The Oceans, Algae, and the Greenhouse Effect

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INTRODUCTION

The oceans play a crucial role in the dynamics of CO₂, the main greenhouse gas, in the atmosphere. They now take up more than a quarter of what is released of this gas in natural and anthropogenic emissions from the land, but there was a net flux of CO₂ from the ocean to the atmosphere and to the land prior to human activities.¹ As concerns about greenhouse gas accumulation and therefore global warming persist, it is well to note that there are, in essence, only two reasonable roads to influence the rate of CO₂ buildup in the atmosphere. On the one hand there are the methods to reduce emissions through energy conservation, fuel shifting to less CO₂-producing fuels, improvements in efficiency, and a transition to greater uses of natural or nuclear-energy sources. On the other hand, there is the enhancement of the uptake and subsequent binding of CO₂ by plants on land or in the sea, with the CO₂ so bound either recycled or stored. The simplest approach to organic carbon storage is by reducing deforestation, especially of the tropical rain forests, and the large-scale planting of trees. There are socioeconomic obstacles to action along these lines, from the unregulated demands of fuel wood for hundreds of millions to demands for land and the high demand for various wood products in international commerce. But when carbon storage is embarked upon in earnest by the community of nations, as it no doubt will be when “things get hotter,” tree management of all kinds has the advantages that no new technologies have to be invented and that trees have reasonably long life spans for carbon storage. For instance, managed temperate forests have turnover times of 30–40 years, and mangroves may live 50 years. (They are now being rapidly destroyed all through the tropics even though they afford excellent means of shore zone stabilization, an important consideration for an impending sea-level rise.) The longest-lived tropical rain-forest giants do far better still, with life spans of 100 years or more on the average.

Unfortunately, global trends in economic development and demographic projections toward the middle of the next century forcefully suggest that carbon fixation by trees will only marginally assist to stabilize atmospheric CO₂ accumulation.

There is, however, the theoretical possibility of greatly enhancing the growth of algae in certain portions of the globe’s vast ocean surface or of installing large-scale intensive algal culture production on land. Both approaches present large and diverse challenges, with the technologies that might be used still essentially on the drawing board. Also, in contrast to trees, the life spans of algae range from days, if not hours, to 1–2 years in the case of a few kelp species.² Both algae’s life spans and high water content pose end use, that is, direct or indirect storage, problems. Related to the turnover rate of algae being faster than that of trees, there are also as yet unassessed ecological consequences of a massive enhancement of algae in the sea and problems of finding space for massive algae cultures on land.

Among currently considered approaches to using algae for enhanced carbon fixation are

1. large-scale treatment of certain upwelling areas with iron as a presently limiting element to greatly enhance the growth of planktonic algae;
2. large-scale, more or less controlled ocean farming of macroalgae (seaweeds);
3. intensive growing of algae in enclosures or containers on land.

These are treated in an overview fashion in this paper, followed by a general discussion. It will be stressed that all avenues of reducing the rate of CO₂ accumulation in the atmosphere must be considered, and thus scenarios must be explored and critical experiments must be encouraged that will help ascertain what role algae can play in the global management of greenhouse gases. That this role can be only a partial one, together with other measures, is clear even now, as is the fact that the technologies employed would be vast and costly. Whether or not it will be prudent for humanity to embark on them to help us out of a very probable global-warming impasse can only be answered by further applied research.

SCHEMES, METHODS, PLANS, AND ENVISAGED PROCESSES TO USE ALGAE FOR THE REDUCTION OF CO₂ IN THE ATMOSPHERE

As one examines the several ways mentioned in the introduction through which carbon fixation by algae could be so enhanced that they become

². T. Abbot, Botany Department, University of Hawaii, conversation, June 1991.