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Driftwood: A mini-review of current knowledge and research for furniture industry

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ABSTRACT

With increasing industrialization, the environmental impact of human activity continues to grow, leading to greater waste production and a depletion of natural resources. The search for alternative, sustainable materials has become a pressing priority, particularly in industries like furniture manufacturing. Driftwood, a natural resource carried to oceanic and coastal areas by currents, ice, and waves, presents a unique opportunity in this context. Originating primarily from boreal forests in Siberia and Russia, driftwood undergoes natural modifications due to prolonged exposure to seawater and Arctic ice, influencing its physical and mechanical properties. This paper investigates the origins, properties, and potential applications of driftwood, emphasizing its role as a sustainable resource for industrial use. Driftwood's machinability, density, and structural integrity are analyzed alongside its historical and modern applications, ranging from construction and fuel in medieval Iceland to contemporary uses in art, furniture, and eco-friendly building materials. Additionally, innovative research exploring driftwood-derived products such as thermo-acoustic panels and bricks highlights its relevance to circular economy practices. The study concludes that while driftwood holds significant promise as an alternative material, challenges related to its structural properties and availability, exacerbated by climate change, require further research. Nevertheless, integrating driftwood into industrial practices could advance sustainability by reducing waste, preserving natural resources, and promoting a transition to a circular economy.

Keywords: Driftwood, Furniture, Industry, Properties

1. Introduction

With the development of industry, the detrimental impact of human activity on the environment increases. The amount of waste grows, and the availability of raw materials decreases. People continue to live according to a linear pattern, where products have a short lifespan after use, despite replacing the linear economy with more sustainable alternatives being a faster process. According to the European Commission, by 2050, Earth's resources will be exploited as if there are three planets available, and the average European produces 5t of waste annually [1]. To reduce waste and become a more ecological society, research about alternative resources becomes popular. In the furniture industry, research is focused on alternative sources for production.

For example, one of the articles has been written on the possibility of replacing wood in hardwood production with alternative natural lignocellulosic ecosystems such as forest, agricultural and food industry biomass waste. Indicates that high-quality boards can be produced from traditional alternatives that meet the requirements for P2 type boards [2]. Another studies indicate that forest waste, such as Scots pine branches, can replace round wood in the production of particleboards. Boards made of forest biomass are characterized by better mechanical parameters, compared to boards made of core wood. The boards produced meet the requirements of the EN 312 standard for P2 type boards, intended for dry indoor conditions (e.g. furniture). However, their swelling is still problematic [3]. Further review focuses on different types of agricultural biomass (straw, stalks, bagasse, seeds/fruits, leaves, grasses, palms) and their mechanical properties in particleboard production. Wood is a significant cost in particleboard production, therefore replacing it with lignocellulosic waste from agricultural biomass can significantly reduce costs. Agricultural biomass, available in large quantities after harvesting and processing, is an ideal alternative raw material [4]. One of the lesser-known alternatives for the furniture industry could be driftwood. It is wood that has been carried to the coasts of seas and oceans by ocean currents, drifting ice, and waves. It is characterized by the fact that it does not come from local tree stands but from remote areas [5]. The aim of this article is to collect and classify information regarding driftwood and its potential applications in industrial sectors. By examining its properties and possible uses, the article seeks to provide a comprehensive overview of driftwood's suitability as a valuable resource for industry.

Figure1. Driftwood sample found in Iceland

2. Method

Initially, all available information regarding driftwood was thoroughly searched and collected. Subsequently, the gathered research was organized and classified into the following subsections: physical and mechanical properties of driftwood, origin and availability, and applications. During research, the three primary academic databases were used in this review – Google Scholar, Scopus, and Web of Science. Google Scholar is a powerful academic search engine that gives users access to a variety of intellectual resources, such as books, conference papers, theses, and peer-reviewed articles. Its user-friendly interface and extensive database are frequently utilised by researchers and students from a wide range of subjects. Scopus, another comprehensive academic database maintained by Elsevier, provides access to a plethora of resources, including books, conference proceedings, patents, and peer-reviewed journal articles across a wide range of subjects. Its extensive collection and trustworthy content have led to its extensive utilisation. Web of Science, a renowned scholarly citation database run by Clarivate Analytics, facilitates access to high-quality academic literature, including books, conference papers, and peer-reviewed articles. The Web of Science is a highly regarded scholarly citation database that Clarivate Analytics manages. It is a vital resource for in-depth academic study due to its advanced search functionality and citation analysis tools. When used in combination, these platforms offer a broad and varied basis for finding and evaluating academic materials.

