# STUDY ON ALGAE CARBON CAPTURING AND CHEMICAL PROPERTIES

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## ABSTRACT

*We highlight the importance of the strain selection process. also provide basic information about the vital algal strains employed for the process of algae-based CO2 and their significant attributes with regard to both micro and microalgae. The criteria employed for selection and the factors which influence the selection process are also concisely presented. We have also accounted the carbon concentrating mechanisms in algae for the people interested in the molecular biology of the process. And the plant operations followed by the feasibility of using algae for carbon capture in power plants.*

***Keywords*****:** *algae, microalgae, power plants, molecular biology, carbon concentrating, carbon capture,, nutrients aquatic plant weeds .*

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## I. INTRODUCTION

The "green algae" is the most diverse group of algae, with more than 7000 species growing in a variety of habitats. The "green algae" is a paraphyletic group because it excludes the Plantae. Like the plants, the green algae contain two forms of chlorophyll, which they use to capture light energy to fuel the manufacture of sugars, but unlike plants they are primarily aquatic. Because they are aquatic and manufacture their own food, these organisms are called "algae," along with certain members of the Chromista, the Rhodophyta, and photosynthetic bacteria, even though they do not share a close relationship with any of these groups.

Algae, ranging from single-celled microalgae to large seaweeds, are the simplest and most abundant form of plant life, responsible for more than half of the world's primary production of oxygen. Algae are an extremely important species. For one, they produce more oxygen than all the plants in the world combined! For another, they form an important food source for many animals such as little shrimps and huge whales. Thus, they are at the bottom of the food chain with many living things depending upon them. The algae production facilities can thus be fed with the exhaust gases from coal-fired power plants to significantly increase the algal productivity and clean up the air. A key benefit from this technology is that the oil found in algae can be processed into a biodiesel. Remaining components of the algae can be used to make other products, including ethanol and livestock feed Possibilities and Limits of Retrofitting CO2 Capture at Power Stations.

In the next twenty years many fossil fuel-fired power stations in Germany (and in many other countries in Europe and overseas) will come up for replacement. Given the long service life of a power station (approx. forty years) and the necessity of achieving a long-term reduction in CO2 emissions from electricity generation, today’s investment decisions should take into account the possibility of later retrofitting with CO2 capture technology. Power stations where the possibility of later retrofitting is taken into account at the planning and construction stages are designated ‘capture ready’.

For upcoming generating capacity replacement programmes economic considerations dictate that only modern conventional power station types in the upper output class with blocks of up to 1,000 MWel and load factors of 25–100 % come into question (Fischedick et al. 2006). Additionally, rising fuel prices are causing R&D efforts to focus on maximising efficiency, which in itself brings about a reduction in specific CO2 emissions (gCO2/kWhel).

There are two possibilities for retrofitting CO2 capture in existing power stations. One is post-combustion CO2 capture from the flue gas, e.g. by MEA scrubbing, the other involves converting the combustion process to pure oxygen (oxyfuel). Both involve considerable modifications to the power station infrastructure. In the case of MEA scrubbing this means first and foremost the provision of substantial additional space for the flue gas scrubbers and the column for regenerating the scrubbing fluid, as well as the associated storage facilities. In the case of retrofitting as an oxyfuel power station, an air separation facility is required for the necessary oxygen supply, and a conversion of this type involves major rebuilding work in the furnace, for example to allow the recirculation of CO2 from the flue gas, in order to control the temperature of combustion.

There are also simpler forms of retrofitting (in the form of pre-combustion technology) if the route of gasification technology is chosen from the outset. Here the initial costs are greater than for conventional power station technology, but the additional cost of retrofitting is less.

Even where the technical and local conditions allow retrofitting at all, retrofitted CO2 capture will always cause a loss in efficiency, which will have to be made up in extra fuel if the electrical output is to remain constant.


