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Some Specific Considerations Regarding the Management of Wood Waste in Romania

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Authors' contributions

This work was carried out in collaboration among all authors. Author BVC designed the study, performed the research analysis and wrote the first draft of the manuscript. Author ANH performed the additional research analysis. Author MC managed the analyses of the entire study. All authors read and approved the final manuscript.

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ABSTRACT

Environmental protection, public health, physical capital, and natural state, maintaining biological diversity and fragile ecosystems balance, waste management, etc. are just some of the current issues facing humanity. Waste management and hence their degree of recycling have different valences from one country to another, in Romania, registering notable efforts to develop viable strategies for sustainable development and integrated waste management, especially of the industrial and household waste. The purpose of this paper is to highlight the remarkable results of the activity of industrial pollution protection, recycling, and the use of wood waste as a raw material in products with an efficient recovery, due to the increasing concerns for use of secondary energy resources.

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1. INTRODUCTION

Environmental protection, population health, natural capital status, maintaining biological diversity, and the balance of fragile ecosystems, waste management, etc. are just some of the topical problems facing Romania [1]. In such a context, the degree of waste recovery as well as the recycling sector functioning as a distinct sector of the economy, is very low in Romania, compared to the Western European countries [2].

Although the wood industry is not one of the most polluting activities, to some extent it has a significant impact on environmental factors (air, water, soil, biodiversity, population), through the considerable amounts of waste it produces [3]. According to the data of the Ministry of Environment, the recovery of waste resulting from the production process in the wood industry compared to other industries amounts to 83.6% [3-5], a percentage that decreases, unfortunately, due to the emergence of small producers of whose concern for the aspects of the environmental policy, implicitly for the waste capitalization is low or even non-existent.

However, at the level of the national economy, in recent years there have been no notable results in the activity of protection against industrial pollution, recycling, and use of wood waste as a raw material in by-products with efficient recovery. The general and continuous evolution of industrial activity, the frequent changes of managers and the form of ownership, the negative financial balances of enterprises, the subordination of the activity of monitoring the quality of environmental factors by the government did not have the expected effects to reduce industrial pollution [6,7]. To these was added the increase in the cost of thermal and electrical energy, which imposes the need to intensify concerns for reducing energy consumption and the use of secondary resources, such as combustible waste, in the production of thermal and even electricity.

In the wood industry, the reduction of energy consumption can be ensured by the correct design, execution, and operation of technological installations [3,4], especially those of filtration and recirculation of hot exhaust air from pneumatic sawdust, wood chips and wood dust installations from technological equipment. These pneumatic transport installations evacuate from the manufacturing sectors, together with the waste, quantities of polluted air of the order of tens, even hundreds of thousands of m^3/hour.

For mechanical wood processing in furniture factories, solid wood panels, triple-layered parquet, etc. it often results in large amounts of dry waste that are excellent fuel for their thermal power plants, providing the necessary energy, which in other conditions would require additional sources of fuel or any form of thermal energy.

At present, relatively few accessible technologies for the complete recovery of wood waste have been developed in Romania [8,9]. For example, at present, in our country there are few machines specialized in removing stumps and roots, this potential for wood waste can not be exploited at least in the short and medium term [10,11]. In the long term, it is necessary to carry out an analysis to determine the opportunity to acquire existing technologies on the European market for the removal and recovery of these stumps and roots, taking into account the fact that this practice is widely applied in northern European countries.

2. MATERIALS AND METHODS

The documentation for this paper started, as was probably obvious, from the authors' concerns for the protection of the environment and forests, for the natural heritage and biodiversity sheltered in the woods, and, last but not least, because they love the idea of a harmoniously developed community - able to learn from nature, and also from the forest ecosystem. Having at hand a series of extremely relevant studies at the national level, both in terms of waste management and sustainable forest resource management strategies, the authors decided to extrapolate these approaches to the relatively limited space of the Maramureș County, Romania.

Thus, the subject of the study, in the form of a wood waste circuit, also touches the lands of Maramureș County, where few studies make direct reference to wood waste management, compared to those related to waste management, in general, or mining waste management studies, in particular.. The sites that formed the basis of the study we sought to be with the latest information, to configure more accurately the reality of today, including the dynamics of wood waste appearances. Finally,

the sites visited were the already established ones - of the Ministry of the Environment, of the Environmental Protection Agency and other entities with responsibilities in environmental protection, in general, and wood waste management, in particular, to which were added the forums and online meetings with other environmental protection experts and waste recovery specialists.

