EFFECT OF EQUIPMENT AGE ON RESIDUES GENERATION IN SAWMILL IN THE MUNICIPALITY OF IRATI-PR

EFEITO DA IDADE DOS EQUIPAMENTOS NA GERAÇÃO DE RESÍDUOS EM SERRARIAS DO MUNICÍPIO DE IRATI-PR

EFECTO DE LA EDAD DE LOS EQUIPOS EN LA GENERACIÓN DE RESIDUOS EN LAS SERRERÍAS DEL MUNICIPIO DE IRATI-PR

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ABSTRACT

The study aimed to describe the relationship between the age of equipment and the generation of residues in small wood processing industries in Irati-PR. Data were collected through a questionnaire, where 3 (three) sawmill industries were selected in order to collect data for their characterization. The companies approached were characterized as micro (2) and small companies (1), operating in the splitting and processing of wood. The species used as feedstock were from the Pinus sp., Eucalyptus sp. Genus and a small number of other species. Companies generate, on average, 175 m^3 of residues, with an average use of 43%. Residues generation was related to the age of the equipment, where the company with the oldest equipment had the highest amount. Companies do not manage waste, which is sold to third parties. Given this scenario, it was concluded that companies generate large amounts of residues, which, in this case, are linked to the lack of maintenance and use of obsolete equipment. The lack of correct disposal is attributed to the lack of incentive and information about the potential uses of waste and the possibility of generating extra income by companies.

KEYWORDS

Management; Wastage; Timber sector; Sawing; Feedstock.

RESUMO

O estudo teve por objetivo descrever a relação da idade dos equipamentos com a geração de resíduos em pequenas indústrias de processamento da madeira em Irati-PR. Os dados foram coletados por meio de um questionário, onde 3 (três) indústrias serrarias foram selecionadas, a fim de coletar os dados para sua caracterização. As empresas abordadas foram caracterizadas como micro (2) e pequenas empresas (1), atuando no desdobro e beneficiamento da madeira. As espécies utilizadas como matéria-prima foram dos gêneros Pinus sp., Eucalyptus sp. e uma pequena quantidade de outras espécies. As empresas geram, em média, 175 m^3 de resíduos, com aproveitamento médio de 43%. A geração de resíduos esteve relacionada com a idade dos equipamentos, onde a empresa com os equipamentos mais antigos, apresentou o maior montante. As empresas não realizam o gerenciamento dos resíduos, sendo estes vendidos para terceiros. Diante deste cenário, concluiu-se que as empresas geram quantidades grandes de resíduos, que, neste caso, estão atrelados à falta de manutenção e uso de equipamentos obsoletos. A falta de uma destinação correta é atribuída a falta de incentivo e informação sobre os potenciais usos dos resíduos e a possibilidade de geração de renda extra pelas empresas.

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PALAVRAS-CHAVE

Gerenciamento; Desperdícios; Setor madeireiro; Desdobro; Matéria-prima.

RESUMEN

El objetivo del estudio era describir la relación entre la antigüedad de los equipos y la generación de residuos en las pequeñas industrias de transformación de la madera de Irati-PR. Los datos se recogieron mediante un cuestionario. Se seleccionaron tres aserraderos con el fin de recoger datos para su caracterización. Las empresas contactadas se caracterizaban por ser microempresas (2) y pequeñas empresas (1), dedicadas al corte y transformación de la madera. Las especies utilizadas como materia prima eran Pinus sp., Eucalyptus sp. y un pequeño número de otras especies. Las empresas generan una media de 175 m³ de residuos, con una tasa media de utilización del 43%. La generación de residuos estaba relacionada con la antigüedad de los equipos, siendo la empresa con los equipos más antiguos la que presentaba la mayor cantidad. Las empresas no gestionan sus residuos, sino que los venden a terceros. Ante este panorama, se llegó a la conclusión de que las empresas generan grandes cantidades de residuos, que en este caso están relacionados con la falta de mantenimiento y el uso de equipos obsoletos. La falta de una eliminación adecuada se atribuye a la falta de incentivos e información sobre los usos potenciales de los residuos y la posibilidad de generar ingresos extra para las empresas.

PALABRAS CLAVE

Gerenciamento; Desperdícios; Setor madeireiro; Desdobro; Matéria-prima.

