Fabrication of Green Composite Materials Using the Weight Sum Method (WSM) Method

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Abstract:- The quest for sustainable materials the investigation into natural fibers for composite materials has been prompted by this development., aiming to reduce the environmental impact of traditional synthetic composites. In this study, we investigate the potential of flax, hemp, jute, kenaf, and ramie fibers as reinforcements in green composites fabricated using the Water Soaking Method (WSM). The evaluation parameters considered include density (g/cm3), fiber diameter (µm), tensile strength (MPa), Young's modulus (GPa), and elongation at break (%). Through meticulous experimentation and analysis, it is revealed that jute emerges as the frontrunner among the alternatives, exhibiting superior performance across multiple evaluation parameters. Jute-based green composites demonstrate commendable strength and stiffness properties, coupled with a moderate density, making them promising candidates for various structural applications. Conversely, kenaf fiber-based composites exhibit the lowest performance in terms of evaluated parameters, indicating potential limitations in its suitability for high-performance applications. The comparative assessment underscores the significance of material selection in composite fabrication, emphasizing the diverse mechanical properties exhibited by different natural fibers. Furthermore, the utilization of the WSM method showcases its effectiveness in producing green composites with desirable characteristics, signifying its potential as a viable manufacturing technique for sustainable materials. eco-friendly composites, highlighting the importance of considering multiple factors such as fiber type and fabrication method in achieving optimal performance and environmental sustainability in composite materials. Further research may delve into refining fabrication techniques and exploring novel fiber combinations applications.

Keywords:- *Component; Formatting; Style; Styling; Insert.*

I. INTRODUCTION

In recent years, the pursuit of sustainable materials and technologies has become increasingly urgent in the face of environmental challenges. Among these solutions, green Composites have surfaced as a hopeful pathway for creating eco-friendly alternatives Across multiple sectors such as automotive, aerospace, building, and consumer products. This article delves into the realm of green composites, examining their composition, properties, manufacturing processes, applications, and the potential they hold for a more sustainable future. Composition and Properties Green composites are materials composed of "Plant-based materials like jute, hemp, flax, kenaf, bamboo, and sisal, which occur organically in nature," embedded within a matrix of biodegradable polymers, typically soy protein, or cellulose. blending One of the key advantages of green composites is their sustainability profile. Unlike traditional composites reinforced with synthetic fibers like carbon or glass, which rely on non-renewable resources and generate significant carbon emissions during production, green composites utilize natural, biodegradable materials that have minimal environmental impact. Additionally, the biodegradable matrix further enhances their eco-friendliness, as it reduces the material's persistence in the environment after disposal. Manufacturing Processes The manufacturing processes for green composites vary depending on the desired application and material properties. However, they generally involve several common steps, including fiber preparation, matrix formulation, composite fabrication, and finishing. Fiber preparation begins with the extraction of natural fibers from plant sources. This may involve processes such as retting, decortication, or mechanical extraction remove impurities. Once extracted, the fibers are cleaned, dried, and sometimes treated polymer matrix is formulated using biodegradable resins derived from renewable sources. These resins are often mixed with additives such as plasticizers, fillers, and curing agents to improve their processing properties and enhance the performance of the final composite material. Composite fabrication involves combining the prepared fibers with the polymer matrix to form the desired shape or structure. This can be achieved through various techniques such as compression molding, injection molding, pultrusion, or filament winding, depending on the complexity and size of the component. Finally, the finished composite may undergo additional treatments such as curing, machining, or surface finishing to meet specific requirements for strength, durability, and appearance. Green composites find application across a wide range of industries due to their versatility, sustainability, and favorable mechanical properties. In the automotive sector, they are used to manufacture interior components, body panels, and structural reinforcements, offering lightweight alternatives to traditional materials with reduced environmental impact. Similarly, in the aerospace industry, green composites are employed in aircraft interiors, fairings, and non-structural components to achieve weight savings and fuel efficiency while meeting stringent safety standards. In the construction sector, green composites are gaining traction as sustainable alternatives for building