3. RESULTS AND DISCUSSION

3.1 Wood Processing and Wood Waste Generation

We cannot talk about wood processing without reviewing the wood resources, which can come, for the most part, as a result of the execution of the following operations [3]:

- thinning, which aims to manage the stands, improve their quality and phytosanitary status, increase resistance to harmful factors; it is characterized by the small volume of the average tree (0.1 m^3), the small volume to be exploited (35-50 m^3/ha), the high density of the stands, as well as a large number of extracted trees;
- the treatments of the successive and progressive cuts applied to the forest regime, to regenerate naturally, consist of a succession of 2-3 cuts made in 20 years. The volume to be exploited per hectare varies between 150-250 m^3, and the volume of the average tree can reach 0.8-0.9 m^3. The wood mass resulting from these cuts is of superior quality.
- the treatment of garden cuttings to ensure the optimal conditions of natural regeneration is characterized by the reduced volume per hectare, 80-100 m^3, the inferior quality of the exploited wood mass and frequent interventions in the stand (as shown in Fig. 1);
- the treatment of cleared cuttings ensures artificial regeneration and is applied to trees that have reached the age of exploitability, but also to degraded trees when the introduced species do not require shelter;
- the cutting of accidental and hygiene products, having the role of extracting from the forest the trees broken or felled by wind or snow, dried and attacked by various pests, lead to the extraction of low-quality wood by exploitation in dangerous conditions and in a relatively short time.

The wood used in the primary processing processes comes from cuts: main, secondary, and accidental. The production structure and the wood assortments are determined by the assortment of species. The share of different species in the composition of forests is also important for the structuring and sizing of the wood processing industry [9,11]. The total timber exploited in Romania is established by the parliament, at the proposal of the government (about 15 mil. m^3/year). By species, this volume consists of conifers - 30%, beech - 30%, oak - 19.2% and various deciduous trees - 20.8% [3].

The timber industry is one of the basic branches of the wood processing industry. This segment uses over 65% of the volume of softwoods and over 35% of the hardwoods from the annual quota [3]. The raw material is round wood of all species. The quality of the harvested logs overwhelmingly conditions the quantity and quality of the timber and, implicitly, its

Fig. 1. How to manage the forest: Without treatment (left) and through the treatment of garden cuttings (right)

commercial value. The characteristics of round wood for timber manufacturing are regulated by national and international standards, admitting minimum lengths and diameters - dimensional characteristics, including the limitation of anatomical defects - qualitative characteristics.

Wood is one of the most important natural raw materials of organic origin for several branches of the national economy, such as the chemical industry (paper and cardboard, pulp), textile industry, furniture industry, construction, musical instruments, sports equipment. As a renewable and non-polluting material, it offers certain advantages to producers, being used as such or transformed into a multitude of finished products.

Under the above conditions, the superior capitalization of wood leads to a series of products with increased economic value. Thus, among the most important uses of wood should be mentioned: the use of wood from ancient times as fuel, construction material, and furniture manufacturing. The use of wood in these fields is closely related to the evolution of human civilization, especially the current needs for wood, namely:

- use as basic raw material for the manufacture of household items, toys, stationery, sporting goods, decorations, exhibition panels, billboards, packaging, construction of railway sleepers, watercraft;
- superior chemical processing, a series of branches of the chemical industry being focused on wood exploitation, respectively on certain chemical components in its composition: tannins, pigments, gums, resins and oils that have different uses;
- manufacture of paper and cellulosic fibers, by processing cellulose from wood composition;
- making textile materials by chemical processing of cellulose;
- wood lignin is the raw material for the manufacture of plastics and an environment conducive to the cultivation of various ferments;
- the field of packaging, especially in certain sectors of the food industry where it cannot be replaced by other materials (manufacture of alcoholic beverages);
- transformation of wood into liquid fuel by hydrogenation, respectively in methyl alcohol (also known as wood alcohol), used as fuel for cars in some countries.

Although a renewable source, irrational exploitation can lead to imbalances, with disastrous influences on the environment. Ecologists' studies lead to alarming conclusions about the negative influence of recent massive deforestation on the climate, the increase in the amount of carbon dioxide in the atmosphere being a determining factor in the evolution of climate change.

