



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

Akhil R. J¹, S. L. Beschi Selvan²

^{1,2}Department of Mechanical Engineering, Mar Ephraem College of Engineering and Technology

ABSTRACT

This study presents a comparative analysis of coir and banana fiber reinforced polymer resin composites, focusing on their mechanical and environmental performance characteristics using the hand lay-up method. Natural fibers such as coir and banana offer sustainable alternatives to traditional synthetic reinforcements due to their renewability, low cost, and biodegradability. The research involves fabricating composite samples through the hand lay-up process, which is a widely used technique in composite manufacturing for its simplicity and cost-effectiveness. Samples with varying fiber content are prepared, ensuring consistency in resin impregnation and fiber distribution. Comprehensive mechanical testing, including hardness, wear and microstructural analyses, is conducted to assess the performance of each composite type. The findings aim to provide insights into the mechanical properties and environmental sustainability of coir and banana fiber composites compared to traditional synthetic composites. It can be contributes to understanding their potential applications in industries such as automotive, construction, and packaging, where lightweight, strong, and eco-friendly materials are increasingly in demand.

Keywords: Natural fibers, Processes and Composites Polymers.

1 Introduction

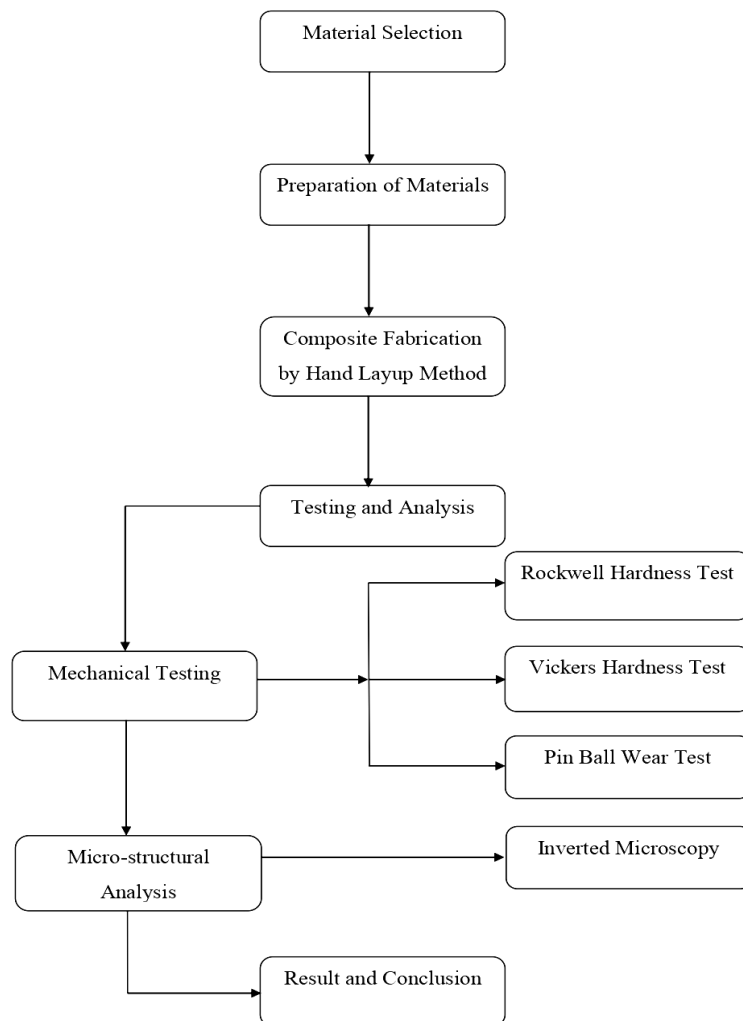
The comparative analysis of coir and banana fiber reinforced polyester resin composites to understand their performance characteristics and suitability for various applications. The project will employ the hand lay-up method for fabricating the composites, which involves manually laying down layers of coir or banana fibers, and polyester resin, to create the composite materials. This method allows for detailed control over the fiber orientation and resin application, ensuring the quality and consistency of the final product. Once the composites are prepared, a series of mechanical tests will be conducted to evaluate their properties. The Rockwell and Vickers hardness tests will be used to assess the hardness of the composites, providing insights into their resistance to deformation and wear. Additionally, wear or pin ball testing will measure the composites' abrasion resistance, which is crucial for applications involving high wear and tear. To further investigate the material properties, the microstructures of the composites will be analyzed using microscopy techniques. This analysis will reveal important details about the fiber-matrix bonding, fiber distribution, and overall