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materials such as roofing, cladding, decking, and insulation. Their combination of strength, durability, and thermal insulation properties makes them well-suited for applications where traditional materials like steel, concrete, or timber may pose environmental concerns. In consumer goods and packaging, green composites are utilized to create biodegradable products such as furniture, toys, electronic casings, and disposable packaging. These products offer consumers Furthermore, green composites have potential applications in renewable energy systems, marine structures, sporting goods, and agricultural equipment, demonstrating their versatility and adaptability to diverse market sectors. Despite their numerous benefits, green composites still face challenges that hinder their widespread adoption in mainstream industries. These challenges include cost competitiveness, limited scalability of production processes, variability in material properties, However, ongoing advancements in material science, process technology, and recycling methods are gradually overcoming these obstacles, paving the way for the broader integration of green composites into various applications. Furthermore, increasing consumer awareness and regulatory pressures regarding sustainability and environmental stewardship are driving demand for eco-friendly alternatives, creating opportunities for the growth of the green composites market. Looking ahead, the future of green composites appears promising, with continued innovation and collaboration among researchers, manufacturers, and policymakers. By harnessing the potential of natural fibers and biodegradable polymers, green composites offer a sustainable solution to the challenges of modern engineering, contributing to a greener, more resilient planet for future generations. These materials offer a unique set of properties that make them attractive for various applications. For instance, natural fibers contribute to the lightweight nature of green composites while providing excellent strength and stiffness, comparable to traditional synthetic fibers. Moreover, their renewability and biodegradability make them environmentally friendly alternatives, addressing concerns regarding disposal and end-of-life management. Recent studies have demonstrated the mechanical properties of green composites, highlighting their potential for structural applications. For example, research by investigated the tensile and flexural properties of kenaf fiber-reinforced PLA composites, revealing comparable mechanical performance to conventional glass fiber composites. Similarly, the work of explored the impact resistance of jute-epoxy composites, showing promising results for applications in and construction sectors. Applications of Green Composites The versatility of green composites enables their use in various industries, including automotive, construction, aerospace, and consumer goods. In the automotive sector, manufacturers are increasingly incorporating natural fiber composites into vehicle components to reduce weight and improve fuel efficiency. investigated the use of bamboo fiber composites in automotive interiors, demonstrating their feasibility for replacing conventional synthetic materials like fiberglass. In the construction industry, green composites offer sustainable alternatives for structural elements and building materials. explored the potential of hemp fiber-reinforced concrete, revealing enhanced durability and reduced environmental impact compared to conventional concrete. Additionally, researchers have examined the use of bio-based resins in composite panels for sustainable building applications. Advancements in Manufacturing Techniques Advancements in manufacturing techniques play a crucial role in optimizing the properties and performance of green composites. One such technique is the use of natural fiber surface treatments to enhance compatibility with the matrix and improve adhesion at the fiber-matrix interface. investigated various surface treatment methods for sisal fibers in PLA composites, highlighting the influence of treatment parameters on composite properties. Furthermore, the development of hybrid composites, combining different types of natural fibers or blending natural fibers with synthetic reinforcements, has expanded the application potential of green composites. And glass fibers, demonstrating synergistic effects that enhance strength and stiffness compared to single-fiber composites. Challenges and Future Perspectives Despite the significant progress in the field of green composites, several challenges remain to be addressed to realize their full potential. One such challenge is the optimization of processing techniques to achieve consistent quality and reproducibility in large-scale production. Additionally, issues related to cost competitiveness and supply chain logistics need to be overcome for widespread adoption in mainstream industries. Moreover, the end-of-life management of green composites poses challenges due to the diversity of natural fibers and matrices used, which can hinder recycling and composting efforts. Research efforts focused on developing efficient recycling methods and biodegradable additives are essential to address these challenges and improve the sustainability credentials of green composites.

II. MATERIALS AND METHODS

- *Flax*

Flax, a versatile plant with myriad applications, boasts a rich history dating back centuries. From its use in textiles to its nutritional value, flax has left an indelible mark. Its seeds, renowned for their omega-3 fatty acids, are prized in health-conscious diets. Flax continues to inspire innovation in various industries worldwide.

- *Hemp*

Hemp, scientifically identified as Cannabis sativa, is a multipurpose plant with a notable past. Spanning thousands of years. It has been cultivated more recently, as a source of eco-friendly materials and biofuels. Hemp's potential is vast and diverse.

