Agronomy Research **19**(3), 1455–1466, 2021
https://doi.org/10.15159/AR.21.131

Bibliometric analysis on the use of natural fibers in construction materials

G.M.G. Ferreira[1], D. Cecchin[1,*], A.R.G. de Azevedo[2], I.C.R.P. Valadão[1], K.A. Costa[3], T.R. Silva[4], F. Ferreira[5], P.I.S. Amaral[6], C.M. Huther[1], F.A. Sousa[7], J.O. Castro[8], P.F.P. Ferraz[8] and M.A. Teixeira[1]

[1]Federal Fluminense University (UFF), Department of Agricultural Engineering and Environment, Street Passo da Pátria, n. 156, Boa Viagem, Niterói-RJ, Brazil
[2]North Fluminense State University (UENF), Civil Engineering Department, Campos dos Goytacazes, RJ, Brazil
[3]Federal Fluminense University (UFF), Production Engineering Department, Avenida dos Trabalhadores, n. 420, Vila Santa Cecília, Volta Redonda-RJ, Brazil
[4]North Fluminense State University (UENF), Advanced Materials Laboratory (LAMAV), Av. Alberto Lamego, 2000, 28013-602 Campos dos Goytacazes-RJ, Brazil
[5]Federal Fluminense University (UFF), Metallurgical Engineering Department (VMT), Volta Redonda-RJ, Brasil
[6]José do Rosário Vellano University (UNIFENAS), Department of Veterinary Medicine, Rodovia Mg-179 km 0, s/n - Bairro Trevo, BR 37130-000 Alfenas-MG, Brazil
[7]SEMAG/Aracruz, Av. Morobá, n. 20, BR 29192-733 Bairro Morobá-ES, Brazil
[8]Federal University of Lavras (UFLA), Campus Universitário, postal scode 3037 Lavras, MG, Brazil
[*]Correspondence: daianececchin@id.uff.br

Received: February 2nd, 2021; Accepted: August 3rd, 2021; Published: August 30th, 2021

Abstract. Due to the increasing interest of the population in the sustainability theme, there was a consequent growth in publications related to the theme in the area of civil construction. Agro-industrial waste has become an environmental problem, and with that natural fibers have found space in the reuse of waste due to its characteristics and possibilities of improving the mechanical properties of its products. In order to achieve sustainable construction demand, along with the need to reuse waste, studies have begun to analyze the application of natural fibers in construction materials. The documents provided by the Web of Science (WOS) database through research carried out with the search for the terms 'Natural Fibers' and 'Building materials' restricted to the period 2010–2020 in the main WOS collection. The institutions involved with the publications, the countries of origin of the documents, the year of publication, the keywords used by the authors and the number of citations for each document were analyzed using bibliometrics in the VOSVIEWER (VOS) software. The result of the analysis shows an increase in documents related to the theme over the years, and that the countries with the most studies in the area are China (16), USA (14) and Brazil (11), respectively. The results presented after analysis of the keywords show that natural fiber (61 occurrences), mechanical properties (44 occurrences) and composites (31 occurrences) are the words with the highest occurrence among the analyzed

documents. The present study shows the growth of research related to the theme, in addition to discriminating countries, institutions and authors, which allows monitoring the scientific expansion of the theme and guiding future studies.

Key words: research, civil construction, building materials; sustainability, co-occurrence analysis.

INTRODUCTION

The growing interest in studies related to sustainability in the civil construction sector has mainly highlighted construction materials (da Silva et al., 2021). Thereby, the focus on the use of renewable sources of raw materials has been aimed at, for example, applications in composite materials of natural fibers in the construction sector, which has been presenting alternatives regarding the use of recycled fibers and reinforcements of natural fibers (organic and inorganic) in building materials (Fan, 2017; Asim et al., 2020; Erkmen et al., 2020).

The world production of natural fibers corresponds to around 32 million and 200 thousand tons, allowing us to state that most of the production of these fibers comes from cotton, which corresponds to approximately 80% of the total production weight, followed by jute, kenaf and allied fibers with about 10% of the total production weight. Wool and coconut fiber represent about 1 million tons each, and the sum of other natural fibers corresponds to 1 million and 530 thousand tons (Townsend & Sette, 2020). Bartolini et al. (2019) evidently show the growth in the number of articles published on the subject between the years 2014 and 2018 when compared to the stability presented in the period from 2006 to 2014.

Natural fibers are considered a renewable and easily obtainable resource, which can enhance the technological properties of composite materials, as well as the improvement of their mechanical and thermoacoustic characteristics, thus replacing synthetic fibers (Reddy et al., 2020). Sathish et al. (2021) also emphasize the need to reduce the use of petroleum-based synthetic fibers, allowing natural fiber to meet this need, in addition to reducing energy consumption and having high availability.

