Unique Dissolved Air Flotation Process Used to Harvest Algae for Biodiesel Research

By Jim McMahon

Figure 1: AHTO (Algae Harvesting Technology Optimized) Dissolved Air Flotation System in Operation at UC San Diego - Scripps Algae-Biodiesel Research Facility in the Sonoran Desert

An algae-based biodiesel research study conducted by the San Diego Center for Algae Biotechnology, a program of the University of California, San Diego (UCSD) in collaboration with the Scripps Institution of Oceanography, utilized a highly specialized patent pending dissolved air flotation system, AHTO® (Algae Harvesting Technology Optimized) to support its biodiesel research.

Algae thrive in fresh water and seawater, and all types of water up to a salinity of about 0.5 percent.

Designed and built by World Water Works, the system processed up to 9,000 gallons of algae-laden water per minute, at a 95 percent capture rate, yielding up to 20 percent algae concentrations.

Since 2008, the San Diego Center for Algal Biotechnology (SD-CAB) has been conducting research into algal applications for biofuel. This has been a joint collaboration between several departments of the University of California/San Diego faculty and students, the University's Scripps Institution of Oceanography, the Scripps Research Institute, as well as non-academic industrial corporate participants. In 2011, the Center moved beyond its campus-oriented algae research facility in San Diego and utilized a field laboratory in the Imperial Valley of California, about 100 miles east in the Sonoran Desert. One-acre ponds were made available by Carbon Capture Corporation, which also outfitted some of the on-site lab necessities.

The field location, which SD-CAB used for two months, gave the Center the opportunity to considerably expand its algae growing volume from in-laboratory vats to one-acre ponds. During this two-month effort, the ponds used by SD-CAB were the largest field laboratory of any academic institution in North America for the growing and research of algae for use as a biofuel.

Algae thrive in fresh water and seawater, and all types of water up to a salinity of about 0.5 percent (50 percent higher than seawater). It can grow in desert ponds, using high-saline water from aquifers that cannot otherwise be used. Algae growth is not dependent on a particular season, and can proliferate wherever there are nutrients and light. ☞ www.algae.ucsd.edu

Figure 2: UC San Diego-Scripps Algae-to-Biodiesel Research Team Aboard the AHTO at the Desert Harvesting Site

Having performed much prior in-lab research with the processing of smaller quantities of algae, the San Diego Center for Algae Biotechnology was well versed and outfitted with a) growing algae; b) handling the drying the biomass on racks to remove 90 percent of the water; c) extracting the oil with a screw press, then purifying it in a centrifuge; and d) converting the oil to biodiesel using a traditional open-processing reaction method. The algae would be tested first to determine the levels of free fatty acids and moisture content to determine what mixture of chemistry was needed, balancing the methanol and sodium hydroxide to effect the desired reaction. But the Center had little experience with how to harvest algae from one-acre ponds, which posed a considerable obstacle for the group.

"We knew, starting off, that the biggest challenge would be the harvest," says Kristian Gustavson, part of the UCSD student-led, algae-based biodiesel research study. "We could grow the algae all day long, and once we had the dry biomass we could turn it into fuel, but it was the matter of harvesting. We experimented with several methods that were not very successful."

Dissolved Air Flotation for Algae Harvesting

Gustavson was able to attract the interest of World Water Works, which had developed a unique dissolved air flotation system specifically equipped for the harvesting of algae from water. After careful review, the San Diego Center for Algae Biotechnology selected World Water Works' Algae Harvesting Technology Optimized (AHTO) dissolved air flotation system (DAF), which provided a highly efficient and compact treatment method.

AHTO is specifically tailored to algae harvesting. Pond water is pumped into the DAF where suspended solids in the form of algae are separated from the water by a process of dissolving air into the water under pressure, with the addition of a polyacrylamide flocculent. Upon release of that pressure, micro-bubbles form. These micro-bubbles interact with the algae particles, attaching to the biomass surface and affecting the particle density, causing them to float to the surface of the DAF. They are then skimmed with a chain and flight mechanism to a sieved Thickening Beach™. The Thickening Beach allows free water to be drained and thickens the algae particles, achieving an efficient liquids and biomass separation.

