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1. Opening Remarks

Opening Remarks

It is a great pleasure for us to open the side event, "Seaweed: Coastal CO_2 Removal Belt in Korea & The Asian Network for Using Algae As a CO_2 Sink," as part of the United Nations Climate Change Conference (UNCCC) in Bali.

Warming of the climate system is unequivocal and caused mainly by greenhouse gases, as reported in the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The 2007 Nobel Peace Prize was awarded to former U.S. Vice President Al Gore and the IPCC in recognition of their devotion to this topic.

Increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea levels are evident and presently of great international concern. The future of the planet Earth is not optimistic. We need an immediate application of adaptive and mitigative measures.

Reduction of CO_2 can be accomplished efficiently only through carbon fixation by photosynthetic organisms. Algae, being immensely abundant, have an excellent photosynthetic capacity, uniquely enabling them to reverse the enormous degradation of the terrestrial and marine ecosystem. The current trends in marine algal research, including technology using seaweeds as a CO_2 sink, are essential in establishing a new policy by which the oceans can be made the key to "environment friendly" development and industrialization. Take, for instance, the recent realization of the dream of the seaweed industry to replace wood paper with seaweed paper containing red algal pulp.

We hope to benefit from your expertise and support as leaders in the Working Group addressing Climate and Oceans. We also hope that this event will represent a turning point with respect to the adoption of a new paradigm in global warming mitigation. We are very pleased to witness this historic event to initiate a formal discussion on environmentally sound and sustainable measures to mitigate global warming and climate change using seaweeds.

Prof. Ik Kyo Chung
Side-Event Organizer
Marine Research Institute
Pusan National University

Prof. Grevo S. Gerung
Local Organizer
Faculty of Fisheries and Marine Science

Prof. Jin Ae Lee
The Secretary
Asian Network for Using Algae as a CO_2 Sink
Asian Pacific Phycological Association
December 2007

Congratulatory Remarks

On behalf of the Asian-Pacific Phycological Association, I welcome you to the meeting of the Seaweed Coastal CO_2 Removal Belt in Korea and the Asian Network for Using Algae as a CO_2 Sink, in the form of a UNFCCC Side Event of the COP 13 Meeting in Bali, Indonesia, 6-10 December, 2007.

We are grateful to Prof. Ik Kyo Chung and his team for pursuing and obtaining this opportunity for us to meet here in conjunction with this very important COP 13 Meeting. Since the establishment of the Asian Network for Using Algae as a CO_2 Sink under the auspices of the Asian-Pacific Phycological Association, the network has been very active organising various activities to enhance collaboration amongst member countries engaging in research on sustainable CO_2 removal by marine ecosystems, especially the algae. Three workshops have been organised, resulting in the consolidation of objectives and plan of action of the network.

The tasks of the network include identification of gaps in the research on using algae for CO_2 removal; development of a database for the use of algae as a Clean Development Mechanism (CDM) in member countries as well as the formulation of bilateral or multilateral research proposals. At the Second Workshop of the Network Working Group, in Kobe in conjunction with the 19th Seaweed Symposium, two mini-symposia were convened by Prof. Ik Kyu Chung, Coordinator of the Korean project “Algae and Global Warming”. Several research topics were proposed by Prof. John Beardall, Australia and his group for possible collaboration within the network; eg. Identification of algal species of high carbon dioxide-sink potential with high growth rates under varying conditions; sea area required for growth of algae to harvestable size; optimization of growth of algae with high carbon dioxide-sink potential; production of biofuel from the algal biomass.

At this meeting in Bali, we hope that our deliberations on the potential of algae as carbon sinks and source of biofuel, will reach the ears of the important community of the COP 13 Agenda, especially the policy- and decision-makers. Their approval and support are important to the aspirations of the network and will enhance the regional cooperation of the Asian Network for Using Algae as a CO_2 Sink.

I would like to thank Prof. Jin Ae Lee for her excellent organization of this meeting. Thank you.

Prof. Dr. Phang Siew Moi
President, Asian-Pacific Phycological Association
December 2007

Congratulatory Remarks

It is a great pleasure for Pusan National University to participate in the United Nations Climate Change Conference in Bali as an organizer of the side event, "Seaweed: Coastal CO_2 Removal Belt in Korea & The Asian Network for Using Algae As a CO_2 Sink," along with many prominent scholars.

The news that former U.S. Vice President Al Gore and the United Nations Intergovernmental Panel on Climate Change have been awarded the 2007 Nobel Peace Prize shows the world how critical the climate crisis is. Recently, there has been more frequent extreme weather involving hurricanes, extreme heat, droughts, heavy snow, and floods. The glaciers in the Arctic Circle are retreating 30 times faster than they used to be, and an ice sheet the size of the American state of Texas has already completely disappeared. Some scientists predict that if this continues, all of the glaciers will have melted down by 2070.

