



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 5, May 2024

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

[ijirset@gmail.com](mailto:ijirset@gmail.com)

[www.ijirset.com](http://www.ijirset.com)

# Kenaf and Banana Natural Fiber Composites: Their Mechanical Performance is Optimized for Space Applications

Panem Venugopal, Muttaiah Modugu

PG Student, Department of Mechanical Engineering, Sree Vahini College of Engineering & Technology, Tiruvuru,  
A.P, India

Associate Professor, Department of Mechanical Engineering, Sree Vahini College of Engineering & Technology,  
Tiruvuru, A.P, India

**ABSTRACT:** Research into eco-friendly and sustainable materials have increased due to the depletion of petroleum supplies and growing environmental concerns. In order to improve mechanical performance while preserving environmental sustainability, this study focuses on the development, characterisation, and optimization of bio composites made from natural fibers and biopolymers, notably sisal fiber, palm fiber, maize starch, and glycerol. Tensile strength, flexural strength, impact resistance, and hardness were among the mechanical properties that were carefully assessed. It was studied how different fiber treatment techniques, including alkali treatment, affected sisal and palm fibers in order to strengthen the interfacial contact between the fibers and the matrix. Furthermore, glycerol's function as a plasticizer in altering the matrix's characteristics for increased ductility and flexibility was carefully investigated. The research delves deeper into the composites' deterioration patterns and recyclable nature, highlighting their potential as stand-ins for traditional plastics in a range of applications. The results show that when compared to conventional petroleum-based plastics and untreated natural fiber composites, the ideal composite formulation has much better mechanical properties. The effective stress transfer from the matrix to the evenly distributed, surface-treated fibers is responsible for the improved performance. This research offers a viable response to the urgent environmental concerns by adding to the body of knowledge on bio-based composites and paving the path for the development of sustainable materials with applications ranging from construction to automobile and space.

**KEYWORDS:** Bio composites, Sustainable materials, Natural fibers: Kenaf fiber and Banana fiber, Corn starch, Glycerol, Mechanical properties.

## I. INTRODUCTION

The transition to environmentally friendly and sustainable materials has gained importance in materials science and engineering in recent years. The pressing need to lessen the environmental impact of synthetic material manufacture and disposal, which is a widespread practice in a number of industries, including packaging, construction, and the automobile industry, is what is driving this trend. Because of their low cost, strong mechanical qualities, and biodegradability, natural fiber composites have become a promising alternative among the many materials being investigated. In particular, sisal fiber, palm fiber, maize starch, and glycerol composites have drawn interest due to their potential to replace traditional materials in certain applications. Natural fibers with intrinsic mechanical strength, such sisal and palm, can be used to create composite materials since they are numerous and renewable. The resulting composites have the advantage of being made from non-food bio-resources, which means they don't compete with food supply chains, and they also help reduce carbon footprint when paired with biodegradable matrices, like those made from glycerol and corn starch. Notwithstanding these benefits, problems with the mechanical performance, moisture sensitivity, and property variability of such composites, which depend on the type of fibers used, the composition of the matrix, and the processing parameters, hinder their widespread use. A thorough grasp of the variables influencing the mechanical performance of sisal fiber, palm fiber, maize starch, and glycerol composites is necessary to overcome these restrictions. Optimizing these variables can also increase the composites' suitability for use in a variety of sectors. Thus, the purpose of this work is to use methodical experimentation and analysis to maximize the properties of these natural fiber composites and characterize their mechanical performance. In order to determine the best formulations and processing parameters that optimize the mechanical performance of the composites while maintaining their biodegradability, the study focuses on assessing the tensile, flexural, and impact strengths of the materials as well as their moisture absorption behavior. This research offers two contributions. First, it offers a thorough analysis of the

mechanical characteristics of composites made of sisal, palm, corn starch, and glycerol, providing insights into the effects of matrix composition, processing factors, and fiber type. Secondly, it offers an optimization framework that can direct the creation of natural fiber composites with improved mechanical performance, opening the door for a wider range of applications where synthetic materials have historically been the norm. Our goal is to fulfil the technical demands of material performance while also addressing environmental concerns in the evolution of sustainable material solutions.

