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Article

The Emerging Role of Plant-Based Building Materials in the Construction Industry—A Bibliometric Analysis

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Abstract: The emergence of plant-based building materials is supported by several factors, such as shortages, adverse effects, and quality deficits of conventional resources, strict legislative frameworks targeting the realization of Sustainable Development Goals (SDGs), and growing environmental awareness on the individual and stakeholder levels. To support these findings, this paper aimed to assess the relevance of these green materials in the construction industry and highlight the most widespread and thoroughly studied plant-based compounds in the literature, using bibliometric analysis. By evaluating 977 publications from 453 sources, the results show that the total number of relevant papers has increased yearly, while most belonged to the engineering discipline. Most articles were dedicated to one or more of the SDGs, which was confirmed by the more comprehensive representation and elaboration of "green", "environmental", and "sustainability" aspects regarding the topics of "materials" and "building" as the most frequent terms. Additionally, a wide range of plant-based building materials are thoroughly evaluated in the literature; these are primarily used to improve conventional materials' mechanical properties, while many are also tested as substitutes for conventional ones. In conclusion, the green transition in the construction industry is aided by the scientific community by proposing plant-based supplements and alternatives to well-known materials and practices; however, further in-depth studies are needed to verify the applicability of such novelties to gain uniform acceptance and foster the expansion of sustainability initiatives in the sector.

Keywords: sustainable construction; green building materials; WoS; Bibliometrix; circular economy

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1. Introduction

The construction industry is a core sector that ensures the infrastructure requirements of housing, public services, and the economy. At the same time, it induces a high environmental impact and socioeconomic burdens in many respects [1,2]. Over their entire life cycle, buildings are directly and indirectly responsible for nearly 37% of the total global CO_2 emission [3]. In comparison, the sector also accounts for a high share of waste generated (30%, [4]), water used (15% globally, [5]), and energy consumed (nearly 50%, [6]). In addition, according to Tokede et al. [7], around 50% of all extracted materials can be linked to construction activities. As a result, greenhouse gas emissions from material extraction, construction product manufacturing, and construction and renovation of buildings alone are estimated at 5–12% of total national GHG emissions [8]. According to estimations, by 2060, the global construction sector's energy demand could increase by 30% and its carbon emissions by 10% if it does not find alternative solutions to global challenges [9].

Due to population growth, by 2050, two-thirds of the world's population will likely live in cities, thereby further increasing the extent of built-in areas [10]. Current demographic trends show that the construction industry will require more urban space in the next 40 years than in the last 4000 [11]. Esch et al. [8] used the World Settlement Footprint 3D method (WSF 3D) to determine the world's entire building stock. According to this evaluation, the built-in area of the world is 291,577 km^2, the average building height is 5.55 m, and the total volume is 1632 km^3. These needs cannot be met with scarce raw materials, leading researchers to develop new solutions that make it possible to create novel, sustainable construction materials using secondary raw materials [12]. The introduction and integration of circular construction economy mechanisms into processes are vital in this progress: the construction cycle must be enforced in existing buildings' materials, tools, technologies, and methods [13]. In the case of buildings, materials are stored for many decades, even several generations long. Thus, the material cycle affecting the construction sector requires long-term thinking and future-proof solutions [14].

This transition requires changes in product design, supply chains, and existing business models. It is well known that raw material stocks are dwindling globally; one of the driving forces behind this phenomenon is the tenfold increase in material extraction intensity between 1900 and 2010 [15]. Krausmann et al. [15] suggest that by 2050, the global convergence of per capita material stocks at the industrial level could quadruple the use of global material stocks. The authors also highlighted specific features regarding previously installed materials that had reached the end of their life cycle: they found that aging buildings, infrastructure, and durable products are mostly discarded, increasing the amount of end-of-life waste. More than half of this material was concrete, 7% was biomass, 5% was metals, and 1% was plastic. At the same time, the share of recycled materials also started to increase in the late 1990s, with metals, biomass, and plastics together accounting for 12% of end-of-life recycling [15]. Today, it is estimated that only 6% of the global economy is circular, and in many cases, most of the extracted building materials are only ground and used for road construction [16]. Therefore, actual circularity has yet to be achieved, although it was previously shown that using brick, concrete, and wood–plastic composites made from secondary materials would significantly reduce carbon emissions [17].

As a result of these trends, the amount of research into specific segments of sustainable construction has increased in recent years. More and more literature deals with sustainable building materials of plant or animal origin [18]. This issue is a hot topic because current crises have highlighted the vulnerability of construction economies, and the disruption of raw material supply chains has resulted in shortages and price increases of raw materials [19]. Three terms appear regularly when novel solutions in the construction industry are assessed. Green building materials contain substances that are sustainable and renewable [20]. To form a smaller group, biobased building materials are ones of partly or entirely biological origin [21]. Within those above, plant-based building materials are considered substances from organs of once-living plants and used for construction [22]. Due to the multiple benefits of their use, the need to involve these materials in comprehensive studies seems highly reasonable.

To further strengthen the relevance of previous progress, this study aims to explore trends related to biobased raw materials based on an extensive, bibliometric analysis-based literature assessment to help stakeholders learn the possible utilization routes of these material types in the construction industry. As a result, this paper seeks to contribute to material use efficiency and thus enable sustainability to be integrated into the construction industry to a higher degree, built on existing know-how. Therefore, this paper focuses on answering the following research questions:

1. What kind of research is being conducted worldwide regarding green and biobased building materials, and what current trends are prevailing?
2. What are the most studied biobased—primarily plant-based—raw materials?

2. Material and Methods

A comprehensive search was run in the Web of Science (from now on WoS) database to assess the scientometric data of its scientific research at the international level. We used this literature database because, according to the unanimous findings of the relevant international study, this data collection achieves an optimal compromise between completeness and non-overlapping. The process of the research is shown in Figure 1.

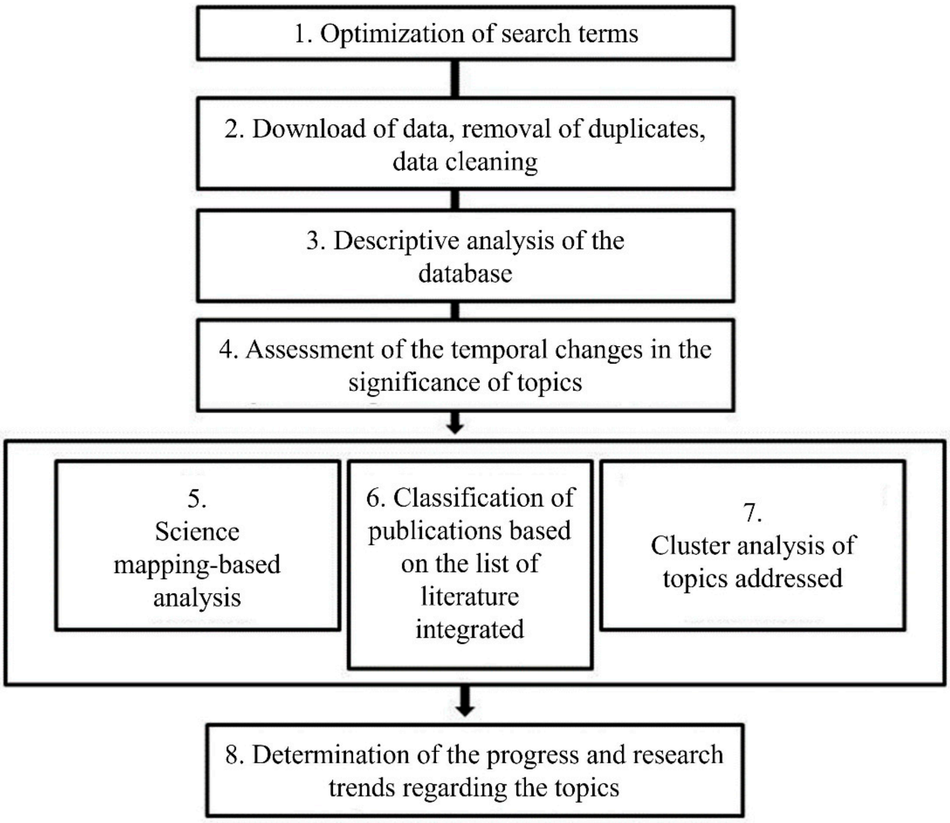

Figure 1. The process of data investigations.