**Fig. 1. Algae in sea water**

The consequential increase in electricity generation costs means that CO2 capture is not economical under today's conditions. However, if the overall conditions were to change (e.g. through the introduction of CO2 certificate trading) retrofitting CO2 capture could become an economic proposition within a few years, and it is this that explains the fundamental interest in the retrofitting option. This has already led certain companies to think about ways they can build plant so that it is 'capture ready', in other words to take suitable measures to prepare plant for later retrofitting.

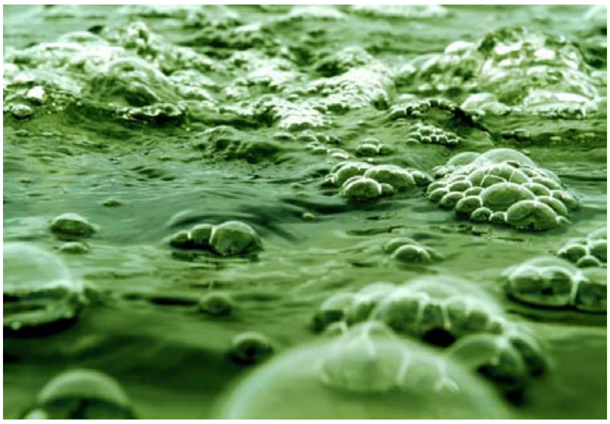

**Fig. 2. Algae in Pound Water**

Sekar et al. (2005) examine future regulatory frameworks for CO2 and current investment in the electricity generating sector. In North America they identify two main technologies that are being considered today for new coal-fired power stations: PC (pulverised coal) technology and IGCC (integrated coal gasification combined cycle). They investigate the effects of future costs of CO2 regimes, of retrofitting CO2 capture and of a possible emissions levy. Using the key data (e.g. CO2 tax) they compare the economic viability of the two concepts and determine the point at which it becomes worthwhile, for example, to retrofit CO2 capture.

In the following we examine some of the preconditions for retrofitting existing power stations. Process integration is particularly important in order to minimize the efficiency losses that several studies predict for post-combustion CO2 capture (in the range > 10 %). Gibbins et al. (2004) propose six rules for retrofitting, and explain them using examples. The aim of their work was to maximize the effectiveness of post-combustion solutions and to identify potential for improvement over and above earlier studies that previously failed to take into consideration optimized process integration. One of the most important preconditions for Retrofitting CO2 capture at the power station is the considerable additional space requirement, which can act as a limiting factor (initial estimates put the additional space requirement at about 50 to 100 %).

If power stations are retrofitted with CO2 capture they should demonstrate a good level of efficiency or else the power generation process itself must be modernised. It makes no economic sense to retrofit flue gas CO2 capture in a power station that is operating at an efficiency of 30 %.

## II. PROPOSED TECHNIQUE

The stationary sources of carbon dioxide emission, power plant emissions constitute more than 50%, of which the principal emitters are coal-based power plants. Algae thrive on a high concentration of carbon dioxide and nitrogen dioxide ($NO_2$), a pollutant of power plants, is a nutrient for the algae. Algae production facilities can thus be fed exhaust gases from fossil fuel power plants to significantly increase productivity and clean up the air.

Conceptually, algae cultivation near power plants is fairly simple. The idea is to pipe the flue gas from the exhaust to the open (eg. ponds) or closed (e.g. photo-bioreactors) algae cultivation systems which are preferably located nearby the power plant. To capture the carbon given off by coal ‑ fired power plants, existing plants must be retrofitted, and newly designed plants must incorporate carbon capture into the exhaust scrubbing system. Integrating power plant design with algal carbon capture could be a means of controlling emissions and capturing $SO_x$, $NO_x$ and heavy metals such as mercury (Hg) and perhaps additional contaminants from the flue stream.

*A. The algae-based carbon capture involves the following steps*

**Step 1 -** In the process, flue gas is withdrawn from a power plant unit and transported through pipes to the microalgae production plant.

