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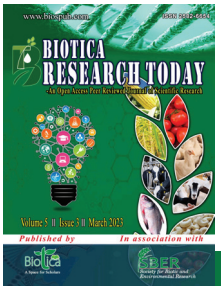

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Advancements in Algae Culture through Raceway System

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Abstract

In recent years, Raceway reactors are becoming popular because of its less cost of construction and mixing energy requirements. The raceways are considered as a most practicable technology for the microalgal energy generation. The raceway pond is 0.25-0.30 m deep closed recirculation canal and algal broth is continuously mixed by the paddlewheel. Paddlewheels are considered as the most efficient technique for creating flow in raceways. Dead zone development is eliminated by deflector baffles. Open raceway ponds are frequently employed for the commercial production of algal biomass. Even though the raceway method of production of algae is slightly costlier than other algal mass culture methods, it finds its place in production of biomass for Biodiesel, Lipids, Pigments and carotenoids, neutraceutical industries.

Keywords: Algae, Algal biodiesel, Paddle wheel, Raceway Tank

Introduction

Most of the algal products are employed in nutrition, medicine, and cosmetics; practically all the important nutrients such as fatty acids (unsaturated), vitamins, minerals, pigments and carotenoids. Microalgae absorb inorganic carbon through photosynthesis, which includes two stages, namely light-dependent (light reactions) and light-independent (dark reactions). The Sustainable and alternative energy produced continuously to replace the use of commercial environment polluting fuels (Kusmayadi *et al.*, 2020). Microalgae is considered as a source of renewable transportation fuels because of its rapid growth rate, it doubles in mass in an hour and sue to their high lipid content, which is used for the production of biofuels. In recent years, Raceway reactors are becoming popular because of its less cost of construction and mixing energy requirements, which is low as 4 W m^3. Hence the raceways are considered as a most practicable technology for the microalgal energy generation (Jorquera *et al.*, 2010).

The History of Raceway

In 1950s, the raceway ponds are known as "high-rate algal ponds," because it was utilised to treat the wastewater in various forms. W.J. Oswald laid foundation for this technology, so it was also termed as Oswald ponds. Raceway culture is used commercially to grow algae and relatively high-value species in United States and some South-East Asian countries. The mass production of microalgae and cyanobacteria in raceways is firmly developed in many countries at present.

Locating the Site

The location site (land topography and geology) for raceway-based production facility must be carefully selected because an ideal climatic condition is required for high productivity in a year. The mean temperature level and sunlight intensity is found to have a greatest impact on productivity throughout the year. Temperature roughly 25 °C is found to be excellent, with minimal diurnal and seasonal change. In addition, precipitation, wind velocity, flood, humidity, risk of cyclone, dust particles and atmospheric pollutants are found to be important factors. Physico-chemical factors of water must be taken into account. Another factor to consider is the cost of land.

Design Considerations of the Raceway Tank

Raceway tanks should possess separating structure at

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the middle. Circulation of algal suspension around the separating wall is the prominent role of paddle wheels (Figure 1). The Raceway bottom is usually made of sand, which in turn covered with an UV-resistant plastic liner. The pond walls are made up of bricks followed by wrapping of synthetic sheets. Lining must be set neatly to prevent bottom wrinkles and water gathering behind the lining. Open raceway method is frequently used for the large-scale microalgae farming because it is easy to scale-up with simple design and operation. To prevent the microalgal biomass accumulation in raceway, mixing is performed continuously. Thorough mixing ensures adequate light dispersion and nutrient availability, heat and CO_2 consumption, which in turn results resulting in more efficient photosynthesis and better biomass yield. The raceway tank composed of a 0.25-0.30 meters deep closed-loop recirculation canal. Individual ponds of 2.5 hectares are utilised for treating wastewater, while single ponds are used for algal biomass with seldom surpassed 0.5 ha.

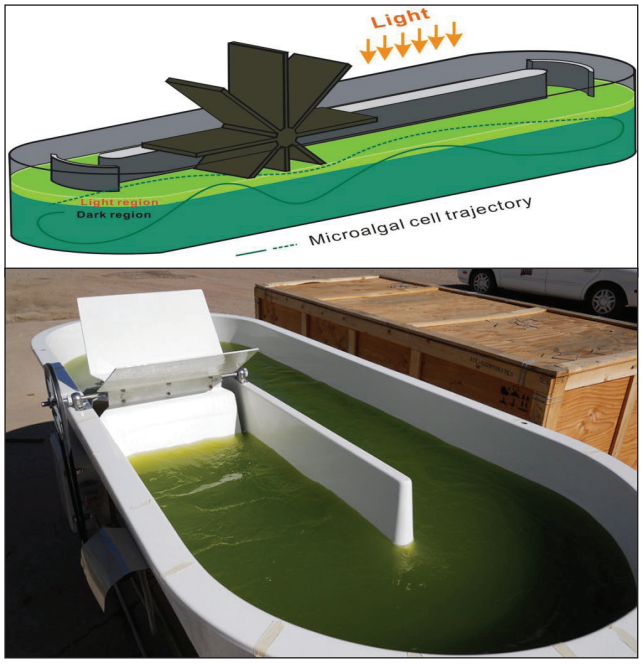

Figure 1: The structure of Raceway tank

Paddlewheel Design

Paddlewheels are considered as the most efficient technique for creating flow in raceways. To eliminate paddlewheel interference, just one paddlewheel having eight blades is typically used (Figure 2). The blades are usually flat; however, bent blade paddlewheels are occasionally employed. Flat bottom surface is mostly preferred for the raceway channels. The paddlewheel's bottom and side clearances should not exceed 0.02 m in its design. During rotation, the height of each blade should be in such a way that water does not tumble over the top edge. Static water depth, the greatest head created by rotation and additional allowances determines the paddles height.

