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a cura di Simona Scalbi e Francesca Reale

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Considerations when accounting for carbon footprint in the life cycle of wine

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Abstract

Carbon Footprint (CF), as a simplified LCA tool, 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 are still not sufficiently addressed. This paper deals with one of these: the accounting of biogenic emissions, focusing on the wine sector where several LCA and CF studies have been developed. As there are some issues to be considered when accounting for exchanges of biogenic carbon, such as forest management, agricultural practices, the inclusion of all parts of a tree, land use and land use change, soil erosion, the inclusion of the end-of-life phase, etc., no certain conclusions can yet be drawn with regard to if cork is a carbon sink or if the wine sector in general can be regarded as low-carbon.

1. Introduction

Simplification in Life Cycle Assessment (LCA) can be vital for disseminating life-cycle (LC) information. This can occur in different LCA phases: i) life cycle inventory (LCI); ii) life cycle impact assessment (LCIA); iii) both LCI and LCIA (Arzoumanidis et al. 2013a). Carbon Footprint (CF) may be seen as a simplified LCA tool, as it focuses on just one impact category: Global Warming (GW). Recently, GW, and thus CF, have been increasingly discussed by scholars and the general public, also in the wine industry (Pattara et al., 2012).

Vázquez-Rowe et al. (2013) compared 9 different wine types and found the CF to range from 0.65 to 1.17 kg (CO_2-eq) per bottle (750ml). Gazulla et al. (2010), having compared the LC of a Rioja-type wine to other ones, concluded that it would be between 0.75 and 0.9 kg (CO_2-eq). Moreover they found the agricultural phase to be more responsible for the Greenhouse Gas (GHG) emissions, mainly due to fertilising-related N_2O. Similarly, in a review by Arzoumanidis et al. (2013b) on food LCAs, agriculture resulted the most mentioned impacting phase. Regarding wine, processes like transport, use of electricity were also mentioned (ibid).

Finally, the exchanges of biogenic carbon (C) in the wine LC are also considered important, especially in the vine-growing stage (e.g., in Smart et al., 2003) and for cork used as a bottle stopper (e.g., in Rives et al., 2012). This paper deals with C accounting in the wine LC with a focus on biogenic emissions, traditionally considered as GW-neutral in LCAs; but scientists have started to question this.

2. Exchanges of biogenic carbon

2.1. Carbon Cycle

The atmospheric concentration of the two major GHGs (CO_2 and CH_4) is related to the C cycle, which, thus, can greatly affect the climate change. This cycle includes a series of C reservoirs interconnected through various flows (Post et al., 1990; Stella, 2013).

When forest wood is used to make durable goods, the C in wood is stored for longer and new forest can grow and carry on C sequestration (Kujanpää et al., 2009). The biomass growing time can be important in CO_2 accounting.

For short-cycle biomass, CO_2 emissions are not accounted for since they roughly equal the amount of sequestered CO_2 (Cherubini et al., 2011). However, this may not be the case for long-cycle biomass (e.g., forests). The C stored in wood products is eventually released back into the atmosphere at their end of life (EOL), even if at a later moment than it would in nature. The difference between tree cutting and tree re-growth, and, more generally, forest management, can be significant for the biogenic C cycle (Kujanpää et al., 2009; Cherubini et al., 2011). Finally, the timing of the bioenergy benefits is also 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

The need for accounting for the biogenic emissions is highlighted in the draft of the ISO 14067 standard and in some international guidelines. The most problematic time-related issues in CF are: the definition of the time horizon (in which the climate impacts are considered) and the identification of the timing of the emissions and related impacts (Peters et al., 2011). Regarding the timing of emissions, this is not often considered in LCA, as the emissions of a substance are summed up regardless of time and space (Levasseur et al., 2012a). Indeed LCA is often described as a static tool, not suitable for assessing the complexity of forest C dynamics (Helin et al., 2012).

C sequestration through land-use, land-use change and forestry (LULUCF) has been increasingly studied as a way for answering the growing GW concerns and several accounting methodologies have been developed (Levasseur et al., 2012b). Yet, there is no standardised methodology or procedure agreed for accounting for temporary C storage, release and delayed emissions in LCA and CF (Brandão et al., 2013), even though there have been some attempts to do so (e.g., BSI 2011; WRI and WBCSD 2011). In theory, a time horizon should always be chosen after which the radiative forcing can be regarded as negligible; LCA and CF adopt the 100-year calculation of Global Warming Potential (GWP). Biomass C neutrality is often assumed, irrespectively of the timing difference between uptake and release; thus, biogenic flows are often omitted in LCA (Brandão et al., 2013).