**Step 2-** Flue gases from electric power stations emit $CO_2$, $NO_x$ and other gases and substances. It can be extremely toxic to algae because of the presence of $H_2$ and $SO_2$ reference. Flue gases are subjected to desulphurization or FGD reference. $SO_2$ can undergo wet scrubbing with limestone to produce $CaSO_3$ which is then used to produce gypsum

**Step 3 -**The flue gas downstream of the FGD contains a high percentage of water vapour however, so the gas is dried before propelled with the aid of a fan through a pipe to the greenhouse.

**Step 4** - The exhaust gas is cooled before it reaches the capture process itself in order to optimize the process. The flue-gas cooler is the largest consumer of cooling water in the process, typically using 50% of the cooling water.

**Step 5** - Propeller propels the flue gas to the aerator and the flow-meter monitors the flow rate of flue gas.

**Step 6** - Appropriate proportion of flue gas and air are mixed and pumped in to the algae feeding vessel.

**Step 7 -** In the feeding vessel algae culture, required water, nutrients and also the air mixed with flue gas are added. The contents of the feeding vessel after going through a process of QC are pumped in to the photo-bioreactor.

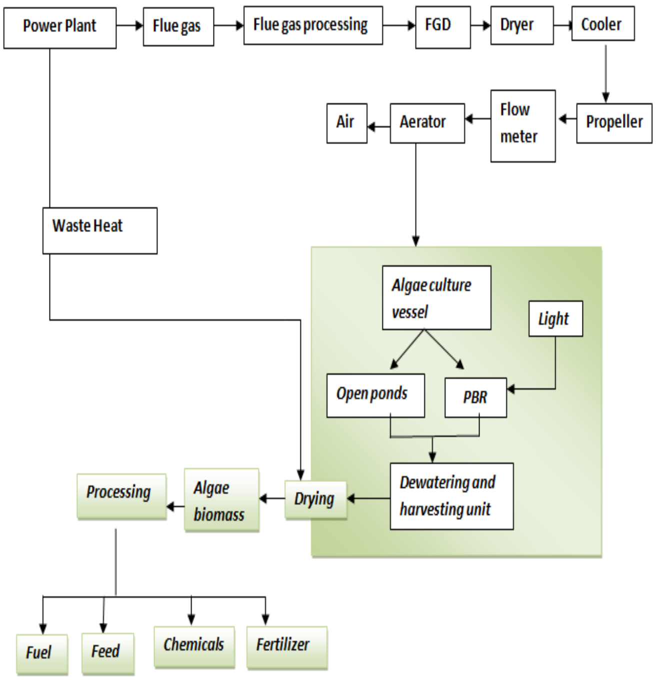


**Fig. 3. Schematic Sketch of Algae-based CO2 Cultivation Near Power plants**

**Step 8** : Photo-bioreactor facilitates mixing and provides optimal environment for algae growth. Mixing is necessary to prevent sedimentation of the algae, to ensure that all cells of the population are equally exposed to the light and nutrients, to avoid thermal stratification (e.g. in outdoor cultures) and to improve gas exchange between the culture medium and the air.

**Step 9**: After reaching the considerable cell density, the algae are harvested from the photo-bioreactor by pumping more medium (water + nutrients).

**Step 10**: High-density algal cultures can be concentrated in the dewatering and harvesting unit by either chemical flocculation or centrifugation. Products such as aluminum sulphate and ferric chloride cause cells to coagulate and precipitate to the bottom or float to the surface. Recovery of the algal biomass is then accomplished by, respectively, siphoning off the supernatant or skimming cells off the surface.

**Step 11**: The algal slurry is then transported to the drying unit.

**Step 12:** In drying unit the algae are dried either by using solar dryer or the waste heat generated from the power plant.

**Step 13**: The dried biomass is processed further to obtain the desired product.

Microalgae, specifically, possess several attractive characteristics in the context of energy and bio-fuels:

- They provide much higher yields of biomass and fuels, 10-100 times higher than comparable energy crops.

