Natural Fiber-Reinforced Polymer Composites: A Review of Material Systems, Computational Optimization and Additive Manufacturing

Ganesh N.[1], Manikandaraja G.[2], Balasundaram R.[3]

[1]Research Scholar, [2]Assistant Professor, [3]Professor, Department of Mechanical Engineering, SRM Institute of Science and Technology, Trichy, India.

E-mail: [1]ganeshn@srmist.edu.in

Abstract

Natural fiber-reinforced polymer composites (NFRPCs) are characterized by low density, biodegradability, renewability, and favorable mechanical properties, making them promising alternatives to traditional synthetic composites. This article reviews recent advances in NFRPCs published from 2019 to 2025, investigating novel materials systems, computational optimization methods and additive manufacturing processes. The studies that have been analyzed and reviewed are divided into single-fiber, hybrid-fiber, filler-modified, and surface-treated composite systems; their impacts on mechanical, thermal, durability properties as well as moisture-resistance properties are critically analyzed. Manuscripts focusing on fiber surface treatments, hybrid reinforcement approaches and matrix selection are highlighted for improving composite properties. This review also thoroughly investigates the application of computational approaches such as Response Surface Methodology (RSM), Taguchi design-based approach, and Artificial Neural Networks (ANN) for performance prediction and process optimization. In addition, the paper reviews recent developments and innovations in 3D printing technologies related to additive manufacturing such as stereolithography (SLA), digital light processing (DLP), vat photopolymerization (VPP) and LCD-based printing towards sustainable composite fabrication. Several challenges, including moisture sensitivity, long-term durability and process standardization were identified, along with future

DOI: https://doi.org/10.36548/rrrj.2026.1.011
Extended version of article received from **International Conference on Smart Innovations in Engineering & Technology (ICSIET 2026)**
Received: 25.04.2026, received in revised form: 30.05.2026, accepted: 17.06.2026, published: 29.06.2026

opportunities such as integration of artificial intelligence-driven material design and sustainable processing of high-performance natural fiber composites.

Keywords: Natural Fiber Composites, Hybrid Composites, Computational Optimization, Response Surface Methodology (RSM), Additive Manufacturing, Sustainable Materials.

1. Introduction

Due to increased environmental awareness, supply of non-renewable materials, and strict sustainability standards, there has been increasing interest in green materials for use in engineering. Among the existing options, natural fiber reinforced polymer composites (NFRPCs) stand out as viable materials because of their low density, biodegradability, renewability, affordability, and acceptable mechanical properties [8]. Natural fibers such as jute, kenaf, coir, sugar palm, oil palm, date palm, and fish tail palm have become widely used as reinforcements for polymers for applications in automotive parts, building materials, packaging products, and lightweight structures [5], [13], [19]. Even though they are environmentally friendly, there are some shortcomings associated with natural fiber composites such as moisture sensitivity, property variation, poor interface bond, and poor durability among others, which result in reduction in mechanical performance and inhibit their extensive industrial application. As a way of addressing these shortcomings, studies have been conducted on surface treatments, fiber hybridization, addition of fillers, and new matrix systems to increase compatibility between fiber and matrix [7], [20]. Recent investigations have shown that there has been marked improvement in tensile strength, thermal stability, impact resistance, and dimensional stability using appropriate materials and processes [2], [5], [13], [20].

Meanwhile, search and optimization strategies like Response Surface Methodology (RSM), Taguchi design, Artificial Neural Networks (ANN) and multi-objective optimization schemes have emerged as useful means of minimizing experimental work and speeding up composite development [3], [6], [16], [18], [23], [24]. With these methods, it can predict the performance of the material and find suitable processing conditions. In addition, advancements in additive manufacturing technologies, such as SLA, DLP, VPP and LCD based printing have facilitated the fabrication of complex composite structures with enhanced design flexibility at an optimal material utilization [1], [4], [9], [11], [17], [25].

This review offers a thorough evaluation of the advancements in natural fiber reinforced polymer composites, with an emphasis on material systems, computational optimization techniques and additive manufacturing technologies. It also highlights several critical research gaps and opportunities for future development of artificial intelligence-enabled composite design, manufacturing and green material processes.

2. Review Methodology

This review was conducted using a systematic review of peer-reviewed journal articles published between 2019 and 2025. Relevant literature was searched in major scientific databases such as Scopus, Web of Science, ScienceDirect, SpringerLink, Wiley Online Library and Taylor & Francis. The search terms were "natural fiber reinforced polymer composites", "hybrid natural fiber composites", "bio-epoxy composites", "surface treatment", "response surface methodology", "artificial neural networks", "additive manufacturing", "stereolithography", "digital light processing" and "sustainable composite materials".