To deal with C sequestration and storage, the Moura-Costa method and the Lashof method use a tonne-year approach (Brandão et al., 2013). Other methods (or scenarios) were also suggested by Kujanpää et al. (2009), such as: the C uptake; the calculation of lost C stock as an emission; the allocation of net C sequestration. Finally, Levasseur et al. (2012b) developed a dynamic LCA method that uses one-year time steps. After comparing it to the Moura-Costa and Lashof methods, the authors (ibid) concluded that all of them did not consider the albedo effect (i.e, the percentage of incoming solar radiation reflected off the Earth), but the proposed method was "superior" for considering more GHGs (not only CO_2). The method suggested in the ILCD Handbook (European Commission, 2010), comprises a 100-year horizon. In accounting for a delayed emission a credit is attributed by multiplying the number of years that the emission is delayed by the kg CO_2-eq by a factor of -0.01.

Emissions beyond 100 years are calculated and discussed separately. According to the method (ibid, p. 67), "the difference between biogenic and fossil delayed emissions for the same time of delay is always the same (i.e. 1 kg CO_2-equiv. difference per kg CO_2 emitted), rewarding both biogenic C storage and long-living products". Other methodologies include the PAS2050, the Greenhouse Gas Protocol and others (see Section 3).

3. Exchanges of biogenic carbon in the wine industry

3.1. Vine-related exchanges

Grapes' growing can be seen as a C sink through the production of sugars and other substances (van der Zanden, De Martino, 2009). The vineyards themselves act as CO_2 sinks through their growth (Sperow et al., 2003); Smart et al. (2003) claim that a vineyard can be a greater C sink when compared to oak woodlands.

As regards the biogenic C emitted in vineyards operations, CO_2 is due to soil management practices, which increase the decomposition of soil organic matter, while CH_4 has a minor impact (Carlisle et al., 2009).

Vineyards normally have a lifespan of 25-30 years, thus C accounting can be performed safely using the methods above, which have 100-year (or more) time horizons.

The vine and wine OIV GHG Protocol (OIV, 2011) specifies that for biogenic emissions two different cycles ought to be taken into consideration[7].

In the case of the short-term cycle, only the vine cycle is suggested to be included in the calculations[8] .

3.2. Cork-related exchanges

Wine packaging is considered to be of high importance for its environmental impacts (van der Zanden, De Martino, 2009), most of which are related to fossil fuel emissions for the production and transport of these materials, with the exception of the stopper (depending on the different materials that can be used for it: most commonly, aluminium, plastic and cork) (Pereira et al., 2008). This paper focuses on cork, due to its link to biogenic emissions and its market role.

Cork stoppers are made from the bark of cork oaks, which is continuously regenerated during a tree's lifetime and can be carefully extracted every 9-14 years, i.e. at least 12 times during a tree's lifespan (Rives et al., 2012). In order for one stopper to be produced, 3.7 times the mass of cork is required (Pereira et al., 2008).

Pereira et al. (2008) claim that 1000 cork stoppers are responsible for 1437 g of CO_2 but they are considered to have environmental advantages in comparison with other stoppers' materials

Rives (2011) suggests that a tonne of raw cork in forest transformed into products generates emissions of about 3.4 t CO_2-eq., whilst it can sequestrate up to 18 t CO_2, thus helping mitigate climate change.

This is based on the assumption that the cork exploitation does not affect the ecosystem C sink role, as could happen in those forests exploited for wood (Rives et al., 2012).

7 The short-term cycle (can be either vine-related or not), and the long-term cycle (where C is withheld into semi-permanent vineyard growth, such as roots and wood structures).

8 This includes: non-permanent vine-growth, grape growth, fermentation, biodegradation of vine structures in the soil, aerobic waste treatment of vitivinicultural origin and the gasification and/or combustion of biomass (OIV, 2011)

As regards the time horizon selected (see Section 2) the PAS2050:2011 (BSI, 2011) states that the portion of C not emitted to the atmosphere during the 100-year assessment period shall be treated as stored C and that supplementary requirements should provide for the inclusion of those significant emissions which might be expected to occur beyond 100 years. It has to be noted here that the PAS2050 accounts for short storage times using a linear approach, whilst for long storage using the average amount of C stored over 100 years (Brandão et al., 2013).

Furthermore, the OIV GHG Protocol (OIV, 2011) specifies that the production system of natural cork should be considered from a holistic approach. The use of cork has an important impact for the sustainable conservation of the forests and this should be considered.

The standard concludes by stating that “[t]he final figures of the GHG emissions due to cork production should consider the managed forest it comes from and its C sink effect” (ibid, pp. 16-17).The Scope 3 (corporate) of the GHG Protocol (WRI, WBCSD, 2011) describes the inventories for all three scopes, where only emissions can be included and not any removals (e.g., GHG sequestration) which may be reported separately from the scopes in the public report (ibid).

4. Discussion

Biogenic emissions accounting in general, and more specifically in the case of wine, is a complex issue. Johnson (2009) suggests that C neutrality cannot be accurate since a tree is actually chopped down at its EOL. It is also argued that CF does not yet consider forest management and preservation, whose importance is highlighted in several papers (e.g., Cherubini et al., 2011). Amongst the several techniques mentioned, afforestation is a site-specific method mentioned for C sequestration, being one of (or combining) tree planting and natural succession. In a study on forest management and preservation (Van Deusen, 2010), the former was found to result in more sequestration rather than the latter. Finally, according to IPCC (2000), issues (or disturbances), such as wildfires[9] and forest project management changes, can tamper with the C sink role of a forest and make the sequestration reversible. In addition, the current status of the land, the expected productivity, the substitution efficiency of forest harvest for fossil fuels need to be considered when using forest land for mitigating climate change (Marland and Marland, 1992, in Johnson, 2009).