The structure of demand for wood species (part is shown in Fig. 2) worldwide differs from one period to another. Thus, the forecasts in the field predict in the next period an imbalance between the demand and supply of wood raw materials, manifested by a shortage of softwood resources, especially in Europe, North America, and the Japanese market, while production Hardwood will be superior to demand. In many situations, due to the restrictive nature of the wood mass, furniture manufacturers have turned to other types of basic raw materials, such as metals, plastics.

The products of the timber industry are obtained by sawing, along the (longitudinal) fibers of the round wood, resulting in pieces with two or more flat faces and with certain dimensions (thicknesses, widths, lengths) standardized or non-standardized. They are used in constructions (various buildings, houses, binaries, parquets, aviation, wagons, ships, car bodies, railways, etc.) and in the manufacture of wooden products (furniture, barrels, musical instruments, boats, sporting goods. The main fields of use worldwide are: various constructions (50-60%), furniture industry (12-14%), packaging industry (12-15%), various other uses (15-18%) of the production volume.

The timber industry evolves through: modernization and improvement of equipment (cutting, processing), cloth, internal transport systems, proprietary technology, management methods, heat treatment systems, etc. The improvement of the technology aims to reduce the loss of wood material (in sawdust and residues), increase labor productivity, mechanization and automation of technological flows. As basic products are considered: timber itself, semi-finished and prefabricated, sleepers, staves, remains.

The classification of wood products can be done according to general or particular criteria, namely the degree of processing (raw, semi-finished, and finished products) and the mode of

processing (mechanical or chemical). Products resulting from mechanical processing may be the following:

- raw wood, obtained by cutting and peeling trees, sorting and marking with an indicator that depends on the destination and quality: CO - for construction, CH - for timber, F - veneer, R - resonance;
- semi-finished products are classified according to the material used in ordinary wood semi-finished products (timber, veneer), semi-finished wood improved by physicochemical and physicomechanical processes (plywood, panel, cellular boards, laminated wood, wood chips - chipboard, wood fibers - PFL, densified wood, etc.), ennobled wood semi-finished products (melamine products, enameled, etc.);
- finished products: furniture, parquet, carpentry for binaries, packaging.

Products resulting from the chemical processing of wood: cellulose, paper, acetone, acetic acid, methanol, dyes, tannins, resinous substances, etc. Depending on the processing stage, products resulting from a technological process, such as wood processing, can be classified into raw, intermediate, and finished products.

3.2 Wood Waste – Specific Characteristics

Waste is generated at different stages of human activity and is an inevitable feature of an industrialized or industrialized society. The composition and quantity of waste are strongly dependent on the nature of consumption, as well as on the industrial and economic structure of society. The generic term „waste" is defined in European legislation, from which it is taken over, in Article 1 of Council Directive 75/442/EC on waste, as subsequently amended and supplemented, as „any substance or object which the holder discards or he is required to dispose of it under the provisions of the national laws in force". The definition was amended by Council Directive 91/156/ECC; thus „waste shall mean any substance or object which the possessor discards, or intends or is obliged to discard".