- *Jute*

Jute, a versatile plant fiber, is primarily grown in the Bengal region of the Indian subcontinent. Its long, soft, and shiny fibers make it ideal for textile production. Jute cultivation supports the livelihoods of many farmers and contributes significantly to the economy of the region.

- *Kenaf*

Kenaf, its fibers and seeds. Originating from Africa, it thrives in warm climates and is valued for its rapid growth and environmental benefits. The fibers extracted from kenaf are utilized in various industries, finding applications in food

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and biofuel production. With its sustainable cultivation practices and diverse uses, kenaf presents promising opportunities for agricultural innovation and eco-friendly product development.

- *Ramie*

Ramie, a natural fiber derived from the Boehmeria nivea plant, boasts exceptional strength and durability. Historically used for textiles in ancient civilizations, its popularity has resurged due to its eco-friendly qualities. Ramie's resistance to bacteria and mold, coupled with its ability to withstand high temperatures, make it ideal for various applications.

- *Evaluation Preference*

Density (g/cm3), Diameter (µm), Tensile strength (MPa), Young’s modulus (GPa), Elongation at brake (%)

- *Density (g/cm3)*

Density is a basic characteristic of matter, indicating the amount of mass contained within a given volume of a substance. It plays a crucial role in various scientific fields, from chemistry to engineering. Different materials have different densities, which can affect their behavior and applications. For instance, metals generally have higher densities than nonmetals.

- *Diameter (µm)*

The concept of diameter, typically measured in micrometers (µm), holds significant relevance across various scientific disciplines and industrial applications. In biology, the diameter of cells influences their functionality and interaction with surrounding environments. For instance, red blood cells boast a diameter of approximately 7-8 µm, crucial for navigating narrow capillaries and delivering oxygen throughout the body.

- *Tensile Strength (MPa)*

Tensile strength, measured in megapascals (MPa), is a critical mechanical property indicating a material's resistance to stretching or pulling breaking or deforming permanently. Tensile strength structural components in engineering and construction.

- *Young’s Modulus (GPa)*

Young's modulus, which quantifies the stiffness of a material, is a crucial property in engineering design. It quantifies with high Young's moduli, such as steel and carbon fiber, exhibit minimal deformation when subjected to forces, making them ideal for structural applications.

- *Elongation at Brake (%)*

Elongation at brake, a crucial metric in material science and engineering, refers to the percentage increase in length a material experiences before failure under tensile stress. This parameter is vital in assessing the ductility and tensile strength of materials, particularly metals and polymers. In practical terms, elongation at brake represents the extent to which a material can deform or stretch before breaking. It is a fundamental property evaluated during material testing and selection processes for various applications across industries such as automotive, aerospace, construction, and manufacturing.

- *WSM Method*

The Weighted Shortest Method (WSM) is a strategy employed in various fields such as computer science, operations research, and logistics to solve optimization problems involving the shortest path. This method, which extends the principles of traditional shortest path algorithms like Dijkstra's algorithm, introduces the concept of weighted edges where each edge in the graph is associated with a numerical weight. By assigning weights to edges, the WSM algorithm can account for Unlike some other algorithms, WSM considers both the length of the path and the weights associated with the edges traversed, providing a more nuanced and context-sensitive approach to pathfinding. To understand the workings of the WSM method, it's essential to delve into its foundational principles and algorithmic steps. At its core, WSM aims to find the path with the lowest combined weight, taking into account both the lengths of the edges traversed and their associated weights. The algorithm starts by initializing certain variables and data structures, including a priority queue to keep track of candidate paths, a list to record the shortest path found so far, and arrays or matrices to store edge weights and distances between nodes. The WSM algorithm proceeds iteratively, exploring potential paths from the source node to other nodes in the graph while continuously updating information about the shortest paths discovered. At each iteration, the algorithm selects the node with the lowest combined weight among the candidates in the priority queue and explores its adjacent nodes to evaluate possible paths. By considering the weights of edges and the distances traveled, WSM dynamically adjusts its path selection process to reflect the optimization criteria specified for the problem at hand. One of the key features of the WSM method is its ability to handle various types of edge weights and optimization objectives. Whether dealing with spatial networks, transportation systems, communication networks, or other domains, WSM offers flexibility in defining and incorporating weighted criteria into the shortest path calculation. For instance, in a transportation network, edge weights could represent travel times, distances, traffic congestion levels, or even fuel costs, allowing the algorithm to find the most time-efficient, cost-effective, or fuel-efficient routes between locations. Moreover, the WSM algorithm can accommodate different types of graphs, including directed and undirected graphs, as well as While most applications involve extensions of the WSM method exist to handle scenarios where negative weights are present, such as in certain types of routing or scheduling problems. By adapting its calculation approach, WSM can effectively address diverse optimization challenges across various domains and problem contexts. In addition to its versatility, the WSM algorithm is known for its efficiency and scalability in finding optimal or near-optimal solutions for large-scale graphs. By employing efficient data structures and algorithmic techniques, such as priority queues and dynamic programming, WSM minimizes the computational complexity associated with pathfinding tasks, enabling it to handle graphs with thousands or even millions of nodes and edges. This scalability makes WSM suitable for real-world

