Journal of Cleaner Production 82 (2014) 16–22

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Review

Unresolved issues in the accounting of biogenic carbon exchanges in the wine sector

Ioannis Arzoumanidis [a,*], Pere Fullana-i-Palmer [b,c], Andrea Raggi [a,*], Cristina Gazulla [b], Marco Raugei [b,d], Gabriela Benveniste [c], Marta Anglada [c]

[a] Department of Economic Studies, University "G. d'Annunzio", Viale Pindaro 42, 65127 Pescara, Italy
[b] UNESCO Chair in Life Cycle and Climate Change (ESCI-UPF), Passeig Pujades 1, 08003 Barcelona, Spain
[c] Cyclus Vitae Solutions S.L., Passeig Pujades 1, 08003 Barcelona, Spain
[d] Oxford Brookes University, Wheatley Campus, OX33 1HX Wheatley, UK

ARTICLE INFO

Article history:
Received 20 December 2013
Received in revised form
7 June 2014
Accepted 25 June 2014
Available online 2 July 2014

Keywords:
Carbon footprint
Cork
Wine
Biogenic carbon exchanges
Carbon dioxide (CO_2)

ABSTRACT

Carbon Footprint (CF) can be of great importance for the dissemination of life-cycle information of products. The use of CF has recently increased, despite some methodology aspects being still not sufficiently addressed. This paper deals with the accounting of biogenic carbon exchanges, focusing on the wine sector, which has been the object of several life-cycle-based studies. A review of guidelines, standards and key papers has shown that there are still unresolved issues to be considered when accounting for exchanges of biogenic carbon, such as forest management, agricultural practices and land use, soil erosion, the inclusion of all parts of a tree, the inclusion of the end-of-life phase, etc. As a result, no clear-cut conclusions can yet be drawn with regard to biogenic carbon exchanges related to the life cycle of wine products.

1. Introduction

Life-cycle-based environmental assessment methodologies and tools have become increasingly used for evaluating the environmental performance of goods and services, because of a number of valuable features.

More specifically, in recent years, as a result of a scientific debate and the increasing concern by the general public about Global Warming (GW), Carbon Footprint (CF), a life-cycle-based methodology focused on Greenhouse Gas (GHG) emissions and sinks, has been spreading in various sectors, including the wine industry (Pattara et al., 2012). CF, being a "reduced scope" tool, as it focuses on only one environmental impact category, can be seen as an opportunity also for small and medium enterprises (SMEs), which need to promote a proactive image and satisfy the interest of the market regarding eco-labelling initiatives (Salomone et al., 2012). Certainly, SMEs would benefit from a transition from Life Cycle Assessment (LCA) to Life Cycle Management (LCM), through which life cycle (LC) issues may be manageable at the company and product chain levels, thanks to a number of factors such as, for instance: higher resource efficiency, better stakeholder involvement, improved communication and methodological simplifications (Fullana-i-Palmer et al., 2011).

Furthermore, even though wine is not meant to meet a basic human necessity, the wine sector in general has become more and more studied, due to its evolving economic significance and structure (Point, 2008; Point et al., 2012). For instance, except for 2009, wine exports have been rising ever since 2000; estimations for 2011 also show an increase in the exports reaching 99.4 million hectolitres, even though the world production remains the same as in 2010 (OIV, 2012).

According to Vázquez-Rowe et al. (2013), a number of factors influence the results of a CF analysis in the wine industry, notably: a) environmental factors, such as climatic and soil characteristics; b) changes in yield, due e.g., to change in use of fertilisers; c) technological factors, depending on the type of wine; d) methodological factors, e.g., different inventories, different time horizons, etc.; e) legislative restrictions, e.g., use of specific materials; f) aesthetic factors, e.g., label and bottle designs. Other factors may have multiple influences, such as using non-validated background databases, which may entail multiple risks, such as (Baitz et al., 2013): CO_2 uptake or storage partly modelled and partly not; and biogenic and non-biogenic emissions partly separated and partly

* Corresponding authors. Tel.: +39 085 4508 3225.
E-mail addresses: i.arzoumanidis@unich.it (I. Arzoumanidis), a.raggi@unich.it (A. Raggi).

http://dx.doi.org/10.1016/j.jclepro.2014.06.073
0959-6526/

not. Vázquez-Rowe et al. (2013) found the agricultural phase to be more responsible for the GHG emissions, mainly due to fertilising-related N_2O. Similarly, in a review by Arzoumanidis et al. (2013a) on food LCA studies, agriculture was the most mentioned impacting phase. When it comes to wine, processes like transport and use of electricity were also mentioned (ibid).

The exchanges of biogenic carbon (C) in the wine LC are also considered important. As it will be discussed, these normally occur during the agricultural phase (e.g., in the vine-growing stage (Smart et al., 2003)) and in the packaging one (e.g., for cork used as a bottle stopper (Rives et al., 2012)). This paper is a methodological review, which builds on the knowledge of already existing LCA case-study reviews and takes into account existing CF accounting methods, international standards and guidelines. It aims at coping with the most recent developments in accounting for biogenic carbon exchanges in the wine life cycle, which are traditionally considered as GW-neutral in LCAs, although some scientists have started to question this, as it will be described.