While optimizing search terms, we used several word combinations to shed light on the importance of biological resources in the construction industry. The use of some terms (e.g., green building, green planning, green materials, or green construction) yielded extensively broad and general lists of publications, so after optimizing the various possible search terms, the term combination "green" AND "building materials" OR "biobased building materials" was selected to be used on the scientific materials published between 1975 and April 2023 (1). We downloaded and reviewed the listed literature items (n = 977) one by one, removed duplicates and incorrect references, and searched for documents that could not be extracted from WoS for any reason (2). Subsequently, we conducted a statistical analysis of the data and analyzed, among others, publications with multiple authors, author collaborations, and the yearly number of publications (3). The temporal analysis was also carried out from the perspective of crises concerning the construction industry and biological resources (e.g., paradigm shifts following crisis periods) (4). In addition to manual analysis methods, we applied software analysis. We could name the relevant scientific areas of the studied publications, their order (5), and the most relevant keywords based on titles and abstracts (6). Then, we formed clusters related to each topic area (7), which determined the prevailing progress and trends in the research area (8). For the statistical analyses, CitnetExplorer [23], Bibliometrics R-package [24], and VOSviewer [25] were used.

3. Results and Discussion

3.1. Green and Biobased Building Materials in the Literature

Based on the analysis of the publications after data cleaning, it can be concluded that the following disciplines were linked to the papers the most frequently: engineering, environmental sciences ecology, materials science, construction building technology, and science technology other topics. It suggests that besides the vital role of engineering, several different research areas significantly influence the introduction and spread of sustainable building materials. These results are summarized in Figure 2.

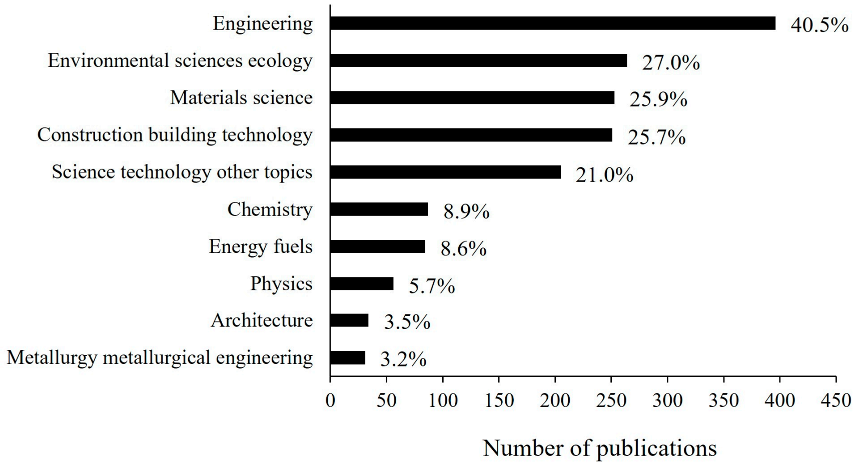

Figure 2. Top 10 main disciplines of the listed publications. Percentage values represent the ratios relative to the total number of papers (n = 977) yielded.

The data of the studied literature show that, with only two minor setbacks, the number of publications has been steadily increasing since 2015 following the adoption of major circular economy policy proposals (Figure 3). The first study addressing the analysis of organic compounds present in weathered building materials of monuments dated back to 1991 [26]. As the WoS search was conducted on papers published until April 2023, the data for 2023 represent partial yearly results; however, compared to the number of publications (181) in the whole year of 2022, a significant improvement is expected by the end of 2023 based on the number of papers (101) published in the first four months.

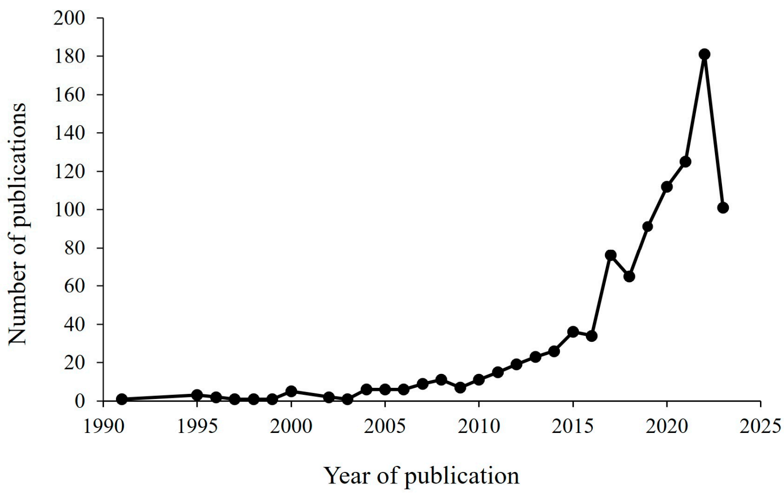

Figure 3. The yearly progress in the number of green- and biobased building-materials-related publications listed.

Further, to assess the publications and their topics regarding one of the most significant international sustainability initiatives, connections with UN Sustainable Development

Goals (SDGs) were determined [27]. As a result, the listed publications show a strong connection with several of the SDGs: the most frequent relations of the papers are associated with "12. Responsible consumption and production"; "13. Climate action"; "11. Sustainable cities and communities"; "3. Good health and well being"; and "7. Affordable and clean energy". This confirms the growing need for sustainable activities related to construction practices and the strong interrelation between the SDGs in general. A summary of these findings is shown in Figure 4.

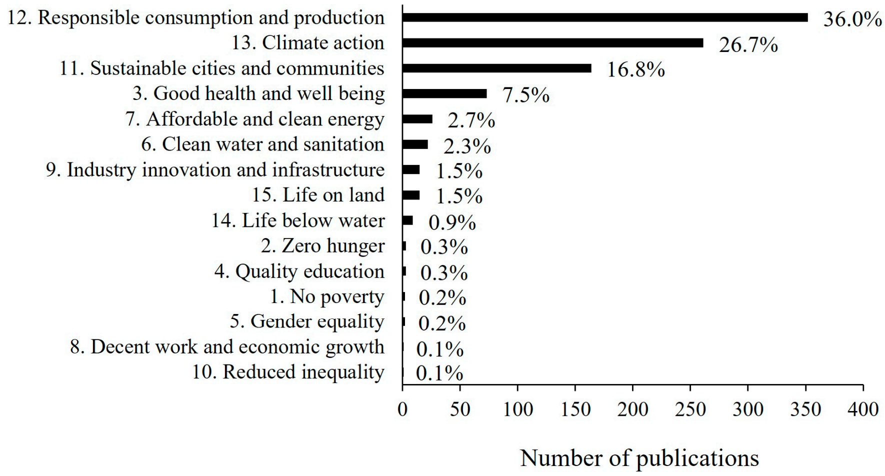

Figure 4. The relation of listed publications to SDGs. Percentage values represent the ratios relative to the total number of papers (n = 977) yielded.

Using the R-program and the Bibliometrix software, we found that the issue of new types of raw materials can be considered an important topic for researchers worldwide. We studied the affiliation countries of the authors, the key terms in the titles of the studies, and the matrix of keywords indicated by the authors. Overall, it can be stated that researchers from China, the USA, India, and Malaysia deal with the issue of green building materials and biobased building materials the most frequently (Figure 5).

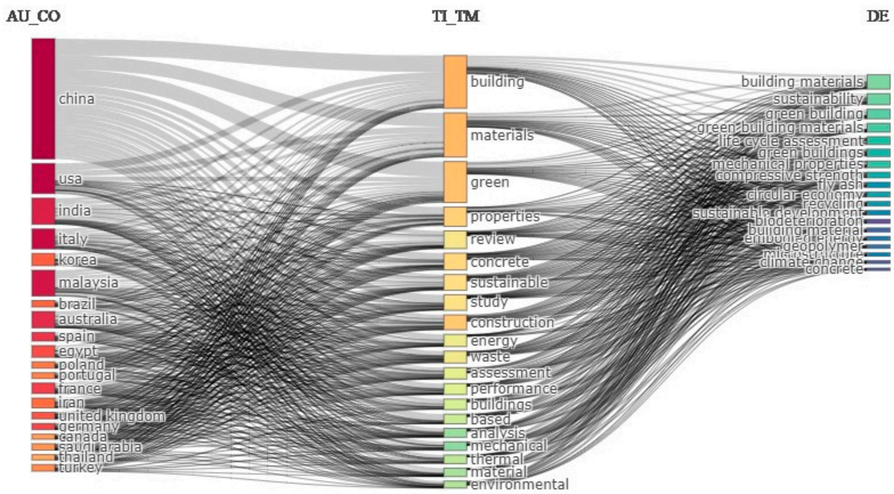

Figure 5. Tree field plot on the matrix of author affiliations, titles, and keywords of the green and biobased materials-related publications. Differences in the height of the rectangles indicate the number of relations connected, while the depth of the color of individual rectangles indicates the relevancy of the items attached.