## II. MATERIAL AND METHOD

**MATERIALS:** The material used in this research Kenaf fiber, Banana fiber, Corn starch, Glycerol.

**METHODOLOGY:** Natural Fibers: You must gather the fibers from palm and sisal trees. For these fibers to be more compatible with the matrix material, they should be cleaned, dried, and perhaps treated. Materials for Matrix: The matrix components are glycerol and corn starch. It is necessary to optimize the ratio of maize starch to glycerol since it has a substantial impact on the composite's characteristics.

TABLE-1: Reinforcement and Matrix Content of the Composite Samples

Sr. No.	Sample ID	Reinforcement Content (wt %)		Matrix Content (wt %)
		Kenaf Fiber	Banana Fiber	
1	10-0-90 (S-1)	10	0	90
2	20-0-80 (S-2)	20	0	80
3	30-0-70 (S-3)	30	0	70
4	5-5-90 (S-4)	5	5	90
5	10-10-80 (S-5)	10	10	80
6	15-15-70 (S-6)	15	15	70

**Fiber Treatment:** To improve their adhesion to the matrix and increase their surface roughness, fibers can be chemically treated (e.g., with an alkali treatment) to remove lignin, waxes, and oils. The fibers are chopped or ground to the required size or length. For the composite's mechanical qualities, the fibers' aspect ratio or their length to diameter ratio is essential. **Creating the Matrix:** A homogenous gel is produced by heating maize starch and glycerol together. Three important parameters need to be optimized: the temperature, the water addition, and the ratio of corn starch to glycerol. **Fabrication of Composites: Hot Press Methodology:** It is also possible to hot-press the fiber and matrix combination. After the materials are put into a mold, heat and pressure are applied. This technique guarantees a more homogeneous dispersion of fibers throughout the matrix and provides improved control over the composite thickness. **Curing and Post-Processing:** In order to guarantee that the matrix hardens, the composites must be cured, which may entail holding them at a particular temperature for a predetermined amount of time. The samples can be demolded and go through any necessary post-processing after curing, such as surface polishing and cutting to testing size.

## III. RESULT AND DISCUSSION

**Tensile testing** is used in mechanical performance characterization to determine the strength and elongation of the composite material at break. This test aids in determining the composite's resistance to pulling forces. Determines the modulus and bending strength by flexural testing. In applications where the composite may experience bending loads, this is essential. **Impact testing:** Determines how well a material can absorb energy from a sudden impact, which is crucial information for determining how tough it is. **Hardness testing:** Determines the composite's surface hardness, which may be a sign of its resistance to wear. **Microstructural Analysis:** The fiber-matrix interface, fiber distribution, and any voids or flaws inside the composite can all be examined using methods like scanning electron microscopy (SEM).

### 3.1 Tensile Strength and Modulus

The maximum modulus and tensile strength for KFR (Kenaf Fibre Reinforcement) and KBFR (Kenaf Banana Fibre Reinforcement) composites are obtained at 20% and 30% of the fiber loading, respectively. This is so that stress can be passed from the matrix to the natural fibers thanks to the strengthening of the fibers. It has been shown that when KFR composite is used, the fibers do not sufficiently constrain the matrix at lower fiber loading, which causes the matrix to experience highly localized strains at low stresses. As the fiber loading increases, the composite gets stiffer and the stress is distributed more evenly. Figure 3.1 shows that for BFR composites, the tensile strength and tensile modulus increase linearly to 240% and 226%, respectively, with an increase in fiber loading from 10% to 30%. For hybrid composites, on the other hand, the tensile strength and tensile modulus increase to 22.5% and 76%, respectively, with an increase in fiber loading from 10% to 20%. It has been observed that at the same 10% and 20% of fiber loading, KBCR hybrid composites have performed stronger than BFR composites. Tensile strength increases with increasing fiber content in BFR (Banana Fibre Reinforcement) composites and can increase by as much as 20% in KBFR composites. In KFR and KBFR composites, the tensile modulus for the 30% of fiber has attained its maximum value.