- They can be grown under conditions which are unsuitable for conventional crop production.
- Microalgae are capable of fixing CO2 in the atmosphere, thus facilitating the reduction of increasing atmospheric CO2 levels, which are now considered a global problem.
- Algae bio-fuel is non-toxic, contains no sulfur, and is highly biodegradable.

The following is the list of fuels that can be obtained from algae:

Biodiesel, Ethanol, Hydrogen, Methane, Biomass where algae biomass is directly used for combustion. Other hydrocarbon fuel variants, such as fuel, gasoline, bio-butanol etc.

The U.S. Department of Energy's Aquatic Species Programme (ASP), undertook over a decade of research (between 1978 and 1996), and found that algae were only economically viable as a bio-fuel at oil prices of more than $60 a barrel.

| S No | Final Product | Processes |
|---|---|---|
| 1 | Biodiesel | Oil extraction and Transesterification |
| 2 | Ethanol | Fermentation |
| 3 | Hydrogen | Triggering biochemical processes in algae gasification pyrolsis of biomass and processing of resulting syngas. |
| 4 | Methane | Anaerobic digestion of biomass Methanation of syngas produced from biomass |

**Table 1. The use of processed industrial flue gas**

*B. Attributes and Advantages of Algae-based CCS*

Algae can be said to present the most feasible biological route for sustainably capturing CO2 for large scale CO2 emitters compared to other technologies.

**The technology for photosynthetic sequestration using algae for the capture of anthropogenic carbon dioxide has the following attributes**

- Maximum rates of CO2 uptake
- Permanent sequestration of carbon
- Revenues from substances of high economic value
- Use of concentrated, anthropogenic CO2 before it is allowed to enter the atmosphere.
- Capturing CO2 at the source

- Recycling CO2 into multiple beneficial uses
- Displacing the use of fossil fuels and their CO2 emissions
- Enhancing the net CO2 emission performance of fossil fuel gasification and thermal extraction processes

For power plants and other entities which are large-scale emitters of CO**2**, capturing the carbon using algae will help a great deal in monetizing the carbon- credits as well as providing algae bio-fuels. Hence, algae can be said to present the most feasible biological route for sustainably capturing CO**2** for large scale CO**2** emitters compared to other technologies.

**Some of the advantages of algae based CO2 capture include**

- ✓ **Sustainable –** Algal carbon capture technology is believed to be environmentally, economically and socially viable.
- ✓ **Ensures Safety -** Leakage concerns associated with other methods are avoided in algal carbon capture technology.
- ✓ **Transportation of CO2** is not needed when the photo-bioreactor is located within the industry premises.
- ✓ **Biodiesel** can be obtained from microalgae that are used for carbon capture
- ✓ **Generates biomass** which provides additional revenue with high and low value co-products

Could be coupled with wastewater treatment to enable recycling of the industrial sewage Additional revenues can be generated with emission trading and carbon credit. The use of processed industrial flue gas and sea water offers a potential advantage of minimizing the expenses incurred over nutrients required to supplement algal growth. This generates nutrient credits.

## III. CONCLUSIONS

The enormity of carbon dioxide emissions from fossil fuel power plants here we discuss the plant operations followed by the feasibility of using algae for carbon capture in power plants. The strategies and the steps involved in algae based carbon capture in power plants, latest technologies in desulphurization, carbonation and cultivation systems are dealt with in detail. We also provide a list of specialized applications of algae-based carbon capture. directly used Flue gas after pretreatment, for algae cultivation due its high content of CO2 and nitrogen. Some species of algae may not be compatible with this method due to the possibility of sulphur toxicity. Hence, it is always preferable to pre-treat the flue gas employing Flue Gas

Desulphurization (FGD) method before use. The direct use of flue gas with FGD helps minimize the costs incurred.

## IV. REFERENCE

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