What is happening with climate change now is induced mainly by human activities connected with industrialization, whose activities are going to continue to threaten mankind, and ever more seriously, if immediate action is not taken. All of the nations of the world have tried to reduce greenhouse gas emissions in many ways over the past 20 years, and finally the Kyoto Protocol took effect in February 2005. The Republic of Korea is not an Annex1 country but ranks 9th in CO_2 emissions. To cope with the new international environment, we should work on reducing greenhouse gas emissions as much as we can.

As far as I understand, the present project to develop CO_2 removal technology using seaweeds is the pioneer in that research area, and its successful result will also lead to the increase of fisheries resources in the form of seaweed forests, not to mention the resultant CO_2 removal. A seaweed forest has a great potential applicability to the newly designed Clean Development Mechanism project activities, and active international cooperation among the many Asian Pacific countries will help develop that methodology.

All through this side event, I hope that the scientists and specialists in phycology and greenhouse-gas-emissions-related fields will have fruitful discussions in expanding their knowledge and experience.

Once again I thank the members of the Korean Phycological Society and the Asian Pacific Phycological Association for their warm support of this side event, and I wish all of the participants of the meeting good luck on behalf of Pusan National University.

Inn Se Kim, M.D., Ph.D.
President, Pusan National University
December 2007

Congratulatory Remarks

I am so glad that the team of the present CO_2-removal-by-seaweed project will participate in the thirteenth United Nations Climate Change Conference in Bali, hosting a side event. I would like to express my sincere gratitude to all of the members of the team, especially to Professor Ik Kyo Chung at Pusan National University, for their effort and work.

Meeting the greenhouse gas emissions target issue is not news any more. Highly intensive regulations and incentive programs are prevalent in developed countries, which are forming part of a new global economic trend. The EU is going to legislate to limit newly produced cars to carbon emissions below 120g/km, and any aircraft departing from or landing at any European airport will be required to conform to greenhouse gas emissions regulations.

The new term, the CO_2 economy, comes from the fact that there are now climate-change-relevant private sectors and markets. The carbon credits valid from 2008 are being traded at 19 euros per ton. There are very many private sectors doing a lot of business by developing CDM methodologies verified by the UNFCCC. Korea, as a country that ranks 9th in gross carbon dioxide emissions and 25th in average carbon dioxide emissions per capita, has sufficient reason to focus on CDMs.

As we can see, I am quite sure that the present project, CO_2 removal using seaweeds, will contribute to the world and make history. The evidence that seaweeds can fix CO_2 as much as land plants can, has been discovered through the twelve national or international seminars that had been held since 2005. Furthermore, if seaweed CDM project activity methodology is approved by the UNFCCC, Korea will be predominant in carbon emissions trading as a major seaweed producing country, which trade involves more than 20 billion dollars. Fostering food and marine bio industries will be beneficial to the national economy as well as to the marine environment and marine resource development.

More seminars and talks should be held for scholars and specialists from all sectors to discuss the details of their participation in the thirteenth United Nations Climate Change Conference with side events. I hope that this will interest other nations in CO_2 removal by seaweeds, and thereby engender additional UNFCCC-approved projects.

As we urgently need to act on climate change, I hope that the present project team will find practical ways to mitigate global warming. I am expecting the best result and I am sure that the result will help Korea become a marine power of the 21st century.

Thank you.

Young Ho Yi
Member of National Assembly
December 2007

2. Program

06-Dec Thursday

Check in *Novotel Benoa Bali* (see room assign)

07-Dec Friday

7:30 Breakfast *Novotel Benoa Bali* Buffet
9:00 Registration *Bali International Convention Centre*
14:00 Group meeting (CO_2 review) *Novotel Benoa Bali*
15:00 APPA WG Network meeting *Novotel Benoa Bali*
(reimbursement paperwork)
17:30 Dinner *to be announced* (hosted by MRI/PNU)
19:00 Depart hotel to the Grand Hyatt
19:30 Side event registration *Biofuel, the Grand Hyatt*
20:00 Side event *Biofuel, the Grand Hyatt*
22:00 Depart the Grand Hyatt

08-Dec Saturday

7:30 Breakfast *Novotel Benoa Bali* Buffet
9:00 Discussion for the future APPA WG
Morning Check-out
11:30 Closing and Farewell Lunch (hosted by MRI/PNU)

Afternoon Return home or stay longer
14:00 Field trip: depart hotel to the airport [Optional, Lombok Island]
16:10 Depart Denparsar (Bali) to Lombok *Merpati Nusantara Airlines*
16:40 Arrive Mataram (Lombok)
19:00 Check in *Novotel Lombok*
19:30 Dinner (hosted by Pegasus International Co.)

