

EMERGING REVOLVING ALGAE BIOFILM SYSTEM FOR ALGAL BIOMASS PRODUCTION AND NUTRIENT RECOVERY FROM WASTEWATER

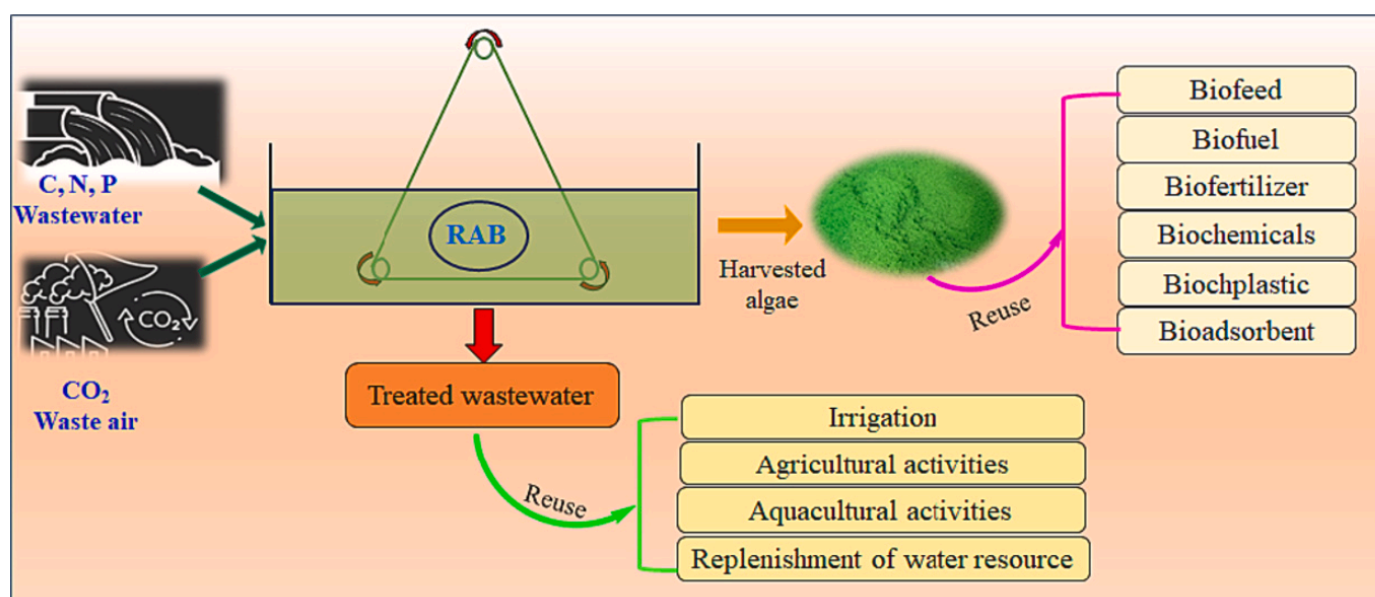
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ABSTRACT