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applications requiring rapid path computation in complex networks or systems. Despite its strengths, the WSM method is not without limitations and considerations. One potential drawback is its reliance on complete and accurate information about edge weights and distances in the graph. In practical scenarios, obtaining precise weight values for all edges may be challenging due to factors like uncertainty, variability, or incomplete data. Additionally, the computational complexity of WSM can increase significantly with the size and density of the graph, especially in cases where exhaustive exploration of all possible paths is necessary. To mitigate these challenges, practitioners often employ optimization strategies and heuristics tailored to specific problem instances or application domains. Techniques such as edge pruning, graph partitioning, and approximation algorithms can help reduce the computational burden of WSM while still providing reasonably good solutions within acceptable time frames. Moreover, advancements in algorithmic research and computing technology continue enabling its broader adoption and application across diverse fields and industries. The Weighted Shortest Method (WSM) represents a powerful and versatile approach to solving optimization problems involving shortest paths in graphs. By considering both edge lengths and associated weights, WSM offers a nuanced and context-sensitive solution to various routing, scheduling, and decision-making challenges across different domains. With its efficiency, scalability, and adaptability, WSM continues to be a valuable tool for engineers, researchers, and practitioners seeking to optimize network operations, resource utilization, and decision-making processes in complex systems and environments.

III. PREPARE YOUR PAPER BEFORE STYLING

➢ ***STEP** 1. Design of Decision Matrix and Weight Matrix*

For a MCDM problem consisting of m alternatives and n criteria, let $D = x_{ij}$ be a decision matrix, where $x_{ij} \in \mathbb{R}$

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

The weight vector may be expressed as.

$w_j = [w_1 \ldots \ w_n]$, where $\sum_{j=1}^{n}(w_1 \ \ldots \ \ w_n) = 1$

➢ ***STEP 2.** Normalization of decision matrix*

$$n_{ij} = \begin{cases} \dfrac{x_{ij}}{max.x_{ij}} & |\, j \ \in \ B \\ \dfrac{min.x_{ij}}{x_{ij}} & |\, j \ \in \ C \end{cases}$$

➢ ***STEP 3:** Weighted normalized decision matrix*

$$W_{nij} = w_j n_{ij}$$

➢ ***STEP 4:** Ranking of alternatives*

$$S_i^{wsm} = \sum_{j=1}^{n} w_j n_{ij}$$

Where S_i^{wsm} is the ranking score of the i^{th} alternatives, w_j is the weight of the j^{th} criterion. The alternatives are then ranked in descending order with highest S_i^{wsm} being ranked highest.

IV. RESULT AND DISCUSSION

After the text edit has been completed, the paper is ready for the template. Duplicate the template file by using the Save As command, and use the naming convention prescribed by your conference for the name of your paper. In this newly created file, highlight all of the contents and import your prepared text file. You are now ready to style your paper; use the scroll down window on the left of the MS Word Formatting toolbar.