09-Dec Sunday

5:00 Depart hotel to Farm site
7:30 Farm (1 hour tour)
12:00 Check out & Brunch *Novotel Lombok*
15:10 Depart Mataram (Lombok) for Bali
15:40 Arrive at Denparsar (Bali)
18:00 Farewell Dinner (hosted by MRI/PNU)
midnight Returen home

Organizer Ik Kyo Chung ikchung@pusan.ac.kr +82 11 9506 2279 (CP)
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3. Participating Nations & List of Participants

Participating Nations

Participating Nations of Asian Network for Using Algae as a CO_2 Sink (Alphabetical in country)

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Japan

Korea

Malaysia

New Zealand

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Thailand

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4. Workshop Agenda

Workshop Agenda

THE 3rd WORKSHOP ON
ASIAN NETWORK FOR USING ALGAE AS A CO_2 SINK
December 6-10, 2007
Bali International Convention Center
Bali 80360, Indonesia

United Nations Climate Change Conference
Side Event - Bali 2007

Seaweed Coastal CO_2 Removal Belt in Korea
and
The Asian Network for Using Algae as a CO_2 Sink

1. Review and endorsement of the Meeting Report of the 2nd Workshop on the Asian Network for Using Algae as a CO_2 Sink

2. Progress report of the network activities
   1) Review the list of the task to be performed by the network (refer to WHAT IS TO BE DONE in the Newsletter, No 1.)
   2) Publications
      - Using marine algae for carbon sequestration: a critical appraisal (Ik Kyo Chung, John Beardall, Smita Mehta, Dinabandhu Sahoo and Slobodanka Stojkovic)
   3) Research & Development
      - Proposal for research into trace gas emissions from kelp farms (Greg Bodeker, Tong Sup Lee and Wendy Nelson)
   4) Development of database for using algae as a CDM

3. Convening of follow-up meetings
   - Participate in Climate Change and Oceans at the 4th Global Conference on Oceans, Coasts and Islands, April 7-11, 2008, Hanoi, Vietnam
   - The workshop at the 5th APPF, November 10-14, 2008, Wellington, New Zealand

5. United Nations Climate Change Conference, Side Event Program

Seaweed: coastal CO_2 removal belt in Korea & the Asian Network for using algae as a CO_2 sink

Seaweeds fix a prodigious quantity of CO_2. We verify their mechanism as a CO_2 sink and develop seaweed CDM methodologies. Currently, the Asian Pacific Phycological Association launched a Working Group, the Asian Network for Using Algae as a CO_2 sink, for the purpose of collaborative R&D on the use of algae to remove CO_2.

07-Dec Friday

19:30 ~ 19:55 Side event registration and welcoming (refreshment)
Biofuel, the Grand Hyatt

Modulator: Lee, JA (APPA)

20:00 ~ 20:05 Welcome and introduction of participants Chung, IK (MRI/PNU)
20:05 ~ 20:15 CCRB in Korea Chung, IK (MRI/PNU)
20:15 ~ 20:40 Review on CO_2 sequestration capacity of macroalgae Chung, IK *et al.* (APPA)

Modulator: Phang. SM & Lee, JA (APPA)

20:40 ~ 21:20 APPA WG Network report & discussion
Ang, Put (Hong Kong)
Beardall, John (Australia)
Gerung, Grevo (Indonesia)
Hong, Dang Dien (Vietnam)
Hu, Zhengyu (China)
Largo, Danilo (Philippines)
Nelson, Wendy (New Zealand)
Oak, Jung Hyun (Korea)
Peerapornpisal, Yuwadee (Thailand)
Phang, Siew-Moi (Malaysia)
Sahoo, Dinabandhu (India)
Yoo, Dong Heun (Korea)

Modulator: Chung, IK (MRI/PNU)

21:20 ~ 21:30 Red algal pulp and bioenergy Yoo, HC & Gerung, G (Pegasus)

21:30 Closing remarks Chung, IK & Phang. SM

22:00 Depart the Grand Hyatt to *Novotel Benoa Bali*

6. Seaweed: Coastal CO_2 Removal Belt in Korea

SEAWEED: COASTAL CO_2 REMOVAL BELT IN KOREA

Ik Kyo Chung

Division of Earth Environmental System, Pusan National University
Busan Metro City 609-735, Korea

In Korea, marine algae are considered to be model organisms in research related to global warming because they fix a prodigious quantity of CO_2. The project 'Algae and Global Warming (AGW): Greenhouse Gas (GHG) Emissions Reduction Using Seaweeds,' also known as 'Project: CO_2 Removal by Seaweed' or the 'Seaweed Clean Development Mechanism (CDM) Project,' funded by the Korean Ministry of Maritime Affairs and Fisheries, has been ongoing since June 2006. The purpose of AGW is to utilize seaweeds as GHG emissions reduction instruments and to develop practical plans for the CDM – Project Design Document (PDD)in the Kyoto Protocol.