1. INTRODUCTION

Brazil is the second largest forested area in the world, with around 498 million hectares (58.5% of its territory), of which 98% is covered by native forests and 2% by planted forests (FAO, 2015; SFB, 2023). With the increase in population and the consequent demand for wood resources, the wood sector increases the processing of raw materials (IBÁ, 2020). The area of planted trees totaled 9.94 million hectares in 2022, with a growth of 0.3% compared to the previous year. The Eucalyptus genus covers 76% of the planted area in Brazil, being the most cultivated species (7.6 million ha). The genus Pinus spp., with 19% of the planted area (1.9 million ha) and around 5% of the total area, includes other species, such as the rubber tree (230 thousand ha), teak (76 thousand ha) and acacia (54 thousand ha) (IBÁ, 2023).

The processing of this feedstock leaves residue in the timber mills after its primary processing. An amount of around 63% is estimated for this sector (WZOREK *et al.* 2012; STOLARSKI *et al.* 2021). This is because the production of wood from the Pinus spp. and Eucalyptus spp. genus, presents, on average, yields between 25 and 63% (MONTEIRO *et al.* 2017; JUIZO *et al.* 2018; MÜLER *et al.* 2019), considered as low yield. In other words, sawmill waste can represent around 55% (by volume) of the feedstock processed (ANTWI-BOASIAKO *et al.* 2016), which depends on the characteristics of the wood (diameter, shape) and also the pattern of sawdust used (MURARA JÚNIOR *et al.* 2013; SALVADOR *et al.* 2020).

The wood processing industry is responsible for a large part of wood removal and imports and exports, providing products and by-products (SCHWARZBAUER *et al.* 2013). Sawn wood production has remained at around 8.0 million m^3 in recent years, with Brazil ranked 10th in the ranking of largest producers. The destination of sawn wood production reached 3.2 million m^3 for export in the year 2022 (FAO, 2021; ABIMCI, 2021; IBÁ, 2023). These can be classified as chips, shavings and dust. The main waste generated, according to the IBÁ report (2023), is bark, branches and leaves. In the case of sawn wood, the main residue with a representative amount is sawdust. The volume of waste generated is estimated at around 17 million/m^3/year (OLIVEIRA *et al.* 2017), and it is necessary to find ways to use this amount. These quantities, according to Garcia *et al.* (2012), for the most part, are not used in the industry where they were generated.

This is because, in the past, waste such as sawdust, wood particles and wood shavings were considered discarded. However, the primary processing industry depended on acquisitions from the paper and panel industry in order to avoid disposal costs (ZIPPUSCH *et al.* 2011). Given this, according to KRISTOFEL *et al.* (2016), the price of this waste remained low. With the demand for energy in the European market, the demand for these materials grew, consisting of the main production input. From this development, what was previously considered just disposal became a valuable raw material, used in different industrial processes (AUSTROPAPIER, 2022).

In addition to this, most sawmills are considered small (family, colonial), with little capital and have equipment in a precarious state of conservation, which reduces their income and, consequently, reducing their use. The lack of maintenance, inadequate maintenance (OLIVEIRA, 2016) and even the age of the equipment are linked to the final performance, therefore, the quality and conditions of the equipment are decisive. This is related to what is known as "non-value-adding work" or "additional work", which are activities that do not increase the value of the product, but provide proportional support for effective work, such as preparation and maintenance activities. equipment.

According to Camargo and Souza (2008), the correct maintenance of equipment helps the quality of workers, but also increases productivity and reduces the costs of industrial activity. Furthermore, according to Oliveira (2016), equipment maintenance can reduce costs, increase the company's profitability and preserve the environment by reducing waste. Waste does not add value to products, which consist of defective products, for example. Above all, they guarantee yield and quality of the raw material, since the lack of maintenance interferes with the productivity of sawmills, in addition to malfunctioning equipment (SILVA, 2001; SOARES, 2002). With the lack of maintenance of equipment and the high generation of waste, understanding the factors that contribute to their generation are relevant, where their identification will contribute to making improvements in the process.

The study aimed to evaluate the generation of waste in the sawmill industries depending on the age of the equipment used in wood processing, contributing to the research by Izekor and Osayimwen (2010), Mello *et al.* (2016), Ramos *et al.* (2018), Salvador *et al.* (2020), Moura *et al.* (2020), Spalenza *et al.* (2023), Dudziec *et al.* (2023), Fuhrmann *et al.* (2024) where they addressed, in general, the main destinations and use of waste generated in sawmills as raw material for other products, energy generation, where the factors involved in the process are not evaluated first hand.