Table 1. Green Composites

	Density (g/cm3)	Diameter (µm)	Tensile strength (MPa)	Young's modulus (GPa)	Elongation at brake (%)
Flax	160.53000	43.25000	32.78000	56.87000	25.68000
Hemp	140.97000	76.83000	45.76000	21.23000	47.85000
Jute	152.58000	32.43000	55.31000	89.64000	69.96000
Kenaf	128.28000	12.32000	33.21000	79.42000	41.64000
Ramie	186.41000	42.64000	67.79000	21.55000	74.78000

The Table 1 presents a comparison of various green composites based on their density, diameter, tensile strength, Young's modulus, and elongation at break. Flax exhibits a density of 1.605 g/cm³, with a diameter of 43.25 µm, a tensile strength of 32.78 MPa, a Young's modulus of 56.87 GPa, and an elongation at break of 25.68%. Hemp, on the other hand, has a slightly lower density of 1.409 g/cm³ but a larger diameter of 76.83 µm, with a higher tensile strength of 45.76 MPa, but a lower Young's modulus of 21.23 GPa and an elongation at break of 47.85%. Jute boasts a density of 1.526 g/cm³, a diameter of 32.43 µm, a notable tensile strength of 55.31 MPa, a high Young's modulus of 89.64 GPa, and an elongation at break of 69.96%. Kenaf showcases a relatively low density of 1.283 g/cm³ and a smaller diameter of 12.32 µm, with a tensile strength of 33.21 MPa, a high Young's modulus of 79.42 GPa, and an elongation at break of 41.64%.

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Lastly, Ramie features the highest density among the composites listed, at 1.864 g/cm³, with a diameter of 42.64 µm, an impressive tensile strength of 67.79 MPa, a modest Young's modulus of 21.55 GPa, and a substantial elongation at break of 74.78%. These characteristics provide valuable insights for selecting suitable green composites for various applications, considering factors such as strength, flexibility, and overall performance.

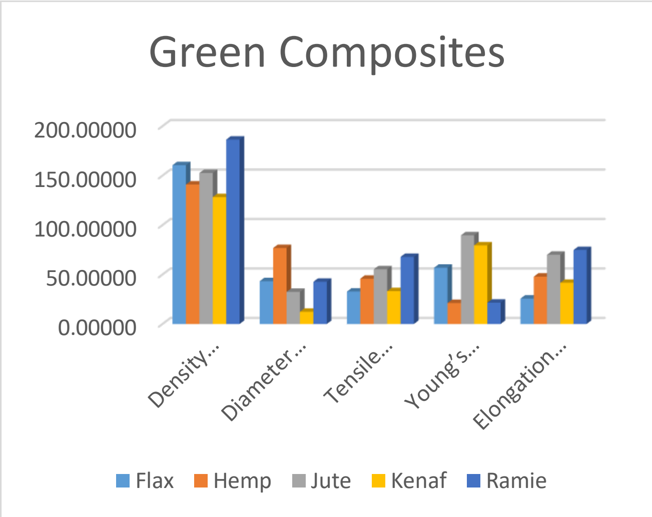

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Table 2. Normalized Data

Normalized				
0.86117	0.56293	0.48355	0.63443	0.34341
0.75624	1.00000	0.67503	0.23684	0.63988
0.81852	0.42210	0.81590	1.00000	0.93554
0.68816	0.16035	0.48990	0.88599	0.55683
1.00000	0.55499	1.00000	0.24041	1.00000

Table 2 presents normalized data, where each value has been scaled to fall within the range of 0 to 1. These normalized values facilitate comparisons across different variables or datasets by removing the effects of differing scales or units. In this table, each row corresponds to a different set of variables or observations, while each column represents a specific attribute or feature. By normalizing the data, it becomes easier to identify patterns, trends, and relationships within the dataset. This normalization process aids in standardizing the data for analysis, allowing for more accurate interpretations and conclusions to be drawn from the information presented.