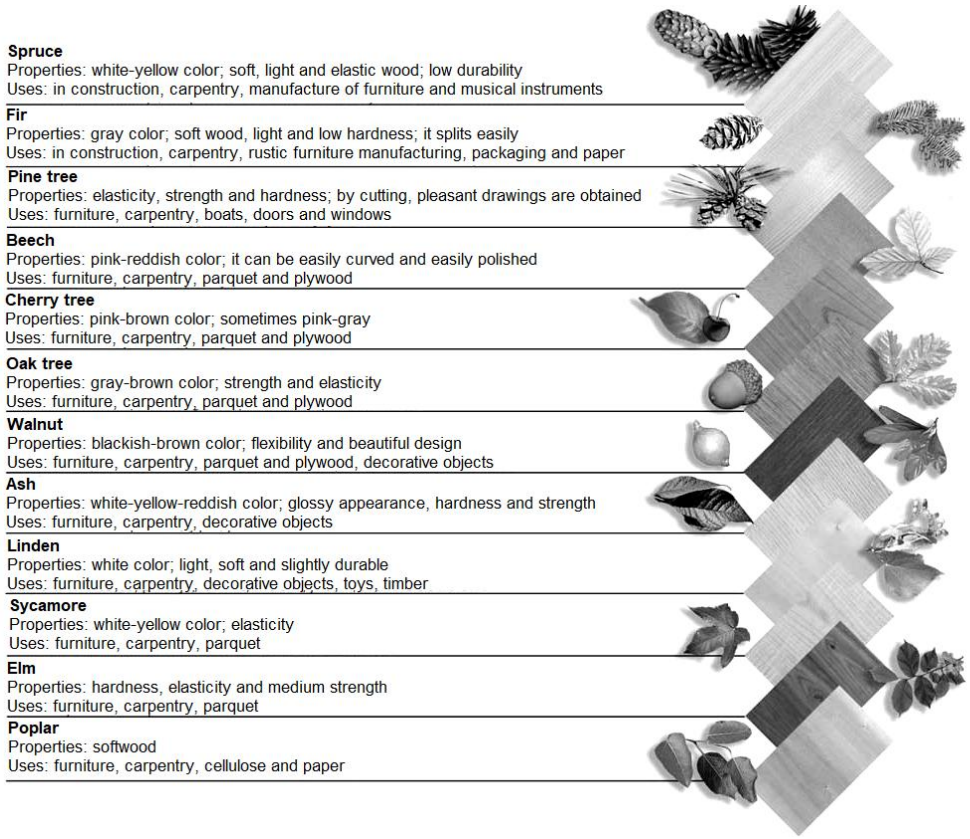

Fig. 2. Wood species - specific properties and uses

Following Decision no. 2,293 of 2004 on the management of waste resulting from the process of obtaining wood materials, with subsequent amendments and completions, the following terms and expressions can be defined [12]:

- wood materials:
  - round or split timber and firewood, obtained as a result of the application of authorized felling of main, secondary, accidental and forestry sanitation products, timber, as well as felled or carved wood, raw, processed or semi-finished wood,
  - round or split timber and firewood, obtained as a result of the application of felling in forested pastures, illegal felling of trees and any other felling of forest vegetation, timber, as well as felled or carved wood, raw wood, processed or semi-finished products, obtained from wood resulting from the cuts provided above.
- wood waste:
  - operating residues defined according to the standards in force;
  - bark, sawdust, wood chips, chips, edges and the like, resulting from the exploitation and / or processing of wood;
  - wood materials stored on land or spaces that are not intended for this purpose: riverbeds and water banks, land related to the facilities for removal and transport, and other such lands.

In accordance with Decision no. 856 of August 16, 2002 on the record of waste management and for the approval of the list containing waste, including hazardous waste, with subsequent amendments and completions. The list of waste, including hazardous waste we have a completely different overview of wood waste [13]. Thus, by means of category 03, designating wood processing waste and the production of boards and furniture, pulp, paper and cardboard, reference is made to an exhaustive and well-defined conceptual classification, regarding the wood waste studied, according to Table 1 [13].

Wood waste, depending on its origin (construction, demolition, special treatments for wood preservation), maybe to some extent contaminated, so it is advisable to collectt hem separately from other generic categories of waste or, as far as possible, in mixture with other inert waste.

Also, the collection of wood waste with other categories of waste should be avoided at all costs, but especially the collection mixed with liquid waste such as paints, oils, varnishes, or other types of substances specific to wood preservation and/or treatment. Wood waste represents approximately 29% of the total non-hazardous waste generated by industrial and commercial companies with more than 10 employees and is used as follows: 61% is used as a raw material in the paper and particleboard industry, 28% is used as fuel, and 11% are landfilled or destroyed non-compliant [3].

Wood considered recyclable waste must be sorted and analyzed according to German Standards DIN 51731 in the following classes of chemical contamination [3]:

- H1 - untreated, unprocessed, unfinished, uncontaminated wood;
- H2 - glued wood, ennobled or covered with materials that do not contain halogenated chemical compounds or protective materials (insecticides, fungicides, antiseptics, fire retardants);
- H3 - wood treated with halogenated chemical compounds, but not treated with protective materials;
- H4 - wood contaminated with harmful substances;
- H5 - wood contaminated with toxic substances.

