Sustainability assessment of blue biotechnology processes: addressing environmental, social and economic dimensions

Paula Perez-Lopez, Gumersindo Feijoo, Maria Moreira

Sustainability assessment of blue biotechnology processes: addressing environmental, social and economic dimensions

Paula Pérez-López[1,2*], Gumersindo Feijoo[1] and Maria Teresa Moreira[1]

[1] Department of Chemical Engineering, Institute of Technology, University of Santiago de Compostela. 15782 - Santiago de Compostela, Spain

[2]MINES ParisTech, PSL Research University, Centre Observation, Impacts, Energie (O.I.E.), 1 rue Claude Daunesse CS 10207, 06904 Sophia Antipolis Cedex, France

* Presenter: P Pérez-López; E-mail address: paula.perez_lopez@mines-paristech.fr

Biotechnology is a wide industrial sector that ranges from high value, low volume products such as pharmaceuticals to low value commodities such as biofuels. The main effort to date has focused on implementing processes effectively to meet the regulatory demands more than optimizing the operations or analyzing sustainability, especially in the case of pharmaceuticals[1].

Life Cycle Assessment (LCA) is one of the available methodologies to measure bioprocess sustainability holistically, although few LCAs applied to bioactive compounds and pharmaceutical ingredients are reported in literature[2,3]. In the specific case of marine biotechnology, the LCA studies conducted to date mainly analyzed the cultivation and extraction of fractions from microalgae and seaweed focusing on biofuels production[4]. Although different bioenergy sources have been evaluated, including renewable diesel, bioethanol or biogas, most of the work dealt with the production of biodiesel by transesterification. Few examples of LCA studies dealing with the production of fine chemicals and bioactive compounds from marine sources are available, due to the lack of information from commercial-scale facilities[3,4]. The studies generally rely on extrapolations and simulation models rather than field data from operating systems[4].

Moreover, according to the principles of sustainable development, measuring sustainability for supply chain decision-making requires the integration of social and economic dimensions together with environmental aspects[5]. An integrated framework for Life Cycle Sustainability Analysis (LCSA) has been proposed, combining conventional LCA with social LCA (SLCA) and LCC[6].

In this work, the sustainability of a blue biotechnology process, namely the production of the red carotenoid astaxanthin by the green microalga *Haematococcus pluvialis*, is evaluated. Process data for the inventory were collected from real facilities at lab, semi-pilot and pilot scale. A socio-economic assessment was conducted according to a Social LCA and a cost-benefit approach. The study allowed the identification of electricity, mainly consumed for cultivation, as the major contributor to the environmental impacts. In addition, a remarkable improvement associated with the scale-up of the process was observed. The conducted socio-economic evaluation completed the sustainability assessment, identifying the main strengths of the process from a holistic perspective.

References:

[1]Woodley JM. New opportunities for process systems engineering in industrial biotechnology. In: De Brito Alves RM, Oller do Nascimento CA, Chalbaud Biscaia E (eds.). Computer Aided Chemical Engineering, Elsevier, 2009, 27:157-162.

[2]Jiménez-González C, Woodley JM. Bioprocesses: Modeling needs for process evaluation and sustainability assessment. Computers & Chemical Engineering 2010; 34(7):1009-1017.

[3]Pérez-López P, Ternon E, González-García S, Genta-Jouve G, Feijoo G, Thomas OP, Moreira MT. Environmental solutions for the sustainable production of bioactive natural products from the marine sponge *Crambe crambe*. Science of the Total Environment 2014, 475:71-82.

[4]Collet P, Hélias A, Lardon L, Steyer JP, Bernard O. Recommendations for Life Cycle Assessment of algal fuels. Applied Energy 2015, 154:1089-1102.

[5]Hutchins MJ, Sutherland JW. An exploration of measures of social sustainability and their application to supply chain decisions. Journal of Cleaner Production 2008, 16(15):1688-1698.

[6]Sala S, Farioli F, Zamagni A. Life cycle sustainability assessment in the context of sustainability science progress (part 2). International Journal of Life Cycle Assessment 2013, 18(9):1686-1697.