

# Algaewheel Technology

## Product Development History

In 1995 Mr. Christopher Limcaco, began development of the algaewheel® technology because of his passion for aquatic life. His mission was to develop a filtration system that would allow him to completely recreate a natural environment within his aquarium. The system that was developed proved tremendously effective in achieving a naturally balanced eco-environment and the aquatic life within the aquarium thrived. Mr. Limcaco patented the technology and developed the manufacturing and shipping processes for the commercial distribution of algaewheel treatment systems through a company called Aquatic Engineers, Inc. In 2003 this technology was licensed to a firm now known as Aquariums By Design, and this company continues to provide service for hobby applications in the marine and tropical fish industry.

It was at this time that Mr. Limcaco truly had his “eureka” moment. Because Mr. Limcaco is a Professional Engineer specializing in wastewater treatment it was evident to him that the algaewheel technology could be refined for the purpose of treating typical domestic wastewater. Mr. Limcaco and his primary research partner, Mr. Joel Johnston, set out on a course of research and development that would require them to spend many years and hundreds of thousands of dollars to reach their goal. In 2004 the bacpac® system design was finalized and the first prototype built. This system provided remarkably effective wastewater treatment for small flow on-site applications. In 2008, Algaewheel licensed this technology to Oldcastle Precast, which has incorporated the technology into its onsite wastewater system package.

Mr. Limcaco and Mr. Johnston then set their eyes on incorporating the algaewheel technology into large scale applications. During 2007 and 2008 the algaewheel team worked to design a biological process for municipal wastewater. The team soon developed a system to efficiently treat wastewater, while at the same time significantly reducing energy usage, carbon footprint of the plant, and significantly reducing nitrogen and phosphorous. Algaewheel worked with various companies engaged in refining biomass and identified several processes best suited for algae biomass. Further research and testing proved that even relatively small wastewater treatment facilities using the algaewheel system could generate enough biomass to actually become “unplugged”. The Algaewheel team had found the holy grail of wastewater treatment: A system that treats water to regulatory standards, reduces nitrogen and phosphorous, zeros its carbon footprint, generates its own power, and costs the same or less than existing technologies.

During the development of its municipal application Algaewheel realized that its system’s ability to produce and harvest significant amounts of algae held value beyond wastewater applications. The marketplace has recently recognized the enormous potential for the lowly algae plant in many applications. Algae can be used as biomass to generate electricity, biomass to generate bio-fuels, carbon dioxide and other emission capture, coagulation of particulate emissions, and fertilizers to name a few. Therefore, Algaewheel has developed packaged systems that will allow users to develop algae technology for any application in which they are interested.

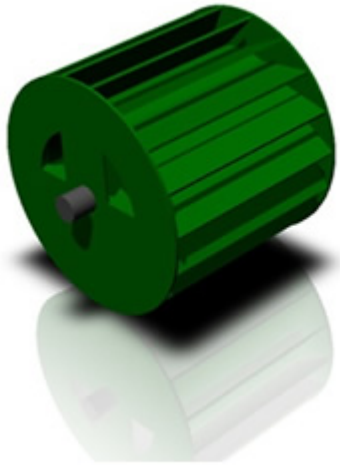
Algaewheel’s passion for the environment, its extraordinary vision, and perhaps good fortune has propelled it to marry one of man’s greatest inventions and one of nature’s greatest natural

processes into a technology that can change our world. Algaewheel has indeed reinvented the wheel, and it's green.

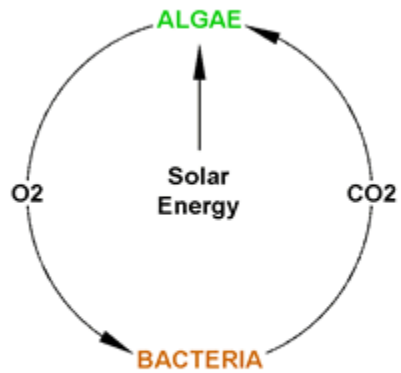
### How it Works

The technology was initially developed for use as an aquatic life support system in mariculture and aquaculture systems. The advantage of the algaewheel is in its name; it provides the proper environment for algal growth. Wave surging and light pulsing are basic environmental conditions required for algae growth and these are provided through the patented design. The wheel is designed to be significantly buoyant in water, requires no mechanical drive mechanism, and is rotated using a constant air flow. Each wheel is supported in water using a modular plastic grid system. The wheel and all components are made of UV stabilized reprocessed plastics, are lightweight, modular, easily assembled in the field, and corrosion proof.