3.3 The Importance of Recovery in Wood Waste Management

In the current context, defined by intensive industrial activities generating pollution and increasing amounts of waste, waste management is a major problem in every European country, but especially in developing countries. Waste generation involves a loss of materials and energy and imposes high costs, economic and environmental, for their collection, treatment, and processing. However, much of the waste is identified as a new source of revenue, previously ignored. In this sense, waste recycling occupies a special place in the concept of integrated waste management and in the context of developing sustainable development strategies at local, regional and global level, giving certain categories of waste an important role as a source of secondary raw material and a source of energy production.

Table 1. Classification of wood waste according to the Government Decision 856/2002

03	Wastes from wood processing and the production of panels and furniture, paper and paperboard
03 01	wastes from wood processing and production of boards and furniture
03 01 01	bark and cork waste
03 01 04*	sawdust, shavings, splinters, planks and veneer containing dangerous substances
03 01 05	sawdust, wood chips, chips, scrap, plywood and veneer, other than those mentioned in 03 01 04
03 01 99	other unspecified waste
03 02	wood preserves
03 02 01*	non-halogenated organic preservatives for wood
03 02 02*	organochlorine preservatives for wood
03 02 03*	organometallic wood preservatives
03 02 04*	inorganic wood preservatives
03 02 05*	other wood preservatives containing dangerous substances
03 02 99	other wood preservatives, not elsewhere specified or included
03 03	wastes from pulp, paper and paperboard production and processing
03 03 01	wood and bark waste
03 03 02	green lye sludge (from boiling solution recovery)
03 03 05	sludges from the removal of ink from the paper recycling process
03 03 07	mechanical waste from the recycling of recycled paper and board
03 03 08	waste paper and paperboard sorting for recycling
03 03 09	caustic sludge waste
03 03 10	fibers, sludges from mechanical separation, containing fiber, fillers, chalk
03 03 11	sludges from wastewater treatment plants other than those mentioned in 03 03 10
03 03 99	other unspecified waste
06 13 01*	inorganic plant protection products, wood preservatives and other biocides
10 01 03	fly ash from burning peat and untreated wood
15 01 03	wooden packaging
17 02	wood, glass and plastics
17 02 01	wood
17 02 04*	glass, plastics or wood containing or contaminated with dangerous substances
19 12 06*	wood containing dangerous substances
19 12 07	wood other than that specified in 19 12 06
20 01 37*	wood containing dangerous substances
20 01 38	wood other than those mentioned in 20 01 37

Waste recycling is and must be seen as one of the most important operations in waste management, focusing on the entire process of waste recovery through the selective collection, sorting and reintroduction into the production circuit, as a result of the opportunities it offers for the following elements, which aim to minimize the impact of waste on the environment and the health of the population by reducing the degree of pollution and, implicitly, the effects that waste has on the environment and the health of the population, by minimizing their dangerous character; or recovery of materials that are difficult to obtain, through expensive and often polluting manufacturing processes and protection (preservation) of non-renewable natural resources.

The issue of waste is a topical one in the sector of wood processing and furniture production; moreover, it is essential that at the management level this problem is aware because the technological progress cannot be analyzed only through the prism of strictly economic criteria. Also, at the global level of the wood processing industry and the resulting wood waste management, new types of technologies have appeared and started to be used more and more frequently, including the following: rational technology - increasing consumption of materials and energy, clean technology - greening existing technologies, and ecotechnology - new technologies, which are adapted to current ecological requirements.

Wood waste management is very topical, given that we are in a process of rapid globalization of the economy, in which the idea of economic policy in correlation with environmental policy must be predominant. The recycling of wood

waste has in this context a special relevance for the development of scientific knowledge in the field of urgent need to ensure the sustainable development of the economic and social activity, being also a basic strategy in the new millennium.

Wood waste comes from primary, secondary, and finished wood processing, demolition, site operations, reconditioning of old furniture, packaging, green space sanitation operations, industrial construction, railway sleepers, poles, and other elements on which it is based. wood harvested from deciduous or coniferous forests comes first. Due to the abundance and diversity of this secondary raw material resulting in the wood, furniture, construction and packaging processing industry, as well as at the end of the life cycle of some wood products in the form of furniture, constructions, etc., they were imposed and they impose new strategies and ways of capitalizing on these types of waste, which are only now recognized and appreciated at their true intrinsic value.

Among the feasible management methods related to wood waste can be presented the operations related to incineration (direct burning, transformation into briquettes or pellets), recovery as a secondary raw material, recovery in the form of compost, but also other possibilities for recovery (poultry industry, food smoking, manufacture of composite), etc.

