0.95	2.98	3.35

**Table 4.** Location of sampling site.

Bil	Parameter	Perhentian 11.00 am	Perhentian 3.00 pm
1	COD	130	85
2	Total nitrogen (N)	23	11
3	Total phosphate (P)	0.02	0.03
4	Total Phosphate (PO <sub>4</sub> <sup>3-</sup> )	0.08	0.1
5	Ammoniacal nitrogen (NH <sub>3</sub> -N)	4.26	2.6
6	Salinity (ppt)	30	30

**Table 5.** Seaweed habitat characteristics.

Environmental parameter	<i>G. edulis</i>	<i>U. lactuca</i>
Temperature (°C)	28.9 ± 2.1	28.9 ± 2.0
Salinity (ppt)	22.15 ± 2.20	19.5 ± 1.5
Dissolved oxygen (mg/L)	3.58 ± 0.05	3.19 ± 0.02
pH	8.43 ± 0.2	7.85 ± 0.3
Turbidity (NTU)	9.74 ± 0.04	8.68 ± 0.03
Ammonium (mg/L)	1.0 ± 0.03	1.25 ± 0.02
Total nitrogen (N) (mg/L)	3.0 ± 1.5	4.2 ± 0.5
Nitrate (mg/L)	0.02 ± 0.01	0.23 ± 0.02
Total phosphate (P) (mg/L)	0.2 ± 0.06	0.5 ± 0.1
Phosphate (mg/L)	1.04 ± 0.05	2.22 ± 0.04

temperature and salinity up from the Philippines and the equatorial regions toward southern Taiwan where it branches into two. The stable, main branch with higher than 20°C water temperature runs past the east coast of Taiwan where some tropical species are found. A smaller branch, subjected to seasonal variability, veers northwestward through the Taiwan Strait to the southern parts of the Pescadores. Flowing south along the Chinese mainland coastal region, the Mainland Coastal Current carries colder water from East China Sea to the northern parts of Taiwan Strait, and is particularly strong in summer and less so in winter. Typhoons also occur disturbing the coastal areas every year and have caused considerable damages to marine ecosystems (Jui-Sheng Chang and Chien-Chang Tseng, 2010).

## Result Presentation

### Sample collection and preservation

Water samples are collected using a van Dorn water sampler and transferred to the bottle samples. Generally, at least one liter of water sample is needed. Sample volume is depending on the sampling location. The water samples are kept from heat and light to avoid pigment decomposition and bacteria infect. The location of each sampling site is marked using GPS and the temperature of sea water is taken immediately to prevent surrounding disturbance. Hence, the water samples are placed in an ice chest at temperature 1-4 °C. Table 2 shows the coordinate for Perhentian, Setiu and Bidong Highland. Tables 3 and 4 show the respective nutrient condition of the water sample collected at the sites. Table 5 shows typical seaweed identified at Setiu location.

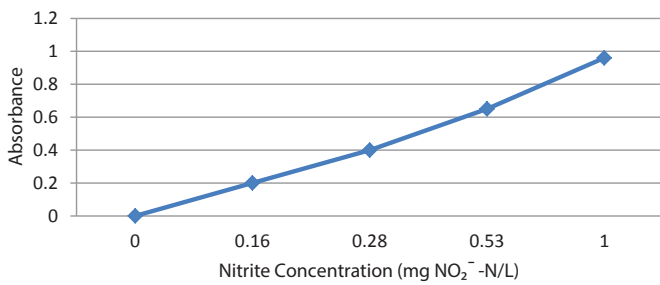
### Sample Laboratory Analysis

The GF/C filter paper is set up onto the vacuum pump. The water sample is gently poured into the vacuum pump through GF/C filter paper after switch on the vacuum pump. The sediment in water sample is ensured filtered with checking the filter paper if there is a clog or not. Experiment was set up in the laboratory to identify the nutrient contents in the seawater which is suitable for types of macro algae. There are four nutrients that may be identified using these experiments which are nitrate, phosphate, nitrogen and ammonia (Figures 7-11).

**Conclusion**

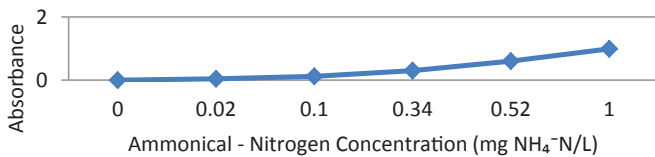
Macro algae may found in many types of habitat in Malaysia such as Bidong Island, Redang Island, Perhentian Island and Setiu Wetland. The use of macro algae as the marine biomass energy sources has the potential to offset substantial use of fossil fuels. The net emission of carbon into the atmosphere can be reducing due to use the macro algae as biomass energy sources.