In this context, several studies have been developed for the application of natural fibers in construction materials such as Ferreira et al. (2020), who evaluated the influence of carboxylated styrene butadiene rubber coating on the mechanical performance of plant fibers and on their interface with the cementitious matrix. The authors highlighted that to reduce or mitigate interferences in the hydration of cementitious matrices, treatments for these fibers are necessary, such as reducing the fiber's dimensional variation, providing a greater interaction between the fiber surface and the hydration reactions, densifying the transition zone of the interface. The authors found that after addition of the polymer, all fibers showed an increase in tensile strength and better adhesion. The treatment reduced the water absorption capacity of all studied fibers (curauá, jute and sisal). From this perspective, it was possible to affirm that the fiber treatment provided a better interaction between the fibers and the cementitious matrix.

Azevedo et al. (2021a) evaluated the technological performance of natural açaí fiber reinforced in cement-based mortars. Different fiber additions under natural conditions and after surface treatment with NaOH were studied. The authors concluded that the addition of açaí fiber to mortar worked by filling part of the internal pores and as a reinforcing material for the cementitious matrix to absorb and redistribute internal

stresses. Furthermore, they emphasize that the açaí fiber must be properly treated with a NaOH solution due to the loss of durable properties found in its untreated use. The authors also state that high proportions of natural fibers in cementitious composites can be harmful, thus confirming that the addition of 3.0% of natural fibers treated with NaOH in mortars is recommended to balance adequate technology and durability.

Wang & Chen (2017) studied the development of bamboo-based composites and showed that bamboo has more than ten cell layers in its cell structure, with each microfibril different and orientation with thick layers and thin layers in alternating arrangements on the cell wall. The results presented verified that bamboo-based composites are a combination of high strength, dimensional stability, durability, with reliable structural properties, having high modulus of elasticity and well dispersed through a matrix of low modulus of elasticity, thus presenting the modulus of composites greater than that of the matrix. Hamad et al. (2017) evaluated the microstructure properties and their bond with the tensile strength of different natural fibers (linen, jute, ramie and sisal fibers) and identified that jute and sisal fibers exhibit less variation in terms of fiber cross-sectional area, shape, inner lumen size and cell wall thickness compared to linen and ramie fibers, which ultimately reflects on the fibers' tensile properties. They also verified that the stress-strain behavior presented two distinct regimes. The authors found that this variation was linked to differences in fiber microstructure. When studying the development of mortar for laying and coating with natural pineapple fibers Azevedo et al. (2020) tested different percentages of fiber incorporation, as treatment (NaOH) and without fiber treatment. The authors observed that the treatment with NaOH solution and the percentage of natural pineapple fiber incorporated in up to 5% in relation to the cement mass form mortars with technological feasibility of application. Valášek & Habrová (2017) studied the hardness and abrasive wear resistance of epoxy resins filled with unordered short sisal fibers. They observed that the surface treatment of the fibers led to the removal of the surface layers of fiber, increasing surface segmentation. As for the hardness, there was a decrease in the same in the composites as the fiber addition increased.

In order to optimize the geopolymer matrix produced with Fired Clay Brick Powder Silva et al. (2020) studied the reinforcement of the material using the application of jute and sisal fibers. The authors observed that the increase in fiber content provides a linear increase in flexural strength, whereas in relation to the compression and tensile tests an optimal fiber content was presented, which varies according to the type of fiber used.

Wongsa et al. (2020) evaluated the performance of sisal fiber and coconut fiber as reinforcement of fly ash-based geopolymer mortar with high calcium content. The authors studied ten different mortar mixes, with sisal fibers, coconut fiber and glass fiber, in proportions of 0%, 0.50%, 0.75% and 1.00% of the volume of the mixture. The authors found a significant improvement in tensile and bending strength when compared to the control sample, and similar to the synthetic fiber sample. The authors observed a trend towards a decrease in compressive strength, workability, dry density and ultrasonic pulse velocity, in addition to no significant effect of the fiber on thermal conductivity and water absorption. Therefore, the authors conclude that geopolymer composites can use coir and sisal fibers as reinforcement material.

Study by Azevedo et al. (2021b) evaluated the physical and mechanical characteristics of geopolymer materials reinforced with natural fibers and geopolymer materials reinforced with synthetic fibers. They observed the need for a pre-treatment in natural fiber for better mechanical performance due to their sensitivity to alkaline environment and low adhesion to the matrix caused by substances present on its surface. When fiber pre-treatment is combined with improved traceability and ideal curing conditions, the application of natural fibers in geopolymer materials allows the replacement of synthetic fibers without harming their performance. However, the particular characteristic of each fiber must be analyzed, since the variation between different types of natural fibers can make the polymer matrix not ideally incorporated.

