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Environmental aspects of oriented strand boards production. A Brazilian case study

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ABSTRACT

Use and production of industrialized wood based panels is increasing in Brazil and one of the outstanding products is the Oriented Strand Boards (OSB). At the same time, environmental concerns by companies and society about products and production systems are also growing, and the current study aims to assess the environmental impacts associated to the Brazilian OSB production in order to propose improvement alternatives focused on their profile's enhancement. Thus, a Life Cycle Assessment (LCA) study was performed according to ISO14040 and 14044 frameworks. The study covers the life cycle of OSB production from a cradle-to-gate perspective and considering real practices carried out in a representative Brazilian company. The production system has been divided in two main subsystems: Forest operations (SS1) and Panel factory (SS2). The environmental profiles have been reported considering characterization factors from the ReCiPe method, in terms of nine impact categories: climate change (CC), ozone depletion (OD), terrestrial acidification (TA), freshwater eutrophication (FE), marine eutrophication (ME), human toxicity (HT), photochemical oxidant formation (POF), terrestrial ecotoxicity (TET), freshwater ecotoxicity (FET), fossil depletion (FD). According to the results, the industrial activities carried out within SS2 have been identified as the largest responsible of contributions to all impact categories under assessment. The production of pyrethroid termiticide, which is applied in the panels to improve their resistance to attack by wood decay organisms, was the largest contributor to OD, FE, HT and FET. Scenarios based on the substitution of pyrethroid termiticide were proposed and results showed that substituting the pyrethroid termiticide by different types of boron based termiticides could lead to reduce environmental impacts up to 35%. The identification of the main environmental hotspots in the OSB cradle-to-gate life cycle can assist the Brazilian industry to improve its environmental profile by adopting the proposed scenarios for SS2. Finally, further research should be focused on exploring more types of termiticides that can be applied in the OSB panel.

1. Introduction

Brazilian wood panel market - mostly constituted by producers of Medium Density Particleboards (MDP), Medium Density Fiberboards (MDF) and Oriented Strand Boards (OSB), is considerably growing in recent years (Brazilian Association of Planted Forest Producers- ABRAF, 2013). In the period 2002–2012, the annual production and consumption of processed wood panels had an average growth of 9% and 10%, respectively, representing the highest annual average growth of forest products in the country (ABRAF, 2013). Furthermore, Brazil is among the countries with the most advanced manufacturing processes for wood panels from reforestation trees. According to data from Brazilian industry tree – IBÁ, in 2015, the country was responsible for the production of 8 million-m^3 of reconstituted wood panels, being the seventh largest worldwide producer (Ibá, 2015).

OSB market is also growing worldwide, and it is expected a growth rate of ≈28% until 2022 (Grand View Research, 2015). This

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increasing consumption by different sectors (mainly construction, furniture and packing sectors) is related with improvements into panels' properties such as strength, workability and versatility (Grand View Research, 2015). Besides that, the growing trend on plywood substitution by OSB is expected to augment demand over the forecast period 2016–2022 (Grand View Research, 2015). While plywood industry has increasingly difficulties to obtain high quality wood logs with the required dimensions to extract the blades, the OSB industry can perfectly use lower quality, unrestricted length and diameter logs as well as wood from fast-growing species (Iwakiri, 2005).

OSB are panels made of strands or wafers oriented in a controlled manner, and bonded with a waterproof synthetic resin and consolidated under heat and pressure applications. The mattress structure and particles confer to OSB excellent mechanical properties that allow the OSB to be used in many areas, especially in civil construction as well as wall coverings and roof panels (Benetto et al., 2009; Rebollar et al., 2007).

Regarding Brazil, there is only one single OSB producer with an annual production capacity of 384 m^3 (LP Brasil 2015), which represents around the 8% of the total global OSB production in the world (Grand View Research, 2015). Brazilian OSB are mostly manufactured with pine wood particles obtained from dedicated forests mainly from *Pinus elliottii* and loblolly pine - *Pinus taeda* (LP Brasil 2015).

A growing concern about the environmental effects derived from the production and use of goods, as well as about how goods are disposed at the end of their life cycles, has led to the interest towards the environmental sustainability of wood-based products (Sathre and González-Garcia, 2014). Life Cycle Assessment (LCA) is a methodology that allows assessing the environmental impacts associated to materials, products and services, as well as it supports on decision-making strategies towards sustainability (Baumann and Tillman, 2004). For that reason, LCA methodology has received special attention in recent years in order to analyze the environmental impacts derived from different production sectors such as agricultural (Meisterling et al., 2009), forest (Klein et al., 2015), bioenergy (Cherubini and Jungmeier, 2010) and food (Roy et al., 2009) sectors. Thus, LCA is used for the evaluation and choice of more environmentally friendly alternatives for a specific production system (ISO 14040, 2006a).