The retrieved articles were screened according to their relevance, originality and contribution to the development of natural fiber composites, computational optimization and additive manufacturing. Studies on synthetic fiber reinforced composites alone were not included, only studies on natural-reinforced composites were included. The review focus on studies reporting mechanical performance, thermal behavior, moisture absorption characteristics, durability assessment, process optimization, and advanced manufacturing approaches.

Twenty-five relevant references have been selected and classified into three main research areas, (i) natural fiber composite systems such as single fiber, hybrid fiber and filler modified composites, (ii) computational design and optimization techniques such as RSM, Taguchi methods, ANN and multi-objective optimization, and (iii) additive manufacturing techniques for sustainable composite fabrication. The selected studies were comparatively analysed to identify the prevailing trends, technological advancements, performance limitations and emerging research opportunities. This systematic approach guarantees an adequate and thorough assessment of recent developments in sustainable natural fiber composite materials.

3. Natural Fiber Composite Systems

Natural fiber composites can be classified based on reinforcement architecture, matrix nature and modification strategy [1]. The reviewed studies can be categorized into four significant categories, as shown in Figure 1 single-fiber composite, hybrid-fiber composites, hybrid filler and surface-modified composites. Such a classification constitutes a systematic tool to compare mechanical, durability and sustainability properties available in the literature.

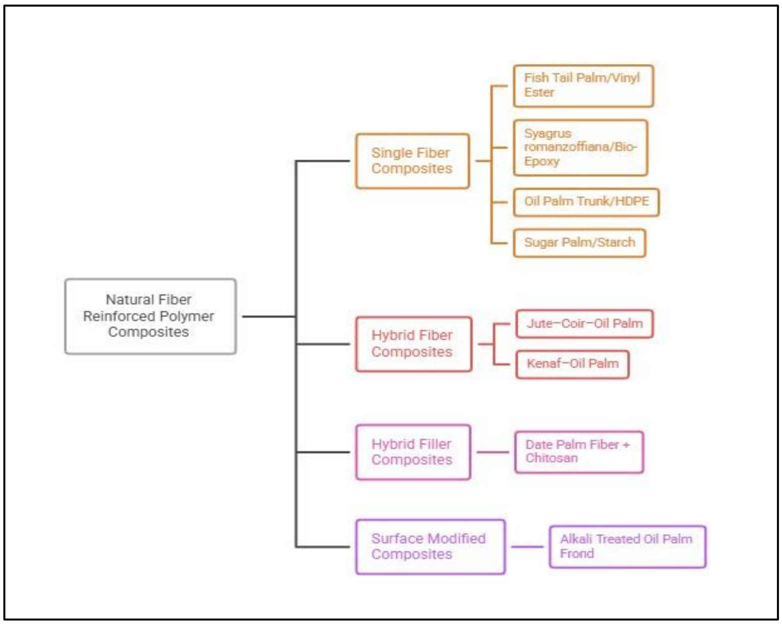

Figure 1. Classification of Natural Fiber Composite Systems

Single-fiber and more complex composite systems develop an understanding of fiber–matrix interacting units in relation to greater scale composite architecture development and may build a foundation for the evolution of advanced composites. Vinyl ester composites reinforced with silane-treated palm fibers showed significant increase in tensile strength due to the strong interfacial bonding and effective transfer of stress between fiber and matrix [19]. Likewise, Syagrus romanzoffiana fiber filled bio-epoxy composites showed improved tensile, flexural and thermal properties as fiber loading increased until optimum value after this moisture absorption and voids imposed negative influences on composite behavior as well [5].

Oil palm trunk fiber reinforced high-density polyethylene composites emphasized the importance of interfacial compatibility as untreated fibers led to poor adhesion and reduced tensile strength due to fiber pull-out and matrix debonding [10]. The potential of completely biodegradable composite systems was shown by sugar palm fiber reinforced cassava starch composites, possessing improved thermal stability and biodegradation properties and acceptable mechanical performance [14].

Hybrid composite systems, which make use of several fibers, have received much attention. Synergetic reinforcement effect and stacking sequences enhanced tensile and impact properties of jute-coir-oil palm hybrid composites. [2] Functional properties for similar systems confirmed the potential of using relatively higher ratios of kenaf fiber, which together with sophisticated load-sharing mechanisms in their respective composites [13] improved the strength-toughness balance of these kenaf-oil palm bio-epoxy hybrid materials.