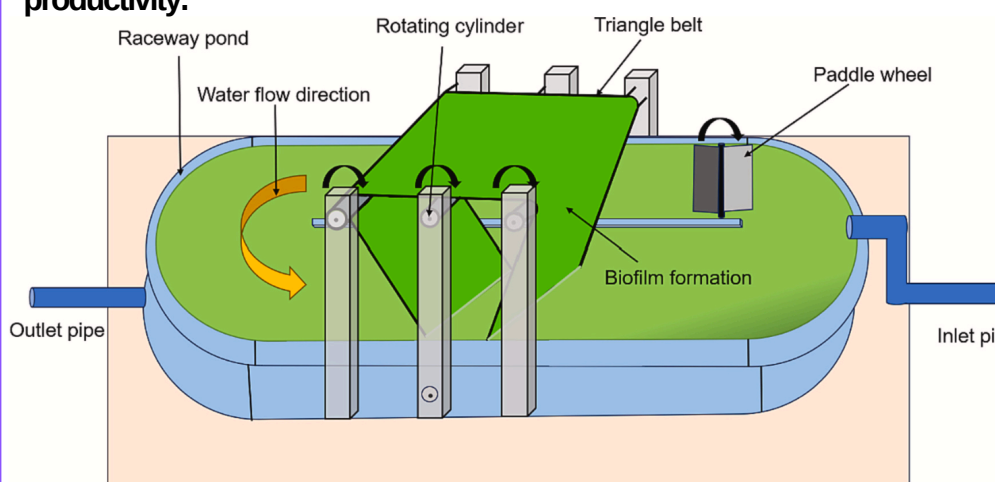
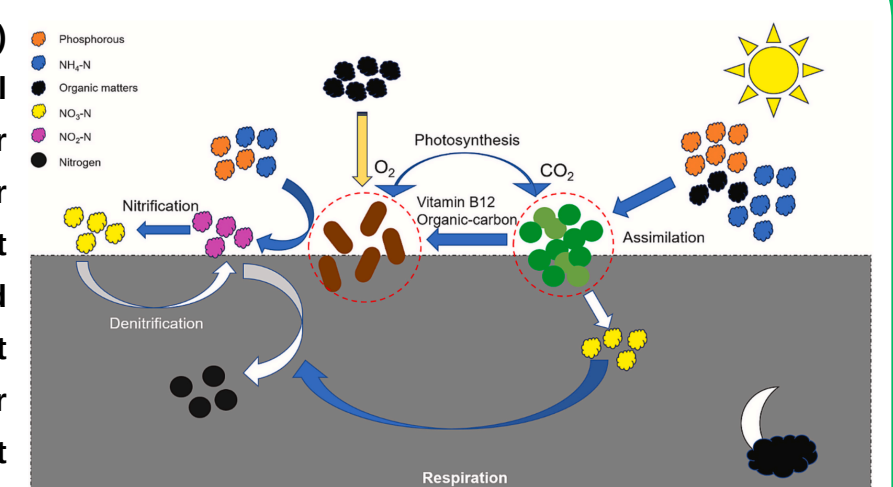
Toward the direction of zero-carbon emission and green technologies for wastewater treatment, algae-based technologies are considered promising candidates to deal with the current situation of pollution and climate change. Recent developments of algae-based technologies have been introduced in previous studies in which their performances were optimized for wastewater treatment and biomass production. Among these, revolving algae biofilm (RAB) reactors have been proven to have a great potential in high biomass productivity, simple harvesting method, great CO₂ transfer rate, high light-use efficiency, heavy metal capture, nutrient removal, and acid mine drainage treatment in previous studies. However, there were few articles detailing RAB performance, which concealed its enormous potential and diminished interest in the model. Hence, this review aims to reveal the major benefit of RAB reactors in simultaneous wastewater treatment and biomass cultivation. However, there is still a lack of research on aspects to upgrade this technology which requires further investigations to improve performance or fulfill the concept of circular economy.

INTRODUCTION



REVOLVING ALGAE BIOFILM REACTOR (RAB)

The Revolving Algae Biofilm (RAB) reactor, based on rotating biological contactors (RBCs), is designed for efficient algae cultivation and wastewater treatment. Unlike traditional methods that often struggle with moisture content and productivity, RAB incorporates flat attachment materials, such as triangular and vertical belts, to improve nutrient absorption, light exposure, and biomass productivity.



The algae biofilm grows on these belts, which are partially submerged in water, allowing for nutrient uptake, and partially exposed to air for light and gas exchange, enhancing photosynthesis.

RAB offers high efficiency in wastewater treatment by co-cultivating algae and bacteria, utilizing extracellular polymeric substances (EPS) to bind heavy metals, such as nickel, and remove other contaminants like sulfate and total dissolved solids (TDS). Studies have demonstrated RAB's high nickel removal efficiency (>90%) and impressive biomass productivity, especially when using cellulose-based materials like cotton fabrics.