Above all, the study presented a qualitative-quantitative approach, seeking to evaluate the reality of small and medium-sized sawmills. The methods used to describe this circumstance were through visits and application of questionnaires, in order to characterize their production systems, identify process variables and, finally, verify the generation of waste throughout the production process, seeking to identify factors linked to this generation.

2. MATERIAL AND METHODS

2.1 Selection of sawmill industries

For the purposes of this study, 3 primary wood processing sawmill industries were selected in the municipality of Irati, Central-West region of the State of Paraná (Figure 1).

Figure 1: Geographic location of the Municipality of Irati-PR.
Source: Google images.

2.2 Characterization of sawmill and its production process

For a better understanding of the production process and waste generation, the industries were classified according to their size, according to the criteria established by SEBRAE, described in Table 1.

Description	
Number of Employees	**Classification according to size**
Up to 19	micro Entreprise
Up to 99	Small
Up to 499	Medium
Above 500	Big

Table 1: Description of the size of the industries according to criteria established by SEBRAE.
Source: SEBRAE, 201, P. 17.

The industries selected in the study were not identified, being named as industry "A", "B" and "C", respectively. The characterization of the production process consisted of obtaining data relating to the feedstock used and quantity, origin and obtaining of the raw material, production line and consumer market and the operations of the industrial process and, finally, the generation of waste from of wood processing. Due to the high generation and the importance of correct waste disposal, a survey was carried out of the management practices for solid waste generated, in which this generation can be reduced with the correct maintenance of equipment, ensuring the best use of waste. natural resources, reducing environmental impacts.

2.3 Data collection

A diagnosis of waste generation was carried out in the selected sawmill industries in the municipality in question, in July 2019. A semi-structured questionnaire (research instrument) was prepared, containing questions about the production process. Through visits to the industries, data collection was carried out, with those responsible for the industries as listeners.

2.4 Data analysis

The data analysis was carried out by descriptive statistics, where realized the summation of each identified residue, obtaining the total volume and calculating the average amount generated.

3. RESULTS AND DISCUSSION

3.1 Characterization of industries

Among the 3 companies covered in the study, 2 are classified as micro-enterprises and 1 as a small company, according to criteria established by SEBRAE. The size of the company is important, as it is related to the amount of wood that is processed, being able to understand the production process. This understanding allows for the standardization of splitting, related to the characteristics of each species, which, according to Luz et al (2020), will contribute to the yield of sawn wood.

3.2 Characterization of the production process

The companies' production process varies from the primary splitting of the raw material to the final processing into sawn wood. The main species used by the companies were the Pinus spp. and Eucalyptus spp. genus. Other species, however, in smaller quantities, were also found (Figure 2). The genus Pinus spp. is one of the most common and most important species for the economy (KRAKAU *et al.* 2013; KOZAKIEWICZ *et al.* 2020; ROSZYK *et al.* 2020). The use of eucalyptus in two of the three companies is also worth highlighting, as this species is widely used as a source of raw material for the paper and cellulose industries in Brazil (MIRANDA *et al.*, 2015).

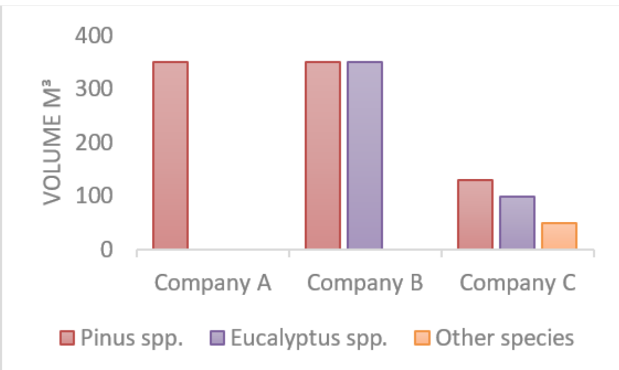

Figure 2: List of species by companies.

The feedstock used in the sawmills production process is all obtained by third parties, none of them have their own plantations. The main production lines are fruit and vegetable boxes, boxes in general and sawn wood. In this way, the time of use of the equipment and its ages were verified, shown in Figure 3.

