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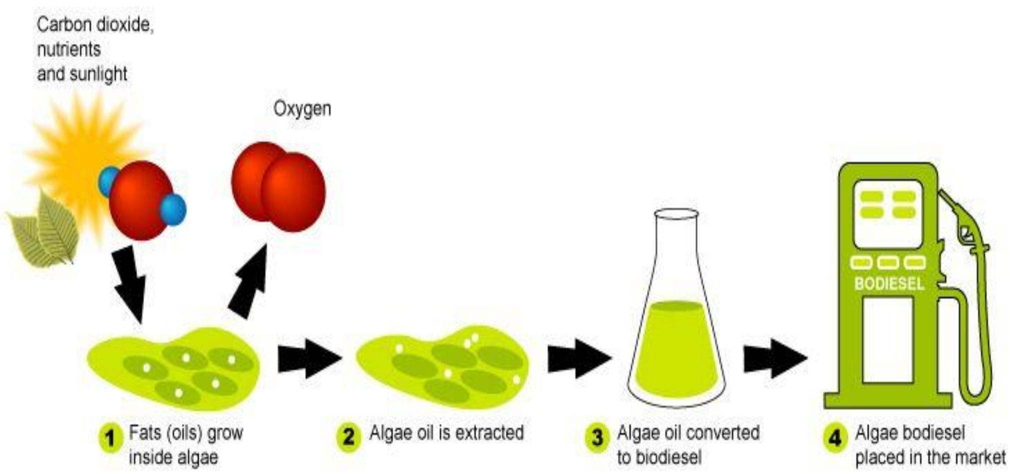
Biofuel from Algae

Algae fuel, **algal biofuel**, or **algal oil** is an alternative to liquid fossil fuels that uses algae as its source of energy-rich oils. Also, algae fuels are an alternative to commonly known biofuel sources, such as corn and sugarcane.

Among algal fuels' attractive characteristics are that they can be grown with minimal impact on fresh water resources, can be produced using saline and wastewater, biodegradable and relatively harmless to the environment if spilled.

Algae can be converted into various types of fuels, depending on the technique and the part of the cells used. The lipid, or oily part of the algae biomass can be extracted and converted into biodiesel through a process similar to that used for any other vegetable oil, or converted in a refinery into "drop-in" replacements for petroleum-based fuels.



Species

Research into algae for the mass-production of oil focuses mainly on microalgae (organisms capable of photosynthesis that are less than 0.4 mm in diameter, including the diatoms and cyanobacteria) as opposed to macroalgae, such as seaweed. The preference for microalgae has come about due largely to their less complex structure, fast growth rates, and high oil-content (for some species). However, some research is being done into using seaweeds for biofuels, probably due to the high availability of this resource·

Mass oil-producers:

- *Botryococcus braunii, Chlorella, Dunaliella tertiolecta, Gracilaria*
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Nutrients and growth inputs

Light is what algae primarily need for growth as it is the most limiting factor.

