Wood Waste Management from the Furniture Industry

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Contributor: Giusilene Costa de Souza Pinho , João Luiz Calmon , Diego Lima Medeiros , Darli Vieira , Alencar Bravo

Proper management of wood waste (WW) from the furniture industry has become an important issue. Life-cycle assessment (LCA) is a tool that is widely used for identifying environmental gains in WW management strategies.

life-cycle assessment | wood waste | furniture industry | circular economy

1. Introduction

Furniture manufacturing is one of the oldest industrial activities worldwide, and technological advances have enabled its manufacturing system to evolve and increase in scale [1]. Worldwide, 77% of furniture production is concentrated in 10 countries, with Brazil being the 6th-largest producer [2][3]. This manufacturing sector generates a large volume of wood waste (WW) from the processes of cutting and sanding, for which the main raw materials are solid wood and wood panels. The Brazilian wood furniture industry represents 80% of the furniture production units in the country [4]. There were a total of 17,900 industries that produced 372 million pieces of furniture in 2022 [2]. Notably, approximately 30 million tonnes of WW is generated annually in Brazil [5]. Therefore, proper management of WW has become an important goal.

WW management should consider WW as an input for the production of materials and energy [6]. An analysis of 49 studies indicated that the generation of heat and electricity is common; in relation to wood products, reconstituted panels such as MDP (medium-density particleboard) and MDF (medium-density fiberboard) are the most investigated [7]. However many places in the world still send WW to landfills; this practice should not be prioritized, due to the accompanying generation of leachate, greenhouse gas (GHG) emissions, reduced landfill life, and wasted land use [8].

The circular economy (CE) is an economic model that describes practices whereby waste is avoided by encouraging its return to production processes or directing it toward new production cycles that can recover its value [9]. This process provides options for reusing and recycling materials. In this context, the concept of industrial symbiosis proposes a connection between production units in which the waste from one unit is adopted as a raw material by another unit [10]. In the study carried out by Cárcamo and Panãbaena-Niebles [11], Brazil stood out as the leader in the number of research projects in the Americas (81%), which is significant for an emerging economy. However, the contaminants in WW can hinder its use in a CE. To ensure quality, it is necessary to separate potential contaminants from potential materials [12]. In this way, the proper handling and classification of WW enhances its circularity.

Life-cycle assessment (LCA) is a widely used tool for identifying environmental gains in WW management strategies [8][13][14]. In this context, LCA is a methodology that supports CE and, thus, supports robust decision-making for a CE model.

Managers in the furniture industry in the state of Espírito Santo (ES), located in the southeastern region of Brazil, lack a systemic vision regarding the full value of this manufacturing sector. This includes knowledge of each stage of the product's life cycle, from the extraction of raw materials to final disposal [15]. The vast majority of companies in the state work in a linear production system, where their waste is disposed of in landfills or incinerated. This type of manufacturing is contained in a paradigm where the main stages are extraction, production, use, and disposal; this process is reaching its limit [9].

The furniture sector in Espírito Santo has 479 establishments, of which 417 produce furniture using predominantly wood materials. Another characteristic of this furniture segment is the number of small companies, which account for 55% of all manufacturing units in the state [16]. In the north-central area of the state, the spatial focus of this research is the furniture hubs of Colatina and Linhares, which together account for 75 industries [17]. The Linhares furniture center occupies a prominent position nationally in the manufacture of mass-produced furniture, while the Colatina furniture center traditionally focuses on the production of custom-made furniture. An annual generation of 80,000 tonnes of WW has been estimated for these two furniture hubs [17][18], which can vary from one year to the next due to market fluctuations [19]. Most of the waste generated is destined for firing in the kilns of the red ceramics industry. In addition, a wood panel industry is located in the far north of Espírito Santo, which is one of the main suppliers of raw materials to the furniture industry. This relationship supports connections between manufacturing units based on the concept of industrial symbiosis, which enables units to work together on a regional or local scale; synergies between industries are detectable and transport distances are feasible in technical and economic terms, thus allowing waste to substitute for natural resources [11].

2. Wood Waste Management from the Furniture Industry

The basic raw materials of the wood furniture industry are solid wood and wood-based materials such as plywood, veneer, MDF, MDP, and OSB (oriented strand board) [20]. Part of these raw materials is lost in manufacturing in the form of waste, which is estimated at 10% of the total mass [21]. However, a study carried out at a medium-sized furniture industries in Espírito Santo showed a percentage loss of over 20% [22].

The technical feasibility of using WW has been proven by many studies. Buschalsky and Mai [23] investigated the recovery of wood fiber from post-use MDF waste via thermohydrolytic disintegration, which proved the viability of this process up to the third generation of panels. Teixeira [24] researched the combined use of MDP waste and fresh residual wood to manufacture new MDP panels, concluding that all of the product's properties remained preserved. Other studies have considered 100% natural WW as a raw material for the production of MDP [6][25]. In addition, Mori et al. [26] found that adding up to 11% WW was feasible without altering the technical properties of solid ceramic bricks.

Kim and Song [8] applied LCA to evaluate the performance of WW recycling systems for the production of particleboard and combined heat and power generation, and the results showed a greater benefit for the production of particleboard. Hossain and Poon [13] carried out an LCA of the current practice in Hong Kong of disposing of WW in landfills compared to three proposed scenarios that included the use of chipboard, wood–cement board, and energy production. The authors concluded that generating energy from WW was the best strategy for environmental gains when compared to generating energy from coal. Sormunen et al. [27] conducted a comparative study with various construction waste products, including wood, for the manufacturing of thermoplastic composites; this study covered environmental and economic aspects based on LCA and accounting principles, respectively. The results of the environmental analysis showed that the use of WW compared to plastic waste in the production of composites had lower benefits due to the lower impacts avoided from its disposal. In addition, Pinho and Calmon [7] conducted a broad critical review of the literature on the LCA of WW management systems. The results showed that although the research followed ISO standards, it was possible to verify the lack of standardization and clarity in relation to how the LCA methodology is applied in investigations centered on the environmental analysis of WW management systems.

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