Secondary fillers contribute to an even better performance of the composite material. Bio-epoxy composites made from date palm fiber reinforced with chitosan demonstrated superior tensile, flexural and impact strength because of increased hydrogen bonding and interfacial interactions [20]. In addition to the above treatments, surface treatments such as alkali treatment have been used for increasing acoustic absorption and surface roughness of fibers, though it can adversely affect dimensional stability [7].

Table 1 summarises the major natural fiber composite systems reported in the reviewed studies including their matrix systems, key performance improvements, principal limitations and supporting references.

Table 1. Summary of Natural Fiber Composite Systems

Composite System	Matrix	Key Improvement	Main Limitation	References
Fish Tail Palm Fiber	Vinyl Ester	Tensile strength ≈108 MPa	Moisture sensitivity	[19]
Syagrus romanzoffiana Fiber	Bio-Epoxy	Improved thermal and mechanical properties	Water absorption	[5]
Oil Palm Trunk Fiber	HDPE	Increased stiffness	Poor fiber-matrix adhesion	[10]
Sugar Palm Fiber	Cassava Starch	Biodegradability and thermal stability	Limited strength	[14]
Jute-Coir-Oil Palm Hybrid	Epoxy	Enhanced tensile and impact performance	Manufacturing complexity	[2]

Kenaf-Oil Palm Hybrid	Bio-Epoxy	Balanced strength and toughness	Moisture uptake	[13]
Date Palm Fiber + Chitosan	Bio-Epoxy	Improved interfacial bonding	Increased hydrophilicity	[20]

4. Computational Design and Optimization Approaches

The computational optimization approach in the study of natural fiber composite is shown in Figure 2. The approach includes experimental design, predictive modeling, and optimization methods which assist in identifying optimal composite designs through minimum experimentation [3], [6], [18], [23], [24].

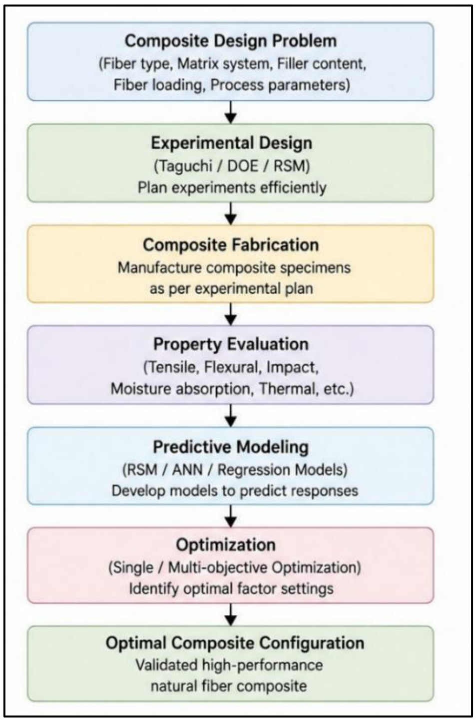

Figure 2. Computational Design Framework for Natural Fiber Composite Development

The growing complexity of natural fiber composite systems, computational optimization techniques have become an important tool. Recently, Response Surface Methodology (RSM), Taguchi design, Artificial Neutral Networks (ANN) and mixture design approaches have shown good potential in both modeling and optimization of the performance composites.

The Response Surface Method (RSM) has been one of the most applied mathematical techniques to correlate processing parameters and material properties. Research using date palm fiber composites has also shown that RSM effectively predicts moisture absorption behavior [3]. Such applications have been even reported for alkali treatment optimization and natural fibers mechanical property [6].

A Taguchi design is a robust way to find which process variables are dominant with fewer runs of the experiment. Hence, factors influencing the natural fiber composites are simply determined through experiments and so many investigations have been tried out using Taguchi orthogonal arrays for the optimization of fiber loading which others focusing on fabrication parameters and also reinforcement combinations [3]. It has shown a proven ability to enhance performance in terms of tensile, flexural, impact properties.

Artificial Neural Networks (ANNs) have been gaining popularity to complement RSM by boosting the model prediction accuracy and managing the nonlinear interactions between process variables. The specific mining approaches were ANN-based that have shown remarkable prediction ability for moisture absorption, machining behavior and mechanical performance of the natural fiber composites [18]. Also, in recent studies it is used to supplement Taguchi and RSM approaches, to multi-objective optimization for higher process reliability [23], [24].

Mixture design methodologies offers a additional advantages for optimizing multi-component systems containing multiple fibers, fillers, and matrix constituents. Such strategies aid in finding suitable formulations with a smaller number of trails in developing the composites [22].