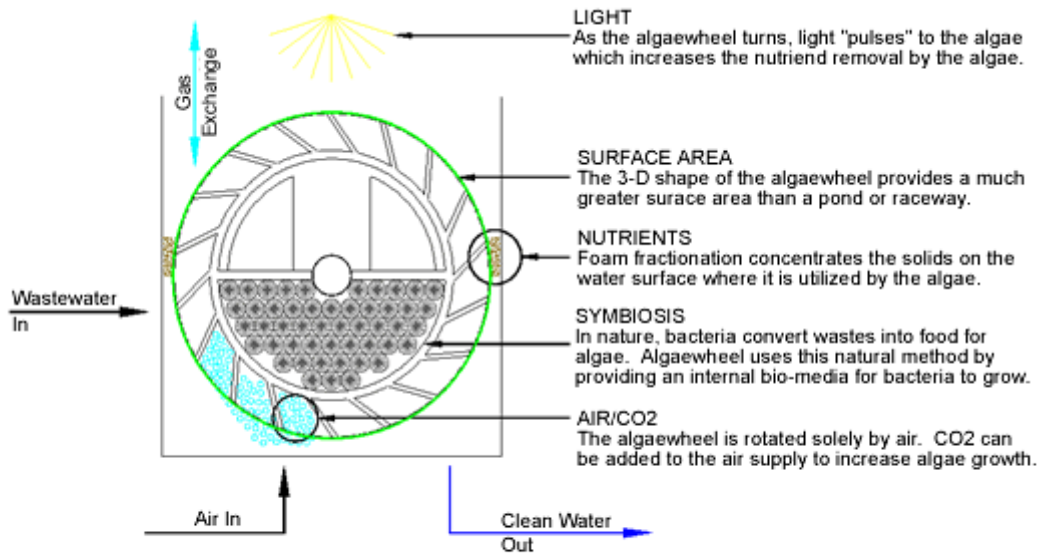
### Illustration of a single Algaewheel®



**The Wheel**



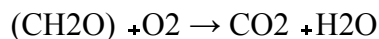
**The Elements**



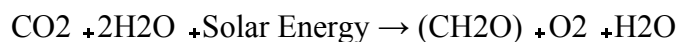
## The Process

### Why it Works

Functionally, the wheel offers a suitable environment where bacteria and algae work in a symbiotic fashion to efficiently synthesize living organic mass from the nutrients in a variety of wastewaters. Algae and bacteria function well together because each organism provides a vital source of energy for the other. Bacteria convert the available organic matter into carbon dioxide (CO<sub>2</sub>) which is readily useable by algae. Algae create oxygen (O<sub>2</sub>) which the bacteria use during cellular growth. Bacterial conversion of wastewater nutrients is generally represented in the following equation.



It is important to note that the O<sub>2</sub> consumed in bacterial treatment represents direct energy input since oxygen must be pumped into the treatment process by mechanical means. O<sub>2</sub> added through certain photosynthetic organisms such as algae is generally represented by the following equation where solar energy provides the energy needed to supply oxygen for bacterial conversion.



As the above equations suggest, there is a mutually beneficial relationship between bacteria and algae. By removal of organic carbon at the front of the process and introduction of CO<sub>2</sub> into the algaewheel system, we can maximize algal biomass production by limiting the competition from bacteria. Maximizing biomass production using a variety of nutrient rich wastewater sources gives the algaewheel a major advantage over bacteria-based treatment processes. Oxygen produced by algae through photosynthesis replaces the need for costly mechanical oxidation of the wastewater. Also the symbiotic relationship between algae and bacteria provide a balanced

environment where wastewater nutrients are most efficiently converted into biomass in less time and less cost. The high value biomass generated in our system can also be used in a variety of renewable energy applications and other beneficial uses such as bio-fuels, fertilizers, nutritional and pharmaceutical products, feed additives, and more.