Tan et al. (2019) studied the application of 15 vegetable fibers from agricultural and forestry residues chosen due to their potential as a raw material for the manufacture of geopolymeric panels. The authors observed good compatibility of the studied vegetable fibers (without additives), with wood fibers being more compatible with the material than non-wood fibers in general. Zhang et al. (2021) studied the manufacture of geopolymer mortar with natural fiber as reinforcement. The authors observed good compatibility of the geopolymer matrix with the pre-treatment of natural fiber with $CaCl_2$, in addition to an increase in flexural strength and tenacity according to the increase in the proportion of fiber. However, it was also observed a decrease in the compressive strength of the material due to the increase in voids caused by the fiber.

With this in mind, it is possible to affirm that the incorporation of natural fibers in construction materials has been constantly the focus for new researches aimed at the application of these fibers. Thus, using bibliometric analysis to enhance the incidence of these researches is very relevant (Hamdaoui et al., 2020). According to Aziz et al. (2020), bibliometrics is related to the quantitative study of the properties of scientific productions, incorporating new understandings about a given topic to the literature.

The purpose of bibliometric analysis is to measure production, impact and collaboration, using different information as indicators, with a broad coverage of information by the database being important (Mallig, 2010). As presented by Ye et al. (2020), the bibliometric analysis allows finding a knowledge map related to certain research metrics. Databases provide valuable bibliometric data for providing global academic information (Xie et al., 2020). The Web of Science (WOS) database is widely known as one of the main sources in the academic world, where research metrics are used taking into account publication and impact algorithms, which made it a reliable and recognized source for conducting research scientific (Powell & Peterson, 2017).

Thus, the aim of this study was to carry out a bibliometric analysis of works regarding the use of natural fibers in construction materials in the period from 2010 to 2020.

MATERIALS AND METHODS

Between the 21st and 22nd of January 2021, a bibliographic search was carried out in the WOS database. The search metrics used in the survey were the keywords ‘Natural Fiber’ and ‘Building Materials’, with the years 2010–2020 being adopted with a search criterion. The analysis was made through the main collection of the WOS database, adopting a broad scope of research, considering all the searchable fields available for

consultation. The documents resulting from the research were exported in a text file (TXT) in tab format (Windows), with the contents of the complete record and references cited.

The institutions involved with the publications found were analyzed with VOS through the co-authored analysis, with the metric 'organizations', considering all documents with at least one occurrence. From the results obtained, the three institutions with the highest occurrence were considered. The countries involved in the research were verified through VOS analysis, considering the co-authorship of the documents restricting to the countries. At least one quote per country was considered.

The information obtained through the database was placed in the Excel software, discriminating the documents by year of publication. To obtain information regarding co-occurrence parameters, countries and institutions linked to the documents, the VOS tool was used. Vosviewer (VOS) is open access software for creating and viewing bibliometric networks, which also allows analysis of text data.

To analyze the co-occurrence of keywords, initially, the metric of at least one occurrence of the keyword was used, which allowed obtaining all the keywords found in the analyzed documents. The search result was exported to a text file and opened in Excel, where equivalent and repeated words with different writing were unified through a model text file provided by VOS and later added to the program. The analysis was redone with the updated information, where the number of occurrences was defined as 5, and the keyword graph was subsequently generated.

The number of citations obtained by the publications was obtained through co-occurrence analysis of the VOS in the 'citations' type with the 'documents' analysis unit, where the 9 most cited documents were considered.

RESULTS AND DISCUSSION

Among the documents found in the WOS database, 107 were found for the period and research metrics analyzed, as shown in Fig. 1.

When analyzing the countries involved in the publications found in the WOS for the period from 2010 to 2020, a total of 43 countries were observed, the results can be seen in Fig. 2. The countries with the highest number of publications were: China (16 publications), United States (14 publications), Brazil (11 publications) and India (10 publications).

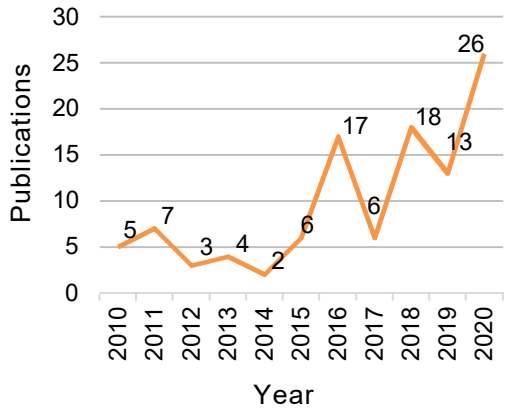

Figure 1. Number of publications per year.

When analyzing the keywords resulting from the search in the VOS software, 34 keywords were found and presented in Fig. 3. Among them, natural fiber (61 key-words), mechanical properties (44 key-words) and composites (31 key-words.