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

structural integrity of the composites. By examining these aspects, the project aims to determine the optimal fiber-to-resin ratios and identify which type of fiber coir or banana offers superior reinforcement and performance. Ultimately, the findings from these tests and analyses will help in developing practical recommendations for the use of these natural fiber composites in various industrial applications, highlighting their advantages and addressing any limitations.

2 Methodology



3 Experimental Process

The hand lay-up method for coir and banana fiber reinforced polyester resin composites is a manual process involving the layering of coir and banana fiber with polyester resin to create a composite material. The hand lay-up technique is a fundamental and versatile method used to prepare polymer composites by manually layering fibers and resin. In this process, four distinct composite materials are fabricated using different combinations of polyester resin, coir fiber, and banana fiber. The first composite includes polyester resin with coir fiber, the second



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

consists of polyester resin with banana fiber, the third is a mix of equal parts polyester resin and coir fiber, and the fourth is made of equal parts polyester resin and banana fiber. To begin, a mold is thoroughly cleaned to remove any dust or impurities that could affect the quality of the final product. A release agent is then applied to the mold surface to ensure that the composite can be easily removed after curing. The materials are measured and prepared according to the desired compositions. The polyester resin is mixed with a hardener or catalyst, following the manufacturer's instructions, to initiate the curing process. It is essential to mix the resin and hardener thoroughly to ensure a uniform cure. For each composite, the process starts by applying a layer of resin to the mold. This initial layer acts as a base and helps to hold the fibers in place. Next, a layer of fibers is evenly distributed over the resin. The fibers can be either coir or banana fiber, depending on the composite being made. More resin is then applied to wet the fibers completely, ensuring they are fully saturated. This step is crucial as it prevents the formation of dry spots and ensures that the resin penetrates all parts of the fiber mat. Additional layers of resin and fibers are added in succession, depending on the desired thickness and properties of the final composite. As each layer is added, rollers or brushes are used to compress the laminate, removing any trapped air bubbles and ensuring good contact between the resin and fibers. This compression is vital for achieving a dense, void-free composite with excellent mechanical properties. Once the lay-up process is complete, the composite is left to cure. Curing can take place at room temperature or in an oven, depending on the specific requirements of the resin and the desired properties of the final product. During curing, the resin hardens and binds the fibers together, forming a solid and durable composite material. After the curing process is finished, the composite is carefully removed from the mold. This step must be done with care to avoid damaging the newly formed composite. The cured composite is then ready for further testing and analysis. Various tests, such as hardness testing and micro-structural analysis, are conducted to evaluate the mechanical properties and structural integrity of the composite. This analysis helps in understanding how well the fibers and resin have bonded and whether the composite meets the required performance standards. The amount of polymer content with arrangement of coir and banana fiber contents for samples were as follows:

- Composite 1: 75%polyesterresin,25%coirfiber(C25%S1)
- Composite 2: 75%polyesterresin,25%banana fiber(B25%S1)
- Composite 3: 50%polyesterresin,50%coirfiber(C50%S2)
- Composite 4: 50%polyesterresin,50%banana fiber(B50%S2)

3.1 Hardness and Wear Test

Hardness and wear testing are essential to evaluate the mechanical properties and durability of coir and banana fiber reinforced polyester resin composites. The hardness of these composites is assessed using the Rockwell and Vickers hardness tests. The Rockwell hardness test involves pressing a diamond cone or steel ball indenter into the composite's surface under a specified



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

load and measuring the indentation depth to determine the hardness value. The Vickers hardness test, on the other hand, uses a diamond pyramid indenter applied with a constant force, and the size of the indentation is measured to calculate the hardness. These tests provide valuable information on the material's resistance to deformation. Wear testing, such as the pin-on-disk method, measures the composite's wear resistance by sliding a hard pin against the composite surface under controlled conditions and assessing the material loss over time. This testing helps to determine the composite's suitability for applications where resistance to surface wear is crucial. By performing these tests, the mechanical performance and durability of the composites can be thoroughly evaluated, guiding improvements in composite formulation and processing.