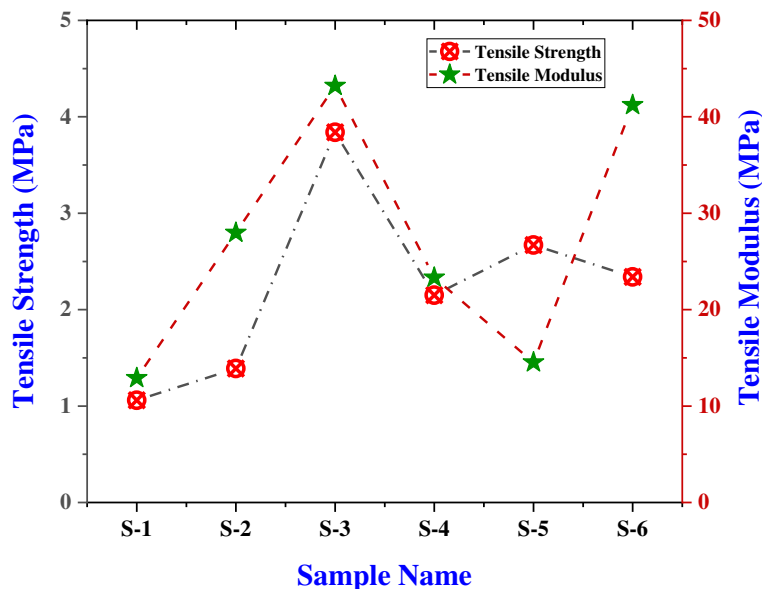


Fig. 1 Tensile strength and Tensile Modulus of various samples

### 3.2 Flexural Strength and Modulus

Flexural stresses are the result of the combination of tensile and compressive stresses. Flexural strength and modulus clearly increase with fiber loading; KFR composites achieve a maximum at 20%, while KBFR composites reach a maximum at 10%. The fiber entanglement and inadequate polymer wetting of the fibers result in a decrease in the flexural strength and modulus under higher loadings. As seen in Figure 3.2, this. Flexural strength for BFR composites rises to 100% as the fiber content goes from 10% to 30%, and modulus rises to 109% when the fiber loading goes from 10% to 20%. In contrast, as the fiber concentration increases in KBFR composites, both the modulus and the flexural strength fall linearly. The flexural properties of KBFR composites decrease with increasing fiber loading (30 wt %). This can be ascribed to problems with dispersion, increased fiber-to-fiber interactions, and insufficient matrix infiltration.

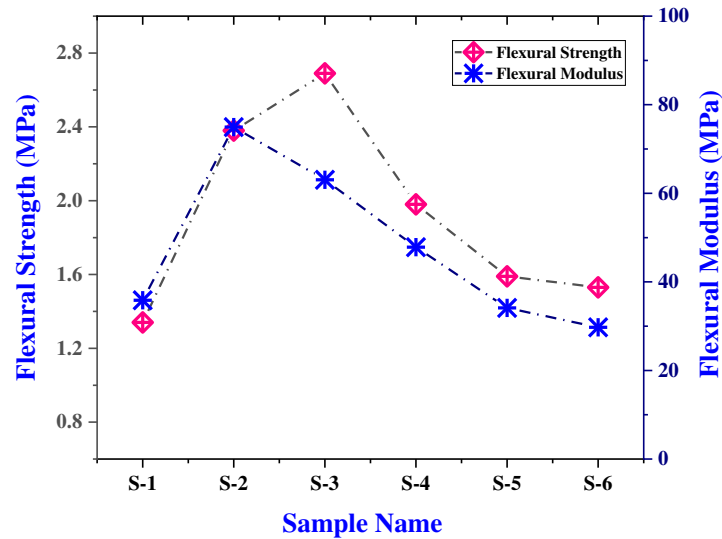


Fig. 2 Flexural strength and Flexural Modulus of various samples

### 3.3 Izod Impact Test

Impact strength is crucial for composites because, in real-world applications, unanticipated loads frequently lead to cracks. The molecular structure does not have time to relax due to the rapid application of impact forces, or stresses, which can cause a fracture that, may involve breaking or interface separation. A composite's impact property is dependent on a number of factors, such as its shape, test conditions, fiber toughness, and interfacial area characteristics. With a 10% to 20% increase in fiber loading, the impact strength of the composites improves to 52.5% and 125% for the KFR and KBFR composites, respectively. When comparing BFR composites with the same fiber loading (20 wt %), the impact strength of KBFR composites is 108% higher. The findings of the Izod impact tests, which are displayed in figure 3.3, indicate that the impact strength of the KFR and KBFR composites increases up to a fiber loading of 20% before it starts to decline considerably. The impact property of the composite is greatly enhanced by the addition of coir fiber.