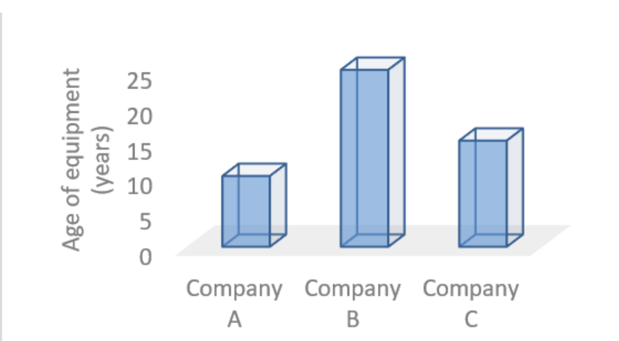

Figure 3: Age of equipment used by companies.

It is noted that all the companies studied have equipment that has been used for more than 10 years. Regarding the maintenance of this equipment, those responsible said that maintenance is carried out, but not on a regular basis. Heinrich (2010), Nolasco and Uliana (2014) and Agra *et al.* (2021) verified factors related to the process that influence the productivity and yield of raw material splitting. Among them is the quality of the equipment used, as well as its respective maintenance. Therefore, the age of the equipment will influence the final performance and waste generation, especially if the equipment has not had its respective maintenance carried out. The lack of maintenance, as well as the use of obsolete equipment, influences productivity and yield throughout the processing of raw materials. The generation of waste would be avoided if adequate equipment and cutting methods were maintained (IZEKOR and OSAYIMWEN, 2010; CAMBERO *et al.* 2015; MELO *et al.* 2016). Low productivity, consequently, corresponds to high waste generation, which will therefore lead to greater waste and increased costs (RAMOS *et al.* 2016). However, solutions for this waste in the country are still incipient, although their potential as a feedstock and energy source is already known (SELLITTO, 2018). This is because they have potential for use in various sectors (BRYNGEMARK, 2019). Use as biofuel (ZETTERHOLM *et al.* 2020, BRYNGEMARK, 2019), gasification (AHLSTROM *et al.* 2017; PETTERSSON *et al.* 2015), biorefinery (ABDOU *et al.* 2021), clean energy generation (STOLARSKI *et al.* 2021) are some of the alternatives.

Table 2 indicates the generation of waste from each industry and correlates with the age of the equipment used in each of them.

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	Feedstock (m3)	Type of Residues	Amount generated (m^3)	Type of Process	Age of Equipment
Company A	350	Coastal	70	1º splitting	10 Years
		Sawdust	105	2º splitting	
		Overflows	18	sectioning	
		Σ	**193**		
Company B	700	Sawdust	100	2º splitting	25 Years
		Log	70	Other process	
		Overflows	20	sectioning	
		Wood shavings	15	finishing	
		Σ	**205**		
Company C	280	Coastal	65	1º splitting	15 Years
		Clippings	25	boards	
		Overflows	25	sectioning	
		Sawdust	11	splitting	
		Σ	**126**		

Table 2: Relationship between waste generation and the age of equipment used by companies.

The main waste generated is sawdust, wood shavings and wood shavings. Vasconcelos and Oliveira, 2020 observed that the main waste generated are peels, dust and chips. Companies generate, on average, 175 m^3 of waste, achieving an average utilization of 43%. Monteiro et al (2013) found that the yield of sawn eucalyptus wood varies from 31.03% to 54.66%, with an average of 43.8%. According to some studies, yield varies between 25 and 63% for Pinus and Eucalyptus species (Monteiro *et al.* 2017; Juizo *et al.* 2018; Müler *et al.* 2019). In random splitting systems, the average yield of Pine logs of different diameters varies from 44.96% to 52.47% and the average is 49.01% (MANHIÇA, 2012). Olmos and Sponchiado (2022) found 49% of waste generated in sawmills.

As can be seen, there is a relationship between waste generation and the age of the equipment used in the sawmills' production process (Figure 4). It is noted that the company with the oldest equipment (25 years), which is still used in wood processing, presented the largest amount of waste generated, or wasted raw material, thus being related to the previously mentioned factors, such as lack of equipment maintenance and idleness. Therefore, one of the main tasks of companies must be the identification and elimination of waste that occurs during feedstock processing activities.