3.2 Micro Structural Analysis

Micro-structural analysis is a crucial testing method for examining the internal structure and quality of coir and banana fiber reinforced polyester resin composites. This analysis involves using an inverted microscope to inspect the microstructure of the composites, providing detailed insights into the fiber-matrix interface, fiber distribution, and the presence of any defects or inconsistencies. During the test, the composite samples are first prepared by cutting and polishing them to create smooth, flat surfaces suitable for observation. Under the inverted microscope, researchers can observe key features such as fiber alignment, the degree of fiber wetting by the resin, and the presence of voids or delaminations. This detailed examination helps in assessing the effectiveness of the fiber reinforcement, the uniformity of resin distribution, and the overall quality of the composite. By identifying any issues in the microstructure, such as inadequate fiber-matrix bonding or the presence of voids, the analysis provides valuable feedback for optimizing the composite formulation and processing methods to enhance the material's mechanical properties and performance.

4 Results and Discussion

4.1 Rockwell Hardness Test

Hardness is a measure of how resistant a solid substance is to different kinds of permanent form change when a compressive force is applied. Rockwell hardness testing is an indentation testing method. It measures the permanent depth of a groove produced by a force/load on an indenter. The Rockwell Hardness Number (RHN) is calculated from the depth of permanent deformation of the indenter into the sample. The indenter is either a conical diamond or a hard steel ball. Although Rockwell Hardness test does not give a straight measurement of any performance properties; hardness of a material correlates directly with its strength, wear resistance and other properties.

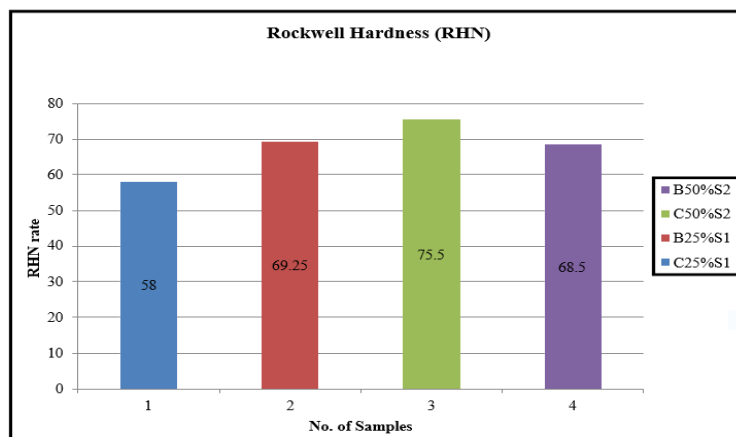


Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

4.1.1 Results of Rockwell Hardness Test Results

Indenter: 1/16*Ball; Load: 100kgf

Samples	No. of Count	Rockwell Hardness Value	Average HR Value
C25%S1	1	55	58
	2	57	
	3	59	
	4	61	
B25%S1	1	75	69.25
	2	77	
	3	76	
	4	74	
C50%S2	1	66	75.5
	2	68	
	3	70	
	4	73	
B50%S2	1	68	68.5
	2	70	
	3	69	
	4	67	



As per the above results, comparing in only coir fiber reinforced composites, 50% coir fiber reinforced polymer composite has the highest Rockwell Hardness Number (RHN) of 75.5RHN and comparing in only banana fiber reinforced composites, 25% of banana fiber reinforced polymer composite has the highest Rockwell Hardness Number (RHN) of 69.25RHN while comparing in both of the coir and banana fiber reinforced composites, 50% of coir fiber reinforced polymer composite has the highest Rockwell Hardness Number (RHN).