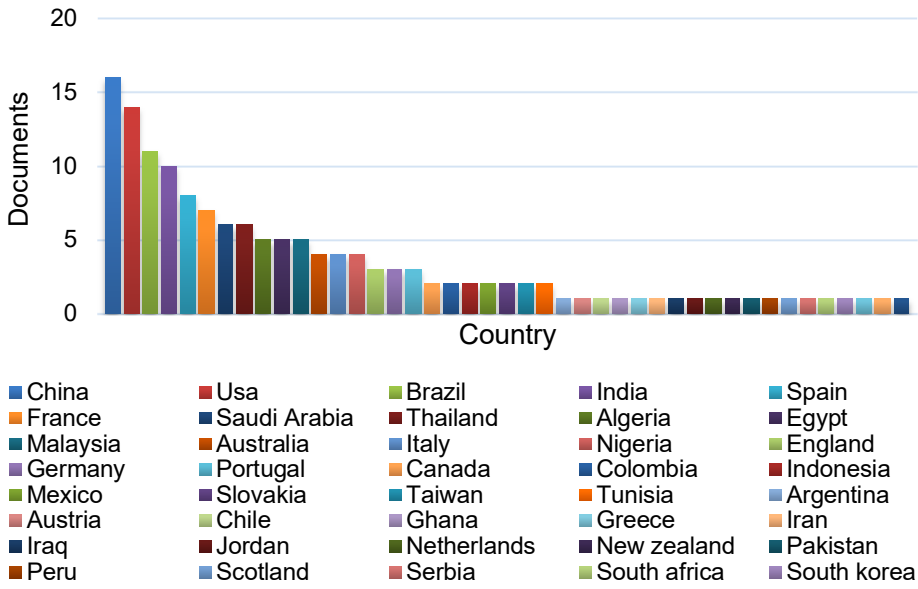

Figure 2. Author by country.

From the bibliometric analyzes performed in the VOS software, it is possible to view the number of citations for each of these documents, those found in the WOS database. The work with the highest number of citations is the study by (Pacheco-Torgal & Jalali (2011), in which he analyzed the use of Bagasse fibers, Banana leaf, Banana trunk, Coconut coir, Coconut tissue, Eucalyptus and Sisal as reinforcement of materials cement, totaling 213 citations, followed by 134 citations, Mahjoub et al. (2014), who analyzed the use of Kenaf fiber applied as reinforcement of polymer composites, and a study by Yan et al. (2016) analyzing the application of coconut fiber in polymers and cementitious materials is in the third position as the most cited document, totaling 91 citations, the ten most cited documents can be seen in Table 1.

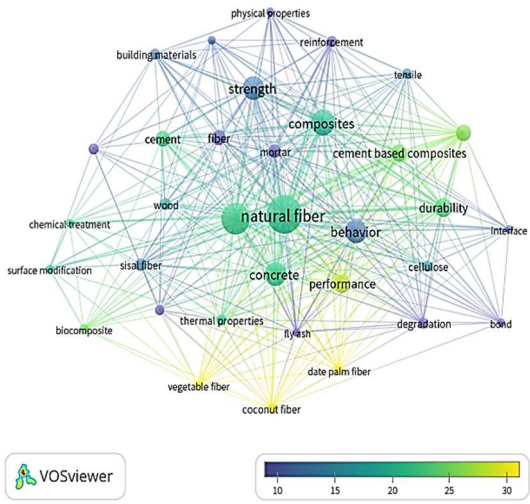

Figure 3. Map of occurrences of keywords.
Source: VOSVIEWER.

Among the documents found, the analysis of the institutions showed that Beijing Forestry University, located in Beijing / China, is more involved in research and publications within the database related to the theme, with 5 documents. Also noteworthy are the institutions with greater engagement related to research on the use of

natural fibers in construction materials such as Princeton University (New Jersey - USA) and University of São Paulo (São Paulo - Brazil), with 4 documents each.

Table 1. The 10 most cited documents

Author	Residue	Citations
Pacheco-Torgal & Jalali, 2011	Bagasse, Banana leaf, Banana trunk, Coconut coir, Coconut tissue, Eucalyptus e Sisal	213
Mahjoub et al., 2014	Kenaf	134
Yan et al., 2016	Coconut fiber	91
Karade, 2010	Wheat straw, Rice straw, Coir, Hazelnut shell, Oil palm residues, Cork granules, Bark, Bagasse, Arhar stalks, Construction demolition wastes, Waste timber, Waste MDF e Furniture industry waste	85
Elsaid et al., 2018	Kenaf	71
Senthilkumar et al., 2018	Sisal	70
Ferreira et al., 2015	Sisal	51
Hamza et al., 2013	Alfa leaves, rush stems, palm leaflets and date palm wood	40
Lertwattanaruk & Suntijitto, 2015	coconut coir and oil palm	39

The increase in interest in the use of natural fibers in civil construction by researchers is evident with the increase in research related to the theme over the years, as an example we can mention the study by Khasawneh & Alyaseen (2020) in which they analyzed the use of coconut fiber in bituminous mixtures for road materials, Alavez-Ramirez et al. (2012) analyzed the use of the same fiber, however in fiber cement sandwich panels. However, Freire et al. (2017) studied the application of agro-industrial waste in the manufacture of medium-density fiberboard (MDF) and high-density fiberboard (HDF) panels in order to add value to waste and reduce the demand for wood and by-products from the production of the panels.

