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# Rice Straw Based Natural Fiber Reinforced Polymer for Sustainable Bio- Composites: A Systematic Review

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**Abstract:** This review provides an overview of use of natural fibers and potential use of rice straw fibers as reinforcement in composite. As it is known that after china, India is the second largest country in the world producing rice as food grains. As a result of producing more amount of rice a large amount of rice straw is left as a residue, some of which is used for fodder feeding and a large amount of which is just burned by the farmers. This burning off practice is very common in the country because it is the cheapest way in which farmers can rid of the waste material, It can be seen that every year our national capital gets into a cover of smog because of burning of parali (rice straw). Scientists have understood the potential of using rice straw natural fiber in place of wood fiber in various uses, hence many experimental labs and commercial research is being conducted in this field and a lot of startups are also being initiated on this. Various composites are being made and their properties are being tested in various parts of the world. These composites are mainly termed as green composites. These green composite have great potential in preventing our environment, giving sustainable replacement towards use of plastic, wood and all other materials in industrial use.

Keywords: Natural Fibers, Rice straw, Rice husk, Polyethylene, Composite, Chemical treatment.

## 1. Introduction

As we know that our society demands are increasing day-by-day. Economic patterns, natural resource consumptions, forest goods etc. Are changing at a very fast rate. These changing patterns are creating a large stress on our environment. This stress is causing fast rate of depletion in environmental resources, along with it humans are facing health hazards. Rising cost of non-renewable plastics composites, deforestation for wood fiber and continuously evolving environmental laws has resulted researchers to look into the eco-friendly field of composite material<sup>1, 2)</sup>. So focus of researchers is now on natural fiber composites also termed as bio- composites, which mainly consists of natural or synthetic type of resin and the resin is reinforced by any kind of natural fiber. This usage of natural fiber in a composite to get better property is not a new concept, it is used by humans in many of the past civilizations, for example usage of husk in mud to make shelter homes, it was a basic concept to get a better usage from waste material. The plant fibrous material used in this composite was for the purpose of giving enhanced strength, stiffness, toughness

and other mechanical properties. This old concept is now again gaining momentum research scholars are now focusing on the various properties such as mechanical, moisture content, wettability etc.<sup>3)</sup>.

If not used properly this rice straw is burned in open ground as it is the cheapest option available to a farmer, but open burning of this stubble is not a good way when it is seen with respect to the atmosphere as this result in production of harmful gases such as carbon monoxide, nitrogen dioxide, sulfur dioxide and methane along with particulate matter. Not only in India but also in China and Asian countries rice production is very high so this stubble burning is not a solution for the waste generated<sup>4)</sup>. Hence these problems of environmental impacts are the main factor which drive for the development of natural fiber reinforced composite(NFRC). All the natural fiber can easily be categorized on the basis of their origin that is whether they are from plants, animals or minerals, But Natural fibers are very hydrophilic in there nature when tested this is mainly because of the hydroxyl group present so they are very much incompatible with any matrix<sup>5)</sup>. Composites are big advancement by the help of

which we can optimize material properties, and lead towards a material which we can use in future. Composite are formed by mixing up of two or more than two materials they can be ceramics, metals even plastics also. A matrix is mixed up with a suitable reinforcement which can be long fiber, short fiber even whiskers also. Glass are used to impart high strength, and were light weight, with advancement of research now carbon nano-particles are also being used in the composite preparation. High temperature resistivity can be said as a major setback in the field of composite to overcome that also work is being done in metal material composites such as aluminium, steel etc. these were mainly manufactured by powder metallurgy but now 3-D additive manufacturing is also being used for metal material composites.

### 1.1 Composites

#### WHAT IS COMPOSITE AND WHY TO USE?

Generally a composite can be defined as a material which is made up of two or more material added together such that the end result gives more advanced properties than the combined ones. Each and everything is mainly made up of composite. One can say that the composite are formed naturally or either made by humans by various processes. One can give an example of bone as natural composite it support the structure by acting all kinds of forces, tooth show highly improved mechanical properties animals like tigers, alligators act a large amount of pressure to tear out

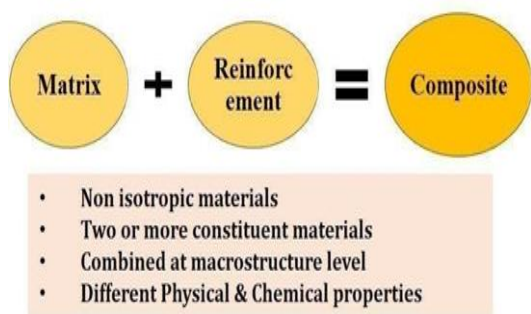


Fig. 1 Characteristics of Composites

flesh. The history of manmade composite can date back up to the starting civilizations such as mud fiber bricks baked for houses and other building material. In laymen term it can be said that composite is a mixture of two materials where both get bonded to each other, such that material get much more advanced properties. As shown in fig 1 one can say that composite have two major component, first one is reinforcement and the second one is matrix, matrix is the continuous phase while reinforcement is the dispersed one, a single matrix can have more than one reinforcement (flakes, long, particles). The matrix gives the shape of the composite and the reinforcement increases and imparts different properties to the composite.

