METHODOLOGICAL CHALLENGES FOR LCA OF ALGAE-BASED PRODUCTS IN A BIOREFINERY CONTEXT

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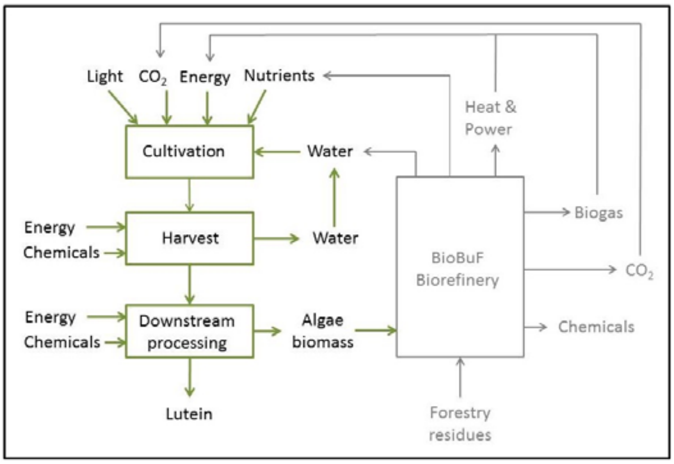
Cultivation of microalgae for bulk product purposes is often associated with high environmental impact due to relatively low yields and intensive use of energy and nutrients. Integrating microalgae cultivation with existing industries is a possibility to improve the environmental performance of algae production by addressing the input flows. Therefore, integration of microalgae production systems with industrial waste streams (nutrients, water, CO_2 and heat) is in focus of this study. Through a detailed literature review we can highlight inconsistencies in data and give recommendations for LCAs.



In the BioBuF-biorefinery, algae will produce the high value compound lutein and provide inputs to further processes in the biorefinery. Lutein is a carotenoid for which there is now an increased interest because it may decrease the risk of age-related macular degeneration. Lutein is accumulated in the human retina and protects it from free radicals produced by blue light.

Lutein is today extracted from Marigold flowers grown primarily in Asia and South America, a process that is resource and labor intensive.

Marigold flowers

Limiting points for process integration:

Energy is a key input in microalgae production. Production of microalgae demands large amounts or electricity where possibilities for integration are minor. For supply of heat, industrial waste heat provides an option. Important issues to considered are the amount and quality of heat, site specific conditions, alternative uses of heat i.e. for district heating, seasonal variation in supply, if the equipment is possible to use in a heat integrated system. Heat is required to maintain culture temperatures at optimum, drying of biomass, improving extraction efficiency and evaporation or recovery of solvents used in downstream processing.

Nutrients are necessary for optimal growth of microalgae. Large scale microalgae production will require huge inputs of fertilizers. An option to reduce this is to use waste waters. The chemical composition of the biomass depends on strain and the nutrient content in the cultivation medium. N-starvation may lead to accumulation of lipids but a slower growth rate. Depending on which form the N has in the waste water a volatilization of N can occur and reduce amount of N available for microalgae and contribute to increased emissions of N_2O which is a potent greenhouse gas. An issue with the use of waste water is the high N:P ratio, especially if industrial waste waters are considered.

Water is a critical issue for microalgae cultivation. In reviewed LCAs, there are inconsistencies in the methods used to calculate water use. There is also a regional aspect since water scarcity is a larger problem in certain regions. Also the evaporation rate depends on the local climate. Issues related to recycling of process water are accumulation of inhibiting compounds and organisms and increased salinity. There are also lack of large scale experimental data that shows the effects of recycling process water many dozens times.

CO_2 is used as carbon source in photoautotrophic growth of microalgae. In an integrated biorefinery this can be supplied from flue gases from a power plant or industry. The CO_2 content of flue gases can vary considerably and potential pollutions in the gas may harm the algae or restrict the uses for the products. The CO_2 uptake efficiency depends on growth factors such as light intensity, temperature and availability of nutrients and the amount of CO_2 dissolved in the growth medium. In an open system part of the CO_2 will be lost to air. The transportation distance is critical since this requires a lot of energy.

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