Representing 47.66% of the publications found in the database used, in the studied period, are China, USA, Brazil and India. Pakistan (1 post), Vietnam (1 post), South korea (1 post), Arab emirates (1 post), Malaysia (5 post), Indonesia (2 post), Iran (1 post), Iraq (1 post), Jordan (1 publication), Taiwan (2 publications), Turkey (1 publication), Saudi Arabia (6 publication), India (10 publication) and Thailand (6 publication), countries belonging to the Asian continent, as observed in the analysis, also demonstrate great interest in research involving the topic, resulting in 46.70% of publications, which is justified by the fact that the continent is a major agricultural producer and most of the fibers from waste in the sector. In South America, research in the area is concentrated in Brazil, with 11 publications, followed by Colombia (2 publications), Argentina (1 publication), Chile (1 publication) and Peru (1 publication).

Asian countries are benchmarks for the strength of scientific research related to sustainability Det Udomsap & Hallinger (2020). The results are consistent with the studies by Li et al. (2018), which shows the growth of China in research related to the reuse of solid waste, where the country reaches the first place surpassing the USA in production in the area.

The residues obtained between the keywords were sisal, with 14 co-occurrences, followed by wood with 8 co-occurrences and coconut fiber with 7 occurrences. Also found during waste keyword analysis such as date palm (6), Fly Ash (5 occurrences),

Hemp (4 occurrences), Jute (4 occurrences), Kenaf (4 occurrences), Bagasse (4 occurrences), bamboo (3 occurrences) and rice straw (2 occurrences).

Hemp, jute, sisal, kenaf and coconut (coconut) residues are also recurrent keywords in WOS studies, such as Bartol & Mackiewicz-Talarczyk (2015), in relation to publications related to fiber studies. The potential of using Coffee husk, Coconut shell, and Banana pseudostem in scientific composites is presented in studies by Ferraz et al. (2020). Study by Kochova et al. (2020), demonstrates that coconut fiber has in its structure characteristics with adequate thermal and mechanical conditions, and can provide several applications in the construction industry. However, De Azevedo et al. (2021a) draws attention to the fact that some materials with cementitious matrix are not suitable for application of natural fibers due to the pH in the pore region of the matrix.

The use of agricultural by-products (natural fibers) in composite materials made with soil matrix and cement / lime has shown results of improved physical, mechanical and durability properties Danso & Manu (2020). The keywords also showed the occurrence of words related to material properties, such as mechanical properties (44) and thermal properties (7). The result showed the occurrence of behavior (26), strength (26), performance (18), tensile (6), physical properties (5), flexural strength (6), which analyze the properties of the material.

The mechanical performance of materials is the target of many studies, the term 'Mechanical Properties' was one of the ten most cited keywords in the study by Liu (2013), with 3,687 citations, with 'Building materials' being the second most cited with 6344 quotes.

The analyzes carried out by Alao et al. (2019) with marijuana fiber in polypropylene composites used tests of traction, compression, flexion, water absorption and expansion, air permeability and spectroscopy.

It is clear from the results presented by Karade (2010), the need for further research to better understand the durability property, a keyword with 18 occurrences in the publications from 2010 to 2020 analyzed in this article.

The literature review work by Pacheco-Torgal & Jalali (2011) reinforced the fact that mechanical properties, one of the keywords, are the focus of much of the available literature. The study by Slebi-Acevedo et al. (2019) draws attention to the lack of information regarding porous mixtures with addition of fibers, in addition to the need for studies on the mixture of two or more fibers to improve the mechanical properties of the composite.

There is a change in the need for studies over time, due to the emergence of new research in the area. The present work allows the monitoring of the scientific expansion of the theme through the bibliometric analysis carried out, allowing then to guide future studies.

CONCLUSIONS

Bibliometric analysis allowed an in-depth study of the number of documents referring to the use of natural fibers in construction materials, showing a considerable increase in the last eleven years, with a total of 26 publications in 2020. Among the countries identified in the documents are China, the United States, Brazil and India. The study found as keywords with the highest occurrence the words natural fiber, mechanical properties and composites.

The present study showed the growing interest in research related to the theme 'Natural Fibers' and 'Building Materials', in addition to presenting institutions and countries more closely linked to the theme and the relevance of the authors, in addition to allowing to follow the scientific expansion of the theme and guide future studies.