It was found that studies on the topics of green building materials and biobased building materials were published in 453 sources. The annual growth rate in the number of publications is 16.1%, which underlines the relevance of the issues. It can be stated that most related papers were published in the Construction and Building Materials, followed by Sustainability and Journal of Cleaner Production (Table 1). Further, by the distribution of articles among the journals and the annual change in the number of publications, the number of articles is expected to grow progressively in these top journals, as well as in other ones that have already recognized the importance of the topic.

Table 1. Top 10 sources with the most articles related to green- and biobased materials.

Source	Number of Published Articles
Construction and Building Materials	68
Sustainability	48
Journal of Cleaner Production	43
Materials	26
Building and Environment	23
Journal of Building Engineering	23
Energy and Buildings	19
Buildings	17
Science of the Total Environment	13
Journal of Green Building	12

Subsequently, the clusters into which the analyzed studies can be classified were also assessed using VOSviewer. The analyses resulted in three clusters, as shown in Figure 6: the first deals with green building industry issues (red color); the second includes research on property management, cement research, and waste reduction (green color); and the third cluster deals with various aspects of environmental impact (blue color). As can be seen, there is also strong interconnectivity primarily within and secondary among the presented clusters.

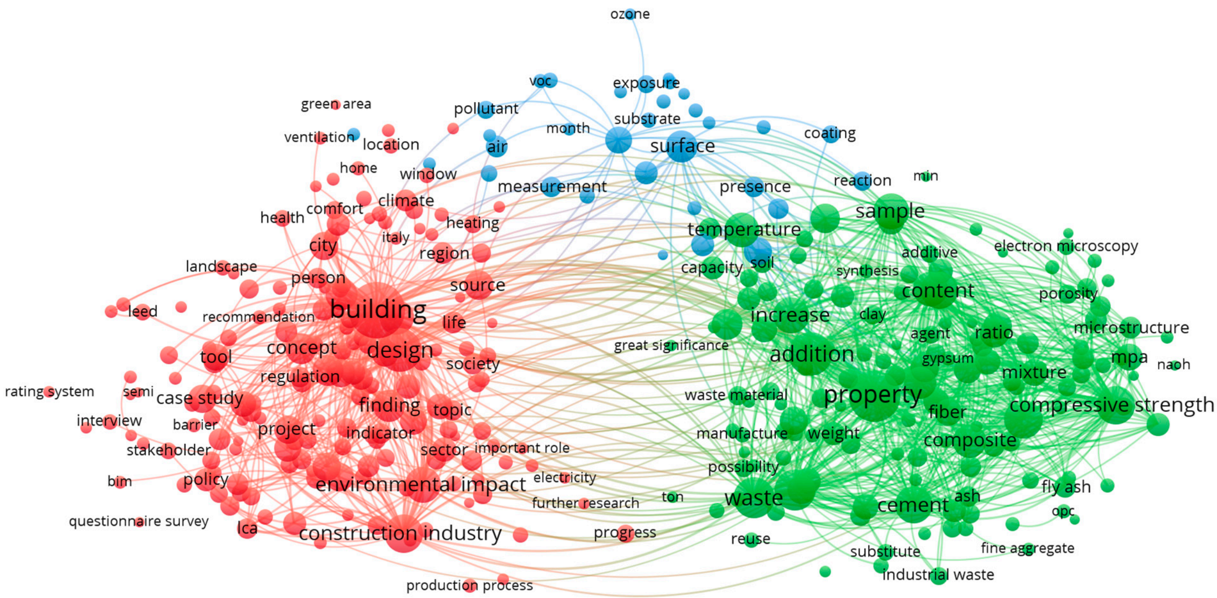

Figure 6. Scientific clusters of the topics of publications related to green- and biobased materials.

To further support these tendencies, the abstracts of the listed publications were also investigated to determine the most frequently used terms.

If the abstracts of studies on green building materials are considered, the number of sections containing the keywords materials, building, and green is outstanding compared to other topics (Figure 7).

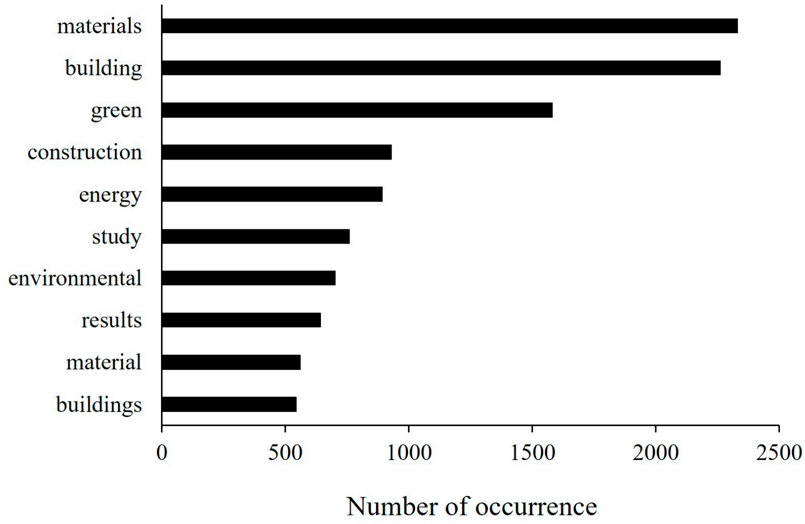

Figure 7. Top 10 most frequently used keywords in the abstracts of listed publications.

The presence of 24 terms was assessed based on their yearly distribution to analyze abstract content more in-depth. Figure 8 confirmed that the most frequent were materials, building, and green covering six years, with the highest number of occurrences in 2020.

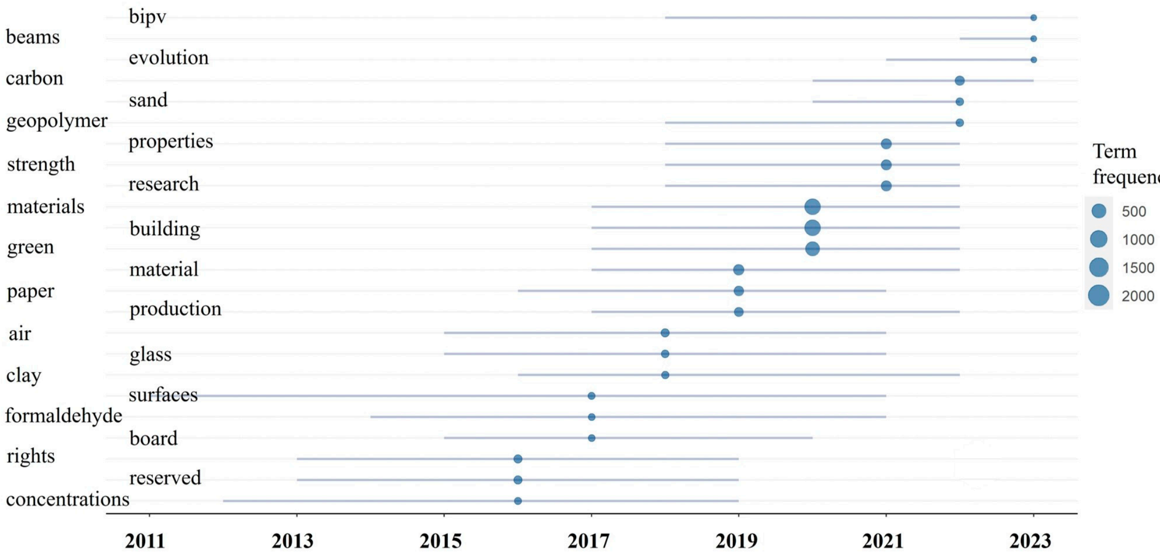

Figure 8. Analysis of the trend topics in abstracts of listed publications related to green building materials.

