# Microalgae-based wastewater treatment for nutrients recovery

The world may face deficits of water supplies in the decades ahead, for both potable water and water for irrigation, due to human population growth, droughts and floods due to climate change, contamination of water resources, and lack of technologies to reclaim used water. This will result in formidable challenges for societal and economic development. Meanwhile, large amounts of wastewater with excessive nutrients are generated by urban, agricultural, and industrial activities, which could inevitably cause eutrophication of the aquatic environment. Conventional nutrient (pollutant) removal methods are facing challenges to meet stringent discharge standards, with more efficient removal, and at lower operating costs.
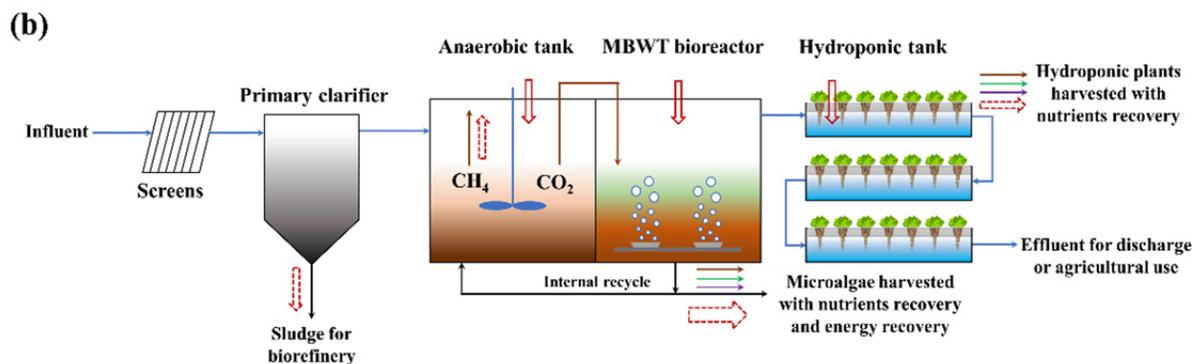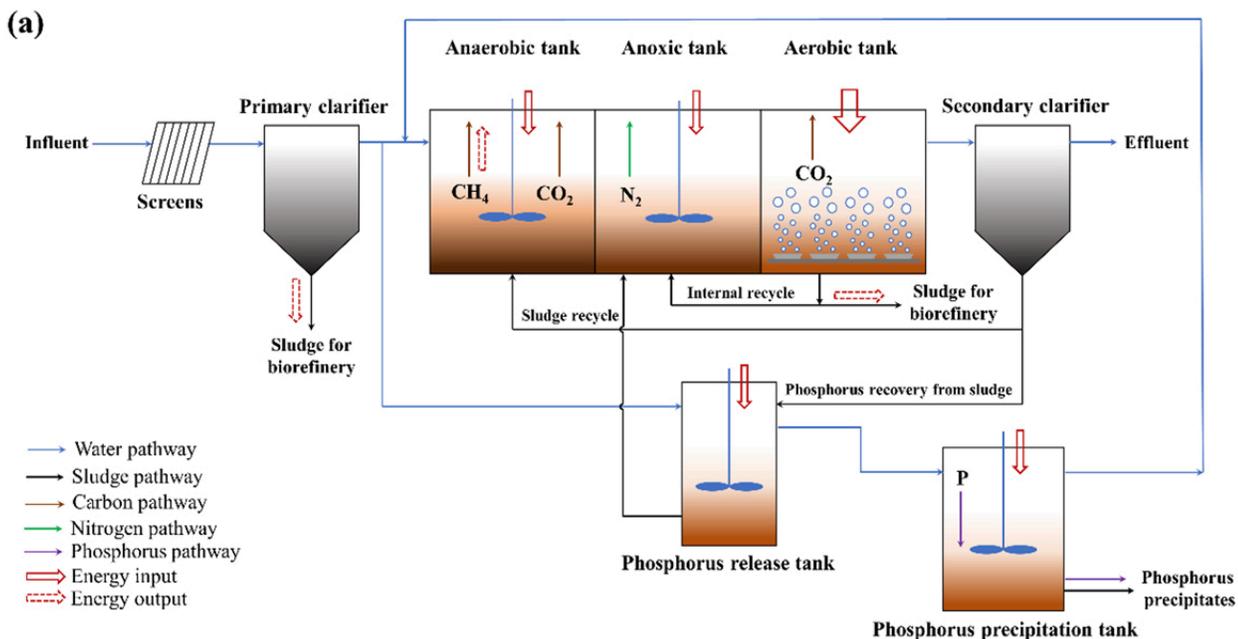
Note: In most situation the pathways of CNP follow the same ones of water and sludge which are not repeated in this diagram.

Fig. 1. Comparison between (a) nutrient recovery enhanced conventional wastewater treatment process, and (b) typical MBWT hybrid process.

Microalgae-based wastewater treatment (MBWT) has demonstrated that it has the potential to meet these challenges, to improve wastewater treatment through utilization (as shown in Fig. 1). The feasibility of using microalgae as a supplement for tertiary wastewater treatment, has been proven by many researchers, for its high efficiency of nutrient removal. Algae, cultivated on waste streams, provides significant benefits over traditional cultivation and treatment processes:

(1) wastewater is treated at a reduced cost since many pollutants are assimilated by microalgae;

(2) microalgae could remove nutrients in wastewater to a very low level, which will meet the increasingly stringent discharge and reuse standards;

(3) microalgae could be transformed into carbon-neutral fuel with inorganic carbon sources or other biogenic carbon sources such as wastewater treatment plants (WWTPs);

(4) microalgae can metabolize the moisture and nutrients provided in wastewater, without (or with very limited) supplemental water and nutrients. Therefore, MBWT has the potential to reduce production costs and greenhouse gas emissions, and minimize the use of fossil based fertilizers; and

(5) the harvested microalgae can be converted to value-added products, such as biogas, biofuels, fertilizers, and feed for animals.

However, considering the issues related to the complexity of wastewater characteristics, adaptability of microalgae species, and the challenges for the design and optimization of treatment processes in order to achieve higher removal efficiencies at lower costs, further exploration and research are still needed. This review provides an overview of microalgae strains commonly used for wastewater treatment, physical and chemical properties of various wastewaters and their suitability for algae cultivation, factors affecting algae growth, nutrient assimilation and removal, biomass productivity, wastewater characteristics, light intensity and light-dark cycle, C/N and N/P ratios, additional carbon sources, cultivation mode, and symbiosis. The design and operation of MBWT processes are also discussed. Moreover, the issues and limitations of microalgae-based wastewater treatment, including the effect of light shading, *V/S* ratio, and cost effectiveness, are also discussed. Finally, future prospects and suggestions are proposed for further research and development.

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