LIFE CYCLE ASSESSMENT (LCA) OF AN INDOOR PILOT AQUAPONICS PRODUCTION FACILITY IN BELGIUM.

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Introduction

Aquaponics arouses a growing interest as a sustainable way to produce fish and vegetables in an integrated system. The main advantages of aquaponics production are water saving and reduced sewage that can be achieved through nutrient cycling. On the other side, several challenges raised from this method as it is energy demanding and often provides sub-optimal growing conditions for fish and/or vegetables in coupled systems (Junge et al., 2017). Sustainability of such systems must be assessed through a global approach taking into account not only the production processes but encompassing also upstream (structure and equipment) and downstream (product distribution and by-product valorisation) impacts. Life Cycle Assessment (LCA) is a method that can be used to investigate the sustainability of production systems such as aquaponics (Forchino et al., 2017). We performed a full analysis of an aquaponics pilot system built in Belgium in 2017. The LCA covers the infrastructure construction, presently completed, and a prediction of system running based on a production model.

Materials and methods

The building hosting the pilot aquaponics system was made in aerated concrete blocks (thermal transmittance U = 0.31W/m²K) with dimensions: 14.6 x 7.1 x 3.5m (l x w x h). The fish culture equipments include 6 GRP rearing tanks (total volume = 6.4m³), a GRP sump tank (1m³), a drum filter (250W; backwash pump 1.1kW), a moving bed biofilter (2m³), a pump (1.1kW), an air blower (1.5kW), a UV sterilizer (120W) and electrical heating (9kW). The system was designed for a yearly production of 1 ton of tilapia (*Oreochromis niloticus*) and 6 tons of vegetables. The plant culture equipments are composed of 50m² of deep water culture tanks (wood and liner) installed on a 3-level structure and artificial LED lighting (6kW). The building is equipped with a double flow ventilation system. System boundaries for LCA were set using a cradle-to-gate approach. Input data were divided in 6 macro-categories: (1) "Heating" (energy consumption for the air and water heating), (2) "RAS + LED" (energy consumption of the recirculated aquaculture system and LED lighting), (3) "Infrastructure" (construction materials used for the building), (4) "Transportation" (for the calculation, a standard range of 50 km was set for material providing), (5) "Water use" (annual water consumption of the system) and (6) "System" (physical equipments). The functional unit (FU) is defined as 1kg of produced vegetables. Fish (tilapia) was considered as a co-product and the allocation was calculated on the base of the expected produced biomass. Calculations were performed using SimaPro® version 8.0.3.14 (PRè, 2014).

Results

The LCA of the aquaponics production system revealed 3 main macro-categories regarding their environmental impact: “RAS + LED”, “Heating” and “Infrastructure” (Fig. 1). In particular, the energy consumption needed for heating and RAS + LED functioning represents from 64% (acidification) up to the 80% (abiotic depletion) of the total impact contribution. “Infrastructure” showed the highest contribution for acidification (21.9%) and eutrophication (14.8%) impact categories. Contributions of the other macro-categories are less relevant, except for “Transportation”.

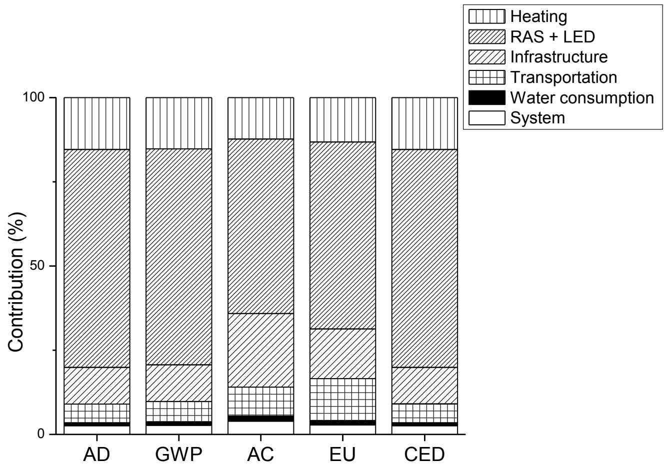

Fig 1. Contribution analysis of the aquaponics production system. AD: abiotic depletion; GWP: global warming potential; AC: acidification; EU: eutrophication; CED: cumulative energy demand.

Discussion

The present analysis underlined that energy consumption and infrastructure represent the most important sources of impacts of the aquaponics facility. Moreover, these macro-categories are linked each other. In fact, the energy consumption due to the heating activities could be reduced by increasing the insulation performance of the building. On the other hand, this increment will increase the contribution to impacts of the infrastructure. Even if the present analysis was run considering a standard distance of 50 km for the provision of all the equipment, the LCA suggests that transportation should be taken into account as a possible source of impact for the aquaponics facility. Thus, minimizing the distance for the provision would be fundamental to reduce impacts deriving from this macro-category. Finally, the present study underlined the importance of LCA as an useful tool to find new technical solutions aimed at increasing the sustainability of aquaponics and expanding this practice at a wider scale.

References

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