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Dilution of anaerobic digestates with agro-industrial effluents for the sustainable and low cost production of microalgal biomass

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PURPOSE OF THE ABSTRACT

Microalgae and cyanobacteria have attracted a lot of attention for their ability to accumulate a large range of valuable compounds including carbohydrates, lipids, pigments, vitamins and proteins [1]. Several studies reported the use of these microorganisms to treat various municipal and industrial wastewaters [3] as well as CO2-based gaseous effluents [2]. New potential fields of application are currently being developed notably for bioremediation, biofuel production, energy applications, development of biomaterials, etc. [4]. Despite this growing interest, high cultivation costs are still a critical factor for the large-scale production of microalgal biomass, limiting the diversification of microalgae-based applications [5].

In this context, an important number of studies have been carried out to develop efficient solutions for the cost-effective production of microalgae. For instance, the use of liquid digestate produced from the anaerobic digestion (AD) of organic wastes appears as a promising and sustainable solution. Indeed, AD digestate are highly available, inexpensive and rich in essential nutrients such as nitrogen (N), phosphorous (P) and other minerals. Moreover, the rapid development of the biogas industry in Europe has accelerated the need of new digestate processing and treating technologies [6], [7]. However, there are some limiting factors for a direct use of liquid digestate (i.e. high turbidity of liquid digestate, high amount of ammonium-nitrogen, etc.) which can potentially inhibit the microalgal growth. Thus, pretreatments such as water-dilution are often used to reduce the digestate toxicity, bringing forward environmental issues due to the high energy and water demand [8]. Therefore, this study investigated the feasibility of cultivating Spirulina microalgae using AD digestate diluted with different agro-industrial effluents instead of freshwater.

Four liquid digestates from various AD units (agricultural, urban, biowaste and dairy) and two agro-industrial effluents (geothermal effluent and brewery waste stream) were selected to perform the cultivation assays. In the first part of the study, several dilution rates (0, 2, 5, 20, 40 and 60) were tested to evaluate the optimal growth using tap water. The cultures were carried out in aerated 200 mL glass tube using 40 mL of Spirulina (Teramer®, FRANCE) as inoculum, supplementing with corresponding amount of fresh water and digestate. Sodium bicarbonate was added as carbon source at a concentration of 8 g.L-1. Experiments were conducted in duplicate under a continuous LED illumination (intensity of 60 µmol.m?2.s?1) and a controlled temperature (25 ± 3°C). Growth of Spirulina cultivated in liquid digestate was compared to the growth observed by using an artificial cyanobacteria culture medium (Cyanobacteria BG-11 Freshwater Solution, SIGMA). Experimental results showed that dilution factors of 2, 20, 20 and 60 were the most suitable for the algal proliferation in the dairy, urban, agricultural and biowaste AD digestates, respectively.

In order to reduce the use of fresh water, additionnal cultivation tests were realised using the two agro-industrial effluents, combined with the best dilution rate found previously. Promising results were obtained with the geothermal effluent with all the four AD digestates tested, presenting an average maximal growth rate of $\mu max=0.30 \pm 0.04$ d-1 compared to $\mu max=0.35 \pm 0.01$ d-1 for Spirulina growth on BG11 medium. Further experiments will be conducted at higher scale using 10 L flat panel photobioreactors in order to confirm these cultivation performances. Finally, the Spirulina biomass will be harvest and characterize to evaluate its biochemical composition.

FIGURES

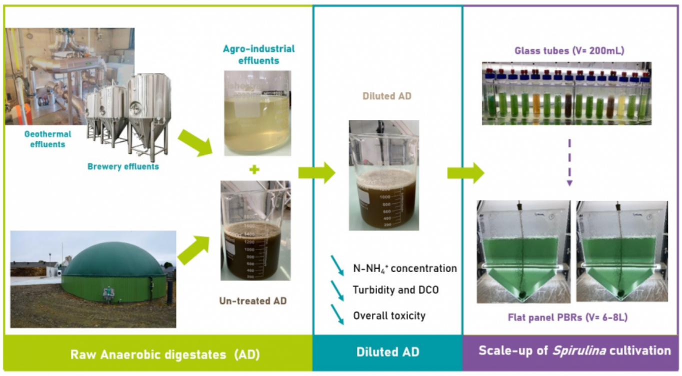

FIGURE 1

Graphical abstract

Experimental procedure

FIGURE 2

KEYWORDS

anaerobicdigestion | microalgae | watertreatment | biotechnology

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