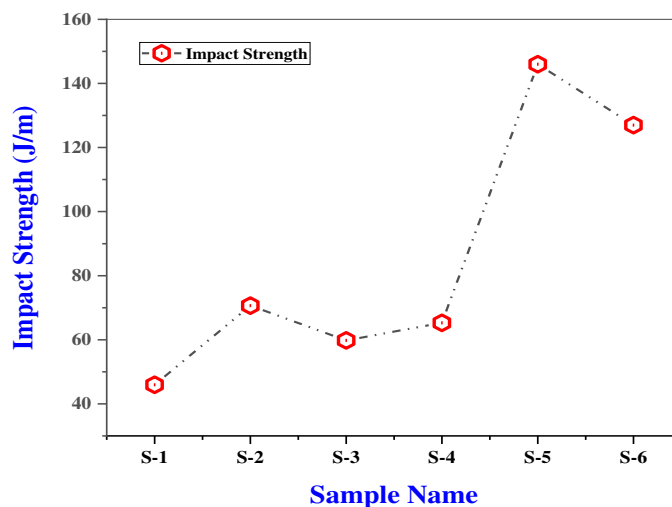


Fig. 3 Impact Strength of various samples

### 3.4 Hardness Test

In all methods of hardness testing, the thickness of the specimen is important because elasticity is usually measured as well. It is important to note that when a material is tested for hardness, its surface hardness is always measured and not its internal hardness. For 20% and 30% and 10% and 20% fiber, respectively, the shore D hardness values of KFR and KBFR composites are almost the same in both cases. It has been noted that when the fiber loading increased by 10% to 20%, the Shore D hardness value in BFR composites improved by 12%. Furthermore, a 20 wt% fiber loading in KFR and KBFR composites did not show any appreciable differences.

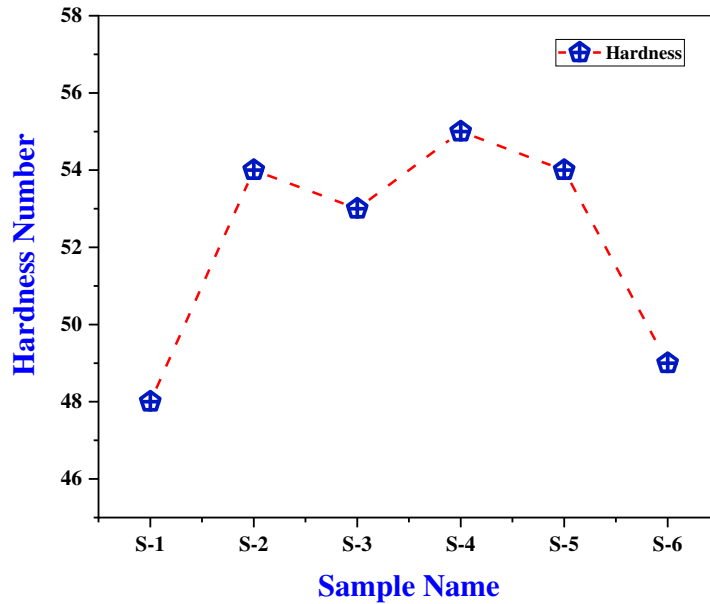


Fig.4 Hardness of various samples

### 3.5 Biodegradability Test

The biodegradability of the biopolymer and the GC samples was assessed for six weeks using the soil burial technique. The six composite samples and one biopolymer sample with a 2 mm thickness were cut into 70×70 mm pieces and put in the clay pot with soil at a depth of approximately 50 mm. To keep the microorganisms alive and the soil's humidity levels stable, water has been sprayed often. The samples were removed every seven days at regular intervals, cleaned with tissue paper to get rid of any leftover clay and other particles, and then dried in an oven at 50°C to observe how the samples broke down.

