Carbon dioxide utilization and seaweed production

V.R.P.Sinha
World Bank Project
Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh
e-mails; vrpsinha@ mymensingh.net, vidyut_s@hotmail.com

Lowell Fraley
L.D. Fraley & Associates, LLC, P.O. Box 1525, Sugarland, TX 77487, USA, e-mail idf@hia.net

BS Chowdhry
ISS Consultants, Inc.
13111 Westheimer, Suite 303, Houston, Texas 77077, USA, e-mail bsc@issci.com

Abstract:
Stronger growth in many plants stimulated by increased CO_2 concentration should lead to greater biological productivity with an expected increase in the photosynthetic storage of carbon. Thus, the biosphere will serve as a sink for CO_2, though it will also act as a source too, because of respiration. Normally net photosynthesis dominates in summer and removes CO_2 from the atmosphere, whereas respiration dominates in winter and releases CO_2 in the atmosphere. However in the tropics where day length is quite long with about 10+ or –2 hours throughout the year, net photosynthesis is expected to dominate. In this background utilization of CO_2 as an industrial by-product for seaweed production holds great promise not only in acting as a significant sink, but also in meeting to some extent global food, fodder, fuel and pharmaceutical requirements, particularly in the tropics. It is interesting to note that 3.5 tons of alga production utilizes 1.27 tons of carbon and about 0.22 tons of nitrogen and 0.03 tons of phosphorus.

CO_2 can be utilized for stimulating the wild growth of seaweed in the sea or in culture on the shore and also possibilities exist for promoting growth of freshwater algae, fern and other submerged weed particularly *Hydrilla*, which is a choice feed for many fast growing fish. However, no such scientific studies have been done to evaluate this and quantify the degree of stimulation of growth and enhanced productivity through anthropogenic CO_2.

Culture and wild harvest of seaweed is commonly practiced in many countries in Japan, North and South Korea, China, Philippines, India and it is coming up in many Asian countries. The common seaweeds harvested and cultured are Porphyra, Undaria, Laminaria, Eucheuma and Gracilaria. Porphyra (purple laver) is the largest of the aquaculture billion-dollar industry in Japan.

It is important that under the new initiative of the USA, pilot scale studies undertaken preferably at suitable institutions dealing with mariculture R&D, to evolve a package of practices to obtain optimal harvest of such aquatic weeds with anthropogenic CO_2. Considering tropical settings, institutional infrastructure, scientific capabilities and cost effectiveness a network of the institution be selected in different countries and such work should be initiated.

1. Introduction:

The release of carbon dioxide to the atmosphere by the burning of fossil fuel or discharge from any industry in conceivably, the most important environmental issue of the present day. Unlike SO_2, which is classified officially as an atmosphere pollutant in many countries and thus scrubbed out of the combustion waste gases of industries, CO_2 is yet not considered as a serious pollutant and incentives to industry to develop and employ CO_2 scrubbers are almost non-existent in many countries. Methods of taking out CO_2 from the combustion waste gases before they ever get into the atmosphere are there but they are still very expensive, difficult and energy intensive. Planting trees and preventing deforestation are usual and common prescription, but the number of trees required would be considerable. For instance, it is roughly estimated that one medium size, one-ton tree might be able to consume the CO_2 produced by burning one barrel of oil.

It is also a well-known fact that CO2 emission is progressively increasing. According to an assessment of the Intergovernmental Panel on Climate Change it may reach to 20 billion tons/year by 2100 from 7.4 billion tons/year in 1997 and the concentrations of CO_2 in the earth's atmosphere may even become double by the middle of the 21st century with disastrous environmental consequences. The Panel also identified key research needs in several aspects of carbon sequestration, including technologies for separating and capturing CO_2 from energy systems and sequestering it in oceans or geologic formations, or possibly by enhancing the natural carbon cycle of oceans, forests, vegetation, soils and crops. It also describes advanced options for chemically or biologically transforming CO_2 in to potentially marketable products (Crow 1999).

Hileman (1999) noted that those existing methods of sequestering carbon dioxide presently being used in some cases, require significant research support if they are to be used safely on a large scale. He further notes that to stabilize future atmospheric concentrations at 550-ppm, about twice the pre-industrial level would require reducing annual worldwide CO_2 emissions from the projected level of about 21 billion tons to 7 billion tons (measured as carbon) by 2100. Research needs are highlighted to evolve possible methods to sequester virtually all of the carbon dioxide emitted by the world's energy industries.