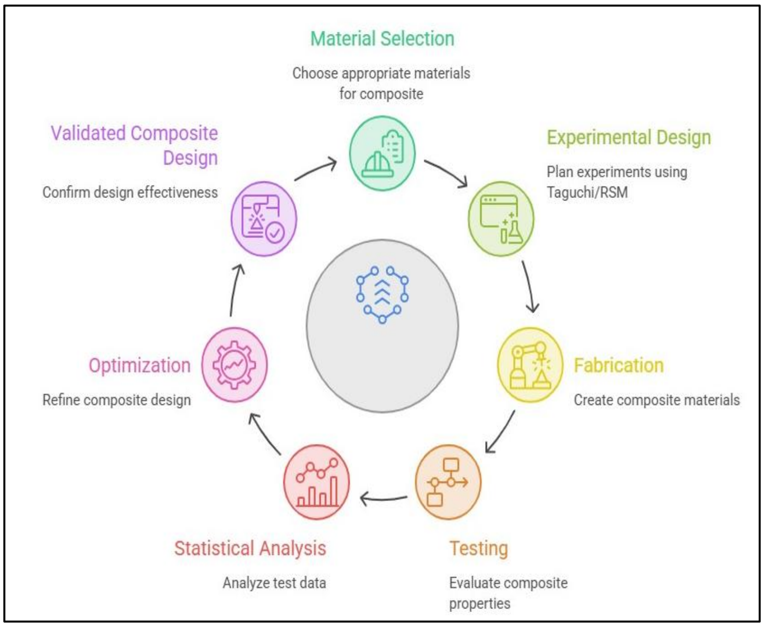

Figure 3. Computational Framework for Composite Optimization

The reliance on computational optimization tools for modern composite development is steadily increasing. Figure 3 Typical workflow used in optimization-based composite design. It illustrates the cycle of material selection, experimental design, fabrication, testing, and optimization that allows users to arrive at validated composite formulations [3], [6], [18], [23].

Table 2 summarizes the most popular computational optimization techniques used in the research of natural fiber composites.

Table 2. Computational Optimization Techniques

Technique	Purpose	Advantages	Representative Studies
Taguchi Method	Parameter optimization	Reduced experimental runs	[17]
Response Surface Methodology (RSM)	Process modeling and optimization	Interaction analysis	[3], [6]
Artificial Neural Networks (ANN)	Property prediction	Handles nonlinear behavior	[18]
Mixture Design	Multi-component optimization	Suitable for hybrid systems	[22]
Hybrid RSM-Taguchi	Multi-objective optimization	Improved prediction accuracy	[23], [24]

5. Additive Manufacturing of Natural Fiber Composites

Additive manufacturing has been widely regarded as a transformative technology for lightweight and customized composite structures. Different technologies, mainly fused deposition modeling (FDM), stereolithography (SLA), digital light processing (DLP) and vat photopolymerization (VPP) have extended the manufacturing possibilities of natural fiber reinforced composites [8], [11].

Stereolithography has exhibited great potential to manufacture high-resolution composite structures containing bio-based fillers. Lignin-reinforced photocurable resins obtained using SLA have shown large enhancements in tensile strength and stiffness with an appropriate print quality obtainable [25]. Research studies recently has also shown successful utilization of bio-based fillers into photosensitive resin systems without sacrificing mechanical performance while increasing the level of sustainability [4].

Photopolymer composites with very high filling levels can be executed through Digital Light Processing (DLP) technology while maintaining a very good dimensional accuracy. Optimized filler incorporation leads DLP-printed composites to an extraordinary combination of high stiffness and low density [21]. Incorporating polysaccharide thin films within DLP-processing derived scaffolds has also been done and provided yet another demonstration that there is an opportunity to develop bio-based composites that are environment friendly [1].

Vat photopolymerization technologies have allowed the integration of cellulose nanofibers and multifunctional nanoparticles into biomedical-grade resins improving their mechanical performance and functionality [9]. Meanwhile, LCD-based printing has allowed the fabrication of fully bio-based polymer composites for sustainable engineering applications [17].