The first stage of AGW takes ground-breaking research on seaweed biology and ecology to establish new methodologies of baselines and monitoring plans and to create an international consensus that seaweeds should be recognized as a GHG sink.

Benchmarking of forests and Afforestation/Reforestation (A/R) in land is a good place to start for the Seaweed CDM. However, a new paradigm for marine A/R as well as for estimation of CO_2 removal by seaweeds should be presented.

In order to institute a practical seaweed CDM, the concept of the Coastal CO_2 Removal Belt (CCRB) has been newly developed. The concept behind the CCRB is that (1) it can be located in the vicinity of the coastal region; (2) it can be a natural and/or man-made plant community that conducts CO_2 removal like a forest, and (3) it is defined with respect to the various levels of the spatio-temporal scales. The operational definitions are as follows: (1) the CCRB should be an additionally constructed man-made marine plant community that is managed by the CDM Project participants; (2) the CCRB has a definite area or volume designated in the PDD with the CDM EB's approval; and (3) the CCRB is operated during the proposed crediting period. As the above is a newly introduced concept, open discussion is required.

Recently, the Asian Pacific Phycological Association has launched a Working Group — 'The Asian Network for Using Algae As a CO_2 Sink' — for the purpose of collaborative R&D on the use of algae to remove CO_2. In the near future, any country wishing to participate in the Seaweed CDM must designate a National CDM Authority to evaluate and approve projects and to serve as a point of contact. Although the Asian Pacific Phycological Association's Working Group should provide general guidelines on baselines and additionality, each country has the responsibility to determine the national criteria for project approval. The national CDM Authority must issue the necessary statements that the project developers participate voluntarily in the project and also must confirm that the project activity assists the host country in achieving sustainable development.

As seaweeds have been recognized for their utility as CO_2 sinks, sustainable seaweed aquaculture has become an important prerequisite, and therefore, sustainable seaweed-integrated multi-trophic aquaculture could be a practical way to develop a CCRB in coastal waters.

7. Review on CO_2 Sequestration Capacity of Macroalgae

Using Marine Algae for Carbon Sequestration: a critical appraisal

Ik Kyo Chung[1], John Beardall[2], , Smita Mehta[2], Dinabandhu Sahoo[3] and Slobodanka Stojkovic[2].

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The global environment is going through a period of rapid change, the pace of which is unprecedented in our geological history and life on the planet is being threatened by elevated temperatures and ocean acidification associated with the release of greenhouse gases. While carbon dioxide (CO_2) levels and global temperatures have both been higher, sometimes much higher, in the geological past than they are at present, it is the current rate of change that will pose problems for biota. It is thus critical for the future of our planet that significant changes are made to our emissions of greenhouse gases, of which CO_2 is the greatest contributor at present.

Various solutions to the problem of excess emissions have been proposed, and many countries are making good progress in stabilizing or even reducing their CO_2 emissions. However, rapid economic growth in developing countries has seen their yearly CO_2 emissions continue to rise, and the latest IPCC report suggests that unless major steps are taken, CO_2 concentrations in the atmosphere will continue to increase exponentially well into the future. It is of paramount importance to the ecological well-being of the planet that all possible steps are taken to reduce our atmospheric CO_2 load to sustainable levels.

Marine photosynthesis accounts for 50% of the total primary productivity of the planet (54 - 59 Pg C y^{-1} from a total of 111-117 Pg C y^{-1}). Of this, marine macrophytes (seaweeds and seagrasses) in the coastal regions account for ~1 Pg C y^{-1}. However, marine macroalgae such as the kelps *Macrocystis* and *Laminaria* are capable of very high rates of photosynthesis and productivity of ≥ 3,000 gC m^{-2} y^{-1} (Gao and McKinley 1994; Muraoka 2004). A range of other species, not presently cultivated for food and other materials, have high productivities and could be utilized. As such they could potentially make a significant contribution to the annual biological drawdown of CO_2 and the global C cycle (Ritschard 1992; Gao and McKinley 1994; Muraoka 2004).

In this paper, we have analysed the current rate of harvesting of both commercially grown and wild-grown macroalgae, as well as their capacity for photosynthetically driven CO_2 assimilation and growth. We suggest that CO_2 acquisition by marine macroalgae can represent a considerable sink for anthropogenic CO_2 emissions and that harvesting and appropriate use of macroalgal primary production could play a significant role in C sequestration and amelioration of greenhouse gas emissions.