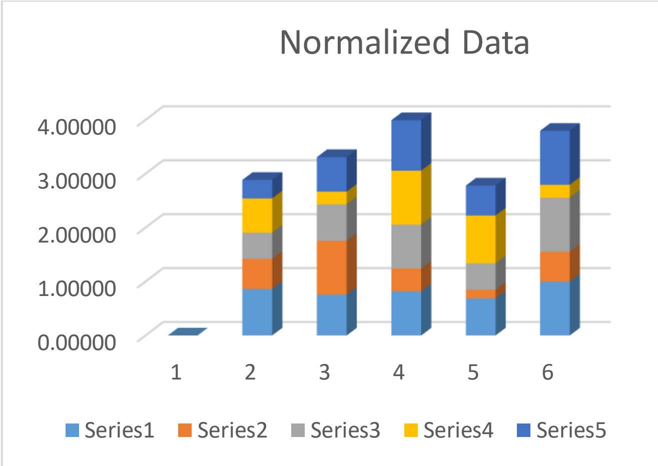

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Table 3. Weight

Weight				
0.25000	0.25000	0.25000	0.25000	0.25000
0.25000	0.25000	0.25000	0.25000	0.25000
0.25000	0.25000	0.25000	0.25000	0.25000
0.25000	0.25000	0.25000	0.25000	0.25000
0.25000	0.25000	0.25000	0.25000	0.25000

The provided table 3 outlines a set of equal weights (all set to 0.25) assigned to each attribute. These uniform weights suggest that all attributes are considered equally important in the evaluation or analysis, indicating a balanced consideration of factors without giving preference to any specific attribute.

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Table 4. Weighted Normalized Decision Matrix

Weighted Normalized Decision Matrix				
0.21529	0.14073	0.12089	0.15861	0.08585
0.18906	0.25000	0.16876	0.05921	0.15997
0.20463	0.10553	0.20398	0.25000	0.23389
0.17204	0.04009	0.12247	0.22150	0.13921
0.25000	0.13875	0.25000	0.06010	0.25000

Table 4. A Weighted Normalized Decision Matrix is a structured tool used in decision-making processes to evaluate multiple alternatives based on various criteria. In the provided matrix, each row represents an alternative, and each column represents a criterion. The numbers in the matrix represent the scores or weights assigned to each criterion for each alternative. These scores are normalized to ensure comparability across criteria and then weighted to reflect their relative importance. By multiplying the scores with their respective weights and summing them up for each alternative, a comprehensive assessment can be made to determine the most suitable option. This approach allows decision-makers to systematically analyze complex scenarios and make informed choices based on predefined criteria and their relative significance.

Table 5. Preference Score & Rank

	Preference Score	Rank
Flax	0.72137	4
Hemp	0.82699	3
Jute	0.99802	1
Kenaf	0.69531	5
Ramie	0.94885	2

Table 5. Among the various natural fibers assessed for their suitability in industrial applications, jute emerges as the clear front-runner with a preference score of 0.99802, securing the top rank. This high rating underscores jute's exceptional qualities, likely attributed to its strength, versatility, and eco-friendliness. Following closely behind is ramie, which garners a respectable preference score of 0.94885, securing the second position. Ramie's impressive performance underscores its potential as a valuable natural fiber resource. Despite trailing slightly, hemp and flax occupy the third and fourth positions, respectively, with preference scores of 0.82699 and 0.72137. These results highlight the competitive landscape among natural fibers, with each possessing unique attributes that cater to diverse industrial needs. Meanwhile, kenaf rounds off the list with a preference score of 0.69531, securing the fifth position. While slightly lower in ranking, kenaf still holds promise as a viable natural fiber option for various applications, albeit with potential areas for improvement. Overall, this assessment provides valuable insights into the relative strengths and weaknesses of these natural fibers, informing decisions regarding their utilization in industrial contexts.