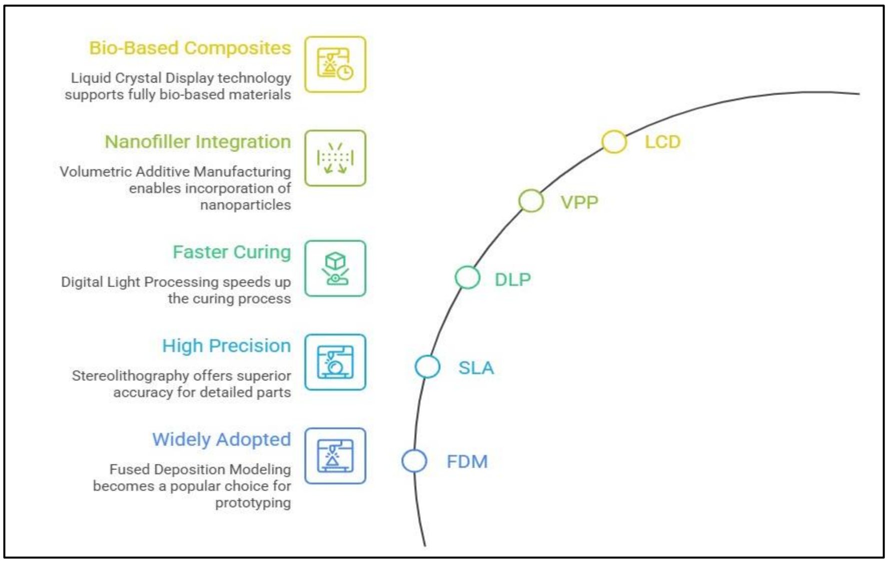

Figure 4. Evolution of Additive Manufacturing Technologies

The evolution of additive manufacturing technologies for natural fiber composites is illustrated in Figure 4. demonstrating the shift from traditional filament-based fabrication to advanced photopolymerization technologies that process bio-based composite materials [1], [4], [9], [11], [17], [25].

However, resin viscosity, filler dispersion, curing efficiency, interlayer bonding and long-term durability challenges still limit large-scale adoption. Future directions will target bio-derived photocurable resins, enhanced filler compatibility, and better process optimization strategies.

A comparison of the principal additive manufacturing technologies employed for NFC fabrication is presented in Table 3.

Table 3. Additive Manufacturing Technologies for Natural Fiber Composites

Technology	Material Form	Advantages	Limitations	References
FDM	Filaments	Low cost, easy processing	Poor surface finish	[8]
SLA	Photopolymer Resin	High accuracy	Limited filler loading	[4], [25]
DLP	Photopolymer Resin	Fast printing speed	UV penetration issues	[1], [21]
VPP	Resin-based composites	Excellent resolution	High resin sensitivity	[9]
LCD	Bio-resin composites	Sustainable fabrication	Limited industrial studies	[17]

6. Comparative Analysis

The analysis indicates that the performance of natural fiber reinforced polymer composites is affected by various factors, viz. Fiber type, matrix choice, surface treatment, reinforcement architecture and processing method employed. Among the single-fiber composite systems, silane-treated fish tail palm fiber reinforced vinyl ester composites were found to exhibit significantly improved tensile performance due primarily to increased interfacial bonding and efficient stress transfer between the fiber and matrix phases [19]. Likewise, optimized fiber loadings were investigated in Syagrus romanzoffiana fiber reinforced bio-epoxy composites that exhibited enhanced thermomechanical behavior and thermal stability [5]. On the other hand, lower tensile performance of oil palm trunk fiber reinforced HDPE composites was attributed to low interfacial compatibility and succumbed to fiber pull-out and matrix debonding during loading 10.

Hybrid reinforcement strategies outperformed single-fiber systems consistently across all the metrics. By utilizing synergistic reinforcement mechanisms and improved stress distribution, tensile and impact properties of jute–coir–oil palm hybrid composites were increased [2]. In the same way kenaf–oil palm bio-epoxy hybrids showed a promising combination between strength, stiffness and toughness, it was recognized that hybridization is a better solution to avoid the disadvantages associated with pure natural fibers [13]. Incorporating secondary fillers further enhanced composite properties. The date palm fiber composites treated with chitosan exhibited higher flexural behavior, tensile strength and dimensional stability due to the development of better fiber–matrix interaction besides its hydrogen bonding effect [20].

Computational optimization techniques have significantly accelerated composite development by reducing experimental effort and improving predictive accuracy. Mechanical Properties, moisture absorption behavior and process optimization have to be modelled using Response Surface Methodology (RSM), Taguchi design and Artificial Neural Networks (ANN) [3], [6], [18]. In addition, the introduction of additive manufacturing technologies (SLA, DLP, VPP and LCD-based printing) has further increased natural fiber composite potential by producing personalized structures with irregular geometric shapes [1], [4], [9], [17], [25].

To facilitate a direct comparison of representative natural fiber composite systems, the key mechanical performance indicators and associated benefits reported in the literature are summarized in Table 4.