4.2 Micro Vickers Hardness Test

In the micro Vickers Hardness Test, two samples are tested by applying a load to create indentations on their surfaces. The indentation diameters are measured, and hardness values



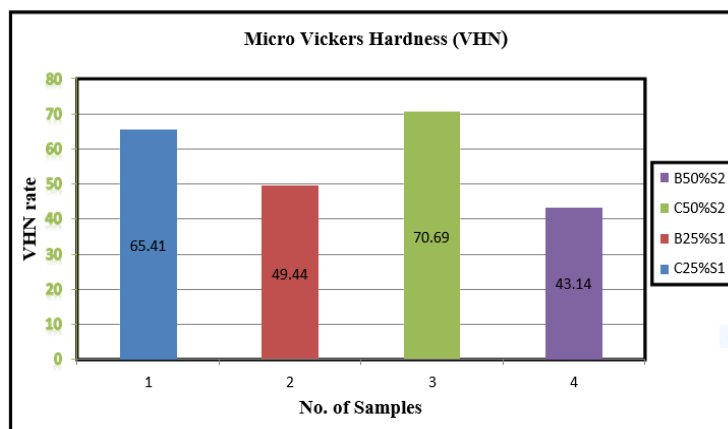
Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

are calculated. Comparing these values provides insight into the relative hardness of the samples, aiding in material assessment and quality control.

4.2.1 Results of Micro Vickers Hardness Test

Indenter: Diamond Pyramid; Load: 1000gf

Samples	No. of Count	Diagonal (d1) Mm	Diagonal (d2) μm	Vickers Hardness (HV)	Averages of		
					d1	d2	HV
C25%S1	1	50.23	41.49	80.17	62.15	47.33	65.91
	2	70.88	62.37	41.78			
	3	66.68	44.82	59.66			
	4	60.84	40.64	72.03			
B25%S1	1	57.18	58.11	55.80	62.46	61.08	49.44
	2	52.54	64.68	53.98			
	3	67.35	72.78	37.77			
	4	72.78	48.76	50.21			
C50%S2	1	34.81	37.27	142.77	56.79	60.55	70.69
	2	45.88	55.69	71.90			
	3	63.93	78.71	36.46			
	4	82.56	70.53	31.65			
B50%S2	1	41.72	38.02	45.66	59.62	60.25	43.14
	2	68.98	78.23	51.36			
	3	64.91	55.26	34.23			
	4	62.89	69.51	42.31			



As per the above result, comparing in only coir fiber reinforced composites, 50% coir fiber reinforced polymer composite has the highest Vickers Hardness Number (VHN) of 70.69VHN



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

and comparing in only banana fiber reinforced composites, 25% of banana fiber reinforced polymer composite has the highest Vickers Hardness Number (VHN) of 49.44 VHN while comparing in both of the coir and banana fiber reinforced composites, 50% of coir fiber reinforced polymer composite has the highest Vickers Hardness Number (VHN).

4.3 Wear Test Analysis

In a wear test, four samples are subjected to controlled conditions such as specific loads, coefficients of friction (COF), and speeds. The test measures the wear diameter of each sample over a set period, allowing calculation of the wear rate. By comparing these parameters that can be assess the materials resistance to wear and friction, vital for understanding their durability and suitability for various applications.

4.3.1 Results of Wear Test Samples

Samples	Wear diameter (mm)	Load (N)	Time (sec)	Speed (rpm)	COF	Wear (Microns)
C25%S1	40	5	300	300	0.31	155
	40	10	300	300	0.46	275
	40	15	300	300	0.6	395
B25%S1	40	5	300	300	0.31	150
	40	10	300	300	0.46	270
	40	15	300	300	0.61	390
C50%S2	40	5	300	300	0.34	185
	40	10	300	300	0.50	315
	40	15	300	300	0.66	445
B50%S2	40	5	300	300	0.34	180
	40	10	300	300	0.51	310
	40	15	300	300	0.68	430

As per the above results, comparing in only coir fiber reinforced composites, 25% coir fiber reinforced polymer composite has showed the higher level of wear resistance compared to 50% coir fiber reinforced polymer composite and comparing in only banana fiber reinforced composites, 25%of banana fiber reinforced polymer composite has showed the higher level of wear resistance compared to 50% banana fiber reinforced polymer composite, while comparing in both of the coir and banana fiber reinforced composites, 25%of banana fiber reinforced polymer composite has showed the higher level of wear resistance.