3. Results and Discussion

3.1. Origin and availability

Driftwood is a material that reaches the coasts of the seas and oceans via ocean currents, drifting ice and waves. Most of the wood's travel takes place when it is frozen in the ice [6]. It is wood that comes from remote areas rather than from local stands [7]. The main source of driftwood is the boreal forest regions of Russia and Siberia [5],[8].

Driftwood is defined as pieces of wood that have been washed away by water and subsequently deposited on shorelines, lake or river banks by river, sea current or wave action. The formation of driftwood is a result of natural processes, including tree branches falling into the water, trees dying on the banks of bodies of water, or through human activities such as logging or timber transport. The wood enters rivers as a result of bank erosion, flooding, and falling trees. The wood enters the ocean via rivers flowing down from forested areas. Many trees find their way into rivers with root systems, indicating natural processes of uprooting them from the ground. Trees can enter rivers with wood systems due to natural processes like erosion and flooding. The Mackenzie River system carries large amounts of driftwood into the Arctic Ocean, mainly during the ice breakup in early June. The trees in this driftwood come from forests that have been undercut by the river. Flooding can cause erosion, leading to trees falling into the river. Logs often have scars, likely from events like ice jams and subsequent flooding.

Additionally, the Liard River, a major tributary of the Mackenzie, is thought to be a significant source of driftwood due to higher erosion rates in the Rocky Mountains. Local people believe that much of the driftwood originates from the Liard River or British Columbia [9]. Larch (Larix) trees in particular often retain their roots, suggesting that they have been pulled from riverbanks. Natural factors such as storms, high winds and flooding also contribute to the increase of trees in the water [10].

Driftwood is formed not only through natural processes but also as a result of human activities such as intensive logging or the practice of floating timber down rivers. Certain components of driftwood, such as planks, may originate from shipwrecks [11]. Driftwood can be found on many beaches, especially along the coasts of Arctic and sub-Arctic areas such as Iceland, Greenland, Spitsbergen, and New Earth. In Iceland, driftwood is found on almost every beach, with the largest concentrations on the Vestfirðir peninsula in the northwest and on Langanes in the northeast [9]. Driftwood is found on coasts, pushed out by water. It is also collected as a byproduct of river maintenance activities, as it poses a threat to infrastructure. However, the total removal of driftwood can have negative consequences for the ecosystem. The presence of driftwood in fluvial environments has been demonstrated to present a risk to infrastructure, with particular concern relating to bridges. Accumulation of driftwood at bridges can result in a reduction or complete obstruction of the river cross-section. This phenomenon can precipitate an escalation in water levels upstream, potentially resulting in the inundation of proximate infrastructure. Furthermore, the accumulation of driftwood can compromise the integrity of the bridge structure due to the force of the water and debris, potentially leading to scouring, the erosion of the riverbed around the bridge foundations. While the removal of driftwood is imperative for the safety of infrastructure, the complete removal of driftwood can have a detrimental effect on the river ecosystem. Driftwood plays a crucial role in the ecology of the river system by providing a habitat for a variety of flora and fauna, offering shelter and spawning grounds for fish species, and increasing the river's hydraulic roughness, thereby trapping sediment. Therefore, a balance must be struck between removing driftwood to protect infrastructure and preserving its ecological benefits [12]-[13].

Arctic driftwood is a valuable resource in Iceland, used historically for constructing houses, boats, churches, and fences. Today, it finds applications in furniture making, building finishing, and artistic endeavors [21]. Eggertsson's research, using dendrochronology, pinpointed the primary source of driftwood in Iceland to be the boreal forests of Siberia [23]. Beyond Iceland, a study investigated the composition and origin of driftwood on the western coast of Nunavik, Canada. Microscopic analysis of 1,057 driftwood samples identified: four coniferous taxa: spruce, larch, fir, and white cedar and four deciduous taxa: willow, poplar, alder, and white birch. Spruce was the most prevalent, while white birch, white cedar, and fir were rare. The study concluded that most of the driftwood likely entered the water during spring break-up or the stormy fall and winter months [15]. The most common species include spruce (Picea), pine (Pinus), and larch (Larix). Spruce and pine trees often come from timber floating, while larch trees are usually of natural origin, with a preserved root system, washed up from riverbanks. Larchs mainly come from eastern Siberia, while pines and spruces come from western Russia [14]-[15].

Driftwood research includes identification of tree species, anatomical analysis of the wood, and dating using dendrochronological methods, or analysis of tree rings. These methods make it possible to determine the origin of the wood and track changes in ocean currents. Analyses indicate that larches are mainly from eastern Siberia, while pines and spruces are from western Russia. The youngest dated wood samples indicate that driftwood may have reached Iceland's shores less than six years after the tree began drifting. The time of arrival in Iceland from the Yenisei area is estimated to be between 1940 and 1980 [16].