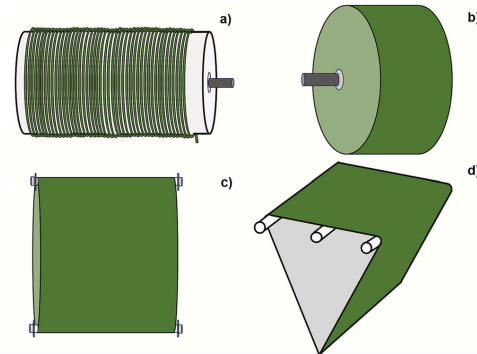
DISTINCTIVE POINTS OF RAB

Superior light utilization: RAB's flexible design (cord, drum, vertical, triangular) optimizes light exposure and air exchange, boosting photosynthesis and biomass productivity.

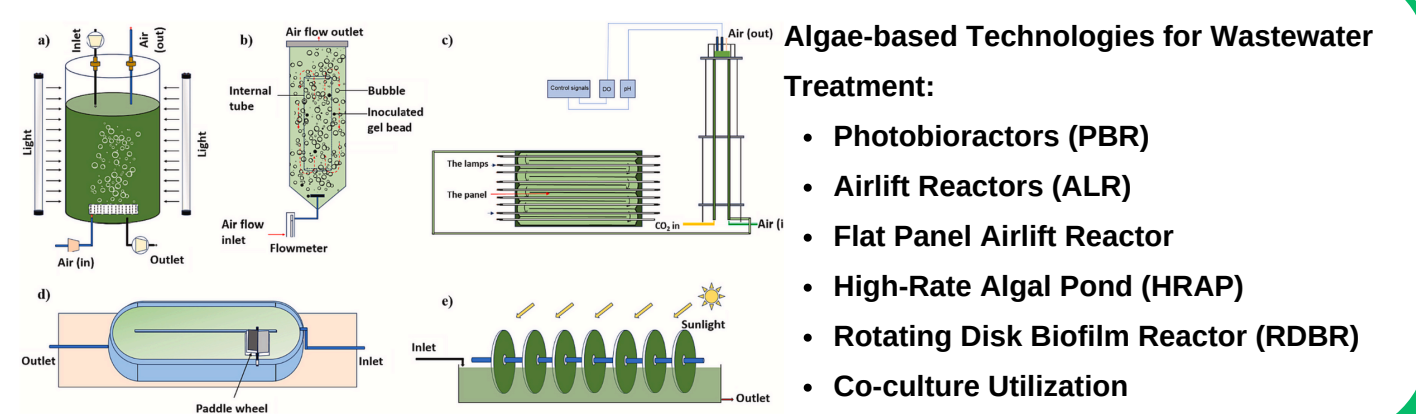
Efficient harvesting: Simple harvesting methods reduce energy use by 83% and lower production costs by 30%.

Nutrient recovery: RAB efficiently removes nitrogen and phosphorus, cutting eutrophication risks. Microalgae-bacteria synergy enhances treatment, saving aeration energy.

Flexibility and scalability: RAB adapts to various biofilm configurations and algae strains, offering potential for biofuel, bioproducts, and wastewater treatment, driving down operational costs.



CONFIGURATION OF ALGAE-BASED TECHNOLOGIES



Algae-based Technologies for Wastewater Treatment:

- Photobioractors (PBR)
- Airlift Reactors (ALR)
- Flat Panel Airlift Reactor
- High-Rate Algal Pond (HRAP)
- Rotating Disk Biofilm Reactor (RDBR)
- Co-culture Utilization

CONCLUSIONS

The RAB system excels in both microalgae cultivation and wastewater treatment. Its innovative revolving biofilm design enhances light exposure, gas transfer, and nutrient absorption, resulting in high biomass productivity with low moisture content. This reduces energy costs and streamlines processing.

Economic and Environmental Impact: By using wastewater as a nutrient source, RAB can produce valuable outputs such as biofuels, bioproducts, and biofertilizers, aligning with several Sustainable Development Goals (SDGs), including sustainability and community development.

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