Patented Nikuni® air dissolving technology is used to create the robust whitewater in the AHTO system, which saturates the effluent pond water entering the DAF with atmospheric air.

Heavy sand and grit particles settle to the bottom, where a timer function controls the removal. The clean water is continuously removed from the DAF and piped back into the ponds, allowing new pond water laden with algae to enter for separation. ☞ **www.worldwaterworks.com**

"Within a few hours of receipt of the AHTO dissolved air flotation unit from World Water Works we had it up and running," says B. Greg Mitchell Ph.D,, Research Biologist and Senior Lecturer at Scripps Institution of Oceanography, UC San Diego, and Associate Director of SD-CAB. "We harvested a good amount of algae, which was pretty easy to dry. It was high quality biomass."

"Our collaborators at the Biodiesel Awareness Action Network (BAAN), at UCSD's Chemistry Department, were ready to convert the biomass into

Figure 3: UC San Diego-Scripps Ion Harvesting Site

fuel," continues Mitchell. "We got the chemistry set and were able to harvest continually from the ponds. We added fertilizer to the ponds as it was being harvested to keep it at a steady state where it was still growing in a nutrient rich environment, to help maximize the lipid content."

The AHTO process is a highly efficient system for separating algae from liquids. The system can achieve biomass removal efficiencies exceeding traditional DAF performance. Up to 9,000 gallons of algae-laden water can be processed per minute, at a 95 percent capture rate, yielding up to 20 percent algae concentrations.

"The DAF that World Water Works provided greatly accelerated our ability to harvest algae in our Imperial Valley facility," continues Mitchell. "We harvested a lot more algae, and more efficiently than with anything else we have used. It is the kind of system that many in this industry should be looking at using. The AHTO dissolved air flotation unit certainly appears to be the most effective way to harvest algae for biodiesel processing."

Algae, Biofuel of the Future

When processed properly, biodiesel runs cleaner and more efficiently than petroleum-based diesel, and provides needed lubricity to petroleum-based diesel. Use of biodiesel in a conventional diesel engine results in a substantial reduction of unburned hydrocarbons, carbon monoxide and carbon dioxide emissions, as well as particulate matter, according to the Department of Energy statistics.

Compared to crops used to produce vegetable oil for biofuels, algae is far more productive, able to generate up to 50 times the yield of oil per acre.

The San Diego Center for Algae Biotechnology scientists plan to make sustainable algae-based fuel production a reality within 5 to 10 years. Its goal is to create a facility that provides a national and global model for the commercialization of algae fuel.

As the popularity of alternative fuels gains momentum, biodiesel, and specifically algal-based biofuel, continues to strengthen its position as an attractive option to offset petroleum-based diesel usage. The introduction of non-commodity feed stocks like algae, along with attractive U.S. Federal and State subsidies both for biodiesel production and consumption, are inciting equipment manufacturers to develop better processing systems that are faster, safer and more efficient, such as the Algae Harvesting Technology Optimized DAF system used by the San Diego Center for Algae Biotechnology.

About the Author

Jim McMahon writes on wastewater and biofuel technologies. His feature stories have appeared in hundreds of industrial and high-tech publications throughout the world and are read by more than 5 million readers monthly.

San Diego Center for Algae Biotechnology was established in 2008 as a consortium of researchers from the University of California San Diego (UCSD), Scripps Institution of Oceanography, and the Scripps Research Institute to engage in algae-based biofuel research. The center collaborates with non-academic organizations to apply its algal laboratory discoveries to industry through robust research and development in biology, chemistry, and engineering.

World Water Works is a manufacturer of specialized process and wastewater technologies focused on performance, flexibility and longevity designed to yield clean water, and recover energy and resources. Our equipment and system designers are engineers, managers, operators, mechanics, and electricians. Some of our staff members have been educated at some of the finest engineering schools while others have had years of practical experience maintaining and operating water and wastewater systems in the field. This talented and diverse team provides multi-dimensional perspectives which yield robust, high-performance, lasting solutions.

To know more about the author, you can write to us. Your feedback is welcome and should be sent at: mayur@eawater.com. Published letters in each issue will get a one-year complimentary subscription of EverythingAboutWater Magazine.