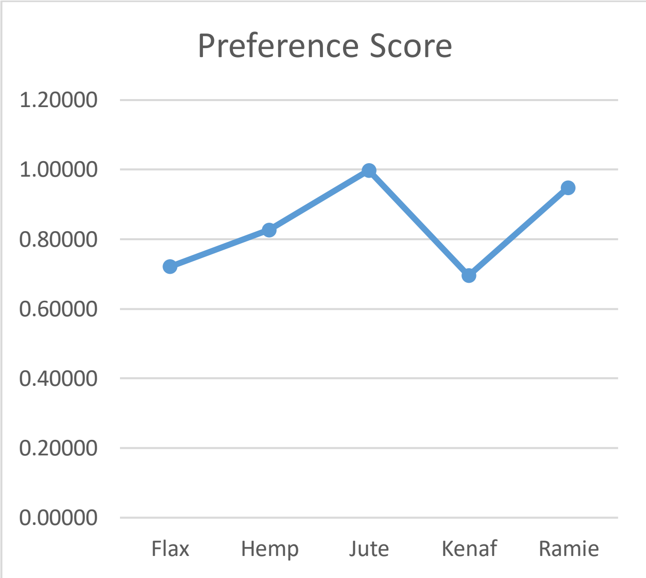

Fig 3. Preference Score

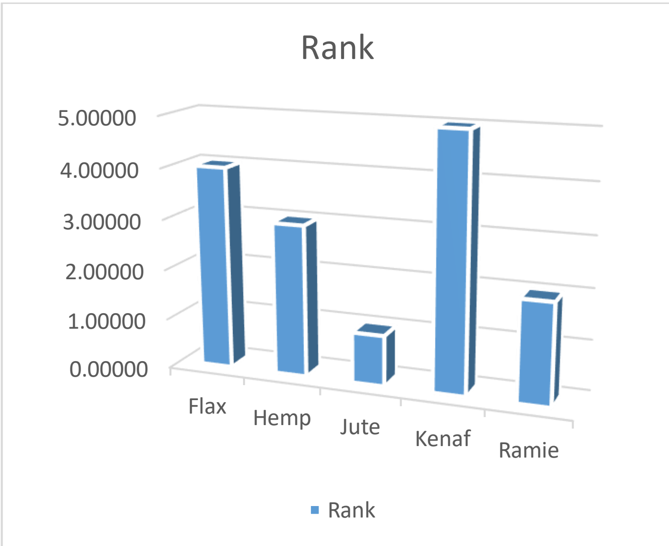

Fig 4. Rank

In the realm of natural fibers, jute takes the crown with a rank of 1. Renowned for its versatility and eco-friendliness, jute holds a prominent position in various industries, ranging from textiles to packaging. Following closely behind is ramie, securing the second spot with its exceptional strength and smooth texture, making it a preferred choice for high-quality fabrics. Hemp claims the third position, celebrated for its durability and sustainability, contributing significantly to textiles, paper, and even construction materials. Flax follows suit at the fourth rank, valued for its strength and breathability, serving as a staple in linen production and beyond. Finally, kenaf rounds off the rankings at fifth place, recognized for its fast growth and diverse applications in paper, fiberboard, and insulation. Each of these fibers brings its unique set of qualities to the table, catering to a wide array of industrial and consumer needs.

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V. CONCLUSION

In this study, the utilization of in Water Soaking Method (WSM) was thoroughly investigated. The evaluation parameters encompassed which are crucial indicators of. Through meticulous experimentation and analysis, it has been revealed that Jute stands out as the most promising natural fiber using the WSM approach. Jute exhibited superior performance across multiple evaluation parameters, earning it the first rank among the alternatives considered in this study. The remarkable attributes displayed by Jute in underscore its suitability for composite applications. The results indicate that Jute-based composites possess favorable mechanical properties, making them highly desirable for various industrial applications where lightweight and sturdy materials are required. The combination of Jute fibers with the WSM method demonstrates great potential for the fabrication of eco-friendly composites that offer competitive performance compared to conventional materials. On the other hand, Kenaf, while still demonstrating respectable properties, attained the lowest rank among the evaluated alternatives. This suggests that further optimization may be necessary when utilizing the WSM method. Nonetheless, Kenaf remains a viable option for composite production, albeit with potential areas for improvement. ongoing efforts in the field of sustainable materials development. By highlighting the efficacy of Jute and identifying areas for refinement in other natural fibers such as Kenaf, this research offers a promising avenue for sustainable materials development. Jute emerges as a frontrunner in this study, showcasing its potential to serve as a key component in the fabrication of eco-friendly composites with robust mechanical properties. Further exploration and refinement of these methodologies hold the key to unlocking even greater advancements in the realm of green composite materials.

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