3.2. The Context of Green and Biobased Building Materials

There is some variation in the description and definition of green and biobased building materials in the relevant literature. According to Pearlmutter et al. [28], "green building materials are raw and processed nature-based materials used in constructing the built environment. These materials are extracted from the biological cycle to serve technical purposes, and their production and processing should result in low environmental impacts in terms of embodied energy and carbon, water consumption, and harmful chemicals. Ideally, they make productive reuse of other resource streams to avoid detrimental by-products and competition with food production, and they guarantee a healthy working and living environment with respect to indoor air quality and climate". On the other hand, Le et al. [29] referred to biobased materials as "materials wholly or partly derived from materials of biological origin". Similarly, focusing on the construction industry, Bourbia et al. [30] found that a "building material is said to be biobased when it incorporates plant or animal biomass". Wang et al. [31] also emphasized the sustainable nature of biobased materials by reflecting on the fact that these "are derived from sustainable and renewable biomass, instead of finite petrochemicals". A highly construction-industry-relevant definition and description was given by Yadav and Agarwal [32] establishing that "biobased materials principally accommodate a substance(s) resulting from existing matter such as biomass and either arise naturally or product created by developments that use biomass. Following a firm description, several common materials, like wood, and animal product, paper, is addressed as biobased materials; however, generally, the term refers to contemporary materials that have undertaken plenty of in-depth processes. New biobased materials will overwhelm conventional materials and thus the prospects to use them in existing and novel ways merely popping out to be explored".

Most authors agree that biobased construction materials are essential for sustainable construction. The past few years' crises and international conflicts have led to a contraction of the raw material markets in the construction industry. In parallel with the adverse effects of the construction industry on the environment, the demand for entirely different types of building materials has arisen [33]. In addition to the technical characteristics related to the functional role of the given material, the list of requirements has been expanded with new ones: the need for improvement in each segment of sustainability, the focus on locally available materials, and the implementation of widespread recycling in the construction industry to promote the circular economy as widely as possible [34]. Many countries can meet these new challenges by encouraging stakeholders in construction value chains to rethink their use and identify resources in their markets. As reliance on conventional materials has already weakened with the appearance of sustainability initiatives, green building materials have become prominent concepts in green construction [35]. Based on the findings above, green building material includes all types of building materials that support the sustainability of buildings and construction. When examining the relationship between sustainability and building materials, most papers focus exclusively on the environmental dimensions of sustainability. Still, the authors of this paper suggest that when assessing novel green building materials, all sustainability segments should be considered. As this approach tends to spread, research on biobased construction materials has intensified in recent years. Within the group of green building materials, biobased building materials contain some plant or animal components. Below, it is introduced how these biological resources can be integrated into the construction industry.

3.3. Plant-Based Resources for a Sustainable Construction Industry

Based on the nearly one thousand studies included in this study, the research focus areas of biobased building materials can be classified as follows:

(a) A significant part of research involves utilizing biological resources that differ from their original, widely known nature. These methods try to exploit the specific properties (e.g., tensile strength, absorbency, porosity) developed in nature over thousands of years, by which it becomes possible to create entirely new biobased or natural construction materials that were not used before. Some of these have similar or better characteristics than existing building materials. Biobased transparent wood, for example, is a biocomposite that combines a porous wood reinforcement with a polymer matrix phase [36]. According to Montanari et al. [37], the heat storage function of this material contributes to reducing energy consumption in buildings, and its transparency contributes to the reduction in artificial lighting. Researchers have achieved similarly outstanding results with cellulose, which is found in large quantities in the cell walls of plants. In addition to its importance in the construction industry, it is an excellent substitute for petroleum-synthesized plastics [38,39].

(b) Another aspect is research that handles biological resources as aggregates. While developing green building materials for such purposes, additives and aggregates of natural origin with lower environmental impact are added to the base composites, thus replacing the original aggregate with a higher environmental impact. For example, composites made from hemp are characterized by low production costs, adequate insulation performance and vapor permeability, and low thermal conductivity [40,41]. Further, much research exists on plant fibers' role in improving composites' mechanical properties. According to Ramamoorthy et al. [42], plant fibers can be classified into different groups: straw, seed, bast, wood, grass, and leaf. These are particularly important in construction research to increase reinforced concrete structures' compressive and flexural strength. Missio et al. [43] highlight that foamed green and sustainable foams made using nanocellulose are stronger, lighter, and fire resistant, have better compressive strength, and are less wettable than formaldehyde crosslinked foams. Researchers also reported that it is possible to develop lightweight cementitious products with lignocellulose of reed and coconut, which improve mechanical properties, such as insulation performance. At the same time, the panels designed in this way also showed better resistance to wet environments [44]. Sapuan et al. [45] highlighted that banana fiber improves the structure of polyester tar.

(c) A leading research direction focuses on how adding plant-based materials can improve specific properties of the building material. Ordinary Portland cement (OPC) has significant CO_2 emissions during manufacturing, accounting for 63% of global CO_2 emissions [46,47]. Therefore, research in the literature is widely devoted to offsetting the harmful effects of cement production [48]. For example, according to Amin et al. [49], the compressive and flexural strength of cementitious composites reinforced with plant fibers increased by up to 43% and 67%, respectively, compared to the original reference composites. The researchers also found that the plant fibers most commonly incorporated into various composites are coconut, flax, jute, hemp and wheat straw, and sugar palm. Similarly, the integration of oil palm shells can also be found in the literature, which is available in large quantities in Malaysia, Indonesia, and Thailand [46]. These initiatives making specific processes more sustainable can be identified in concrete production: research suggests that in concrete construction, eucalyptus fiber improves cracking and shrinkage properties [50]. Concrete research targeting self-healing concrete production is also of primary importance. It is well known that concrete is a low-tensile and brittle material that is highly susceptible to cracking [51], against which Vijay et al. [52] proposed using bacteria as suitable agents for repairing cracks in the matrix. Additionally, Dewi et al. [53] found that using bamboo fibers in concrete increased the tensile strength of concrete and improved its characteristics regarding microcrack formation and plasticity. Menor et al. [54] investigated the role of cork in concrete production. They observed that the material has a high absorption value and can be used as a light additive for internal hardening of concrete. Klapiszewski et al. [55] developed hybrid materials containing lignin, resulting in low porosity and improved mechanical strength parameter values. Similarly, several projects have concerned the application of plant-based materials to wooden structures. Ercan et al. [56] investigated the burning properties of wood elements in green building composite panels. The researchers have shown that slow-burning materials can delay the risk of collapse in the event of a fire in a building. Research suggests that coating with the addition of peanut shells reduced burning time and increased combustion temperature compared to control conditions. Charai et al. [57] developed an Alpha drywall roofing building material using alfa grass (*Stipa tenacissima* L.) fibers from the eastern Moroccan region. The material significantly improved the thermal insulation quality of the roof and reduced its heat transfer value, and based on simulations, the research suggests that retrofitting the 40 mm thick Alfa drywall reduced the energy demand of residential buildings by 4%. Aouba et al. [58] investigated the significance of adding olive flour and wheat straw residues in brick production to improve heat performance while maintaining carrying capacity.

(d) As an additional group, research on the construction use of waste from an agri-food sector, including agricultural and livestock farms, can be named. Ryłko-Polak et al. [47] highlighted that lignin and its derivatives are also used in construction, mainly as additives in cement composites and bitumen substitutes [59]. Tawasil et al. [60] studied the production of fiberboard made from waste coconut shells and found that the higher the composition of coconut fiber in the coconut fiber sawdust sheets was, the better the physical and mechanical performance became; the percentage of water absorption decreased, and the bending modulus of the plate also increased. Maximino et al. [61] evaluated the applicability of sustainable building materials from waste with mycelium binders in the construction industry. The authors found that the average compressive strength of bricks made of sawdust and rice bran mixed with mycelium increased compared to non-mycelium bricks. Romano et al. [62] assessed ten biobased waste insulation materials and recognized sawdust and wool as the most promising green materials.

(e) Biobased building material research is often conducted at the compound (molecule) level, which has given new impetus to the development of green chemistry [63]. The behavior of fibers from natural ingredients (e.g., coconut, flax, hemp, etc.) depends mainly on the pre-treatment of the fibers. For example, Khalid et al. [64] concluded that higher concentrations of chemicals and longer soaking times in fibers tend to improve mechanical properties. According to Khoshnava et al. [65], the polluting nature of conventional building materials (CBMs) that are extracted from non-renewable resources can be offset by non-toxic green building materials containing natural and organic compounds. In this regard, biocomposites can be an environmentally friendly solution to reduce indoor and outdoor impacts on human health. For example, Mija et al. [66], describing the role of humines in construction, found that these compounds play an essential role in the evolvement of new classes of thermosetting materials and composites, as well as in the green processes of wood impregnation.

(f) Green architectural structures also appear in the focus of recent research. This group includes green roofs consisting of planted vegetation, growing medium, filter layer, drainage and storage layers, protective and storage wool, and waterproof layers [67,68]. A specific type of this is vertical green belt systems, which are usually implemented on the façade of buildings [69].