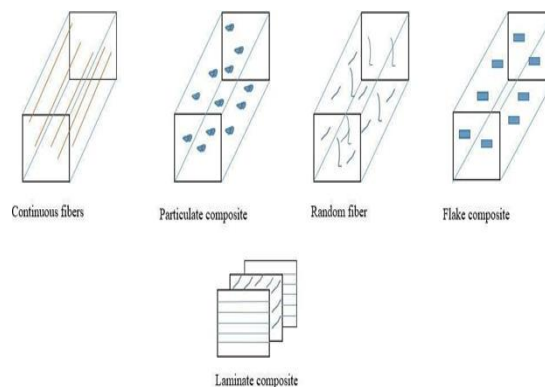


Fig. 2 Types of composites

As shown in Fig 2, the reinforcement used in the composites can create different types of it such as continuous fiber having long length of continuous fibers, randomfiber have randomly oriented fibers. In particulate composite the reinforcements can be of any shape and size and configuration ,it does not matter they are randomly oriented and suspended inside the matrix. While laminate matrix has multiple layers of fibers in random way, each layer is 2 D in dimension that is planar. While flake composite have planar and flat reinforcement in matrix, this help in giving more strength, flexure strength and also reduces the cost of composite. Jartz W<sup>6)</sup> stated that a composite material possess that kind of properties which are impossible to be possessed by a single material. They get a physical and chemical structure which forms after amalgamation occurs between two or more than two materials which are totally different in there characteristics. Kelly<sup>7)</sup> focused that the composites should not be simply taken as a mixture of two materials as the new mixture formed give rise to its own new properties with respect to strength heat resistance and other mechanical properties. Van Suchetchan<sup>8)</sup> defined composites having different number of solid phases which are interacted to each other on a microscopic level he also claimed that any part of the composite if separated will have the same properties as that of the initial one that is properties will not change by physical separation.

### 1.2 Classification of Composite

On the basis of the matrix material used composites can be generally classified into three groups

#### 1- Metal Material Composite

These are composite of metals they have much better properties when compared to that of monolithic materials. This composite consist of at least two parts as constituents one is mainly a metal the other may be a metal or may be any other material (ceramics etc). Because of all these qualities metal material composites have great use in aerospace technology, in automobile industry.

## 2- Ceramic Matrix Composites

Ceramic material composite are those special ones in which matrix and reinforcement are both ceramic one. Sometimes add on fiber reinforcement are also added to the composite.

## 3- Polymer Matrix Composites

These composites are best substitute when compared to conventional metals since there cost is less. Alone a polymer cannot compete with a material as all its material properties are very low when compared .So one can improve the composites properties by adding reinforcement in the composite, this reinforcement process is itself not a tough one ,it does not include high operating temperatures or high working pressures. Not even the type of reinforcement but also the geometry of the reinforcement effect the properties of the composite formed.

The polymer composite can be classified into two broad's categories, on the basis of the reinforcement which is added in the composite.

- 1- Fiber composite
- 2- Particulate composite

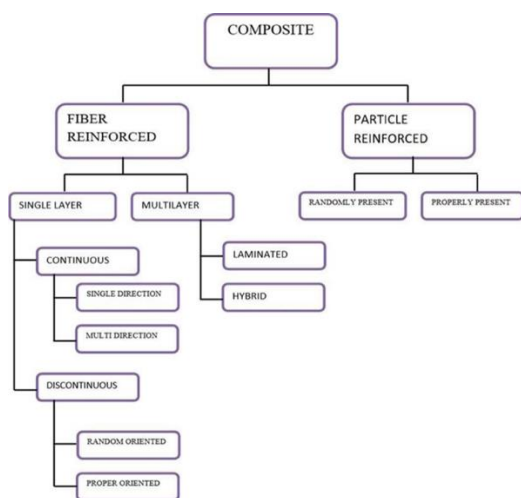


Fig. 3: Classification of composite

### 1.3 Rice Straw

It is a lignocellulosic fiber which belongs to a category other than wood bio fiber. Cultivation of rice is an important part of human existence always, since the beginning of the human evolution rice cultivation is done, currently it is done on a large scale across the globe .Hence as a by-product the availability of rice straw is in a very large number, rice straw is produced mainly after paddy cultivation and per kg of rice approximately gives same amount of rice husk. Hence we can use it as a potential resource for utilization in place of wood fiber, thus reducing the amount of trees being cut for wood fiber and decreasing deforestation. We also know that this rice straw is just treated as a