The amount of driftwood found depends on many factors. The amount of driftwood found depends on various interconnected factors. Geographic location plays a fundamental role, as regions closer to densely forested areas naturally contribute more wood debris to rivers and oceans. Proximity to forests, rivers, and oceans influences the supply of driftwood, as these are the primary pathways through which wood is transported. For instance, rivers serve as conduits, carrying fallen trees and branches from upstream forests to coastal regions. Atmospheric phenomena, such as storms, heavy rains, or floods, significantly amplify the driftwood supply. These events dislodge trees and branches, carrying them downstream into water bodies. Floods, in particular, can uproot entire trees, leading to an increase in driftwood volume. Ocean currents and coastal morphology dictate the movement and eventual deposition of driftwood, as certain currents may transport it over long distances, while sheltered bays and specific coastline shapes can encourage accumulation. Human activity also has a dual influence. Activities like deforestation and timber floating increase the amount of driftwood by introducing more wood into waterways. Conversely, infrastructure such as dams, bridges, or weirs can obstruct the flow of rivers, trapping driftwood before it reaches the sea. This may reduce its natural distribution while creating localized buildups. Furthermore, river maintenance efforts often involve the removal of driftwood to prevent potential hazards to infrastructure, which can decrease its presence downstream. Ultimately, the interplay of these factors shapes the quantity and distribution of driftwood, affecting not only its availability but also its role in ecological and human systems [17]-[18].

To forecast the availability of driftwood in the future, one must also take into account climate change, which is altering the amount of ice and water levels, and causing increasingly frequent disasters like hurricanes and tornadoes [19]. According to [20], the loss of sea ice due to global warming is likely to end Iceland's driftwood supply by 2060 AD. The research combined dendrochronological analysis of 289 driftwood samples collected in northeastern Iceland with climate model simulations to understand the interplay between driftwood supply and sea ice dynamics. Most driftwood reaching Iceland originates from the Yenisei River catchment in central Siberia, carried by Arctic Ocean currents and ice. The presence of multiyear sea ice is essential for transporting and depositing driftwood along Iceland's coastlines.

3.2. Mechanical and physical properties

Arctic driftwood, a resource used for centuries in Iceland, possesses unique properties due to prolonged exposure to Arctic Sea water and ice. This natural modification process significantly alters the wood's characteristics, influencing its machinability and potentially impacting its use in various applications. One study focused on comparing the machinability of Siberian larch driftwood with natural Siberian larch. The research revealed that driftwood larch exhibited higher normalised cutting forces than natural larch, likely attributed to a higher mineral content absorbed during its time in the Arctic Sea [21]. This observation suggests that the extended contact with seawater and the freezing conditions of Arctic ice significantly modify the wood's mechanical properties. The impact of natural modification extends beyond machinability. A study on oak wood revealed that density decreases significantly with increasing age and residence time in water. Oak wood dating over 7,000 years old becomes soft enough to be scratched deeply with a fingernail [22]. This finding highlights the transformative effect of water and time on wood properties.

This study investigated the technical properties of driftwood collected from the marine coast in Dubrovnik, Croatia, which was repurposed for art installations promoting the use of recyclable materials. Three samples were analyzed: poplar, sycamore, and softwood species. All samples exhibited signs of discolouration, partial rot, or damage caused by wood-boring insects. Density measurements revealed that poplar driftwood-maintained values close to standard references but showed slight reductions in areas affected by insect damage. The sycamore sample's density and shape indicated its origin as part of a tree root system, while the softwood sample displayed reduced density due to burning. Mechanical tests, including compressive and bending strength assessments, showed significant degradation in properties in areas exposed to external factors, rendering the driftwood unsuitable for construction purposes. The findings highlight the altered quality of driftwood and its limited potential for structural applications [24].

A study conducted on Scots pine driftwood samples from Spitsbergen, comparing them to contemporary Scots pine wood, revealed several key distinctions. Driftwood exhibited an increased equilibrium moisture content, approximately 1.5% higher in both sapwood and heartwood compared to contemporary wood. This could be attributed to driftwood's slightly lower density, potential heightened hygroscopicity, and the impact of moisture hysteresis. The compressive strength of driftwood was also reduced, particularly in the sapwood, likely due to its lower density.

