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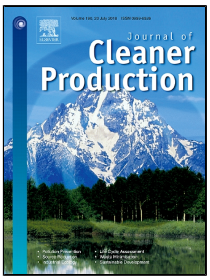

Carbon and nutrient recovery in the cultivation of *Chlorella vulgaris*: a Life Cycle Assessment approach to comparing environmental performance.

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Carbon and nutrient recovery in the cultivation of *Chlorella vulgaris*: a Life Cycle Assessment approach to comparing environmental performance.

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Abstract

Microalgae cultivation is arousing interest for its ability to provide biomass for food, feed and energy. Microalgae are more efficient in converting solar energy into biomass than terrestrial plants, and microalgae cultivated in a mixotrophic mode showed a higher biomass productivity. This work aimed to evaluate the environmental impacts of the cultivation of microalgae in autotrophy and mixotrophy and to define under what conditions mixotrophic cultivation gives the best environmental performance. To make this comparison, primary data of *Chlorella vulgaris* cultivation in autotrophy and mixotrophy were used. The scenarios considered were autotrophy (Scenario 1); mixotrophic cultivation on cheese whey, (Scenario 2); and mixotrophic cultivation using dairy wastewater (cheese wastewater) (Scenario 3). In addition, since commercial nitrogen fertilizers are one of the major contributors to the environmental impact of *Chlorella* production, two other scenarios were modelled: autotrophy on recovered nitrogen from digestate (Scenario 4) and mixotrophic culture on recovered nitrogen and carbon (Scenario 5). The mixotrophic growth of microalgae was shown to be an environmentally effective process (i.e. it showed a decrease of the impact categories), when the organic carbon provided had no other allocation and could be considered free of a cost burden. The cultivation of microalgae on recovered nitrogen and recovered carbon was found to decrease the CO_2 emission by almost 60% and similar decreases were obtained for the other impact categories in comparison with autotrophy. A value of CO_2 emission equal to 1.05 kg CO_2 eq. kg^{-1} of microalgae was achieved for Scenario 5, and a decrease of more than 50% was assessed for the impact categories: Marine eutrophication, Human toxicity, Freshwater ecotoxicity, Marine ecotoxicity and Fossil fuel depletion

Keywords: *Chlorella vulgaris*; Cheese whey; LCA; Microalgae; Mixotrophy; By-products.

1. Introduction

Microalgae are photosynthetic microorganisms which convert sunlight, water, carbon dioxide, inorganic N and P into algal biomass and thus into valuable organic compounds such as lipids (in particular Poly Unsaturated Fatty Acids), proteins, pigments, biopolymers, animal feed products, nutraceuticals and pharmaceuticals (Pulz and