**Graph Absorbance vs Nitrite concentration**



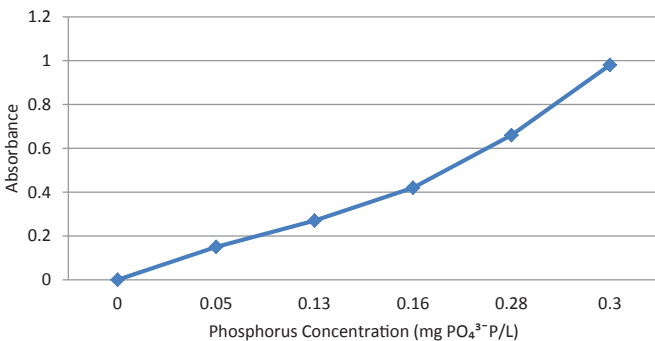
**Figure 7:** Ammonical - Nitrogen Concentration (mg NH<sub>4</sub><sup>+</sup>N/L).

**Graph Absorbance vs Ammonical - Nitrogen Concentration**

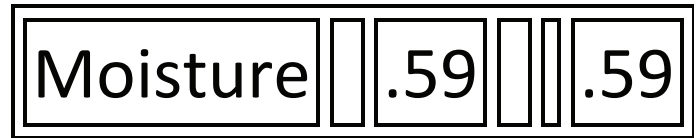


**Figure 8:** Phosphorus Concentration (mg PO<sub>4</sub><sup>3-</sup>-P/L).

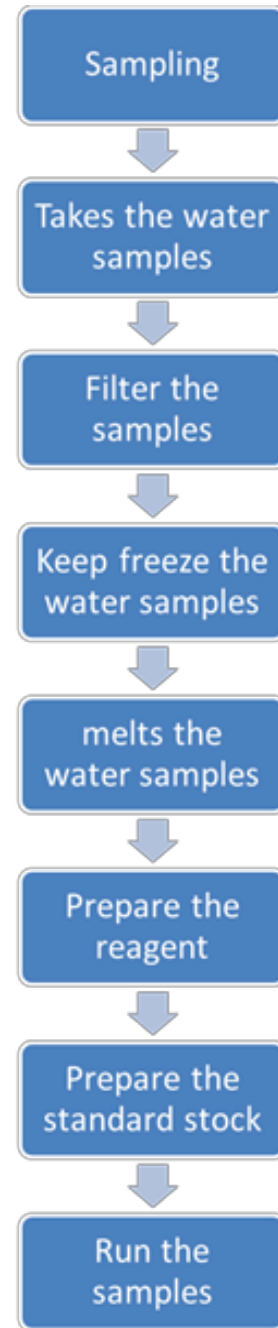
**Graph Absorbance vs Phosphorus Concentration**



**Figure 9:** Phosphorus Concentration (mg PO<sub>4</sub><sup>3-</sup> P/L).



**Figure 10:** Total moisture content.



**Figure 11:** Sampling.

## References

- Singh, S.K., Seema Srivastava., (2008). A Textbook of Algae. Campus Books International 313-322.
- Nisizawa, K., Noda, H., Kikuchi, R., Watanabe, T., (1987). The main seaweed foods in Japan. Proc Intl Seaweed Symp 12:5-29.
- Chiang, Y.M., Wang, W.L., (1987). Distribution of seaweed of the Hengchun Peninsula, Taiwan. K. H. Chang (ed), Marine science. National Science Council Symposium Series 10:71-87.
- Indergaard, M., Minsaas, J., (1991). Animal and human nutrition. In Guiry, M. D. Blunden, G. (Ed.) Seaweed Resources in Europe: Uses and Potential. John Wiley & Sons, Chichester 21-64.
- Janet R. S., (1973). Handbook of Physiological Methods. Press Syndicate of the University of Cambridge.
- Haug, A., Jensen, A., (1954). Seasonal Variations on the Chemical Composition of *Alaria esculenta*, *Laminaria saccharina*, *Laminaria hyperborea* and *Laminaria digitata* from Northern Norway. Reports of the Norwegian Institute of Seaweed Research No. 4.
- Chang, J.S., (2002). The Taxonomy, life cycle and seasonal growth of *Vodium* and its effect on coral communities in Nanwan Bay, southern Taiwan. Ph. D dissertation, the Institute of Oceanography, National Taiwan University, p. 144.
- Guillermo D.P., Laurence J., McCook (July 2008). Macroalgae (Seaweeds). Environmental Status. Australian Government Great Barrier Reef Marine Part Authority.
- Jensen, A., (1956). Component sugars of some common brown algae. Rep. Norw. Inst. Seaweed Res. No. 9.
- Jensen, A., (1956). Preliminary investigations of the carbohydrates of *Laminaria digitata* and *Fucus serratus*. Rep. Norw. Inst. Seaweed Res. No. 10.
- Morgan, K.C., Wright, J.L.C., Simpson, F.J., (1980). Review of chemical constituents of the red alga *Palmaria palmata* (dulce). Econ Bot 34:27-50.
- Arasaki, S., Arasaki, T., (1983). Vegetables from the Sea. Japan Publ. Inc., Tokyo.
- Baardseth, E., (1970). Synopsis of biological data on knobbed wrack *Ascophyllum nodosum* (Linnaeus) Le Jolis. FAO Fisheries Synopsis 38:1-38.
- Dawson., (1966). Fisheries and Aquaculture Department: Production, Trade and Utilization of Seaweeds and Seaweed Products. Retrieved from <http://owl.english.purdue.edu/owl/resource/560/10/>.