3.4. The Use of Plant-Based Green Building Materials

In addition to the above research questions, the studied publications discuss several plant-based materials and plant derivatives in terms of their application in the construction industry. The most frequently mentioned materials are presented in Table 2.

Table 2. The most assessed plant-based materials and their use in the construction industry in the studied literature.

Building Material/Procedure	Plant-Based Material	Products Created after Plant-Based Material Use	Related Publication(s)
Cement production	agricultural palm waste	cement composites	[47,70]
	mixed plant-based agricultural waste	biocomposites as reinforcers, plasticizers, and insulators	[47,71]
	rice and reed fiber	reinforced cementitious panels and biocomposites with increased compressive strength	[72,73]
	hemp fiber	cement-based mortar with increased compressive and flexural strength	[74]
	sugarcane bagasse ash	cement-based products with increased compressive strength	[75,76]
Concrete production	palm kernel shell	lightweight concrete aggregate	[46,77]
	mixed plant fibers	reinforced concrete	[78]
	coconut fiber	high-strength reinforced concrete with increased compressive and bending strength	[46,49,79–82]
	biofilm with microorganisms	concrete with increased bioreceptivity	[83]
	hemp	concrete with reinforced internal structure and increased self-healing ability	[84–87]
	bamboo fiber	agent treating concrete cracks, high-performance concrete with decreased shrinkage	[53,88–90]
	juta fiber	reinforced concrete	[91–93]
	pineapple leaf fiber	reinforced concrete	[94]
	flax fiber	reinforced concrete with increased compressive strength	[49,95]
	granulated cork	concrete and mortar with increased insulating property	[54]
	tobacco waste	lightweight concrete	[96]
	resins from different origin	translucent concrete	[97]

Table 2. *Cont.*

Building Material/Procedure	Plant-Based Material	Products Created after Plant-Based Material Use	Related Publication(s)
Brick production	building waste materials with mycelium	bio-composite mycelium bricks	[61]
Wood-based products	delignified, succinylated birch wood	transparent wood	[37]
	chitosan	wooden surfaces with increased flame resistance	[98]
	fungal melanin, linseed, and tree tea oil	wooden materials with increased antibacterial effects and water resistance	[99]
	peanut husk	green composite panels with increased flame resistance	[56]
Sealing and insulation materials	nanocellulose	performance improvement of tannin-based foams	[43]
	various plant species	bio-green insulation panels	[100,101]
	coconut fiber	insulation ceiling board, fibrous thermal insulation	[102,103]
	peat	thermal insulation material	[104,105]
	sawdust	green insulation panels	[106]
	arch, pine, spruce, fir, and oak tree bark resins	insulation panels	[107]
	beet-pulp fiber with potato starch	biopolymer composites with increased insulation property	[108]
	almond skin	sound absorber materials	[109]
Other	spent coffee grounds	mortar with increased technical and sustainability performance	[110]

4. Conclusions

This study aimed to evaluate plant-based construction research characteristics and trends. In addition, this paper provided a comprehensive overview of the scientometric relations of types, properties, and applications of biobased building materials. Based on the review of 977 publications available in the Web of Science database, it was found that research regarding the integration of biobased resources into the construction industry has increased significantly in recent years, especially in the post-pandemic period. This can be explained by the extraordinary demand for raw materials in the construction industry, the depleting resources, the compensation for the significant adverse environmental impact of the sector, and the spillover effect of the crises of recent years. These phenomena anticipate a high degree of openness from the stakeholders and users regarding sustainable building materials.

The scientometric analysis reflected on the concepts of green and biobased building materials and the relationship between the two. Extensive research is being carried out into using alternative, plant-based substances or derivatives for various raw materials and processes to reduce environmental degradation. Due to their excellent specific properties, ecological benefits, structural features, availability, and low cost, such materials should be considered and advised more frequently by professionals, bringing these sustainable practices into common knowledge. However, complementary actions (e.g., cost-efficiency analyses and popularizing campaigns) could also be necessary for this progress, while the insistence on conventional materials and solutions seems still strong. Further, the role of researchers and publications in testing and establishing materials is also considered a huge step ahead.

Besides the afore findings, this research also has some limitations: the paper neither dealt with the mechanical and sustainability analysis of individual raw materials and composites nor did it evaluate the use of mineral materials in construction (e.g., silt, adobe, gravel rocks, biochar, or even various mineral photocatalyst building materials used for urban air purification). These aspects should be integrated into future studies, giving a more thorough technical demonstration of the materials and their functions in the sustainable construction industry to shift plant-based material application from theory to practice.

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Data Availability Statement: Data supporting the results of this research are available in the text.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Tippu, J.; Saravanasankar, S.; Sankaranarayanan, B.; Ali, S.M.; Qarnain, S.S.; Karuppiah, K. Towards sustainability: Analysis of energy efficiency factors in buildings of smart cities using an integrated framework. *J. Inst. Eng. India Ser. A.* **2023**, *104*, 223–235. [CrossRef]
2. Chileshe, N.; Kavishe, N.; Edwards, D.J. Identification of critical capacity building challenges in public-private partnerships (PPPs) projects: The case of Tanzania. *Int. J. Construct. Manage.* **2023**, *23*, 495–504. [CrossRef]
3. Scherz, M.; Hoxha, E.; Maierhofer, D.; Kreiner, H.; Passer, A. Strategies to improve building environmental and economic performance: An exploratory study on 37 residential building scenarios. *Int. J. Life Cycle Assess.* **2023**, *28*, 828–842. [CrossRef]
4. Pomponi, F.; Moncaster, A. Embodied carbon mitigation and reduction in the built environment–What does the evidence say? *J. Environ. Manage.* **2016**, *181*, 687–700. [CrossRef] [PubMed]
5. Pomponi, F.; Stephan, A. Water, energy, and carbon dioxide footprints of the construction sector: A case study on developed and developing economies. *Water Res.* **2021**, *194*, 116935. [CrossRef] [PubMed]
6. Hamada, H.M.; Thomas, B.S.; Yahaya, F.M.; Muthusamy, K.; Yang, J.; Abdalla, J.A.; Hawileh, R.A. Sustainable use of palm oil fuel ash as a supplementary cementitious material: A comprehensive review. *J. Build. Eng.* **2021**, *40*, 102286. [CrossRef]
7. Tokede, O.O.; Rodgers, G.; Waschl, B.; Salter, J.; Ashraf, M. Harmonising life cycle sustainability thinking in material substitution for buildings. *Resour. Conserv. Recycl.* **2022**, *185*, 106468. [CrossRef]
8. Esch, T.; Brzoska, E.; Dech, S.; Leutner, B.; Palacios-Lopez, D.; Metz-Marconcini, A.; Marconcini, M.; Roth, A.; Zeidler, J. World Settlement Footprint 3D—A first three-dimensional survey of the global building stock. *Remote Sens. Environ.* **2022**, *270*, 112877. [CrossRef]
9. Abergel, T.; Dean, B.; Dulac, J.; Hamilton, I.; Wheeler, T. Global Status Report. Towards a Zero-Emission, Efficient, And Resilient Buildings and Construction Sector. Global Alliance for Buildings and Construction. 2018. Available online: https://worldgbc.org/wp-content/uploads/2022/03/2018-GlobalABC-Global-Status-Report.pdf (accessed on 4 September 2023).
10. United Nations. World Population Prospects 2019 Highlights. 2019. Available online: https://population.un.org/wpp/Publications/Files/WPP2019_Highlights.pdf (accessed on 4 September 2023).
11. Eberhardt, L.C.M.; Birgisdottir, H.; Birkved, M. Potential of circular economy in sustainable buildings. *IOP Conf. Ser. Mater. Sci. Eng.* **2019**, *471*, 092051. [CrossRef]
12. Benachio, G.L.F.; do Carmo Duarte Freitas, M.; Tavaras, S.F. Circular economy in the construction industry: A systematic literature review. *J. Cleaner Prod.* **2020**, *260*, 121046. [CrossRef]
13. Ghufran, M.; Khan, K.I.A.; Ullah, F.; Nasir, A.R.; Al Alahmadi, A.A.; Alzaed, A.N.; Alwetaishi, M. Circular Economy in the Construction Industry: A Step towards Sustainable Development. *Buildings* **2022**, *12*, 1004. [CrossRef]
14. Norouzi, M.; Chàfer, M.; Cabeza, L.F.; Jiménez, L.; Boer, D. Circular economy in the building and construction sector: A scientific evolution analysis. *J. Build. Eng.* **2021**, *44*, 102704. [CrossRef]
15. Krausmann, F.; Wiedenhofer, D.; Lauk, C.; Haas, W.; Tanikawa, H.; Fishman, T.; Haberl, H. Global socioeconomic material stocks rise 23-fold over the 20th century and require half of annual resource use. *Proc. Natl. Acad. Sci. USA* **2017**, *114*, 1880–1885. [CrossRef]
16. Haas, W.; Krausmann, F.; Wiedenhofer, D.; Heinz, M. How circular is the global economy? An assessment of material flows, waste production, and recycling in the European Union and the world in 2005. *J. Ind. Ecol.* **2015**, *19*, 765–777. [CrossRef]
17. Hu, M.; van der Voet, E.; Huppes, G. Dynamic material flow analysis for strategic construction and demolition waste management in Beijing. *J. Ind. Ecol.* **2010**, *14*, 440–456. [CrossRef]
18. Gasparri, E.; Arasteh, S.; Kuru, A.; Stracchi, P.; Brambilla, A. Circular economy in construction: A systematic review of knowledge gaps towards a novel research framework. *Front. Built Environ.* **2023**, *9*, 1239757. [CrossRef]
19. Farooq, S.A.; Indhu, B.; Jagannathan, P. Impact of covid-19 on supply chain management in construction industry in Kashmir. *Asian J. Civ. Eng.* **2023**, *24*, 429–438. [CrossRef]
20. De Luca, P.; Carbone, I.; Nagy, J.B. Green building materials: A review of state of the art studies of innovative materials. *J. Green Build.* **2017**, *12*, 141–161. [CrossRef]
21. Dams, B.; Maskell, D.; Shea, A.; Allen, S.; Cascione, V.; Walker, P. Upscaling bio-based construction: Challenges and opportunities. *Build. Res. Inf.* **2023**, *51*, 764–782. [CrossRef]
22. Amziane, S.; Sonebi, M. Overview on Biobased Building Material made with plant aggregate. *RILEM Tech. Lett.* **2016**, *1*, 31–38. [CrossRef]
23. van Eck, N.J.; Waltman, L. CitNetExplorer: A new software tool for analyzing and visualizing citation networks. *J. Informetr.* **2014**, *8*, 802–823. [CrossRef]
24. Aria, M.; Cuccurullo, C. bibliometrix: An R-tool for comprehensive science mapping analysis. *J. Informetr.* **2017**, *11*, 959–975. [CrossRef]
25. van Eck, N.J.; Waltman, L. Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics* **2021**, *84*, 523–538. [CrossRef] [PubMed]