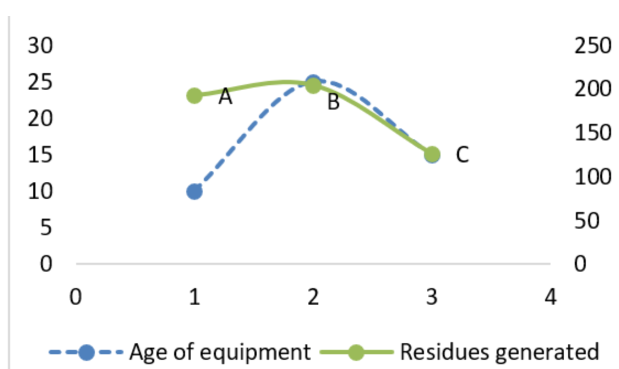

Figure 4: Relationship between the age of equipment and waste generation.

3.3 RESIDUES MANAGEMENT

The high amount of waste generated by sawmills throughout their production processes consequently increases the amount stored without destination. The lack of waste disposal is an environmental liability that causes impacts at local and regional levels, where companies are located. The search for use represents an additional source of revenue for these industries (ZETTERHOLM *et al.* 2020), in addition to an adequate destination (RAMOS *et al.* 2017), as the part that generates the most concern is the final destination of these wastes (BAUER and SELLITTO, 2019). Losses in wood splitting processes range from 50 to 65% (MURARA JUNIOR *et al.* 2013) and require alternative uses and environmentally appropriate management (CERQUEIRA *et al.* 2012). Waste generation in the wood processing sector is high, with a lack of alternatives for use and final disposal, making the management of these materials a pertinent and important tool (NATALLI *et al.* 2023). Furthermore, inadequate waste disposal affects the environment as a whole, both aquatic and terrestrial (OWOYEMI *et al.* 2016; HAJAM *et al.* 2020).

The approach in the 3 sawmills brought information that corroborates the other studies, since all companies sell their waste to third parties and they will give it some destination. Only 1 company transforms its waste into wood chips and then sells it to third parties. The lack of incentives, such as public policies, income generation, cooperatives, specialization courses, information about new technologies, means that this waste, which has the potential for reuse on numerous fronts, such as fertilizer production and composting (SILVA *et al.* 2017), energy generation (CHARIS *et al.* 2019; SPALENZA *et al.* 2023), panel production (AKUTAGAWA *et al.* 2020; NATALLI *et al.* 2022), are discarded in such a way that their real value is not perceived as extra income generation.

According to Ochôa and Lhamby (2016), Vasconcelos and Oliveira (2020), the lack of adequate disposal for the waste generated is due to the lack of investment and appreciation, above all, the lack of information and technical knowledge regarding the potential uses of this material and the consequent generation of extra income from its sale. Furthermore, the use of older, unmaintained equipment corroborates this, highlighting the lack of information and knowledge on the part of operators.

4. CONCLUSIONS

The study aimed to evaluate the generation of waste in sawmill industries depending on the age of the equipment used in wood processing. From the results, the study concluded that the companies studied present a high generation of solid waste, presenting a yield of less than 50%. As they are micro and small companies, generally family-owned, investments are smaller. The results of this study demonstrated that the use of outdated equipment and lack of maintenance influence the processing and final yield of the raw material, and result in the high generation of waste.

This corroborates other studies that demonstrated high waste generation mainly due to the lack of cutting planning, characteristics of the raw material used, but also the list of equipment and their respective preventive and periodic maintenance, identifying that the lack these interfere with processing and final yield. The vast majority of sawmills, as they are small companies, lack long-term credit policies for equipment with greater technological capacity in production. The results demonstrate that the lack of equipment maintenance, inadequate maintenance, and the use of old equipment is a reality in these companies, affecting the productivity and profitability of these industries, increasing the generation of waste, due to waste.

Combined with this lack of incentive, especially information, the companies studied do not manage the solid waste generated, which is, in its entirety, sold to third parties, without a correct destination. Waste management would allow these companies to generate greater income. The scarcity of technologies, regulation, periodic and preventive maintenance, control systems, disassembly systems, inefficiency in use are also factors that affect yield and waste generation. These factors were not evaluated in the present study and make it limited. Therefore, new studies can be carried out to evaluate not only the age of the equipment, but also the operations and deployment systems, types of maintenance that are carried out and whether they are carried out.

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