CHALLENGES AND FUTURE PERSPECTIVES

Based on this study, it is possible to affirm that the topic is very relevant, but it also needs to advance in certain issues, especially with regard to the emergence of new unconventional fibers. It was evidently possible to verify that materials produced with natural fibers contribute to improve the development of construction materials in terms of performance and sustainability. However, it is necessary to point out that the search for this theme should not be limited only to these parameters, but also to be sought considering that there is a large market behind it for these materials to be applied, not only to develop them.

Materials that incorporate natural fibers can offer a number of advantages over the traditional ones used in construction, however, the challenges continue to move towards the replacement of conventional materials by those that can exert a structure and function comparable to traditional ones, as well as presenting durability to long term, in addition to the cost and design of the material. Thus, it is possible to list some of these challenges that should be considered for future perspectives for the development of building materials using natural fibers: Mechanical property variability and stiffness; Standardization of these new materials; Long term durability; Cost reduction; Market acceptance.

REFERENCES

Alao, P.F., Kallakas, H., Poltimäe, T. & Kers, J. 2019. Effect of hemp fibre length on the properties of polypropylene composites. *Agronomy Research* **17**(4), 1517–1531. doi: 10.15159/AR.19.146

Alavez-Ramireza, R., Chiñas-Castillo, F., Morales-Dominguez, V.J. & Ortiz-Guzmana, M. 2012. Thermal conductivity of coconut fibre filled ferrocement sandwich panels. *Construction and Building Materials* **37**, 425–431. doi: 10.1016/j.conbuildmat.2012.07.053

Asim, M., Uddin, G.M., Jamshaid, H., Raza, A., Tahir, Z. ul R., Hussain, U., Satti, A.N., Hayat, N. & Arafat, S.M. 2020. Comparative experimental investigation of natural fibers reinforced light weight concrete as thermally efficient building materials. *Journal of Building Engineering* **31**, 101411. doi: 10.1016/j.jobe.2020.101411

Azevedo, A.R.G. de; Cruz, A.S.A., Marvila, M.T., Oliveira, Leandro B., Monteiro, S.N., Vieira, C.M.F., Fediuk, R., Timokhin, R., Vatin, N. & Daironas, M. 2021b. Natural Fibers as an Alternative to Synthetic Fibers in Reinforcement of Geopolymer Matrices: A Comparative Review. *Polymers* **13**(15), 493. doi: 10.3390/polym13152493

Azevedo, A.R.G. de; Marvila, M.T., Tayeh, B.A., Cecchin, D., Pereira, A.C. & Monteiro, S.N. 2021a. Technological performance of açaí natural fibre reinforced cement-based mortars. *Journal of Building Engineering* **33**, 101675. doi: 10.1016/j.jobe.2020.101675

Azevedo, A.R.G., Marvila, M.T., Zanelato, E.B., Alexandre, J., Xavier, G.C. & Cecchin, D. 2020. Development of mortar for laying and coating with pineapple fibers. *Revista Brasileira de Engenharia Agrícola e Ambiental* **24**(3), 187–193. doi: 10.1590/1807-1929/agriambi.v24n3p187-193

Aziz, E., Mustapha, H. & Jamila, E.A.A 2020. bibliometric study of the recent advances in open innovation concept. *Procedia Computer Science* **175**, 683–688. doi: 10.1016/j.procs.2020.07.100

Bartol, T. & Mackiewicz-Talarczyk, M. 2015. Bibliometric Analysis of Publishing Trends in Fiber Crops in Google Scholar, Scopus, and Web of Science. *Journal of Natural Fibers* **12**(6), 531–541. doi: 10.1080/15440478.2014.972000

Bartolini, M., Bottani, E. & Grosse, E.H. 2019. Green warehousing: Systematic literature review and bibliometric analysis. *Journal of Cleaner Production* **226**, 242–258. doi: 10.1016/j.jclepro.2019.04.055

da Silva, T.R., de Azevedo, A.R.G., Cecchin, D., Marvila, M.T., Amran, M., Fediuk, R., Vatin, N., Karelina, M., Klyuev, S. & Szelag, M. 2021. Application of Plastic Wastes in Construction Materials: A Review Using the Concept of Life-Cycle Assessment in the Context of Recent Research for Future Perspectives. *Materials* **14**, 3549. doi: 10.3390/ma14133549

Danso, H. & Manu, D. 2020. Influence of coconut fibres and lime on the properties of soil-cement mortar. *Case Studies in Construction Materials* **12**, e00316., doi: 10.1016/j.cscm.2019.e00316

Det Udomsap, A. & Hallinger, P. 2020. A bibliometric review of research on sustainable construction, 1994–2018. *Journal of Cleaner Production* **254**. doi: 10.1016/j.jclepro.2020.120073.