4.4 Micro Structural Analysis

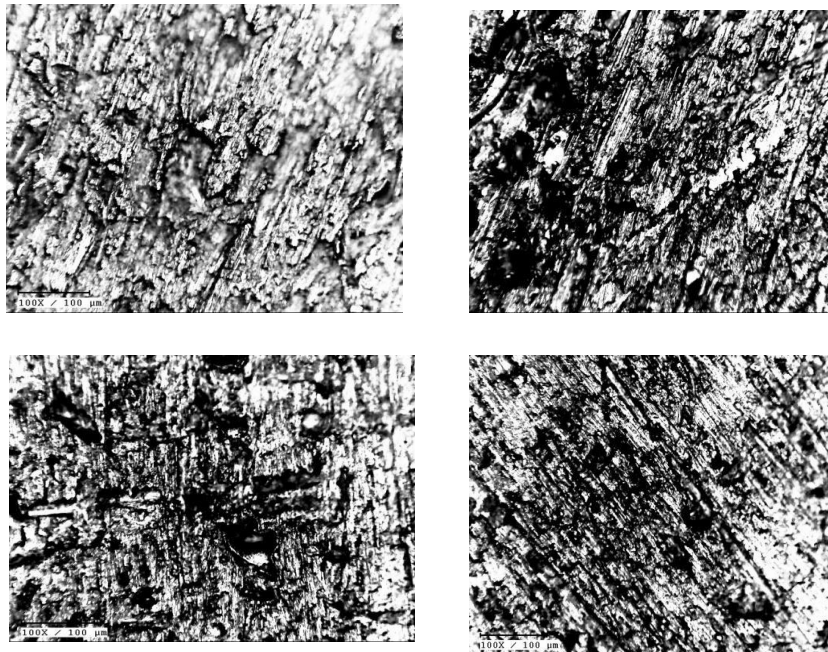
Micro-structural analysis of polymer composites reinforced with coir and banana fibers, using an inverted microscope, focuses on examining the fiber dispersion and matrix interaction at a



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

detailed level. This approach allows for a clear view of how fibers are embedded within the polymer matrix and how different fiber loadings (25% and 50%) influence the overall composite structure. By utilizing the inverted microscope, we can assess fiber distribution, interface bonding, and detect any potential defects or irregularities in the composite material.

4.4.1 Results of Micro Structural Test Samples



As per the results, the 25% coir fiber reinforced polymer composites exhibit relatively even fiber distribution throughout the matrix. These results in moderate improvements in mechanical properties, such as increased stiffness and strength compared to pure polymer. The fiber-matrix bonding is generally good, though some gaps at the interface may be present, potentially affecting overall adhesion quality. In 25% banana fiber reinforced polymer composites, the fibers are dispersed evenly within the matrix. This leads to significant improvements in both strength and toughness. The matrix-fiber bonding is generally strong, contributing to a balanced enhancement of mechanical properties without substantial issues in fiber distribution.

For composites with 50% coir fiber, fiber clustering becomes more pronounced, which may lead to non-uniform distribution within the matrix. While mechanical properties, such as stiffness and strength, see a significant boost, the presence of fiber agglomeration can result in reduced toughness and potential voids, affecting overall performance and fiber-matrix adhesion. The 50% banana fiber reinforced polymer composites show a tendency for higher fiber agglomeration. Although there is a notable increase in mechanical strength and stiffness, this clustering can lead to localized weak spots and less effective fiber-matrix bonding in some areas. As a result, while strength is enhanced, impact resistance and uniform bonding may be compromised.



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

5 Conclusion

Processed Coir and Banana fiber reinforced composites were fabricated successfully using hand by up method. Based on the Hardness and Wear test (Rockwell Hardness Test, Vickers Hardness Test & Wear Test) and micro structure analysis conducted, the study of coir and banana fiber reinforced polyester resin composites revealed that the 50% coir fiber composite demonstrated the highest hardness, making it ideal for applications requiring high strength and durability, such as construction materials and automotive parts. The 25% banana fiber composite exhibited the best wear resistance, suitable for applications where surface durability and abrasion resistance are crucial. These findings highlight the importance of selecting appropriate fiber-resin ratios to optimize composite performance for specific uses, ensuring a balance of hardness, wear resistance, and structural integrity. We conclude that the 50% of coir fiber reinforced polyester resin composite is the most effective overall, offering the highest hardness and strength.

