APPLICATION OF THE LIFE CYCLE APPROACH TO THE SET-UP OF A PILOT AQUAPONIC FACILITY IN BELGIUM.

A. A. Forchino[1], V. Gennotte[2,3], C. Mélard[3], D. Brigolin[1], R. Pastres[1]

[1]Department of Environmental Sciences, Informatics and Statistics (DAIS), University of Ca' Foscari, Via Torino 155 Venezia Mestre, Italy.

[2]CERER Pisciculture asbl, Chemin de la Justice 10, 4500 Tihange, Belgium.

[3]Aquaculture Research and Education Centre (CEFRA), University of Liège, Chemin de la Justice 10, 4500 Tihange, Belgium.

E-mail: andrea.forchino@unive.it

Introduction

Aquaponics is a technique which combines recirculating aquaculture systems (RAS) with hydroponic cultivation. In the last decades aquaponics gained increasing attention as a sustainable way of producing fish and vegetable for human consumption (Karimanzira et al., 2017). However, previous studies, suggest that the environmental and economic sustainability of aquaponics is still a controversial subject matter. Flexible assessment tools such as Life Cycle Assessment (LCA) and Life Cycle Costing (LCC), allow one to investigate the whole process, from the design up to the operating phases (Boxman et al., 2017; Forchino et al., 2018). The aim of the present study is the combined application of LCA and LCC to highlight critical aspects related to the construction of an indoor pilot aquaponic facility in Belgium.

Materials and methods

The aquaponic system (total volume = 19 m³) is hosted in a 104 m² aerated concrete building. The RAS is composed of 6 GRP rearing tanks (total volume = 6.4m³), 2 GRP sump tanks (1m³), a GRP swirl separator (3m³), a drum filter (100W; backwash pump 1.1kW), a moving bed biofilter (1.5m³), 2 circulation pumps (500W), an air blower (1.3kW), a UV sterilizer (90W) and a heat pump (1.1kW). The system was designed for a yearly production of 700kg of tilapia (*Oreochromis niloticus*) and 3 tons of vegetables. Hydroponic cultures are arranged on 3 levels and made of 33m² of deep water cultures and 17 m² of NFT equipped with LED lighting (7.2kW). The building is equipped with a double flow ventilation system (1kW) and an air heater (2kW). For both LCA and LCC, system boundaries were set using a cradle-to-gate approach and all the primary data used for the calculation were collected during the construction phase of the system. Input data were grouped in 4 categories: (1) "BUILDING" (i.e. all the materials used to construct the building hosting the aquaponic system), (2) "RAFT" (i.e. the hydroponic cultivation equipment), (3) "Pumps" (i.e. air and water pumps), (4) "RAS" (i.e. the recirculating aquaculture unit). The functional unit is defined as "the building of an aquaponic indoor system for the production of 700kg of tilapia and 3 tons of vegetables." Calculations were performed using the SimaPro® software.

Results

The results of LCA and LCC contribution analysis are reported in Figure 1. For all the LCA impact categories the main contributions were found for "BUILDING" (AD = 29.77%; GWP = 41.80%; AC = 37.97%; EU = 37.10%), RAS (AD = 43.67%; GWP = 35.53%; AC = 37.70%; EU = 40.12%) and RAFT (AD = 24.71%; GWP = 21.46%; AC = 23.24%; EU = 21.87%), while impacts linked to "PUMPS" appeared definitely limited (AD = 1.85%; GWP = 1.22%; AC = 1.09%; EU = 0.92%). On the contrary, this latter category showed an important contribution for LCC representing about the 16% of the total expenditure. However, concerning this analysis, the higher economic burdens are linked to the “RAS” equipment (43.76%) and “BUILDING” (27.54%) while the contributions of “RAFT” appeared to be lower (12.48%).

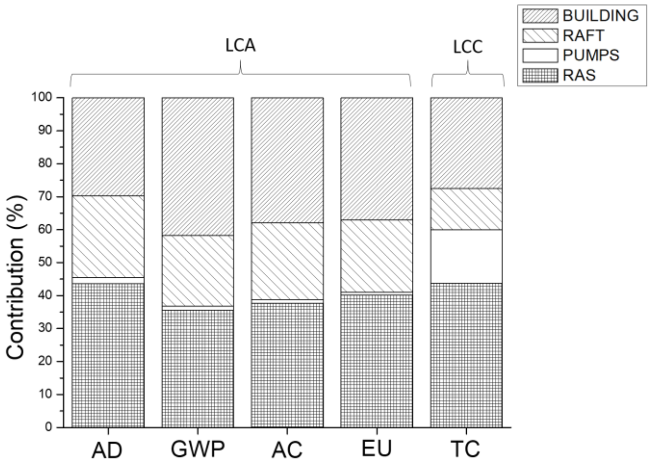

Figure 1. LCA and LCC contribution analysis. AD: Abiotic Depletion; GWP: Global Warning Potential; AC: Acidification; EU: Eutrophication; TC: Total Cost.

Discussion and conclusion

Even if previous studies suggested that Life Cycle Thinking represents a useful approach to evaluate the burdens of an aquaponic system, only a limited number of work is available in the literature, nowadays (Boxman et al., 2017; Forchino et al., 2017; Forchino et al., 2018; Maucieri et al., 2018). In this respect, the present work represents an interesting case study, focusing the attention on the impacts linked to the construction of an aquaponic system. A specific element of strength of the study presented here is the use of only primary data. The combined application of LCA and LCC underlined that “RAS” equipment represented the most relevant critical issue in the system set up, in terms of both environmental and economic impact. The extended lifespan considered for the building hosting the aquaponic system (25 years) limited the contribution of this category to the overall impacts. The comparison of LCA and LCC results showed that environmental and economic impacts are, in some instances, not correlated. This appeared quite clearly in relation to “PUMPS” category, which showed the lower percentages of contribution for all the impact categories of the LCA but represented a quite important item of expenditure for LCC. Thus, only the combined application of LCA and LCC will allow to get a more complete picture of the sustainability of aquaponics.

References

Boxman S.E., Zhang Q., Bailey D., Trotz M.A., 2017. Life Cycle Assessment of a commercial freshwater aquaponic system. Environmental Engineering Science 34(5): 299-311.

Forchino AA, Lourguioui H, Brigolin D, Pastres R, 2017. Aquaponics and sustainability: the comparison of two different aquaponic techniques using the Life Cycle Assessment (LCA). Aquacultural Engineering 77: 80-88.

Forchino A.A., Gennotte V., Maiolo S., Brigolin D., Mélard C., Pastres R., 2018. Eco-designing Aquaponics: a case study of an experimental production system in Belgium. Procedia CIRP, IN PRESS.

Karimanzira D., Keesman K., Kloas W., Baganz D., Rauschenbach T., 2017. Efficient and economical way of operating a recirculation aquaculture system in an aquaponics farm. Aquaculture Economics & Management 21(4): 470-486.

Maucieri C., Forchino A.A., Nicoletto C., Junge R., Pastres R., Sambo P., Borin M., 2018. Life cycle assessment of a micro aquaponic system for educational purposes built using recovered material. Journal of Cleaner Production 172: 3119-3127.