Elsaid, A., Dawood, M., Seracino, R. & Bobko, C. 2011. Mechanical properties of kenaf fiber reinforced concrete. *Construction and Building Materials* **25**(4), 1991–2001. doi: 10.1016/j.conbuildmat.2010.11.052

Erkmen, J., Yavuz, H.I., Kavci, E. & Sari, M. 2020. A new environmentally friendly insulating material designed from natural materials. *Construction and Building Materials* **255**, ISSN: 09500618. doi: 10.1016/j.conbuildmat.2020.119357

Fan, M. 2017. Future scope and intelligence of natural fibre based construction composites. *Advanced High Strength Natural Fibre Composites in Construction* 545–556. doi: 10.1016/B978-0-08-100411-1.00022-4

Ferraz, P., Mendes, R., Ferraz, G., Carvalho, V., Avelino, M., Narciso, C., Eugênio, T., Cadavid, V. & Bambi, G. 2020. Thermal analysis of cement panels with lignocellulosic materials for building. *Agronomy Research* **18**(S1), 797–80. doi: 10.15159/AR.20.124

Ferreira, S.R., Neto, A.R.S., Silva, F. de A., de Souza Jr, F. G. & Filho, R. D. T. 2020. The influence of carboxylated styrene butadiene rubber coating on the mechanical performance of vegetable fibers and on their interface with a cement matrix. *Construction and Building Materials* **262**, 15–36. doi: 10.1016/j.conbuildmat.2020.120770

Ferreira, S.R., Silva, F.A., Lima, P.R.L. & Toledo Filho, R.D. 2015. Effect of fiber treatments on the sisal fiber properties and fiber-matrix bond in cement based systems. *Construction and Building Materials* **101**, 730–740. ISSN: 09500618, doi: 10.1016/j.conbuildmat.2015.10.120

Freire, A., Júnior, C., Rosa, M.O., Almeida Neto, J. & Figueirêdo, M. 2017. Environmental assessment of bioproducts in development stage: The case of fiberboards made from coconut residues. *Journal of Cleaner Production* **153**, 230–241. doi: 10.1016/j.jclepro.2017.03.100

Hamad, S.F., Stehling, N., Holland, C., Foreman, J.P. & Rodenburg, C. 2017. Low-Voltage SEM of Natural Plant Fibers: Microstructure Properties (Surface and Cross-Section) and their Link to the Tensile Properties. *Procedia Engineering* **200**, 295–302. doi: 10.1016/j.proeng.2017.07.042

Hamdaoui, O., Limam, O., Ibos, L. & Mazioud, A. 2020. Thermal and mechanical properties of hardened cement paste reinforced with Posidonia-Oceanica natural fibers. *Construction and Building Materials* **269**, 121339. doi: 10.1016/j.conbuildmat.2020.121339

Hamza, S., Saad, H., Charrier, B., Ayed, N., Charrier-El, F. & Charrier - El Bouhtoury, F. 2013. Physico-chemical characterization of Tunisian plant fibers and its utilization as reinforcement for plaster-based composites. *Industrial Crops and Products* **49**, 357–365. doi: 10.1016/j.indcrop.2013.04.052

Karade, S.R. 2010. Cement-bonded composites from lignocellulosic wastes. *Construction and Building Materials* **24**(8), 1323–1330. doi: 10.1016/j.conbuildmat.2010.02.003

Khasawneh, M.A. & Alyaseen, S.K. 2020. Analytic methods to evaluate bituminous mixtures enhanced with coir/coconut fiber for highway materials. *Materials Today: Proceedings* **33**, 1752–1757. doi: 10.1016/j.matpr.2020.04.870

Kochova, K., Gauvin, F., Schollbach, K. & Brouwers, H.J.H. 2020. Using alternative waste coir fibres as a reinforcement in cement-fibre composites. *Construction and Building Materials* **231**, 117121. doi: 10.1016/j.conbuildmat.2019.117121

Krishnasamy, S., Saba, N., Rajini, N., Muthukumar, C., Jawaid, M., Siengchin, S. & Alothman, O. 2018. Mechanical properties evaluation of sisal fibre reinforced polymer composites: A review. *Construction and Building Materials* **174**, 713–729. doi: 10.1016/j.conbuildmat.2018.04.143

Lertwattanaruk, P. & Suntijitto, A. 2015. Properties of natural fiber cement materials containing coconut coir and oil palm fibers for residential building applications. *Construction and Building Materials* **94**, 664–669. doi: 10.1016/j.conbuildmat.2015.07.154

Li, N., Han, R. & Lu, X. 2017. Bibliometric analysis of research trends on solid waste reuse and recycling during 1992–2016. Resources, *Conservation and Recycling* **130**, 109–117. doi: 10.1016/j.resconrec.2017.11.008

Liu, T. 2013. A bibliometric analysis of the performance of Advanced Materials Research from 2005 to 2012. *Advanced Materials Research* **803**, 165–168. doi: 10.4028/www.scientific.net/AMR.803.165