References

1. K. Bledzki; A. A. Mamun; M. Lucka-Gabor; V. S. Gutowski, Year: 2008, "The effects of acetylation on properties of flax fiber and its polypropylene composites", *Express polymer letters*, Vol: 2, pp. 413 – 422.
2. A. I. S. Brígida; V. M. A. Calado; L. R. B. Gonçalves; M. A. Z. Coelho, Year: 2009, "Effect of chemical treatments on properties of green coconut fiber", *Carbohydrate Polymers*, Vol: 79, pp. 832 – 838.
3. Alveera Khan; M. Ayaz Ahmad; Shirish Joshi; Said A. F. Al Said, Year: 2013, "Abrasive wear behavior of chemically treated coir fiber filled epoxy polymer composites", *American Journal of Mechanical Engineering and Automation*, Vol: 1, no: 1, pp. 1 – 5.
4. B. Wang, S. Panigrahi, L. Tabil, W. Crerar, S. Sokansanj, Year: 2003, "Modification of flax fibers by chemical treatment", *Composites Science and Technology*, Vol: 3, pp. 333 – 337.
5. F. Z. Arrakhiz; M. El Achaby; A. C. Kakou; S. Vaudreuil; K. Benmoussa; O. Fassi Fehri; A. Qaiss; R. Bouhfid, Year: 2012, "Mechanical properties of high density polyethylene reinforced with chemically modified coir fibers: Impact of chemical treatments", *Materials and Design*, Vol: 37, pp. 379 – 383.
6. C. Girisha; Sanjeevamurthy; Gunti Rangasrinivas, Year: 2012, "Tensile properties of natural fiber reinforced epoxy-hybrid composites", *International Journal of Modern Engineering Research (UMER)*, Vol: 2, pp. 471 – 474.
7. Isiaka Oluwole Oladele; Oluyemi Ojo Daramola; Solomon Fasooto, Year: 2014, "Effect of chemical treatment on the mechanical properties of sisal fiber reinforced polyester composites", *Leonardo*



Article Title: Comparative Analysis of Coir and Banana Fiber Reinforced Polymer Resin Composites

Electronic Journal of Practices and Technologies, Vol: 24, pp. 1 – 12.

8. Mansour Rokbi; Hocine Osmani; Abdellatif Imad; Noureddine Benseddiq, Year: 2011, “Effect of chemical treatment on flexure properties of natural fiber-reinforced polyester composite”, *Procedia Engineering*, Vol: 10, pp. 2092 – 2097.

9. M. M. Kabir; H. Wang; K.T. Lau; F. Cardona, Year: 2012, “Chemical treatments on plant-based natural fibre reinforced polymer composites: An overview”, *Composites Part B: Engineering*, Vol: 43, no: 7, pp. 2883 – 2892

10. O. M. L. Asumani; R. G. Reid; R. Paskaramoorthy, Year: 2012, “The effects of alkali-silane treatment on the tensile and flexural properties of short fiber non-woven kenaf reinforced polypropylene composites”, Vol: 43, no: 9, pp. 1431 – 1440.

11. R. Narendar; K. Priya Dasan, Year: 2007, “Chemical treatments of coir pith: morphology, chemical composition, thermal and water retention behavior”, *Composites Part B: Engineering*, Vol: 56, pp 770 – 779.

12. S. M. SureshKumar; D. Duraibabu; K. Subramanian, Year: 2014, “Studies on mechanical, thermal and dynamic mechanical properties of untreated (raw) and treated coconut sheath fiber reinforced epoxy composites”, *Materials and design*, Vol: 59, pp. 63 – 69.

13. Samia S. Mir; Syed M. N. Hasan; Md. J. Hossain; Mahbub Hasan, Year: 2012, “Chemical modification effect on the mechanical properties of coir fiber”, *Engineering journal*, Vol: 16, pp 70 – 83.

14. Xue Li; Lope G. Tabil; Satyanarayan Panigrahi, Year: 2007, “Chemical treatments of natural fiber for use in natural fiber- reinforced composites A Review”, *Polymer Environment*, Vol: 15, pp. 25 – 33.