As regards the wood based sector, numerous studies have been carried out to determine the environmental performance of wood-based products destined for different uses such as floor coverings (Jönsson et al., 1997; Nebel et al., 2006; Petersen and Solberg, 2003), window frames (Richter and Gugerli, 1996; Salazar and Sowlati, 2008), medium density fibreboards (Rivela et al., 2007; Piekarski et al., 2017; Wilson, 2010), hardboards (González-García et al., 2009a), particleboards (Garcia and Freire, 2014; Rivela et al., 2006; Silva et al., 2013, 2014), oriented strand boards (Benetto et al., 2009; Earles et al., 2011), glue laminated timber-GLT (Puettmann and Wilson, 2004), furniture (Iritani et al., 2015; Medeiros et al., 2017; Taylor and van Langenberg, 2003), goods containers (González-García et al., 2011a), paper pulp (González-García et al., 2009b, 2011b; Silva et al., 2015), wall assemblies (Lippke and Edmonds, 2006; Werner, 2001), and packaging materials (Farreny et al., 2008). These studies have aimed to evaluate the overall environmental performance of different wood-based products, as well as to identify the processes with the highest contributions to the environmental profiles (or environmental hotpots). However, there are differences among LCA studies of wood-based products mainly concerned to the definition of the system boundaries (cradle-to-gate vs cradle-to-grave) as well as to the life cycle inventory data quality (i.e. primary or secondary datasets) and selection of environmental impact categories and methods for the life cycle impact assessment.

It is important to highlight that there are no published LCAs of OSB produced in Brazil, although a number of studies have been developed for other regions, for instance, United States (Kline, 2005; Puettmann et al., 2012b) and Luxembourg (Benetto et al., 2009). The main differences regarding OSB produced in Brazil and in these identified regions are from the use of pyrethroid termiticide and resin types. For example, in the Brazilian OSB production process there is an application of termiticide, with the purpose of increasing its resistance to the attack of decay organisms, while for other countries there is no evidence about the application of such chemical. Besides that, MDI (methylene diphenyl diisocyanate) resin is the only binder used to produce OSB for structural applications in the Brazilian construction sector, while in the North American countries phenol-formaldehyde resins are commonly used for the adhesion of the OSB's strands of the surface layers and MDI resin is only used for adhesion of strands from the core layer.

Considering the global expected increasing market for OSB and also the need to produce more environmentally sustainable composites materials, this paper aims to quantify the potential environmental impacts related to the Brazilian OSB production in a cradle-to-gate perspective by using LCA methodology, and take decisions on the suggestions of improvement solutions to eliminate or reduce environmental hotspots.

2. Methodology

For the development of this study the ISO 14040 and 14044 (2006) standards were followed, as it will be described from sections 2.1–2.5. Thus, the four stages of an LCA study, i.e., goal and scope definition, inventory analysis, impact assessment and interpretation were organized and described as follows on the next paragraphs.

2.1. Goal and scope definition

This study aimed to analyze the cradle-to-gate production system of Brazilian OSB to detect the main environmental hotspots and to improve its environmental performance profile. The study covered the life cycle of OSB from a cradle-to-gate perspective, that is, from raw materials production up to the OSB delivery at the factory gate. The company considered for the case study is located at Ponta Grossa city, Paraná state of Brazil. The South region of Brazil is composed of three states (Rio Grande do Sul, Santa Catarina and Paraná) and it is an important industrial pole related to timber production and wood products, such as wood based panels, furniture, pulp and paper, resin extraction and sawn wood (ABRAF, 2013). Furthermore, approximately 90% of the potential Brazilian Pine production takes place in that region today (ABRAF, 2013).

2.2. Functional unit and system boundaries

Firstly, as reported in the ISO 14040 and 14044 standards (ISO 14040, 2006a; ISO 14044, 2006), the functional unit must be defined since it will provide the reference flow to which all the inputs to and outputs from the production system will be referred (ISO 14040, 2006a).

On this study, the adopted functional unit was 1 m^3 of OSB produced under the classification of home type without covering, considering an average density of 600 kg/m^3 and produced following the current practices performed in Brazil. A volumetric unit was used here because of prior studies on the topic, those have been also considered such functional unit for measuring all inventory and environmental life cycle impacts related to woody