The uses of macro marine algae (seaweeds) are well known. Out of approximately 20,000 known species of seaweed distributed in different parts of the world, only 221 species are used commercially (Critcheley and Ohno 1998). Many of the taxa are exploited from their natural habitats as the technology for their cultivation is not yet developed. During the last 50 years, approximately 100 seaweed taxa have been tested in field farms, but only a dozen are being commercially cultivated (Sahoo and Yarish, 2005). There are mainly 3 types of seaweeds, namely red (Rhodophyta), brown (Phaeophyta) and green (Chlorophyta) of which the first two are economically important. Today, around 7.5 – 8 million tonnes wet weight seaweeds are harvested annually both from wild and cultivated sources. China is the largest producer of seaweeds with 5 million tons (wet weight) followed by Korea 800,000 tons and Japan 600,000 tons. While the bulk of China's contribution mainly comes from the cultivation of *Laminaria japonica*, 50 % of Korea's production is contributed by *Undaria pinnatifida* and 75 % of Japan's contribution comes from the cultivation of *Porphyra* sp (Table 1). In addition, countries like the Philippines, Indonesia, Tanzania and India are involved mainly in the cultivation of *Kappaphycus alvarezii* and *Eucheuma denticulatum* (carragenophyte) as well as *Gracilaria* species (agarophytes). As detailed by the FAO (2003), although more than a dozen species of macroalgae are cultivated, the bulk of the annual production is attributable to only 5 genera: *Laminaria* (4,580,000 metric tons wet weight), *Porphyra* (1,011,000 metric tons wet weight), *Undaria* (311,105 metric tons wet weight), *Eucheuma* and *Kappaphycus* (628,576 metric tons wet weight) and *Gracilaria* (12,510 metric tons wet weight).The growth rate of various species varies depends on the site of cultivation, the season and the cultivation methodology. For example the daily growth rate (DGR) of *Kappaphycus alvarezii* varies between 3-12 % and that of *Gracilaria spp.* between 3.3-8.4 % depending on various factors.

Table 1: **Major seaweed production through large scale cultivation and wild harvests. (D, dry wt.; W, wet wt.)**

Country	Production (metric tones)	Species	Uses
China	5 x 10^6(W) 550,000(D)	*Laminaria japonica* (more than 70% contribution)	Alginates, food and other industries
Korea	800,000(W) 98,400(D)	*Undaria pinnatifida* (nearly 50% contribution)	Food
Japan	600,000(W) 71,820(D)	*Porphyra yezoensis* *P. tenera* (75 % of total production)	Food
Philippines	70,102(D)	*Kappaphycus alvarezii* *Eucheuma denticulatum*	Carragenan
Indonesia	61,447(D)	*Kappaphycus alvarezii* *Eucheuma denticulatum*	Carragenan
	13,447(D)	*Gracillaria* sp.	Agar
Tanzania	5,000(D)	*Kappaphycus* *Eucheuma*	Carragenan
India	500(D)	*Kappaphycus* + *Gracillaria*	Carragenan agar

The above figures give an annual harvest for these species alone of 0.87 x 10^6 tonnes dry matter. Macroalgae have, on average, 30% carbon so this figure represents 0.26 x 10^6 tonnes C incorporated into harvested algae annually.

Consideration of the scale of harvesting in some selected countries (Table 2) indicates the extent to which their current harvest might contribute to any offset against their CO_2 emissions. With current levels of harvest this represents, for most countries, only a small proportion of C emissions. However, it should be noticed that most countries have a low level of harvest given their coastline. France, while only harvesting from the wild, uses ~180 tonnes dry matter y^{-1} km^{-1}. If other countries were to increase their production in line with this level of harvest, then some at least would be in a position where algal utilization could make significant inroads into annual C emissions (Table 2).

Table 2. Comparison between CO2 emissions of selected countries, their current seaweed harvest and potential for C sequestration with improved utilization of coastline for seaweed cultivation (harvest data from Zemke White and Ohno 1999; emission data from UN Millennium Development Goals Indicators (http://mdgs.un.org/unsd/mdg/).

Country	**Algal harvest (tones dry matter y-1)**	**C in harvest (tones y-1)**	**Annual CO2 emissions (Thousand tones) -2004**	**C in Annual emissions (Thousand tones)**	**C in harvest/ C in emissions %**	**Coastline (km)**	**Harvest (tones dry matter y-1) per km**	**Harvest if increased to per km level of France**	**increase (fold)**	**% emissions at higher level of coastline usage**
China	698,529	209,559	5,010,169	1,366,410	0.0153	14,500	48.2	2,610,000	3.74	0.06
Korea	137,461	41,238	465,643	126,994	0.0325	2,413	57.0	434,340	3.16	0.10
Japan	123,074	36,922	1,257,962	343,081	0.0108	29,751	4.1	5,355,180	43.51	0.47
Philippines	46,218	13,865	80,511	21,958	0.0631	36,289	1.3	6,532,020	141.33	8.92
India	3,003	901	1,342,962	366,262	0.0002	7,516	0.4	1,352,880	450.51	0.11
France	616,762	185,029	373,692	10,1916	0.1816	3,427	180.0	616,860	1.00	0.18
Chile	109,308	32,792	62,418	17,023	0.1926	6,435	17.0	1,158,300	10.60	2.04
Thailand	200	60	268,082	73,113	0.0001	3,219	0.1	579,420	2,897.10	0.24
Indonesia	26,894	8,068	378,250	103,159	0.0078	54,716	0.5	9,848,880	366.21	2.86