2. Aquatic Biomass Production:

Increased CO_2 concentration should lead to greater biological productivity with an expected increase in the photosynthetic storage of carbon and also stronger growth in many plants. Thus the biosphere will serve, as a sink for CO_2, though it will also act as a source too, because of respiration of the plants. However, net photosynthesis should dominate. The annual oscillation in the concentration of CO_2 observed in the Mauna Loa data is the result of an annual shift in the metabolism of the forest. Net photosynthesis dominates in summer and removes CO_2 from the atmosphere, whereas respiration dominates in winter and release CO2 in the atmosphere. The oscillation is because of two opposing processes that actually involve very large quantities of carbon. However, in the tropics where day length is quite long with about 10+ or –2 hours throughout the year and of longer summer spell, net photosynthesis is expected to dominate.

Presently, of the total annual CO_2 emissions of about 7.4 billion tons, the terrestrial biosphere sequesters about 2 billion tons of carbon, whereas the net oceanic uptake of carbon is about 2 ± 0.8 billion tons per year. However, much is needed to be known about the physics and the chemistry of the CO_2 seawater interaction (Adam *et. a.l* 1998).

Utilization of anthropogenic CO_2 as an industrial by-product for seaweed production holds great promise not only in acting as a significant carbon sink, but also in meeting to some extent global food, fodder, fuel and pharmaceutical requirements, particularly in the tropics. CO_2 can be utilized for stimulating the wild growth of seaweed in the sea or in culture on the shore and also possibilities exist for promoting growth of freshwater algae, fern and other submerged weed particularly *Hydrilla*, which is a choice feed for many fast growing fish. However, no such scientific studies have been done to evaluate this and to quantify the degree of stimulation of growth and enhanced productivity through anthropogenic CO_2. It is important to note that 3.5 tons of alga production utilizes 1.27 tons of carbon and about 0.22 tons of nitrogen and 0.03 tons of phosphorus.

3. Status of Seaweed Harvest:

Seaweeds are produced through gathering and/or harvesting of natural stocks and through certain culture techniques (Sinha 1992). During the last over three decades especially in Asia and the Western Pacific region, the commercial farming of several important seaweed species has gained momentum and it is expected that their production in Asia and the Pacific will continue to change from a total dependence on harvesting natural stocks of commercially important species to the more controlled methods of production by cultivation (Trono 1986).

Presently, commercial production of seaweeds through culture is by and large limited to Japan, China, Republic of Korea, Taiwan (Province of China) and the Philippines. However, reports of seaweed culture are available from many Asian countries (such as India, Indonesia, Sri Lanka, Myanmar and Vietnam) but their production is not in bulk and does not constitute any significant component of world market.

The bulk of the production of Japan consists of *Prophya, Undaria* and *Laminaria*, whereas the production in China consists of *Prophrya, and Laminaria*, in Republic of Korea *Prophyra, Laminaria*, and *Undaria*, in the Taiwan (province of China) *Gracilaria* and certain amounts of *Prophyra* and in the Philippines *Eucheuma* and *Caulerpa*. Thus, the common seaweed harvested and cultured are *Porphyra, Undaria, Laminaria, Eucheuma* and *Gracilaria*. But presently *Porphyra* (purple laver) is the largest of the aquaculture billion dollar industry in Japan. Wild harvest of it in Japan amounts to over 1.6 million tons (fresh weight) and culture contributes to about 0.6 million tons.

Laminaria wild harvest accounts for about 0.128 million tons valued at USD 227 million and culture accounts for 0.057 million tons valued at USD 93 million. *Undaria* wild harvest yield is 0.0056 million tons valued at USD 10 million and culture contributes about 0.109 million tons valued at USD 124 million.

The utilization of seaweed colloids in the industry remains to be one of the more exciting aspects of the world seaweed production (Doty 1982). Seaweed gel business runs in over one billion U.S. dollars a year and the annual carrageenans market in the U.S. is worth hundreds of million dollars. The bulk of the raw materials are produced mainly in Asia and the Pacific and it is expected that the region will continue to be the major producer of seaweeds for some time to come. It is also true that there exist big untapped potentials of seaweed resources in the region.

Prospects for the seaweed culture industry appears very promising in the Asian region with the growing demand for seaweeds primarily as food resources with increasing population in the tropics and also for raw materials for industrially useful seaweed extracts. The relatively low cost of production in the region render these Asian products highly comparative in the world market.