Mahjoub, R., Yatim, J., Mohd.Sam, A.R. & Hashemi, S.H. 2014. Tensile properties of kenaf fiber due to various conditions of chemical fiber surface modifications. *Construction and Building Materials* **55**, 103–113. doi: 10.1016/j.conbuildmat.2014.01.036

Mallig, N. 2010. A relational database for bibliometric analysis. J*ournal of Informetrics* **4**(4), 564–580. doi: 10.1016/j.joi.2010.06.007

Pacheco-Torgal, F. & Jalali, S. 2011. Cementitious building materials reinforced with vegetable fibres: A review. *Construction and Building Materials* **25**(2), 575–581. doi: 10.1016/j.conbuildmat.2010.07.024

Powell, K.R. & Peterson, S.R. 2017. Coverage and quality: A comparison of Web of Science and Scopus databases for reporting faculty nursing publication metrics. *Nursing Outlook* **65**(5), 572–578. doi: 10.1016/j.outlook.2017.03.004

Reddy, P.V., Reddy, S., Jeeru, L.R., Krishnudu, D.M. & Rajendra Prasad, P. 2020. An overview on natural fiber reinforced composites for structural and non-structural applications. *Materials Today: Proceedings* **45**, 6210–6215. doi: 10.1016/j.matpr.2020.10.523

Sathish, S., Karthi, N., Prabhu, L., Gokulkumar, S., Balaji, D., Vigneshkumar, N., Ajeem Farhanb, T.S., AkilKumar, A. & Dinesh, V.P. 2021. A review of natural fiber composites: Extraction methods, chemical treatments and applications. *Materials Today: Proceedings*, **45**, 8017–8023. doi: 10.1016/j.matpr.2020.12.1105

Silva, G., Kim, S., Bertolotti, B., Nakamatsu, J. & Aguilar, R. 2020. Optimization of a reinforced geopolymer composite using natural fibers and construction wastes. *Construction and Building Materials* **258**, 119697. doi: 10.1016/j.conbuildmat.2020.119697

Slebi, C., Lastra-González, P., Pascual-Muñoz, P. & Castro-Fresno, D. 2019. Mechanical performance of fibers in hot mix asphalt: A review. *Construction and Building Materials* **200**, 756–769. doi: 10.1016/j.conbuildmat.2018.12.171

Tan, J., Lu, W., Huang, Y., Wei, S., Xua, X., Liu, L. & Zheng, G. 2019. Preliminary study on compatibility of metakaolin-based geopolymer paste with plant fibers. *Construction and Building Materials* **225**, 772–775. doi: 10.1016/j.conbuildmat.2019.07.142

Townsend, T. & Sette, J. 2016. *Natural Fibres and the World Economy. Natural Fibres: Advances in Science and Technology Towards Industrial Applications,* 381–390 doi: 10.1007/978-94-017-7515-1_30

Valášek, P. & Habrová, K. 2017. Influence of sisal fibres on tribological properties of epoxy composite systems. *Agronomy Research* **15**(S1), 1242–1250.

Wang, G. & Chen, F. 2017. *Development of bamboo fiber-based composites. Advanced High Strength Natural Fibre Composites in Construction*, pp. 235–255. doi: 10.1016/b978-0-08-100411-1.00010-8

Wongsa, A., Kunthawatwong, R., Naenudon, S., Sata, V. & Chindaprasirt, P. 2020.Natural fiber reinforced high calcium fly ash geopolymer mortar. *Construction and Building Materials* **241**, 118143. doi: 10.1016/j.conbuildmat.2020.118143

Xie, H., Zhang, Y. & Duan, K. 2019. Evolutionary overview of urban expansion based on bibliometric analysis in Web of Science from 1990 to 2019. *Habitat International* **95**, 102100. doi: 10.1016/j.habitatint.2019.102100

Yan, L., Chouw, N., Huang, L. & Kasal, B. 2016. Effect of alkali treatment on microstructure and mechanical properties of coir fibres, coir fibre reinforced-polymer composites and reinforced-cementitious composites. *Construction and Building Materials* **112**, 168–182. doi: 10.1016/j.conbuildmat.2016.02.182

Ye, N., Kueh, T., Liu, L., Yongxin, H. & Yu, H. 2020. A bibliometric analysis of corporate social responsibility in sustainable development. *Journal of Cleaner Production* **272**, 122679. doi: 10.1016/j.jclepro.2020.122679

Zhang, N., Ye, H., Pan, D. & Zhang, Y. 2021. Effects of alkali-treated kenaf fiber on environmentally friendly geopolymer-kenaf composites: Black liquid as the regenerated activator of the geopolymer. *Construction and Building Materials* **297**, 123787. doi: 10.1016/j.conbuildmat.2021.123787