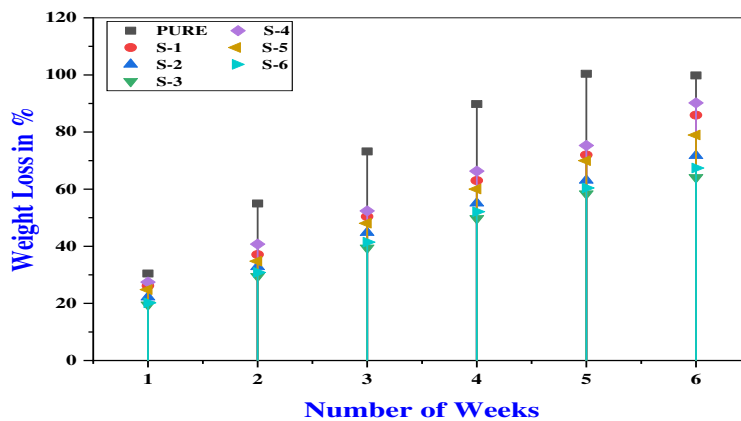


Fig. 5 Biodegradability Test of various samples

Figure 3.5 illustrates that the net weight loss for each of the seven samples shows a roughly linear relationship with degradation time. These studies show that the addition of natural fibers lowers the rate of biodegradation and that the strong structure of cellulose inhibits microbial attack, resulting in a decreased rate of breakdown. BCFR composites broke down faster than BFR composites because banana fibers contained more cellulose than coir fibers did. The biopolymer made from corn starch disintegrated the fastest, losing over 40% of its initial weight in the first week and going away completely by the fourth.

#### IV. CONCLUSION

The alkaline treatment has two effects on fibers: (1) increases surface roughness to improve mechanical interlocking; (2) increases the surface area of exposed cellulose on the fiber to increase the number of possible reaction sites. SEM analysis reveals that the multicellular fiber wall is free of cemented materials such as lignin, pectin, wax, and hemicelluloses, enhancing the mechanical qualities of the composite and enhancing the visibility of individual cells. In this experimental study, the injection molding process was used to develop hybrid green composites reinforced with banana and banana-coir fiber, based on maize starch. The matrix and reinforcement of injection-molded composites are strongly interlocked.

This study shows that adding banana fibers up to 30% of the total weight can result in maximum modulus and tensile strength of 44.11 MPa and 3.92 MPa, respectively. Hybrid composite produces results for the same weight percentage that are up to 20% better than KBRC. Higher banana fiber content is correlated with a higher tensile modulus. The maximum flexural strength and modulus values for BFR composites at 30% and 20% fiber loading, respectively, are 2.42 MPa and 75.05 MPa. The maximum values for hybrid composites at 5% fiber loading of banana and coir fiber are 2.04 MPa and 48.26 MPa, respectively. When coir fiber is added, flexural properties have been observed to diminish. It has been found that the maximal impact strength can be achieved with as little as 20% of fiber loading. After then, impact strength progressively decreases. It has been measured at 70.82 J/m for KFR reinforced composites and 147 J/m for BFR reinforced composites. It has also been noted that coir fiber greatly increases impact strength when compared to KBRC. The shore hardness values for KFR and KBFR hybrid composites drop when fiber loading increases above 20% and 10%, respectively, according to the experimental results. There is no noticeable change observed when the fiber loading increases by more than 20%.

Thus, we can say that the same hardness can be achieved in a hybrid composite with a lower amount of reinforcement. The biodegradation rate shows that as the fiber concentration rose, the GC broke down more slowly than pure corn starch. Due to the facile microbial attack on starch, samples of biopolymer based on maize starch broke down in about five weeks, losing more than half of their weight in just the first two weeks. Furthermore, as KBFR composites break down more quickly than KFR composites, it has been observed that cellulose inclusion slows down the pace of decomposition. Green composites are reasonably priced and eco-friendly materials that can be utilized for a range of interior car parts, such as the language mat, glove box, door panels, dashboard, shelving, and glove box surfaces.

#### REFERENCES

- [1] Foulk JA, McAlister Iii DD (2002) Single cotton fiber properties of low, ideal, and high micronaire values. *Text Res J* 72(10):885–891.
- [2] Mohanty AK, Misra M (1995) Studies on jute composites a literature review. *Polym Plast Technol Eng* 34(5):729–792.
- [3] Biswas S, Srikanth G, Nangia S (2001) Development of natural fibre composites in India. In: Proceedings of annual convention & trade show, Composites, Composites Fabricator's Association at Tampa, Florida, USA, October 03–0
- [4] Yan L, Chou N, Jayaraman K (2014) Flax fibre and its composites—a review. *Compos Part B Eng* 56:296–317.
- [5] Shahzad A (2012) Hemp fiber and its composites—a review. *J Compos Mater* 46(8):973–986.
- [6] Li Y, Mai Y-W, Ye L (2000) Sisal fibre and its composites: a review of recent developments. *Compos Sci Technol* 60(11):2037–2055.
- [7] Akil H, Omar MF, Mazuki AAM, Safiee S, Ishak ZAM, Bakar AA (2011) Kenaf fiber reinforced composites: a review. *Mater Des* 32(8–9):4107–4121.
- [8] Jayavani S, Deka H, Varghese TO, Nayak SK (2016) Recent development and future trends in coir fiber-reinforced green polymer composites: review and evaluation. *Polym Compos* 11(37):3296–3309.
- [9] Pandey SN (2007) Ramie fibre: part I. Chemical composition and chemical properties. A critical review of recent developments. *Text Prog* 39(1):1–66.