Deflector Baffles

Deflector baffles are frequently installed in the curved end tanks (Figure 3). The baffles ensure a uniformity of flow throughout the curved bend and minimize the formation of dead zones. Dead zones create negative impact in mixing and permits sedimentation which leads to unwanted energy losses.

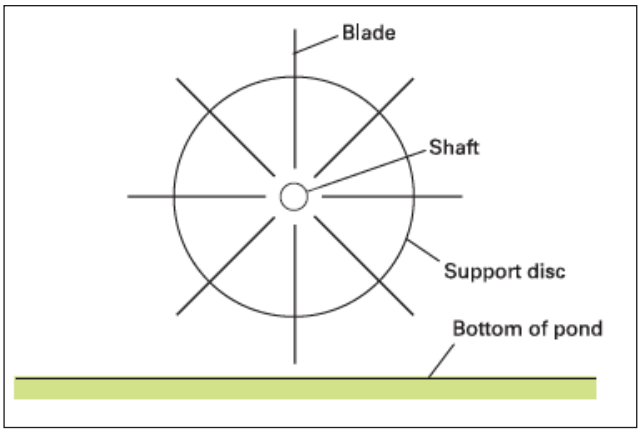

Figure 2: Paddle wheel

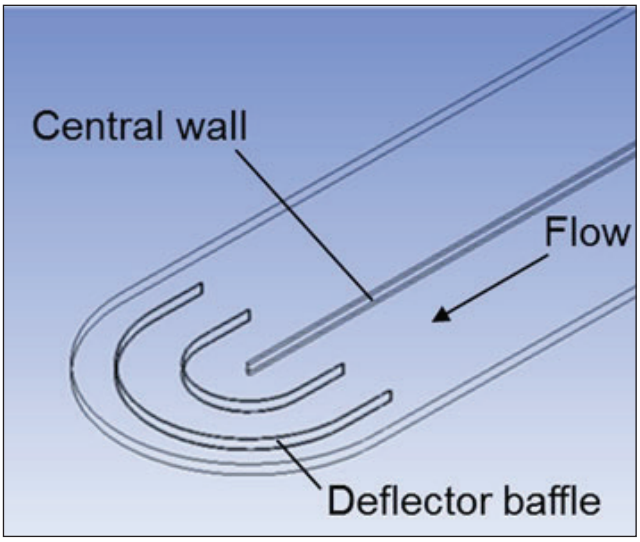

Figure 3: Position of deflector baffle in the raceway tank

Temperature and Evaporation in Raceway

The algae to be produced should be suitable for the local climate. Solar irradiation, evaporation and air temperature all influence the temperature in the raceway system; because it is impractical to manage the temperature in large raceways. The algal biomass productivity more or less constantly maintained all over the year in raceways located in tropical climates because of warm uniform temperature with low diurnal temperature change. Evaporative loss and increase in salinity tackled by addition of freshwater constantly. Irradiance, wind, temperature and absolute humidity are prominent factors in affecting the evaporation rate. In some tropical locations, mean evaporation rate of 10 L m^{-2} d^{-1} recorded for freshwater. Under the same climatic conditions, freshwater evaporates faster than the seawater in raceway tank.

Carbon Supply and Oxygen Inhibition

In raceways, carbon dioxide diffused as bubbles by microporous gas diffusers. At the bottom of the raceway channel, gas diffusers are positioned. Removable diffusers

from gas distribution tube should be used in raceway tank for cleaning and replacement purpose. Inorganic carbon must be provided as bicarbonate in the culture system. This might potentially lower the cost of supplying carbon. Oceanic algae may not be able to grow in alkaline pH environments because marine salts precipitate at pH levels above 8. The conventional raceway system has no mechanism for oxygen removal other than the paddlewheel agitation. Sparging the culture regulates the accumulation of oxygen. Despite having a large surface area in relation to the culture depth, raceway ponds have poor oxygen removal and the dissolved oxygen concentration rises substantially during peak photosynthesis. The quantity of dissolved oxygen in saturated water can surpass 300% during peak sunny weather. The rate of photosynthesis reduces in the presence of dissolved oxygen and thereby it reduces the biomass productivity. Dissolved oxygen plays a vital role in microalgal biomass composition. The addition of air to the pond may lower the oxygen inhibition of photosynthesis, but this needs energy. Improved biomass production made achievable by lower oxygen inhibition has been claimed to compensate for the energy involved with this sparging. The smaller pond accomplishes higher oxygen removal than the bigger tank for a given fluid depth. This is due to the fact that in a small tank, efficiency of the paddlewheel is greater than the bigger tank. This explains why small tanks are often claimed to be more productive than bigger tanks when placed under the same conditions.

Conclusion

In this article, the layout and execution of raceway tanks for the production of microalgal biomass were examined. Open raceway ponds are commonly used for large-scale commercial algal biomass production. Even though the raceway method of production of algae is slightly costlier than other algal mass culture methods, it finds its place in production of biomass for Biodiesel, Lipids, Pigments and carotenoids, neutraceutical industries.

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