The methodology followed for this review was based on identifying recent case-study reviews that focused on wine, CF accounting methods and relevant international standards and guidelines. This was performed by means of searching scientific databases (such as, Scopus, ScienceDirect, Google Scholar, etc.) and using combined keywords such as “LCA”, “wine”, “review”, “Carbon Footprint”, “Greenhouse Gas”, “accounting”. The results were then screened in order to obtain the most recent and relevant ones.

The identified papers included two case-study reviews (Rugani et al., 2013; Petti et al., 2010), a series of international standards and guidelines that tackle issues on C exchanges accounting (European Commission 2013; ISO 2013; OIV 2011; WRI and WBCSD 2011; BSI et al., 2011; BSI 2011; European Commission (Joint Research Centre – Institute for Environment and Sustainability) 2010; BIER 2010; WBCSD & WRI 2004), and papers dealing with CF accounting methods and issues (Brandão et al., 2013; Helin et al., 2012; Levasseur et al., 2012a, 2012b; Kendall, 2012; Cherubini et al., 2011; Peters et al., 2011; Guinée et al., 2009; Kujanpää et al., 2009; Moura-Costa and Wilson, 2000; Fearnside et al., 2000). Finally, a review that was recently accepted for publication was taken into consideration, as well (Petti et al. n.d.).

The layout of the paper is as follows: first, some general information on existing C accounting methods and standards is provided. Then, an illustration of the carbon cycle in general and the biogenic exchanges in the wine sector is outlined. Finally, in the discussion section, issues which should be taken into consideration when accounting for biogenic exchanges in the wine sector are described.

2. Exchanges of biogenic carbon

2.1. Carbon cycle

Landsberg and Gower (1997, in Newell and Vos, 2012) claim that forests, which cover approximately 65% of the total land surface, hold 90% of the plant biogenic carbon and 80% of soil carbon found in all terrestrial ecosystems, and they also sequester 67% of the total carbon dioxide removed from the atmosphere by these ecosystems. According to IPCC (2013), the increase in the concentration of the anthropogenic CO_2 from 1750 to 2011 is estimated to be around 555 GtC, out of which 28% was absorbed by the oceans, 29% was absorbed by Earth's ecosystem and 43% remained in the atmosphere.

The engagement of the carbon cycle in regulating the concentration of the two major greenhouse gases in the atmosphere, namely CO_2 and CH_4, cannot be ignored, because it can greatly affect the climate change dynamics. This cycle is represented as a series of reservoirs able to sequester the carbon in various forms, and connected to each other through various flows. Three reservoirs are generally identified: the oceans, which store the largest amount of carbon; the terrestrial system; and the atmosphere, which, despite retaining the least amount of carbon, plays the role of a means of transfer between the other reservoirs (Stella, 2013; Post et al., 1990).

In order to better comprehend the influence of human activities within the carbon cycle, the natural cycle may be divided into two subcategories (Riebeek, 2012; Kujanpää et al., 2009): the geological cycle, which refers to an estimated period of 100–200 million years, and the biological one, with a reference period varying from a few days to thousands of years.

When forest wood is used to make durable goods, the carbon in that wood is stored for longer and new forest replacing the cut trees can grow[1] and carry on carbon sequestration (Kujanpää et al., 2009). The biomass growing time can be important in CO_2 accounting. For short-cycle biomass, CO_2 emissions should not be accounted for, since they roughly equal the amount of sequestered CO_2 (Cherubini et al., 2011). This is the case for fast growing biomass such as annual crops used for biofuels, for which CO_2 emissions from combustion are traditionally not accounted for as GHGs when the bioenergy system is carbon neutral, or – in other words – when the CO_2 released from biofuel combustion approximately equals the amount of CO_2 sequestered in biomass within the project lifetime (Cherubini et al., 2011).

However, this may not be the case for long-cycle biomass (e.g., forests). The carbon stored in wooden products is eventually released back into the atmosphere at their end of life (EOL), although at a later moment than it probably would in nature. The difference between tree cutting and tree re-growing, and, more generally, forest management, can be significant for the biogenic carbon cycle (Cherubini et al., 2011; Kujanpää et al., 2009). Indeed, modifying it can be a fair cost-effective mitigation option for Global Warming (Raymer et al., 2009). Finally, the timing of the bioenergy benefits is also considered to be important. This refers to the time between the emissions' release and the sequestration by the re-grown forest (Brandão et al., 2013; Cherubini et al., 2011).

2.2. Accounting methodologies

Stechemesser and Guenther (2012, p. 36) define carbon accounting as the accounting that “comprises the recognition, the non-monetary and monetary evaluation and the monitoring of greenhouse gas emissions on all levels of the value chain and the recognition, evaluation and monitoring of the effects of these emissions on the carbon cycle of ecosystems”. They claim that the accounting should be defined on different scales, such as national, project, organisational, and product scale. Additionally, any uptake of greenhouse gases needs to be accounted for as well. In particular, the need for accounting for all the biogenic exchanges (i.e. emissions and uptakes) of greenhouse gases is highlighted in the ISO/TS 14067:2013 technical specification (ISO, 2013) and in some international guidelines, as described in this paper.

Peters et al. (2011) state that the most problematic time-related issues are: the definition of the time horizon within which the climate impacts are taken into consideration and the identification of the timing of the emissions and their related impacts.

In terms of the time horizon used, in theory, this should always be chosen after which the radiative forcing can be regarded as

[1] This can be guaranteed in the case of well-managed forests. Otherwise, issues such as deforestation and desertification should be considered, especially when it comes to natural ecosystems.