While the Asia-Pacific region contributes to nearly 80 % of the world's seaweeds production, most of the value addition takes place in the developed countries. Of the 221 species harvested currently, 145 species are used for food and 110 species for phycocolloid production (Table 1). We argue that while the provision of food from macroalgae is of undoubted importance to some nations' nutrition and/or economy, conversion of algal carbon into biofuel could represent a more important global contribution in terms of CO_2 sequestration, analogous to the concept of carbon credits currently being applied in developed, industrialized countries. While the lipid content of macroalgae is considerably less than that of microalgae, and is usually < 7%, the content of soluble and structural carbohydrate can be much higher (values of >30 % soluble carbohydrate are not uncommon for tropical rhodophytes; Renaud and Luong-Van 2006). Lipid can be directly converted to biodiesel, but the other components such as carbohydrate (and protein) can also be chemically converted to useful fuels and chemical feed-stocks (Petrus & Noordermeer 2006). By converting algal biomass to useful fuels, we decrease our reliance on fossil fuels for both transport and chemical feedstock. Recent development of a red algal pulp will provide an alternative to the use of trees and will thereby minimize further deforestation. Thus the use of algal-based fuels and algal pulp would by-pass the critical and ecologically damaging conversion of fossil fuel into atmospheric CO_2 and could also play a role in conserving terrestrial forest which plays an important role in the global C cycle.

In planning future development of algal-based CO_2 sequestration programs, it will be important to take into account the potential impacts of climate change on growth and production of the algae to be used. It is expected that climate change will have an effect on both macroalgal distribution and biodiversity, but also on their physiology and photosynthetic performance. That, in turn, can change their capacity to sequester CO_2. Increased CO_2 concentration, in some cases, can increase their capacity to photosynthesize. For instance, it was shown by Gao et al (1991) that high CO_2 concentrations increased growth of the macroalga *Porphyra yezoensis* both in length and width, but did not change the morphology. Other species are essentially CO_2 saturated under present day CO_2 levels and are not expected to show increased performance in the future (see Beardall et al 1998). Temperature shifts may also affect the ability of macroalgae to perform in particular geographic areas (see e.g. Breeman 1990), while both increased storm events and run-off from land are likely to have impacts on algal growth (Dayton & Tegner 1984; Nielsen 2003).

Future developments in using marine macroalgae for CO_2 sequestration will need to take into account a range of environmental, social and economic parameters if it is to be used effectively. However, we are living in a time where we are seeing dramatic changes to our planet and there is an urgent need for positive action if we are not to reach a tipping point in our ecosystems.

A full, critical, review of the matters raised in this abstract is in preparation.

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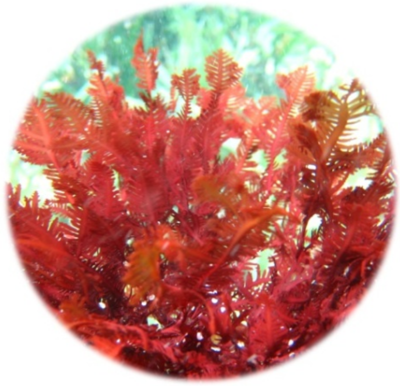
8. National Report of Working Group Members

9. Red Algal Pulp and Bioenergy

Red Algae *has the solution for the planetary emergency of global warming.*

PEGASUS International



Red Algae

Cultivation

Pulp

Bio-Ethanol

- Red algae absorb more CO_2 than rain forest from same unit area.
- No logging – Forest preservation
- Releasing less CO_2 than wood pulp process.
- Renewable energy

Solutions of Global Warming

Red Algae

Extraction → **Fiber** → **Bleaching** → **Pulp**

Extraction → **Gel** → **Fermen-tation** → **Ethanol**

Simple and easy process

No toxic chemicals use

High quality products

Higher economical efficiency

Low energy consumption

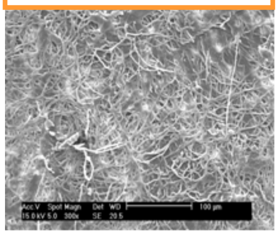
The New Era of Pulp & Paper

	Growth Cycle	Production (1 ha.)	Environmental Concern	Production Process	Quality	Energy Consumption	Byproducts
Wood Pulp	Long (over 8 years)	4 mts/ha/yr	Logging Toxic chemicals	Complex (BEP500k mts)	Low to High	High	Limited Low Economical Value
Red Algae Pulp	Short (60~70days)	16 mts/ha/yr (5–6 times)	None	Simple	High ++	Low	Various Byproducts

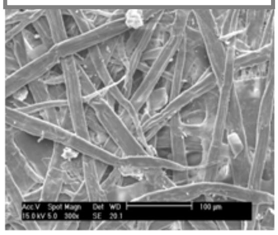
Paper Comparison

- High quality specialty paper can be easily produced with red algae pulp.

