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Wastewater Treatment Smart Tip

Algal Treatment for Wastewater Treatment Plants

Introduction

A new process to enhance water treatment and minimize energy consumption is gaining traction in Water Resource Recovery. The concept is to minimize the need for mechanical aeration for treatment processes and make use of nutrients in wastewaters rather than just removing and disposing of them. Lagoon operators have long known that algae, when properly managed, can provide dissolved oxygen to lagoon ponds without detrimental impact to the treatment process. New advances in algal treatment technology pass the benefits of algal treatment from lagoons to other treatment plants.

Early Algal Wastewater Treatment Systems

In the 1950's high-rate algal ponds (HRAP) were developed. Designed as an improvement on traditional lagoon treatment to generate algae for biofuels and bioplastics production, HRAP's are shallow raceways that encourage the growth of microalgae. As algae grows and is exposed to sunlight, it absorbs nutrients from the wastewater, increasing its biomass. It also absorbs CO2 produced by bacteria in the treatment stream and emits dissolved oxygen into the pond, which supports the bacteria. Sunlight penetrating the shallow waters provides purification of harmful microbes and allows for photosynthesis through the entire water column for the algae.

Due to their shallow depth, HRAPs take up a lot of land area. In addition, they are typically constructed outdoors, which makes them susceptible to seasonal temperature impacts to their treatment efficacy. Lastly, recovering algae from the ponds requires the addition of a coagulant chemical and separate basin for removal, usually through dissolved air floatation. Despite a large land footprint, treatment energy needs are only about 0.02 kWh/m3 (75.7 kWh/MG) of flow.[1] The current average for Illinois wastewater treatment plants is around 0.69 kWh/m3 (2,600 kWh/MG). Total nitrogen and phosphorus removal rates of 75% and 40-45%, respectively, have been achieved with HRAP systems.

Figure 1 image source: https://www.energy.gov/eere/bioenergy/algal-production
Credit to Sapphire Energy.

[1] *https://sswm.info/pavitr-toolkit/getting-know-pavitr-technologies/high-rate-algal-ponds-%28hraps%29#:~:text=Design%20considerations&text=Depending%20on%20the%20climate%2C%20the%C2%B7ha%E2%88%921%C2%B7d*

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Modern Algal Wastewater Treatment Systems

Modern algal treatment systems attempt to reduce the footprint of these ponds while retaining their ability to remove nutrient loads from wastewater streams. Also, they make harvesting the algae easier by fixing the biomass growth to a medium that is easily cleaned. One technology is the Gross-Wen Revolving Algal Biofilm (RABTM) System, and the other is the OneWater AlgaeWheel®. Both systems have smaller footprints than HRAPs and fit inside a greenhouse structure, which provides access to sunlight for the algal treatment process and protection from temperature swings. As with HRAPS, they maintain very low energy intensities for the treatment process. Where they differ is in the method of shrinking their process footprint.

The Gross-Wen Revolving Algal Biofilm (RABTM) System

The RABTM System grows the algal biofilm on a set of vertical conveyor belts that alternate the biofilm between a wastewater basin and the air. In the basin, algae encounter nutrients in the wastewater that are absorbed to grow the algal biomass and supply dissolved oxygen to the bulk fluid. In the air, the algae are exposed to sunlight and CO2 for photosynthesis. The algae are scraped off the conveyor belts into a harvesting receptacle for conversion into fertilizer, biofuel, bioplastics, or other side-stream products. These byproducts can become an additional revenue source for the plant. Energy consumption is limited to the conveyor belt motors and any supplemental lighting that may be desired to improve the algal growth.

Total nitrogen and phosphorus removal rates for this system have been as high as 87% and 80%, respectively, with ammonia and ortho-phosphorus removal rates of 100%. These removal rates are affected by water temperatures, but as the system is housed in a heated greenhouse structure, temperature impacts can be minimized.

The OneWater® AlgaeWheel® System

The Algaewheel® system uses floating paddlewheels as the growth medium for the algal biomass. The core of the wheels also houses polymer media for the growth of bacterial biomass. Oxygen produced by photosynthesis from the algae is taken up by bacteria growing on media inside the wheels, and CO2 produced by the bacteria is taken up by the algae, creating a symbiotic ecosystem for wastewater treatment. As with the RAB system, Algaewheel is housed in a temperature-controlled greenhouse to protect the process from temperature swings and provide access to sunlight for algal growth. A regenerative blower system is used to rotate the wheels using bubblers in the treatment basins and is the only energy consumer for the process. OneWater estimates the energy consumption at 0.1 kWh of energy per pound of BOD removed. The system is usually used for small on-site WWTPs or side-stream treatment, such as the supernatant from digesters. Effluent nutrient levels <10 mg/l total nitrogen and <1 mg/l total phosphorus are attainable with the system.

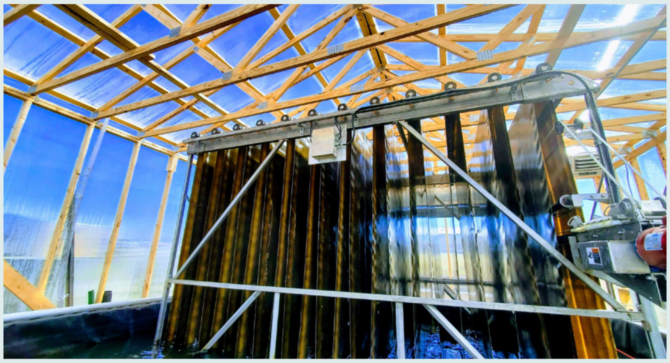

Figure 2 Image source: https://algae.com/

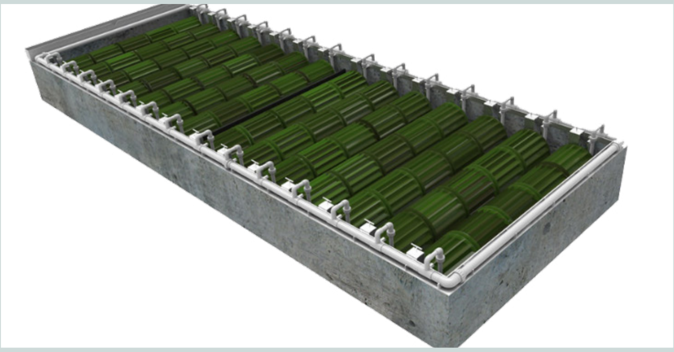

Figure 3 image source: https://algaewheel.com/