26. Saiz-Jiménez, C.; Hermosin, B.; Ortega-Calvo, J.J.; Gomez-Alarcon, G. Applications of analytical pyrolysis to the study of stony cultural properties. *J. Anal. Appl. Pyrolysis* **1991**, *20*, 239–251. [CrossRef]
27. United Nations. Transforming Our World: The 2030 Agenda for Sustainable Development. 2015. Available online: https://www.refworld.org/docid/57b6e3e44.html (accessed on 2 September 2023).
28. Pearlmutter, D.; Theochari, D.; Nehls, T.; Pinho, P.; Piro, P.; Korolova, A.; Papaefthimiou, S.; Garcia Mateo, M.C.; Calheiros, C.; Zluwa, I.; et al. Enhancing the circular economy with nature-based solutions in the built urban environment: Green building materials, systems and sites. *Blue-Green Syst.* **2020**, *2*, 46–72. [CrossRef]
29. Le, D.L.; Salomone, R.; Nguyen, Q.T. Circular bio-based building materials: A literature review of case studies and sustainability assessment methods. *Build. Environ.* **2023**, *244*, 110774. [CrossRef]
30. Bourbia, S.; Kazeoui, H.; Belarbi, R. A review on recent research on bio-based building materials and their applications. *Mater. Renew. Sustain. Energy* **2023**, *12*, 117–139. [CrossRef]
31. Wang, J.; Euring, M.; Ostendorf, K.; Zhang, K. Biobased materials for food packaging. *J. Bioresour. Bioprod.* **2022**, *7*, 1–13. [CrossRef]
32. Yadav, M.; Agarwal, M. Biobased building materials for sustainable future: An overview. *Mater. Today Proc.* **2021**, *43*, 2895–2902. [CrossRef]
33. Vagtholm, R.; Matteo, A.; Vand, B.; Tupenaite, L. Evolution and Current State of Building Materials, Construction Methods, and Building Regulations in the U.K.: Implications for Sustainable Building Practices. *Buildings* **2023**, *13*, 1480. [CrossRef]
34. Sahlol, D.G.; Elbeltagi, E.; Elzoughiby, M.; Abd Elrahman, M. Sustainable building materials assessment and selection using system dynamics. *J. Build. Eng.* **2021**, *35*, 101978. [CrossRef]
35. Sangmesh, B.; Patil, N.; Jaiswal, K.K.; Gowrishankar, T.P.; Karthik Selvakumar, K.; Jyothi, M.S.; Jyothilakshmi, R.; Kumar, S. Development of sustainable alternative materials for the construction of green buildings using agricultural residues: A review. *Constr. Build. Mater.* **2023**, *368*, 130457. [CrossRef]
36. Hai, L.V.; Muthoke, R.M.; Panicker, P.S.; Agumba, D.O.; Pham, H.D.; Kim, J. All-biobased transparent-wood: A new approach and its environmental-friendly packaging application. *Carbohydr. Polym.* **2021**, *264*, 118012. [CrossRef] [PubMed]
37. Montanari, C.; Chen, H.; Lidfeldt, M.; Gunnarsson, J.; Olsén, P.; Berglund, L.A. Sustainable Thermal Energy Batteries from Fully Bio-Based Transparent Wood. *Small.* **2023**, *19*, 2301262. [CrossRef] [PubMed]
38. Tu, H.; Zhu, M.; Duan, B.; Zhang, L. Recent progress in high-strength and robust regenerated cellulose materials. *Adv. Mater.* **2021**, *33*, 2000682. [CrossRef]
39. Rasheed, M.; Jawaid, M.; Karim, Z.; Abdullah, L.C. Morphological, physiochemical and thermal properties of microcrystalline cellulose (MCC) extracted from bamboo fiber. *Molecules* **2020**, *25*, 2824. [CrossRef]
40. Elkhaoulani, A.; Arrakhiz, F.Z.; Benmoussa, K.; Bouhfid, R.; Qaiss, A. Mechanical and thermal properties of polymer composite based on natural fibers: Moroccan hemp fibers/polypropylene. *Mater. Des.* **2013**, *49*, 203–208. [CrossRef]
41. Manaia, J.P.; Manaia, A.T.; Rodriges, L. Industrial Hemp Fibers: An Overview. *Fibers* **2019**, *7*, 106. [CrossRef]
42. Ramamoorthy, S.K.; Skrifvars, M.; Persson, A. A review of natural fibers used in biocomposites: Plant, animal and regenerated cellulose fibers. *Polym. Rev.* **2015**, *55*, 107–162. [CrossRef]
43. Missio, A.L.; Otoni, C.G.; Zhao, B.; Beaumont, M.; Khakalo, A.; Kämäräinen, T.; Silva, S.H.F.; Mattos, B.D.; Rojas, O.J. Nanocellulose removes the need for chemical crosslinking in tannin-based rigid foams and enhances their strength and fire retardancy. *ACS Sustain. Chem. Eng.* **2020**, *10*, 10303–10310. [CrossRef]
44. Mucsi, Z.M.; Hasan, K.F.; Horváth, P.G.; Bak, M.; Kóczán, Z.; Alpár, T. Semi-dry technology mediated lignocellulosic coconut and energy reed straw reinforced cementitious insulation panels. *J. Build. Eng.* **2022**, *57*, 104825. [CrossRef]
45. Sapuan, S.M.; Leenie, A.; Harimi, M.; Beng, Y.K. Mechanical properties of woven banana fibre reinforced epoxy composites. *Mater. Des.* **2006**, *27*, 689–693. [CrossRef]
46. Wang, J.; Zheng, K.; Cui, N.; Cheng, X.; Ren, K.; Hou, P.; Feng, L.; Zhou, Z.; Xie, N. Green and durable lightweight aggregate concrete: The role of waste and recycled materials. *Materials* **2020**, *13*, 3041. [CrossRef] [PubMed]
47. Ryłko-Polak, I.; Komala, W.; Białowiec, A. The Reuse of Biomass and Industrial Waste in Biocomposite Construction Materials for Decreasing Natural Resource Use and Mitigating the Environmental Impact of the Construction Industry: A Review. *Materials* **2022**, *15*, 4078. [CrossRef] [PubMed]
48. Zailan, S.N.; Mahmed, N.; Abdullah, M.M.A.B.; Rahim, S.Z.A.; Halin, D.S.C.; Sandu, A.V.; Vizureanu, P.; Yahya, Z. Potential Applications of Geopolymer Cement-Based Composite as Self-Cleaning Coating: A Review. *Coatings* **2022**, *12*, 133. [CrossRef]
49. Amin, M.N.; Ahmad, W.; Khan, K.; Ahmad, A. A comprehensive review of types, properties, treatment methods and application of plant fibers in construction and building materials. *Materials* **2022**, *15*, 4362. [CrossRef]
50. Jongvisuttisun, P.; Negrello, C.; Kurtis, K.E. Effect of processing variables on efficiency of eucalyptus pulps for internal curing. *Cem. Concr. Compos.* **2013**, *37*, 126–135. [CrossRef]
51. Coppola, L.; Beretta, S.; Bignozzi, M.C.; Bolzoni, F.; Brenna, A.; Cabrini, M.; Candamano, S.; Caputo, D.; Carsana, M.; Cioffi, R.; et al. The Improvement of Durability of Reinforced Concretes for Sustainable Structures: A Review on Different Approaches. *Materials* **2022**, *15*, 2728. [CrossRef]
52. Vijay, K.; Murmu, M.; Deo, S.V. Bacteria based self healing concrete—A review. *Constr. Build. Mater.* **2017**, *152*, 1008–1014. [CrossRef]