Table 4. Performance Comparison of Natural Fiber Composite Systems

Composite System	Matrix	Tensile Strength	Additional Benefit	References
Fish Tail Palm Fiber (FTP)	Vinyl Ester	108 MPa	Improved interfacial bonding through silane treatment	[19]
Syagrus romanzoffiana Fiber (SrF)	Bio-Epoxy	83.21 MPa	Enhanced thermal stability and crystallinity	[5]
Jute–Coir–Oil Palm Hybrid	Epoxy	1573.33 N (maximum tensile load)	Synergistic hybrid reinforcement	[2]
Kenaf–Oil Palm Hybrid (7K30)	Bio-Epoxy	37.66 MPa	Balanced strength–toughness performance	[13]
Date Palm Fiber + Chitosan (20 wt%)	Bio-Epoxy	24.04 MPa	Improved interfacial adhesion and flexural strength	[20]

Sugar Palm Fiber (5 wt%)	Cassava Starch	11.78 MPa	High biodegradability and thermal stability	[14]
Oil Palm Trunk Fiber	HDPE	~6 MPa	Increased stiffness but poor fiber–matrix adhesion	[10]

7. Research Gaps

Despite significant progress in natural fibers are reinforced polymer composites, several research challenges remain unresolved. Most existing studies majorly advance single properties, such as tensile strength, moisture resistance or thermal stability, however sport few multi-functional optimization efforts. Absence of standardized and procedure for test characterization (especially for composites fabricated through additive manufacturing) limits comparative assessments across studies, hindering the creation of reliable design schemes [1], [4], [9], [11], [17]. Any of these applications are not supported by long-term durability investigations covering environmental aging, ultraviolet exposure, cyclic loading, thermal degradation and biodegradation. Because natural fibres are naturally sensitive to environmental conditions, further studies have been needed to quantify their service life and long-term structural performance [3], [5], [18], [20].

Although computational approaches including Response Surface Methodology (RSM), Taguchi design and Artificial Neural Networks (ANN) have proved effective for process optimization and performance prediction, most studies are single-objective optimization and separate from manufacturing [6], [16], [18], [23], [24]. In addition, there exists a lack of information relating to the combination between optimization and additive manufacturing processes who are concerned in improving together material performance, process efficiency and sustainability. Lifecycle assessment, recyclability evaluation and large-scale industrial validation are also still under-investigated, even though they are crucial for the development of sustainable materials [8], [11].

8. Future Directions

The future research should be targeted towards the development of multi-functional natural fiber composites, which can satisfy mechanical, thermal, acoustic, and environmental performance requirements at the same time. Further research should concentrate on advanced surface treatments, bio-based coupling agents, and hybrid reinforcement systems to improve the compatibility of fiber and matrix, durability and performance of the composite. Application of artificial intelligence (AI) and machine learning (ML) techniques provides an important scope for the composite design and optimization. The experimental datasets, which include physical properties of the fibers, physical properties of the matrix, processing conditions, and response in terms of mechanical performance of the composite structure, can be used to develop prediction models like Artificial Neural Networks, Random Forest, etc. AI-based optimization framework can help in making decisions involving strength, durability, manufacturing cost, and sustainability aspects at the same time. In the field of additive manufacturing, ML techniques can be used for optimizing the processing parameters, predicting defects, assessing the quality of the printed composite structure and process monitoring. Digital twin technique is another approach, which can allow simulating and validating the structure virtually prior to its manufacture. Moreover, future developments will have to focus on fully bio-based photocurable resins, improved dispersion techniques for fillers, large scale production process, and lifecycle assessment to promote industrial use of natural fiber composites.

9. Conclusion

Natural Fiber Reinforced Polymer Composites (NFRPCs) have been recognized as viable sustainable materials that can be employed to meet the increasing demand for lightweight, environmentally-friendly, and high-performance engineering solutions. The review article highlights some recent developments in natural fiber composite materials, such as single fiber, hybrid fiber, filler modified, and surface treated natural fiber composite systems. In particular, this paper explores the impact of the above-named developments on the mechanical, thermal, and durability properties of natural fiber composite materials. It has been shown that hybrid reinforcement approaches and proper surface treatments are helpful in improving fiber-matrix interface, which consequently enhances the strength and toughness of the composites. Some advanced optimization algorithms such as Response Surface Methodology (RSM), Taguchi design, and Artificial Neural Networks (ANN) have been successfully applied to save the experiment time and predict the performance and optimize the processes. Moreover, additive manufacturing techniques such as SLA, DLP, VPP, and LCD printing provide more design freedom and sustainability for natural fiber composite materials. Still, there are some limitations associated with the sensitivity to moisture, durability, process standardization, and industrial scalability.