- [10] Balaji A, Karthikeyan B, Raj CS (2014) Bagasse fiber—the future biocomposite material: a review. *Int J Cemtech Res* 7(1):223–233.
- [11] Campilho RDSG (2015) *Natural fiber composites*. CRC Press, Boca Raton.
- [12] Alix S, Colasse L, Morvan C, Lebrun L, Marais S (2014) Pressure impact of autoclave treatment on water sorption and pectin composition of flax cellulosic-fibres. *Carbohydr Polym* 102:21–29.
- [13] Gurunathan T, Mohanty S, Nayak SK (2015) A review of the recent developments in biocomposites based on natural fibres and their application perspectives. *Compos Part A Appl Sci Manuf* 77:1–25.
- [14] Faruk O, Bledzki AK, Fink H-P, Sain M (2012) Biocomposites reinforced with natural fibers: 2000–2010. *Prog Poly Sci* 37(11):1552–1596.
- [15] Madsen B, Gamstedt EK (2013) Wood versus plant fibers: similarities and differences in composite applications. *Adv Mater Sci Eng* 2013:1–14.
- [16] Rana AK, Mandal A, Bandyopadhyay S (2003) Short jute fiber reinforced polypropylene composites: effect of compatibiliser, impact modifier and fiber loading. *Compos Sci Technol* 63(6):801–806
- [17] Jawaid M, Khalil HPSA (2011) Cellulosic/synthetic fibre reinforced polymer hybrid composites: a review. *Carbohydr Polym* 86(1):1–18
- [18] Stamboulis A, Baillie CA, Peijs T (2001) Effects of environmental conditions on mechanical and physical properties of flax fibers. *Compos Part An Appl Sci Manuf* 32(8):1105–1115.
- [19] Summerscales J (2018) Bast fibres and their composites. University of Plymouth, UK, [https://www.fose1.plymouth.ac.uk/sme/mats347/bast\\_book.htm](https://www.fose1.plymouth.ac.uk/sme/mats347/bast_book.htm), Accessed 10 Aug 2019.
- [20] George J, Sreekala MS, Thomas S (2001) A review on interface modification and characterization of natural fiber reinforced plastic composites. *Polym Eng Sci* 41(9):1471–1485.
- [21] John MJ, Thomas S (2008) Biofibres and biocomposites. *Carbohydr Polym* 71(3):343-364.
- [22] Zini E, Scandola M (2011) Green composites: an overview. *Polym Compos* 32(12):1905–1915.
- [23] La Mantia FP, Morreale M (2011) Green composites: a brief review. *Compos Part A Appl Sci Manuf* 42 (6):579–588.
- [24] Ku H, Wang H, Pattarachaiyakoop N, Trada M (2011) A review on the tensile properties of natural fiber reinforced polymer composites. *Compos Part B Eng* 42(4):856–873.
- [25] Dittenber DB, GangaRao HVS (2012) Critical review of recent publications on use of natural composites in infrastructure. *Compos Part an Appl Sci Manuf* 43(8):1419–1429.
- [26] Khalil HPSA, Bhat AH, Yusra AFI (2012) Green composites from sustainable cellulose nanofibrils: a review. *Carbohydr Polym* 87(2):963–979.
- [27] Koronis G, Silva A, Fontul M (2013) Green composites: a review of adequate materials for automotive applications. *Compos Part B Eng* 44(1):120–127.





INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  [ijirset@gmail.com](mailto:ijirset@gmail.com)



[www.ijirset.com](http://www.ijirset.com)

Scan to save the contact details