53. Dewi, S.M.; Wijaya, M.N. The use of bamboo fiber in reinforced concrete beam to reduce crack. *AIP Conf. Proc.* **2017**, *1887*, 020003. [CrossRef]
54. Menor, M.C.P.; Ros, P.S.; García, A.M.; Caballero, M.J.A. Granulated cork with bark characterised as environment-friendly lightweight aggregate for cement-based materials. *J. Clean. Prod.* **2019**, *229*, 358–373. [CrossRef]
55. Klapiszewski, Ł.; Klapiszewska, I.; Ślosarczyk, A.; Jesionowski, T. Lignin-based hybrid admixtures and their role in cement composite fabrication. *Molecules* **2019**, *24*, 3544. [CrossRef]
56. Ercan, E.; Atar, M.; Kucuktuvek, M.; Keskin, H. Characterization of formaldehyde emission and combustion properties of peanut (*Arachis Hypogaea*) husk-based green composite panels for building applications. *Drv. Ind.* **2022**, *73*, 139–149. [CrossRef]
57. Charai, M.; Mezrhab, A.; Karkri, M.; Moga, L. Thermal performance study of plaster reinforced with Alfa fibers. *AIP Conf. Proc.* **2021**, *2429*, 020005. [CrossRef]
58. Aouba, L.; Bories, C.; Coutand, M.; Perrin, B.; Lemercier, H. Properties of fired clay bricks with incorporated biomasses: Cases of olive stone flour and wheat straw residues. *Constr. Build. Mater.* **2016**, *102*, 7–13. [CrossRef]
59. Li, S.; Li, Z.; Zhang, Y.; Liu, C.; Yu, G.; Li, B.; Mu, X.; Peng, H. Preparation of concrete water reducer via fractionation and modification of lignin extracted from pine wood by formic acid. *ACS Sustain. Chem. Eng.* **2017**, *5*, 4214–4222. [CrossRef]
60. Tawasil, D.N.B.; Aminudin, E.; Abdul Shukor Lim, N.H.; Nik Soh, N.M.Z.; Leng, P.C.; Ling, G.H.T.; Ahmad, M.H. Coconut fibre and sawdust as green building materials: A laboratory assessment on physical and mechanical properties of particleboards. *Buildings* **2021**, *11*, 256. [CrossRef]
61. Maximino, C.; Ongpeng, J.; Inciong, E.; Sendo, V.; Soliman, C.; Siggaoat, A. Using waste in producing bio-composite mycelium bricks. *Appl. Sci.* **2020**, *10*, 5303. [CrossRef]
62. Romano, A.; Bras, A.; Grammatikos, S.; Shaw, A.; Riley, M. Dynamic behaviour of bio-based and recycled materials for indoor environmental comfort. *Constr. Build. Mater.* **2019**, *211*, 730–743. [CrossRef]
63. Kobayashi, T.; Nakajima, L. Sustainable development goals for advanced materials provided by industrial wastes and biomass sources. *Curr. Opin. Green Sustain. Chem.* **2021**, *28*, 100439. [CrossRef]
64. Khalid, M.Y.; Imran, R.; Arif, Z.U.; Akram, N.; Arshad, H.; Al Rashid, A.; García Márquez, F.P. Developments in Chemical Treatments, Manufacturing Techniques and Potential Applications of Natural-Fibers-Based Biodegradable Composites. *Coatings* **2021**, *11*, 293. [CrossRef]
65. Khoshnava, S.M.; Rostami, R.; Mohamad Zin, R.; Štreimikienė, D.; Mardani, A.; Ismail, M. The role of green building materials in reducing environmental and human health impacts. *Int. J. Environ. Res. Public. Health* **2020**, *17*, 2589. [CrossRef] [PubMed]
66. Mija, A.; van der Waal, J.C.; Pin, J.M.; Guigo, N.; de Jong, E. Humins as promising material for producing sustainable carbohydrate-derived building materials. *Constr. Build. Mater.* **2017**, *139*, 594–601. [CrossRef]
67. Weiler, S.; Scholz-Barth, K. *Green Roof Systems: A Guide to the Planning, Design, and Construction of Landscapes Over Structure*, 1st ed.; John Wiley & Sons: Hoboken, NJ, USA, 2009.
68. Grant, G.; Gedge, D. Living Roofs and Walls from Policy to Practice, 10 Years of Urban Greening in London and beyond. Blanche Cameron of the Bartlett UCL. 2019. Available online: https://livingroofs.org/wp-content/uploads/2019/04/LONDON-LIVING-ROOFS-WALLS-REPORT-2019.pdf (accessed on 25 August 2023).
69. Hachoumi, I.; Pucher, B.; De Vito-Francesco, E.; Prenner, F.; Ertl, T.; Langergraber, G.; Fürhacker, M.; Allabashi, R. Impact of Green Roofs and Vertical Greenery Systems on Surface Runoff Quality. *Water* **2021**, *13*, 2609. [CrossRef]
70. Iskandar, M.J.; Baharum, A.; Anuar, F.H.; Othaman, R. Palm oil industry in South East Asia and the effluent treatment technology—A review. *Environ. Technol. Innov.* **2018**, *9*, 169–185. [CrossRef]
71. Luca, B.I.; Panțiru, A.; Timu, A.; Bărbuță, M.; Diaconu, L.I.; Rujanu, M.; Diaconu, A.C. Eco-concrete for obtaining "green" construction elements. *IOP Conf. Ser. Mater. Sci. Eng.* **2023**, *1283*, 012007. [CrossRef]
72. Liu, D.; Yao, Q.; Jia, Y. Experimental study of vegetable fiber-mortar composites in ecological and energy-saving composite wall. *J. Beijing Jiaotong Univ.* **2011**, *35*, 34–38.
73. Hasan, K.F.; Horváth, P.G.; Bak, M.; Le, D.H.A.; Mucsi, Z.M.; Alpar, T. Rice straw and energy reed fibers reinforced phenol formaldehyde resin polymeric biocomposites. *Cellulose* **2021**, *28*, 7859–7875. [CrossRef]
74. Çomak, B.; Bideci, A.; Bideci, Ö.S. Effects of hemp fibers on characteristics of cement-based mortar. *Constr. Build. Mater.* **2018**, *169*, 794–799. [CrossRef]
75. Bayapureddy, Y.; Muniraj, K.; Mutukuru, M.R.G. Sugarcane bagasse ash as supplementary cementitious material in cement composites: Strength, durability, and microstructural analysis. *J. Korean Ceram. Soc.* **2020**, *57*, 513–519. [CrossRef]
76. Guirguis, M.N.; Farahat, Z.; Micheal, A. Developing an interior cladding fiberboard by utilizing sugarcane bagasse as a local agro-waste in Egypt. *Sci. Rep.* **2023**, *13*, 12870. [CrossRef] [PubMed]
77. Alengaram, U.J.; Al Muhit, B.A.; bin Jumaat, M.Z. Utilization of oil palm kernel shell as lightweight aggregate in concrete—A review. *Constr. Build. Mater.* **2013**, *38*, 161–172. [CrossRef]
78. Rai, A.; Joshi, Y.P. Applications and properties of fibre reinforced concrete. *Int. J. Eng. Res. Appl.* **2014**, *4*, 123–131.
79. Ramli, M.; Kwan, W.H.; Abas, N.F. Strength and durability of coconut-fiber-reinforced concrete in aggressive environments. *Constr. Build. Mater.* **2013**, *38*, 554–566. [CrossRef]