References

[1] Abidnejad, Roozbeh, Mehrdad Mousapour, Ziba Fathi, Sahar Babaeipour, Vishnu K. Arumughan, Ira Smal, Hossein Baniasadi, Mika Salmi, and Eero Kontturi. "Embedding Polysaccharide Thin Films in Digital Light Processing (DLP) for Biobased Composites." ACS Applied Polymer Materials 2025, vol. 7, no. 10, 6021-6032.

[2] Aziz, Alberuni, and Mahibul Hasan Pulak. "Development and Comprehensive Analysis of Eco-Friendly Epoxy Composites Reinforced with Jute, Coir, and Oil Palm Fibers." Hybrid Advances 2026, 100604.

[3] Benyettou, Riyadh, Salah Amroune, Mohamed Slamani, Khalissa Saada, Hassan Fouad, Mohammad Jawaid, and Shirsendu Sikdar. "Modelling and Optimization of the Absorption Rate of Date Palm Fiber Reinforced Composite Using Response Surface Methodology." Alexandria Engineering Journal 2023, vol. 79, 545-555.

[4] Müller, Miroslav, Jiří Urban, Jaroslava Svobodová, and Rajesh Kumar Mishra. "Modification of the Mechanical Properties of Photosensitive Resin by Using Biobased Fillers During Stereolithography (SLA) 3D Printing." Materials 2025, vol. 18, no. 12, 2699.

[5] Ferfari, Oussama, Ahmed Belaadi, Boon Xian Chai, and Djamel Ghernaout. "Enhancing Bio-Epoxy Composites with Syagrus Romanzoffiana Palm Fibers: Impact of Fiber Loading On Thermomechanical and Water Absorption Properties." Industrial Crops and Products 2025, vol. 238, 122384.

[6] Fnides, Mohamed, Salah Amroune, Ahmed Belaadi, Khalissa Saada, Boon Xian Chai, Mahmood MS Abdullah, Ibrahim MH Alshaikh, Djamel Ghernaout, and Amar Al-Khawlani. "Modeling and Optimizing the Alkaline Treatment Process to Enhance the Date Palm Fibers' tensile mechanical properties using RSM." Journal of Natural Fibers 2024, vol. 21, no. 1, 2384663.

[7] Istana, Budi, I. Made Londen Batan, Sutikno Sutikno, Ubaidillah Ubaidillah, Iwan Yahya, Asranudin Asranuddin, Agus Wedi Pratama, Victor Feizal Knight, and Mohd Nor Faiz Norrrahim. "Impact of Alkali Treatment On the Mechanical, Acoustic, And Morphological Characteristics of Sustainable Oil Palm Frond Fiber Composites." South African Journal of Chemical Engineering 2025.

[8] Khalid, Muhammad Yasir, Ans Al Rashid, Zia Ullah Arif, Waqas Ahmed, Hassan Arshad, and Asad Ali Zaidi. "Natural Fiber Reinforced Composites: Sustainable Materials for Emerging Applications." Results in Engineering 2021, vol. 11, 100263.

[9] Vidakis, Nectarios, Markos Petousis, Nikolaos Michailidis, Vassilis Papadakis, Apostolos Korlos, Nikolaos Mountakis, and Apostolos Argyros. "Multi-Functional 3D-Printed Vat Photopolymerization Biomedical-Grade Resin Reinforced with Binary Nano Inclusions: The Effect of Cellulose Nanofibers and Antimicrobial Nanoparticle Agents." Polymers 2022, vol. 14, no. 9, 1903.

[10] Laftah, Waham Ashaier, Rohah A. Majid, and Akos N. Ibrahim. "Preparation and Characterization of Bio-Film Composite Based On High Density Polyethylene and Oil Palm Trunk Fiber." Polymers and Polymer Composites 2022, vol. 30, 09673911221095988.

[11] Maines, Erin M., Mayuri K. Porwal, Christopher J. Ellison, and Theresa M. Reineke. "Sustainable Advances in SLA/DLP 3D Printing Materials and Processes." Green Chemistry 2021, vol. 23, no. 18, 6863-6897.

[12] Arora, Nishtha, Sachin Dua, Vivek K. Singh, Shailesh Kumar Singh, and T. Senthilkumar. "A Comprehensive Review On Fillers and Mechanical Properties of 3D Printed Polymer Composites." Materials Today Communications 2024, vol. 40, 109617.