Chemically, driftwood displayed higher ash content (approximately five times greater) and lower ethanol extractive content in both sapwood and heartwood. Conversely, it exhibited a higher concentration of water-soluble substances in the heartwood. Additionally, the study noted variations in the levels of cellulose, lignin, and pentosans among driftwood logs, suggesting they originated from diverse sources. The heartwood zone of driftwood demonstrated higher acidity, exhibiting a pH value 0.3 units lower than that of contemporary pine heartwood. Additionally, the heat of combustion and calorific value of driftwood were lower in comparison to contemporary pine wood. Concerning its biological properties, driftwood sapwood exhibited a comparable or greater susceptibility to brown rot, a condition caused by the fungus *Coniophora puteana*. Notably, the heartwood of a particular log displayed significantly heightened susceptibility to this condition.

The elevated mineral content and chlorine levels of driftwood, which were 20 times higher than those of contemporary pine, support the impact of prolonged seawater immersion. The variation in the appearance and properties of driftwood logs, including differences in lignin and cellulose content, wood density, and compressive strength, further emphasises their diverse origins [25]. These studies collectively demonstrate the unique characteristics of Arctic driftwood and its value as a resource. Further research is crucial to understand the full extent of natural modification on the wood's properties, ensuring its sustainable and optimized use across various applications.

3.3. Exploitation

One application of this material is the LuRon Method is a driftwood carving technique that focuses on preserving the natural beauty and patina of the wood. Artists search for hard pieces of wood with intriguing shapes and then remove the rotten wood to reveal the hardcore. The wood is meticulously scraped, sanded and polished to enhance its natural beauty. Beeswax and turpentine are used for the finish. The base of the sculpture is carefully selected to work in harmony with the wood. Maintenance consists of dusting and waxing, avoiding polyurethane-based finishes [26]

Driftwood was of crucial importance in medieval Iceland. It was used to build houses, churches, coffins, and as fuel. Excavations at Thorarinsstadir show how versatile its use was. The 11th-century church at Thorarinsstadir used driftwood for the structure, floor and coffins. Species such as larch, Scots pine and limber have been found there. The discovery of pine, a Mediterranean species, suggests the importation of wood or objects from the region. This is also confirmed by the presence of altar stone, probably imported. The lime fragments indicate the presence of carvings or other decorative elements. Linden was a popular material for carving in medieval Europe but does not occur naturally in Iceland. Charcoal from alder and willow has been found in the hearth, suggesting that they were used as fuel. Charcoal from these species has also been found in some graves, possibly indicating a ritual of spreading coal on the corpse. Thorarinsstadir is an example of adaptation to harsh environmental conditions. Settlers were able to use available resources, such as driftwood, to meet their needs [27].

Historically, driftwood was an important source of fuel and building material for early settlers in regions where trees did not grow. In Iceland in the past, the wood was a valuable resource used to build houses, boats and tools [5]-[6]. Driftwood was an extremely important raw material in medieval Iceland, but today scientists are also exploring its use. Italian researchers described their research into the use of driftwood to produce ecological building materials in the article ‘Sustainable New Brick and Thermo-Acoustic Insulation Panel from Mineralisation of Stranded Driftwood Residues’. Their research shows that driftwood can be successfully used to produce bricks and thermo-acoustic panels. The material has good thermal and acoustic insulation properties and its use fits in with the concept of sustainability [28].

4. Conclusions

The analysis of driftwood's origins, properties, and applications reveals its significant potential as a sustainable resource for various industries. Driftwood, predominantly sourced from boreal forests and transported by natural and anthropogenic processes, is abundantly available along Arctic and sub-Arctic coastlines. However, its availability is increasingly affected by climate change and human activities, which alter ocean currents, ice coverage, and the volume of wood entering waterways. The unique physical and mechanical properties of driftwood, shaped by prolonged exposure to Arctic seawater and ice, make it a distinct material with potential for specialized applications. While these natural modifications enhance certain aspects, they also pose challenges like reduced structural integrity in some cases. Further research is needed to optimize its processing and address these limitations. Historically, driftwood has played a critical role in regions where conventional timber resources are scarce, such as Iceland, where it was used in construction, fuel, and crafting. Modern applications, including its use in furniture, art, and sustainable building materials, demonstrate its versatility and alignment with eco-friendly practices. Innovative research, such as the production of thermo-acoustic panels and bricks from driftwood residues, highlights its relevance in the context of circular economy initiatives.

In conclusion, driftwood represents a promising resource for advancing sustainability in various industrial sectors. To fully harness its potential, further exploration into its mechanical properties, environmental impact, and scalable applications is essential. For the furniture industry, key aspects to investigate include its density, tendencies to deform due to shrinkage and swelling, biological durability, compressive and bending strength, degree of contamination, and workability. By integrating driftwood into industrial practices, societies can contribute to reducing waste, preserving natural resources, and transitioning towards a more circular and sustainable economy.

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