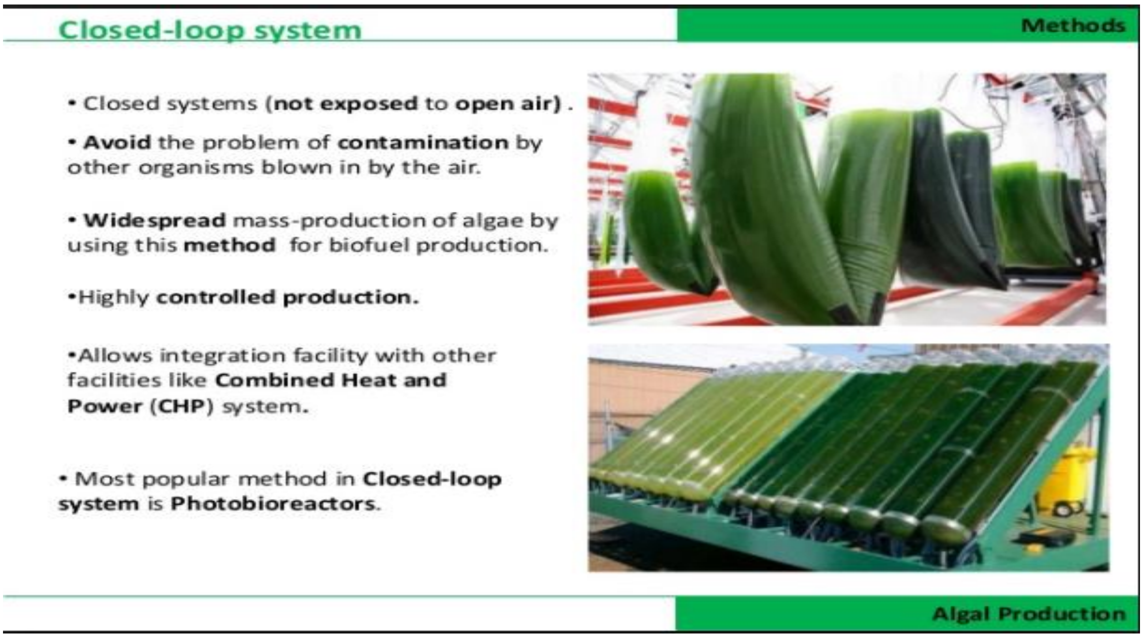
Water temperature also influences the metabolic and reproductive rates of algae. Although most algae grow at low rate when the water temperature gets lower Other than light and water, phosphorus, nitrogen, and certain micronutrients are also useful and essential in growing algae. Nitrogen and phosphorus are the two most significant nutrients required for algal productivity, but other nutrients such as carbon and silica are additionally required. There are two enrichment media that have been extensively used to grow most species of algae: Walne medium and the Guillard's F/2 medium. These commercially available nutrient solutions may reduce time for preparing all the nutrients required to grow algae.

Cultivation

Algae grow much faster than food crops, and can produce hundreds of times more oil per unit area than conventional crops such as rapeseed, palms, soybeans, orjatropha. As algae have a harvesting cycle of 1–10 days, their cultivation permits several harvests in a very short time-frame, a strategy differing from that associated with annual crops. Most research on algae cultivation has focused on growing algae in clean but expensive photobioreactors, or in open ponds, which are cheap to maintain but prone to contamination.

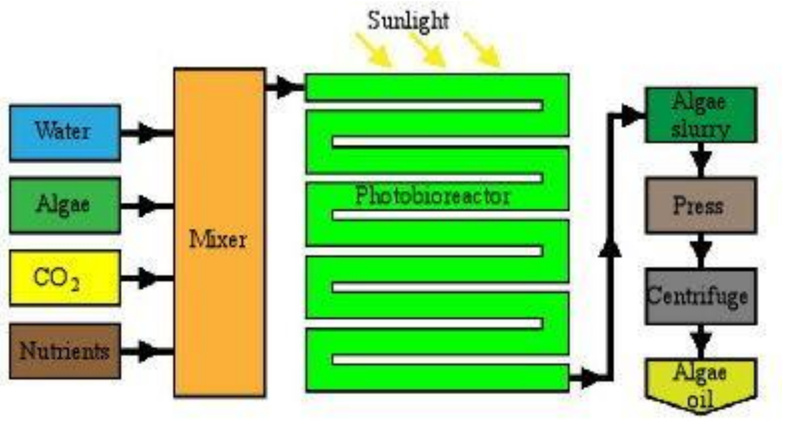
1-Closed- loop System

Closed systems (not exposed to open air) avoid the problem of contamination by other organisms blown in by the air. The problem for a closed system is finding a cheap source of sterile CO_2.