[13] Nadeem, M. Mohammed, Mohammad Sayem Mozumder, Naheed Saba, Ahmad Safwan Ismail, and Mohammad Jawaid. "Effect of Kenaf and Oil Palm Fibers on the Mechanical, Physical and Morphological Properties Of The Bio-Epoxy Hybrid Composites." Journal of Materials Research and Technology 2025.

[14] Mousa, Saaed Abdullah, S. M. Sapuan, M. M. Harussani, Tarique Jamal, M. A. M. Azri, R. A. Ilyas, Muhammad Amin Azman, Vasi Uddin Siddiqui, and Tahrim Rafin. "Development and Characterization of Sugar Palm (Arenga Pinnata (Wurmb. Merr)) Fiber Reinforced Cassava (Manihot Esculenta) Starch Biopolymer Composites." Journal of Natural Fibers 2023, vol. 20, no. 2, 2259103.

[15] Gide, Kunal Manoj, Clara Elise Tranchemontagne, Muhammad Zaryyab Sardar, and Z. Shaghayegh Bagheri. "Precise Fiber Alignment in Stereolithography (SLA) 3D Printing of Composite Polymers." Hybrid Advances 2025, vol. 10, 100501.

[16] Nwobi-Okoye, Chidozie Chukwuemeka, Martins Kenechukwu Anyichie, and Clement Uche Atuanya. "RSM and ANN Modeling for Production of Newbouldia Laevies Fibre and Recycled High Density Polyethylene Composite: Multi Objective Optimization Using Genetic Algorithm." Fibers and Polymers 2020, vol. 21, no. 4, 898-909.

[17] Colucci, Giovanna, Francesca Sacchi, Federica Bondioli, and Massimo Messori. "Fully Bio-Based Polymer Composites: Preparation, Characterization, and LCD 3D Printing." Polymers 2024, vol. 16, no. 9, 1272.

[18] Saaidia, Aziz, Ahmed Belaadi, Messaouda Boumaaza, Hassan Alshahrani, and Mostefa Bourchak. "Effect of Water Absorption on The Behavior of Jute and Sisal Fiber Biocomposites at Different Lengths: ANN and RSM Modeling." Journal of Natural Fibers 2023, vol. 20, no. 1, 2140326.

[19] Sabarinathan, Palaniyappan, V. E. Annamalai, K. Rajkumar, K. Vishal, and Veeman Dhinakaran. "Synthesis and Characterization of Randomly Oriented Silane-Grafted Novel Bio-Cellulosic Fish Tail Palm Fiber–Reinforced Vinyl Ester Composite." Biomass Conversion and Biorefinery 2023, vol. 13, no. 17, 16067-16084.

[20] Sarmin, Siti Noorbaini, Mohammad Jawaid, Sheikh Ahmad Zaki, Ali Mohd Radzi, Hassan Fouad, Ramzi Khiari, Sri Rahayu, and Mohd Hazim Mohamad Amini. "Enhancing The Properties of Date Palm Fibre Reinforced Bio-Epoxy Composites with Chitosan–Synthesis, Mechanical Properties, and Dimensional Stability." Journal of King Saud University-Science 2023, vol. 35, no. 7, 102833.

[21] Shah, Darshil M., Joshua Morris, Thomas A. Plaisted, Alireza V. Amirkhizi, and Christopher J. Hansen. "Highly Filled Resins for DLP-Based Printing of Low Density, High Modulus Materials." Additive Manufacturing 2021, vol. 37, 101736.

[22] Sojobi, A. O., and K. M. Liew. "Multi-Objective Optimization of High Performance Bio-Inspired Prefabricated Composites for Sustainable and Resilient Construction." Composite Structures 2022, vol. 279, 114732.

[23] Toapanta, Oscar G., Juan Paredes, Manuel Meneses, and Gabriela Salinas. "Validation of DOE Factorial/Taguchi/Surface Response Models of Mechanical Properties of Synthetic and Natural Fiber Reinforced Epoxy Matrix Hybrid Material." Polymers 2024, vol. 16, no. 14, 2051.

[24] Haniel, B. Bawono, and P. W. Anggoro. "Optimization of Characteristics Polymer Composite Reinforced Kenaf and Jute Fiber Using Taguchi-Response Surface Methodology Approach." Journal of Natural Fibers 2023, vol. 20, no. 2, 2204453.

[25] Zhang, Shuyang, Mi Li, Naijia Hao, and Arthur J. Ragauskas. "Stereolithography 3D Printing of Lignin-Reinforced Composites with Enhanced Mechanical Properties." ACS omega 2019, vol. 4, no. 23, 20197-20204.