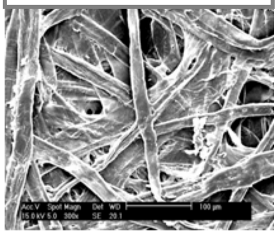
Red Algae Paper



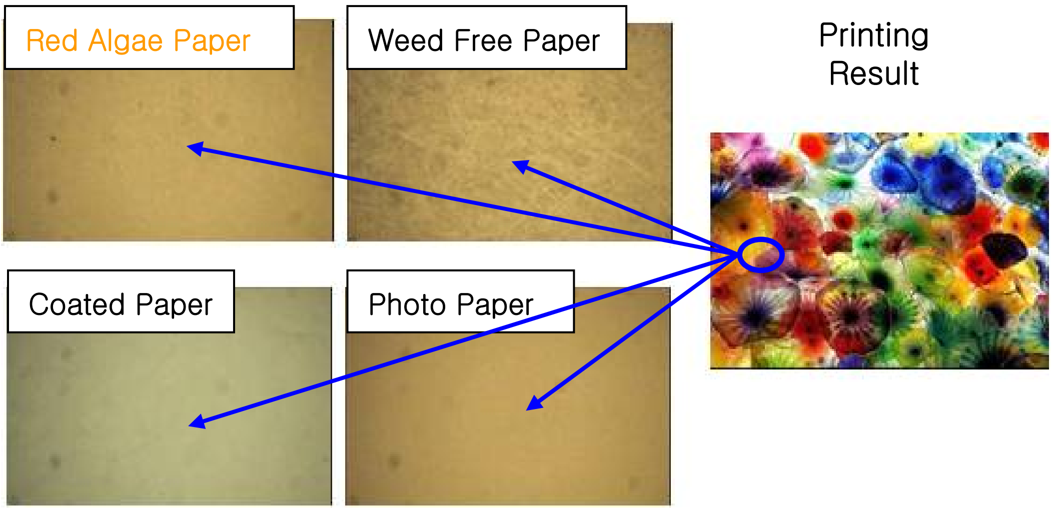
Hard Wood Paper



Soft Wood Paper



- The uniformity and fine fibers from red algae pulp enhance the paper properties that wood pulp can not materialize. – higher opacity, stiffness, smoothness, and etc.



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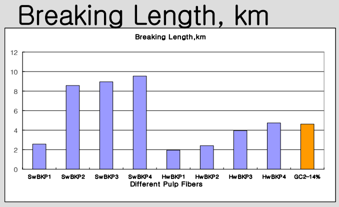
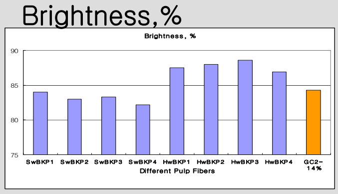
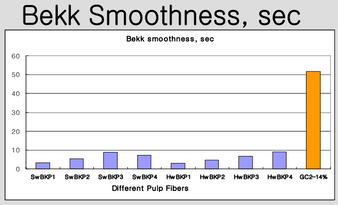
Breaking Length, km