80. Arrakhiz, F.Z.; Elachaby, M.; Bouhfid, R.; Vaudreuil, S.; Essassi, M.; Qaiss, A. Mechanical and thermal properties of polypropylene reinforced with Alfa fiber under different chemical treatment. *Mater. Des.* **2012**, *35*, 318–322. [CrossRef]
81. Sodangi, M.; Kazmi, Z.A. Integrated evaluation of the impediments to the adoption of coconut palm wood as a sustainable material for building construction. *Sustainability* **2020**, *12*, 7676. [CrossRef]
82. Ahmad, W.; Farooq, S.H.; Usman, M.; Khan, M.; Ahmad, A.; Aslam, F.; Al Yousef, R.; Al Abduljabbar, H.; Sufian, M. Effect of coconut fiber length and content on properties of high strength concrete. *Materials* **2020**, *13*, 1075. [CrossRef]
83. Stohl, L.; Manninger, T.; von Werder, J.; Dehn, F.; Gorbushina, A.; Meng, B. Bioreceptivity of concrete: A review. *J. Build. Eng.* **2023**, *76*, 107201. [CrossRef]
84. Nazmul, R.T.; Sainsbury, B.A.; Al-Deen, S.; Garcez, E.O.; Ashraf, M. An Experimental Evaluation of Hemp as an Internal Curing Agent in Concrete Materials. *Materials* **2023**, *16*, 3993. [CrossRef]
85. Sáez-Pérez, M.P.; Durán-Suárez, J.A.; Castro-Gomes, J. Improving the Behaviour of Green Concrete Geopolymers Using Different HEMP Preservation Conditions (Fresh and Wet). *Minerals* **2022**, *12*, 1530. [CrossRef]
86. Zhou, X.; Saini, H.; Kastiukas, G. Engineering properties of treated natural hemp fiber-reinforced concrete. *Front. Built Environ.* **2017**, *3*, 33. [CrossRef]
87. Viel, M.; Collet, F.; Prétot, S.; Lanos, C. Hemp-straw composites: Gluing study and multi-physical characterizations. *Materials* **2019**, *12*, 1199. [CrossRef]
88. Kumar, G. Review on Feasibility of Bamboo in Modern Construction. *Int. J. Pf. Civ. Eng. SSRG-IJCE* **2015**, *2*, 66–70.
89. Ede, A.N.; Olofinnade, O.M.; Joshua, O.; Nduka, D.O.; Oshogbunu, O.A. Influence of bamboo fiber and limestone powder on the properties of self-compacting concrete. *Cogent Eng.* **2020**, *7*, 1721410. [CrossRef]
90. Bittner, C.M.; Oettel, V. Fiber Reinforced Concrete with Natural Plant Fibers—Investigations on the Application of Bamboo Fibers in Ultra-High Performance Concrete. *Sustainability* **2020**, *14*, 12011. [CrossRef]
91. Kundu, S.P.; Chakraborty, S.; Chakraborty, S. Effectiveness of the surface modified jute fibre as fibre reinforcement in controlling the physical and mechanical properties of concrete paver blocks. *Constr. Build. Mater.* **2018**, *191*, 554–563. [CrossRef]
92. Krishna, T.S.V.; Yadav, B.M. A comparative study of jute fiber reinforced concrete with plain cement concrete. *Int. J. Res. Eng. Technol.* **2016**, *5*, 111–116.
93. Ali, A.; Nasir, M.A.; Khalid, M.Y.; Nauman, S.; Shaker, K.; Khushnood, S.; Altaf, K.; Zeeshan, M.; Hussain, A. Experimental and numerical characterization of mechanical properties of carbon/jute fabric reinforced epoxy hybrid composites. *J. Mech. Sci. Technol.* **2019**, *33*, 4217–4226. [CrossRef]
94. Abirami, R.; Vijayan, D.S.; John, S.J.; Albert, A.; Alex, A.K. Experimental study on concrete properties using pineapple leaf fiber. *Int. J. Adv. Res. Technol.* **2020**, *11*, 913–920. [CrossRef]
95. Yaremko, C. Durability of flax fibre reinforced concrete. Ph.D. Thesis, University of Saskatchewan, Saskatoon, SK, Canada, 2012.
96. Öztürk, T.; Bayrakl, M. The possibilities of using tobacco wastes in producing lightweight concrete. *Agric. Eng. Int. CIGR J.* **2005**, *7*, BC05006.
97. Juan, S.; Zhi, Z. Preparation and study of resin translucent concrete products. *Adv. Civ. Eng.* **2019**, *2019*, 8196967. [CrossRef]
98. Kausar, A. Scientific potential of chitosan blending with different polymeric materials: A review. *J. Plast. Film. Sheeting* **2017**, *33*, 384–412. [CrossRef]
99. Tran-Ly, A.N.; Heeb, M.; Kalac, T.; Schwarze, F.W. Antimicrobial effect of fungal melanin in combination with plant oils for the treatment of wood. *Front. Mater.* **2022**, *9*, 915607. [CrossRef]
100. Almusaed, A.; Almssad, A.; Alasadi, A.; Yitmen, I.; Al-Samaraee, S. Assessing the Role and Efficiency of Thermal Insulation by the "BIO-GREEN PANEL" in Enhancing Sustainability in a Built Environment. *Sustainability* **2023**, *15*, 10418. [CrossRef]
101. Nagdeve, S.S.; Manchanda, S.; Dewan, A. Thermal performance of indirect green façade in composite climate of India. *Build. Environ.* **2023**, *230*, 109998. [CrossRef]
102. Omar, M.F.; Abdullah, M.A.H.; Rashid, N.A.; Abdul Rani, A.L.; Illias, N.A. The Application of Coconut Fiber as Insulation Ceiling Board in Building Construction. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *864*, 012196. [CrossRef]
103. Manohar, K.; Ramlakhan, D.; Kochhar, G.; Haldar, S. Biodegradable fibrous thermal insulation. *J. Braz. Soc. Mech. Sci. Eng.* **2006**, *28*, 45–47. [CrossRef]
104. Yli-Halla, M.; Lötjönen, T.; Kekkonen, J.; Virtanen, S.; Marttila, H.; Liimatainen, M.; Saari, M.; Mikkola, J.; Suomela, R.; Joki-Tokola, E. Thickness of peat influences the leaching of substances and greenhouse gas emissions from a cultivated organic soil. *Sci. Total Environ.* **2022**, *806*, 150499. [CrossRef]
105. Bakatovich, A.; Gaspar, F. Composite material for thermal insulation based on moss raw material. *Constr. Build. Mater.* **2019**, *228*, 116699. [CrossRef]
106. Zou, S.; Li, H.; Wang, S.; Jiang, R.; Zou, J.; Zhang, X.; Liu, L.; Zhang, G. Experimental research on an innovative sawdust biomass-based insulation material for buildings. *J. Clean. Prod.* **2020**, *260*, 121029. [CrossRef]
107. Kain, G.; Tudor, E.M.; Barbu, M.C. Bark thermal insulation panels: An explorative study on the effects of bark species. *Polymers* **2020**, *12*, 2140. [CrossRef] [PubMed]
108. Karaky, H.; Maalouf, C.; Bliard, C.; Gacoin, A.; Lachi, M.; El Wakil, N.; Polidori, G. Characterization of beet-pulp fiber reinforced potato starch biopolymer composites for building applications. *Constr. Build. Mater.* **2019**, *203*, 711–721. [CrossRef]

109. Liuzzi, S.; Rubino, C.; Stefanizzi, P.; Martellotta, F. Performance characterization of broad band sustainable sound absorbers made of almond skins. *Materials* **2020**, *13*, 5474. [CrossRef] [PubMed]
110. La Scalia, G.; Saeli, M.; Miglietta, P.P.; Micale, R. Coffee biowaste valorization within circular economy: Evaluation method of spent coffee grounds potentials for mortar production. *Int. J. Life Cycle Assess.* **2021**, *26*, 1805–1815. [CrossRef] [PubMed]