4. CONCLUSION

Environmental protection, population health, the state of physical and natural capital, maintaining biological diversity, and the balance of fragile ecosystems, waste management, etc. are just some of the current issues facing humanity. In Romania, although the recycling sector functions as a distinct sector of the economy and there is a network of recycling units that cover virtually the entire territory of the country and the full range of reusable materials and waste, compared to EU member states, we are far behind. chapter due to the lack of specialized “product” units that affect the endowment possibilities, as well as the quality of the materials obtained through recycling or other forms of capitalization.

The forest is a huge reservoir of energy and raw materials if it is properly exploited so that it does not consume more than it produces. Contrary to some preconceived ideas, wood waste, generated from the processing of wood from wood resources, is not free, so to be able to be capitalized, investments and energy consumption are needed to be transformed and used as a secondary material, for the manufacture of another product or as an energy source. Although in Romania the technological endowment often has its say, and the steps regarding environmental protection are mostly in the incipient phase, it is noted that the waste resulting from wood processing can have many destinations and can be used more for the good of the environment than for its degradation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Coman M. General and applied ecology, Risoprint Publishing House, Cluj-Napoca, Romanian; 2010.
2. Fînățan GH, Cioruța B. Some considerations regarding the integrated management applied to waste in Romania. Journal of Environmental Research and Protection (ECOTERRA®), Universitatea Babeș-Bolyai Cluj-Napoca. 2011;29:26-28. (Romanian)
Available:www.ecoterra-online.ro/files/1330970969.pdf
3. Fînățan GH, Coman M, Cioruța B. Some considerations specific to the engineering and management of wood waste in Romania. Journal of Environmental Research and Protection (ECOTERRA®), Universitatea Babeș-Bolyai Cluj-Napoca. 2012;31:48-56. (Romanian)
Available:www.ecoterra-online.ro/files/1355165370.pdf
4. Anonymous. Did you know that wood... The recycling map. (Romanian)
Available:https://hartareciclarii.ro/homepage/stiati-ca/stiati-ca-lemnul
Accesed 13.06.2020
5. Anonymous. Wood and wood management. Retail Forum for Sustainability. (Romanian)
Available:https://ec.europa.eu/environment/industry/retail/pdf/issue_paper_4/ENV-2012-00378-00-00-RO-TRA-00.pdf
Accesed 18.06.2020
6. Suteu D, Zaharia C, Popovici C, Malutan T, Rusu L, Tabacaru L. Wood waste as a renewable source of energy. Environmental Engineering & Management Journal (EEMJ). 2016;15(3).
7. Dunea D, Iordache S, Dincă N, Casadei S, Petrescu N, Niţu I. Considerations

regarding the agronomical variables associated to the performances of SWAT model simulations in the Romanian eco-climatic conditions. Agriculture and Agricultural Science Procedia. 2016;10:83-93.

8. Anonymous. Waste collection, storage and recycling. Recycling - collection. (Romanian)
   Available:www.reciclarecolectare.ro/articol-colectarea-depozitarea-si-reciclarea-deseurilor
   Accesed 18.06.2020
9. Anonymous. Wood recycling. Construct your Dreams. (Romanian)
   Available:https://cyd.ro/reciclarea-lemnului.
   Accesed 18.06.2020
10. Timofte AI. Modern methods and equipment for forest exploitation, University of Oradea - Faculty of Environmental Protection; 2018. (Romanian)
11. Timofte AI. Considerations regarding the sources and recovery of wood waste. The situation in Bihor County, Analele Universității,,Ștefan cel Mare" Suceava, secțiunea Silvicultură, serie nouă. 2004;2(12):137-140. (Romanian)
    Available:www.silvic.usv.ro/anale/as_2004_2/as_timofte_2004_2.pdf
    Accesed 13.06.2020
12. Anonymous. Decision no. 2.293/2004 on the management of waste resulting from the process of obtaining wood materials. (Romanian)
    Available:www.cdep.ro/pls/legis/legis_pck.htp_act_text?idt=60899.
    Accesed 15.06.2020
13. Anonymous. Decision no. 856/2002 on waste management records and for the approval of the list of wastes, including hazardous waste. (Romanian)
    Available:http://legislatie.just.ro/Public/DetaliiDocument/38294
    Accesed 15.06.2020

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