Ageing of forests is important, as well. Indeed, managed forests sequester CO_2 from the atmosphere during their growing phase; on the other hand, net C sequestration in old forests is closer to zero since the amount of absorbed CO_2 is the same as that released via degradation of organic matter (Pregitzer and Euskirchen, 2004; Kujanpää et al., 2009).

The LC stages of the product are also important: e.g., the inclusion or not of the disposal stage. In the case of wine, the disposal of vines, branches, leaves etc. in the vineyards and the one of cork need to be considered. The latter, at its EOL, is normally burnt and the C that was bound is returned to the atmosphere as CO_2 (Pereira et al., 2008). In this case C neutrality can be argued, but only for cork itself; not for other processes required during its life cycle. If cork is landfilled, the C will be eventually emitted into the atmosphere both as CO_2 and CH_4 (landfill gas). Depending on cork degradability and on whether the landfill gas is collected and burnt, different GHG emissions may occur.

[9] Especially when it comes to the cork oak trees, it is believed that they are capable of resisting a fire and quickly regenerating after one (Pereira et al., 2008).

This means that if the incineration is complete then all emitted gas is CO_2. The final C balance also depends on whether the landfill gas is just flared or it is used as a fuel, i.e. it is burned with energy recovery. If cork is recycled[10], however, other issues should be taken into account, such as its recyclability, the methods used, etc.

Furthermore, unsustainable agricultural practices have been found to be responsible for some crops releasing soil C to the point that a supposedly C-neutral biofuel was more impacting than normal fossil fuels (EMPA, 2012). In this way, unsustainable agricultural practices for vineyards and, most importantly, for cork oak forests can be critical for the biogenic emissions accounting, as much as they can promote the bacterial decomposition of soil organic matter.

Other, more indirect effects do exist, such as soil erosion and land use change. Land degradation (e.g., soil erosion) occurs due to intensive agriculture (Olesen and Bindi, 2002) and, also in the case of vineyards, it can cause changes in the product quality and quantity. This, along with the land use and land use changes, should be considered in CF. For instance, if on the land before becoming a vineyard there used to be a forest, the land change would have provoked a lower sequestration of GHGs. In addition, the current use of the land, as a vineyard, needs to be considered as a contribution to the impact category "land use”). Here, the what-if scenarios reasoning of Consequential LCA can be of great importance for the accounting itself, where an alternative land-use situation becomes the reference (Helin et al., 2012). Finally, Bright et al. (2012) suggest that harvesting biomass induces a radiative forcing due to a change in surface albedo.

Finally, in an LC study the part of a cork oak tree that is considered should be clarified. If it is only the bark (renewed by nature), then safer assumptions can be made about C neutrality or sequestration. If, on the other hand, the entire forest management is considered, including all parts of the tree, then the results could differ. Moreover, it should be further investigated whether using cork to make well-kept durables would generally postpone the release of its C content into the atmosphere (as it happens for wood). If not, there would be no significant differences in degradation times between cork left in nature and cork used as a long-lived material (e.g.; through recycling it, in case of stoppers).

For all the aforementioned reasons, in the case where a question such as “can cork be considered as a C sink?” needs to be tackled with, the answer should be “it depends”. International standards and guidelines should be capable of taking into account all these in order for special care for wine to be provided. The potential of CF itself as a methodology should also be discussed. It can be argued that CF, being a simplified LCA tool that considers only one environmental impact, can lead to lack of communication to the consumers for a specific product. For example, a product that may have low C emissions or can be regarded as a C sink (under specific assumptions), may as well have other environmental impacts that a consumer should be aware of. The same should also be for decision-makers, where one should be aware of all the environmental impacts before deciding about measures regarding specific products, etc.

[10] It should be further investigated whether recycling can actually extend C storage compared to other EOL treatments.

5. Conclusions

Simplification in LCA can be of great importance for the dissemination of LC information. CF can be considered a simplified LCA, as it takes into account only one impact category. This paper tackled the CF in the wine sector, and more specifically the biogenic C exchanges during the LC of wine.

As regards methodological issues, the time horizon chosen for the analyses and the system boundaries selected are important. Two issues can be responsible for biogenic C exchanges in the wine LC; the agricultural phase (vineyards) and the use of natural cork stoppers in packaging. International standards were analysed and found to be lacking in providing with adequate guidelines for dealing with biogenic accounting in the wine LC. Wine sector processes need to be studied more in depth so that specific guidelines can be issued.

Because of many issues to be considered, no certain conclusions can be drawn with regard to if cork is a C sink or if the wine sector in general can be regarded as low-C. Finally, CF actually provides information for just one impact category. This may lead to misinterpretation of the results by both consumers and decision makers, thus leading them to wrong choices.

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