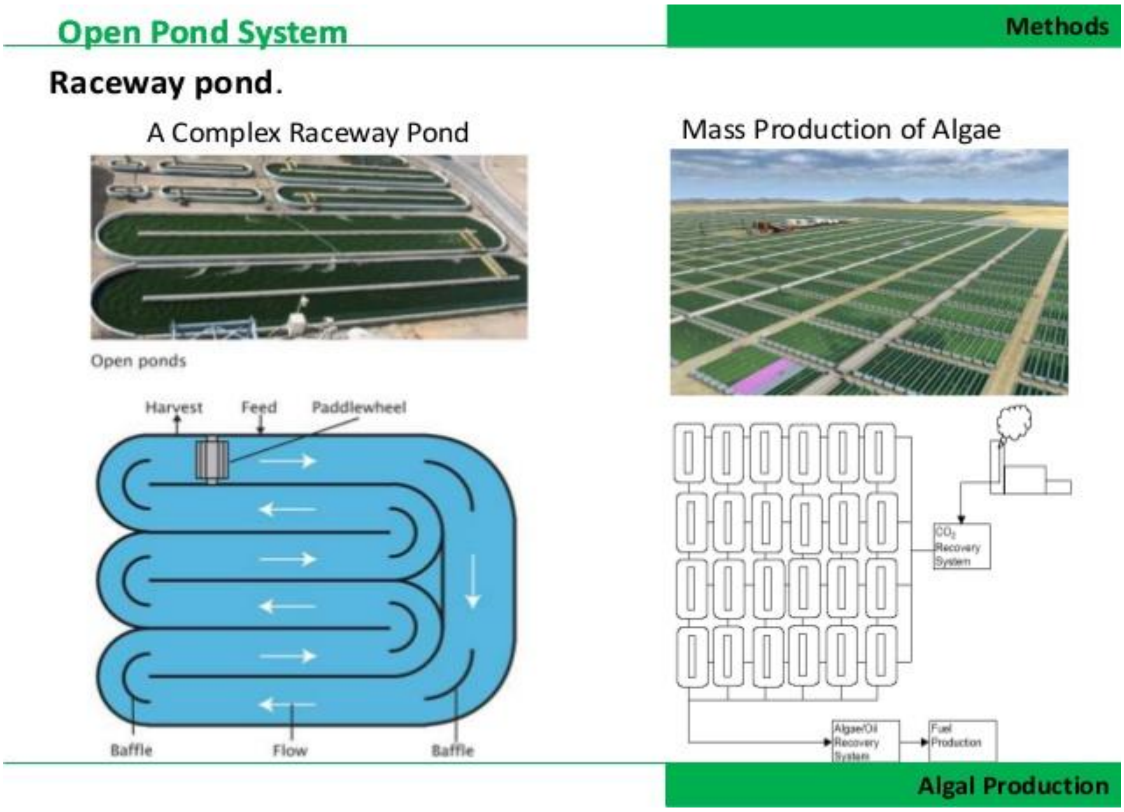
2-Photobioreactors

Most companies pursuing algae as a source of biofuels pump nutrient-rich water through plastic or borosilicate glass tubes (called "bioreactors") that are exposed to sunlight (and so-calledphotobioreactorsor PBR).



__3-Open pond__

Open-pond systems for the most part have been given up for the cultivation of algae with especially high oil content. Many believe that a major flaw of the Aquatic Species Program was the decision to focus their efforts exclusively on open-ponds;



Biofuels of Algae

__Biodiesel__

Microalgae are capable of producing large amounts of biomass and usable oil in either high rate algal ponds or photobioreactors.

This oil can then be turned into biodiesel which could be sold for use in automobiles. Regional production of microalgae and processing into biofuels will provide economic benefits to rural communities.

Biobutanol

Butanol can be made from algae or diatoms using only a solar powered biorefinery. This fuel has an energy density 10% less than gasoline, and greater than that of either ethanol or methanol. In most gasoline engines, butanol can be used in place of gasoline with no modifications.