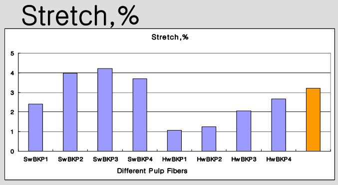
Brightness,%



Bekk Smoothness, sec

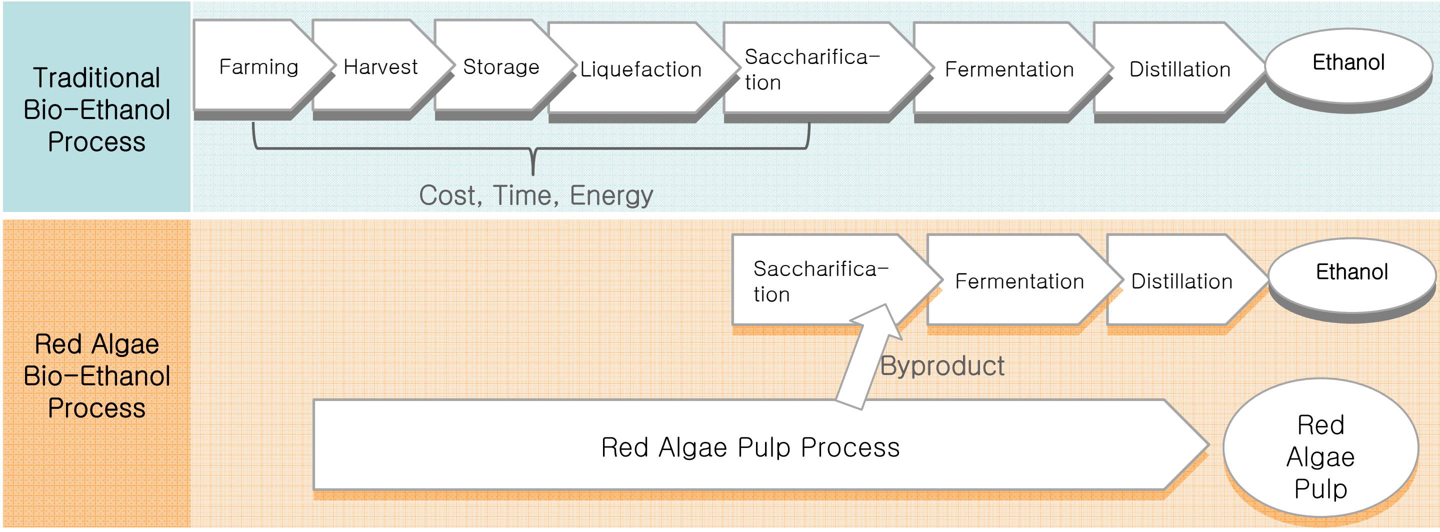


Stretch,%



Bio-Ethanol – Renewable Green Energy

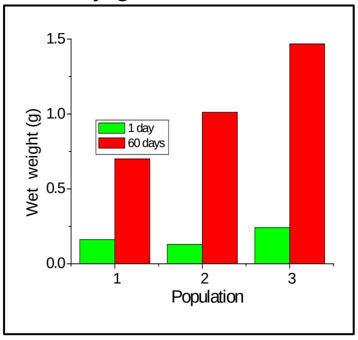
	1st Generation	2nd Generation	3rd Generation	Our Tech.
Raw Material	Sugar, Starch-Based	Wood-Based	Algae	**Byproduct from Red Algae Pulp**
Raw Material Cost	High	Low	Mid.	**None**
Production Cost	Low	High	Low	**Very Low**
Yield	Mid.	Low	High	**High**
Remarks	Foods	Pollution, Complex Process	New Tech.	**Need Pulp Process**

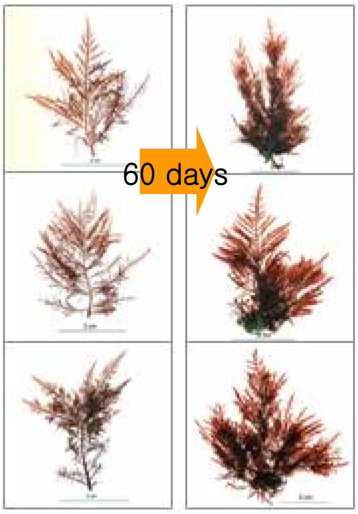


Red Algae Cultivation – the Clean Development Mechanism

in Korea

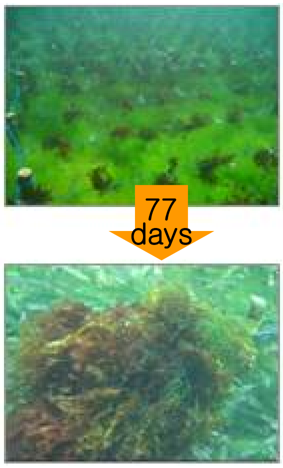
- Low Temperature condition
- Daily growth rate 3.48%

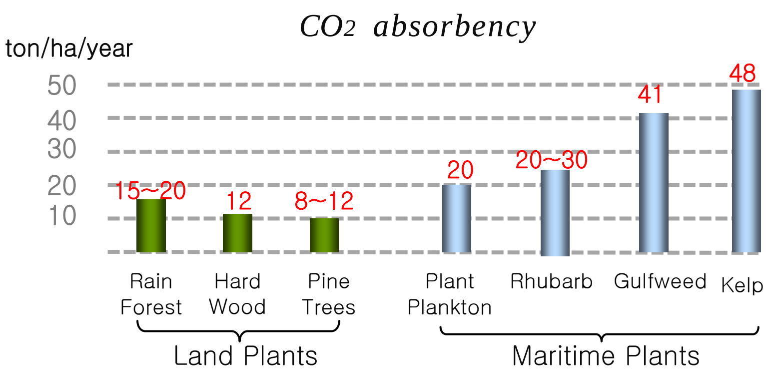




in Vietnam

in Indonesia





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