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Continuous cultivation of Chlorella vulgaris using condensate derived from agricultural biogas digestate

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The search for alternatives to conventional synthetic culture media, capable of ensuring both high biomass productivity and sufficient availability of essential macronutrients such as nitrogen, remains a key factor determining the feasibility of large-scale microalgae cultivation. In this context, the present study explores the use of digestate as a nutrient source for microalgal growth. Digestate, obtained as a by-product of anaerobic methane fermentation in an agricultural biogas plant, was subjected to thermo-pressure fractionation. This process enabled the separation and recovery of a liquid fraction rich in nitrogen compounds, which was subsequently applied as a culture medium.

The experimental work focused on the cultivation of *Ch. vulgaris*, a widely studied green microalga with high biotechnological potential.

Biomass production was carried out in tubular photobioreactors with a working volume of 70 L, using a culture medium prepared based on the chemical composition of 3N-BBM+V. Nitrogen compounds in the culture medium were derived from condensate obtained during the thermal treatment of digestate originating from an agricultural biogas plant. A 0.25% dose of nitrogen compounds from the standard culture medium was added to the reactors and supplemented, in varying proportions, with ammonium compounds contained in the condensate.

Microalgae were cultivated under semi-continuous conditions. Following biomass growth, ammonium compounds were automatically dosed using pumps to maintain the desired concentration level. Three nitrogen loading variants were tested: 50, 100, and 150 mg N/L.

The results confirm that digestate-derived condensate can serve as an efficient nutrient source for microalgae cultivation while enabling simultaneous nutrient recovery and biomass production.

Optimal nitrogen concentration was identified at ~100 mg N/L. The system exhibited characteristics typical of continuous cultivation, with an initial growth phase followed by the establishment of steady-state conditions. The maximum biomass concentration (1.8 g/L) was achieved at a nitrogen loading of 100 mg N/L. At lower nitrogen loading, nutrient limitation was observed, resulting in reduced biomass accumulation (~1.1 g/L). In contrast, higher nitrogen loading led to signs of inhibition and decreased productivity. Biomass production and nutrient removal can be effectively coupled in a continuous system. A dynamic equilibrium was established after approximately 6–8 days, as indicated by stable biomass concentrations.

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