The green waste left over from the algae oil extraction can be used to produce butanol. In addition, it has been shown that macroalgae (seaweeds) can be fermented by*Clostridia* genus bacteria to butanol and other solvents·

Biogasoline

Biogasoline is gasoline produced from biomass. Like traditionally produced gasoline, it contains between 6 (hexane) and 12 (dodecane) carbon atoms per molecule and can be used ininternal-combustion engines.

Methane

Methane, the main constituent of natural gas can be produced from algae in various methods, namely gasification, pyrolysis and anaerobic digestion. In gasification and pyrolysis methods methane is extracted under high temperature and pressure. Anaerobic digestion[52] is a straightforward method involved in decomposition of algae into simple components then transforming it into fatty acids using microbes like acidogenic bacteria followed by removing any solid particles and finally adding methanogenic bacteria to release a gas mixture containing methane.

Ethanol

The Algenol system which is being commercialized by BioFields in Puerto Libertad, Sonora, Mexico utilizes seawater and industrial exhaust to produce ethanol. Porphyridium cruentum also have shown to be potentially suitable for ethanol production due to its capacity for accumulating large amount of carbohydrates.

Fuel production

After harvesting the algae, the biomass is typically processed in a series of steps, which can differ based on the species and desired product; this is an active area of research and also is the bottleneck of this technology: the cost of extraction is higher than those obtained. One of the solutions is to use filter feeders to "eat" them. Improved animals can provide both foods and fuels. An alternative method to extract the algae is to grow the algae with specific types of fungi. This causes bio- flocculation of the algae which allows for easier extraction

Dehydration

Often, the algae is dehydrated, and then a solvent such as hexane is used to extract energy-rich compounds like triglycerides from the dried material. Then, the extracted compounds can be processed into fuel using standard industrial procedures. For example, the extracted triglycerides are reacted with methanol to create biodiesel via transesterification. The unique composition of fatty acids of each species influences the quality of the resulting biodiesel and thus must be taken into account when selecting algal species for feedstock.

Benefits of microalgal biofuels

Microalgae are a diverse group of single-celled organisms that have the potential to offer a variety of solutions for our liquid transportation fuel requirements through a number of avenues. Algal species grow in a wide range of aquatic environments, from freshwater through saturated saline. Algae efficiently use CO2, and are responsible for more than 40% of the global carbon fixation, with the majority of this productivity coming from marine microalgae. Algae can produce biomass very rapidly, with some species doubling in as few as 6 h, and many exhibiting two doublings per day. All algae have the capacity to produce energy-rich oils, and a number of microalgal species have been found to naturally accumulate high oil levels in total dry biomass. For example, some *Botryococcus* spp. have been identified that have up to 50% of their dry mass stored as longchain hydrocarbons. With potentially millions of species, algal diversity gives researchers many options for identifying production strains and also provides sources for genetic information that can be used to improve these production strains.

Microalgae have additional advantages over terrestrial plants. Since they are single-celled organisms that duplicate by division, high-throughput technologies can be used to rapidly evolve strains. This can reduce processes that take years in crop plants, down to a few months in algae. Algae have a reduced impact on the environment compared with terrestrial sources of biomass used for biofuels. They can be grown on land that would not be used for traditional agricultural, and are very efficient at removing nutrients from water. Thus, not only would production of algae biofuels minimize land use compared with biofuels.

Challenges for algal fuel commercialization

The high growth rates, reasonable growth densities and high oil contents have all been cited as reasons to invest significant capital to turn algae into biofuels. There are a number of hurdles to overcome ranging from how and where to grow these algae, to improving oil extraction and fuel processing. **The major challenges include strain isolation, nutrient sourcing and utilization, production management, harvesting, coproduct development, fuel extraction, refining and residual biomass utilization.**

Stability

The biodiesel produced from the processing of microalgae differs from other forms of biodiesel in the content of polyunsaturated fats. Polyunsaturated fats are known for their ability to retain fluidity at lower temperatures. While this may seem like an advantage in production during the colder temperatures of the winter, the polyunsaturated fats result in lower stability during regular seasonal temperatures.