Besides its importance as a raw material for industry and as food resources such as *Prophyra*, *Gracilaria* and *Rhodymenia*, some are used as seaweed meal for animals. However, some are also used in some countries as manure, and offers alternative source of manure instead of costly commercial fertilizers

The importance of seaweed industry in providing gainful employment and/or livelihood to thousands of coastal inhabitants in countries such as Japan. China and Korea, where it is a major aquaculture industry, has been amply documented.

Thus, significant increase in the production of the seaweed reflects the growing importance of seaweeds as marine biological resources, not only as an important primary producers in the shallow-water marine ecosystem, but are directly utilized as human food, as components of animal feeds and as organic fertilizer. Biological products derived from them, such as agars, alginates, furcellaran and carrageenans, have and will continue to have diverse applications in the food, chemical, pharmaceutical and other industries (Trono 1986)

Success in seaweed culture achieved in few countries are providing momentum in many other countries in the region and some have started, research and development on expansion of production areas through location of new farming sites. While, some countries, which have perfected culture techniques, are resolving the associated problems, other countries depending mainly on the natural stocks, are looking for the new areas for exploitation and the protection of stocks from over harvesting through proper management practices, such as the control of harvested amounts and harvesting methods (Trono, 1986). However, seaweeds are generally considered as low priority crops in most national development programs and thus lack research expertise and facilities, leadership and sustained funding support for research and development.

4. Brief Outline of Project:

It is important that under the new initiative of the USA to support research on the science and arts of CO2 sequestering through different means, pilot scale studies need to be undertaken preferably at suitable institutions dealing with mariculture R&D, to evolve a package of practices to obtain optimal harvest of such aquatic weeds with anthropogenic CO_2.

Considering favorable tropical settings, institutional infrastructure, scientific capabilities and cost effectiveness a network of the institutions be selected at least in three countries in Asia having different levels of seaweed R&D such as Bangladesh, India and the Philippines be strengthened to undertake such research.

There are research institutions and scientific manpower in the region to undertake such work. With the modern facilities and needed orientation and scale of research and with an inter-disciplinary effort suitable technology need to be evolved which will serve basic national objectives of increased productivity and also as an alternative means of carbon sink. The output of such studies will be highly relevant for the poor coastal communities.

4.1 Development Objective of the Project:

The development objective of such a project is to assess, evaluate and quantify aquatic biomass increased production through anthropogenic supply of CO2 to commercially important seaweed, without impairing the environment and biodiversity and packaging the technology for wider application in the tropics.

4.2 Main Activities of the Project:

The activities of the proposed project should basically include selection of the institutions and finalization of the collaborative mechanism, strengthening of facilities particularly in building facilities for Anthropogenic Free Air Co_2 Enrichment (FACE) for aquatic weeds, planning and initiation of the research studies, co-ordination and management of the studies, pilot scale testing, packaging of the technology and Human Resource Development. However these activities should only supplement national efforts and thus this project should catalyze the present national endeavor and reorient their approach toward utilization of anthropogenic CO2 for stimulated growth and for higher aquatic productivity.

4.3 Proposed Budget:

While the Funding/Donor agency provides the following financial support the national government should provide the required counterpart personnel, facilities and other infrastructure.

Project budget covering:

International person and support	Total m/m	US$	2002	US$	2003	US$	2004	US$	2005	US$	2006	US$
1.Research planning & management specialist	18	180,000	6	60,000	3	30,000	3	30,000	3	30,000	3	30,000
2.Environmental engineering	12	100,000	6	50,000	3	25,000	-	-	-	-	3	25,000
3. Ecologists & Biodiversity specialist	9	75,000	3	25,000	3	25,000	-	-	-	-	3	25,000
4.Seaweed specialist	12	98,000	3	25,000	2	16,000	2	16,000	2	16,000	3	25,000
5.Administrative support		50,000		10,000		10,000		10,000		10,000		10,000
6.Mission cost		25,000		15,000								10,000
7.Human resource development		100,000						50,000				50,000
8.Equipment		200,000		100,000		25,000		25,000		25,000		25,000
9.Operation & maintenance		95,000		15,000		20,000		20,000		20,000		20,000
10. Sundry		70,000		10,000		15,000		15,000		15,000		15,000
Total		993,000		310,000		166,000		166,000		116,000		235,000

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