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Bioremediation of cattle manure using microalgae after pre-treatment with biomass ash

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ABSTRACT

In this work, cattle manure was diluted and pre-treated with biomass ash to yield a liquid fraction and a solid precipitate. Microalgae grown in the liquid fraction, in batch and semi-continuous mode, achieved maximum biomass productivities of 522.9 and 554.3 mg L^{-1} day^{-1} (12 days) for *Chlorella protothecoides* and *Tetradesmus obliquus*, respectively. Nutrient removal efficiency was highest for the semicontinuous mode with replacement of 10% of reactor volume every 48 h. The produced algal biomass was characterized for its nutrient composition. Both, algal biomass, and precipitate aqueous extracts, were evaluated as biostimulants for wheat and watercress seeds Increments in the germination index were 177% for wheat with *Chlorella protothecoides* and 34% for watercress with *Tetradesmus obliquus*. The strategy adopted in this work is coherent with circular economy principles, combining effluent treatment with the production of added-value materials that could be used as biostimulants or animal feed additives.

1. Introduction

The growth of world population leads to a significant pressure on natural resources such as soil and water, namely by accumulation of wastes produced by different activities, and their dispersion in the environment. Wastes and effluents from animal production are among those with higher contents of nutrients and microorganisms that may contribute to soil contamination and eutrophication of water bodies (Zouboulis et al., 2015). Dairy farms produce massive quantities of manure and wastewaters that cannot be drained into conventional wastewater treatment plants or deposited in landfills, and that exceed the demand of such organic wastes for fertilizer applications as soil amendment agents (Markou et al., 2018). The treatment of these effluents generally requires multiple methods to efficiently decrease their chemical oxygen demand (COD), nitrogen content and microbiological contamination thus constituting a significant economic load for animal producers.

Currently the two most used solutions for manure treatment are the deposition in open ponds to reduce moisture and subsequent dispersion in soils, and the anaerobic digestion of its liquid fraction (Font-Palma, 2019). The deposition in the soil causes high risks of soil and ground water contamination and is a source of considerable gas emissions. Anaerobic digestion implies tight control of the operating parameters and a high dilution ratio, so that microorganisms are not inhibited by high nitrogen concentrations, being a limited solution for processing large volumes of manure (Siddique and Wahid, 2018).

Microalgae have been used in the bioremediation of effluents as an alternative to more complex and expensive conventional treatment (Ferreira et al., 2018; Patel et al., 2017; Suganya et al., 2016). Microalgae are ubiquitous and not very demanding microorganisms, as well as resistant and easy to handle, that have shown high efficiency in the remediation of different agro-industrial effluents (Batista et al., 2015; Ferreira et al., 2019, 2018; Gramegna et al., 2020; Labbéa et al., 2017). This solution could constitute a complementary alternative to anaerobic digestion and does not involve significant costs. Nevertheless, the high solids content of manure and its high degree of microbial contamination require the use of adequate pre-treatment processes before microalgae could be successfully used for nutrient removal.

Microalgae have been used to remediate the liquid fraction of cattle effluents, but only after high dilution to reduce soluble and suspended components, and the produced algal biomass has been used for biofuel production (Beevi and Sukumaran, 2014; Gramegna et al., 2020; Hena

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