waste product a large quantity is just burned down, as we see in Haryana and Punjab borders of Delhi. This causes a large quantity of air pollution in the area around Delhi and Northwestern UP. Various researchers are utilizing the potential of this rice fiber for composite preparation HabibiYoussef et al<sup>9)</sup> used lignocellulosic mainly from cotton, rice straw, bagasse and banana and made different composite .He stated that the chemical composition such as lignin, cellulose and hemicellulose effects the composites properties .One can calculate the Tensile strength of this composite by using the rule of Hybrid Mixture<sup>10)</sup>. From Fig 4 we can see that Rice plant mainly consist of Hollow culms, internode, prophyllum, Tiller etc. The hollow culms are mainly separated by nodes, the branches sprouting out from nodes re mainly termed as tillers. When we study rice straw we can say that it has cellulose, hemicellulose, lignin, ash .All these parts when combined makes up the rice straw structure .Cellulose can be said as a chain of large polysaccharides having large number of glucose monomers. Hemicellulose and lignin helps in binding of micro fibrils which are fiber like strands mainly consisting of cellulose<sup>11)</sup>. All these composition never remain constant they vary by the area, moisture content, climatic constraint and many more factors.

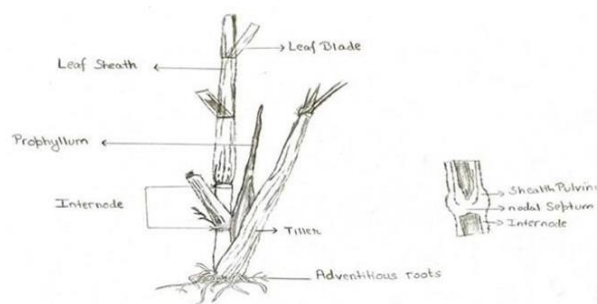


Fig. 4: Detail view of rice straw plant (from Chang, T.-T. and Bardenas, E. A. 1965. The Morphology and Varietal Characteristics of the Rice Plant)

#### 1.3.1 Chemical Composition Of All Natural Fiber Cellulose

-One can say it is the main reinforcing material, which provides strength to fiber. glucose monomers are there in it which makes hydrogen bond in self chain creating fibrils, and with other chains creating microfibrils. This gives rise to a crystal structure giving strength.

#### Hemicellulose

-On comparison to cellulose they have different sugar units. It shows chain branching mechanism not like cellulose which is linear. It has less tendency of polymerization when compared to that of cellulose.

#### Lignin

-it is mainly a chaotic, cross linked polymer, emerging after Polymerization of monomer units. It helps trees to

stand upright for even 100 meters. It deprivates towards UV light

**Pectin**

-it is mainly acidic structure polysacrides. On comparison it is most hydrophilic in nature. Has carboxylic acidic group mainly which is hydrophilic.

**1.4 Literature Survey**

By going through the various articles on natural reinforced composites one can easily get an overview of the complete variation in the properties of composites formed by natural or synthetic fibers or by their combine combination as hybrid composite, various method of formation and composite fabrication. Currently for researcher natural fibers are becoming area of interest for the researchers as these fibers are available in bulk, they are cheap ,biodegradable in nature and gives better properties ,hence a good substitute to our conventional reinforced materials.

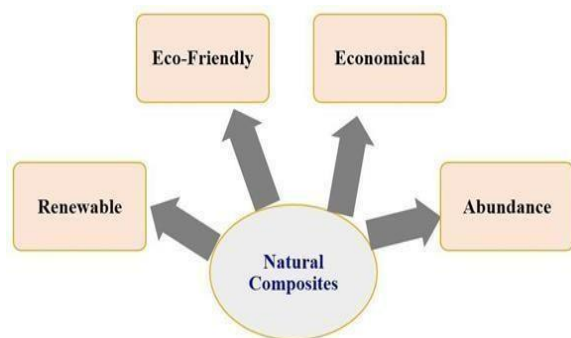


Fig. 5: Characteristics of Natural Composite

In 2003 Donnel et al<sup>12)</sup> used VARTM vacuum assisted resin transfer moulding Resin infusion process in making composites panels, He used AESO as reference for flexure modulus, recycle paper was also used as a cheap resource of cellulose in the formation of the composite. Complete bio based materials used such as plant oil resin (soya bean oil) and Natural fibers were used for the preparation of the composites. Test performed were dynamic mechanical analysis and permeability measurement in results obtained with natural reinforcement composite strength increased to 5 times end results obtained were positive. Kim et al.<sup>13)</sup> in 2003 analyzed thermal degradation and thermal stability of rice husk floor by thermo gravimetric analysis, it was concluded that with the increase of the natural fiber the thermal stability got decreased because the ash content got increased in the composite. He used a proper nitrogen atmosphere for the preparation of the composite to make a resistive environment. Negative results were obtained hence natural fibers addition was not good for thermal stability in this study. Thermo gravimetric analysis is mainly done for thermal analysis of the composite made, over different time range and temperature changes

composite thermal stability is checked. Along with natural fibers other reinforced material were also studied as reinforcement and were studied ,such as Yang et al.<sup>14)</sup> in 2004 mixed rice straw and waste tire material with each other just as the same method by which insulation boards in construction are made which are used in wood based panel industry. Rice straw was mixed with waste tire particle in various ratio composite binder was used “polyurethane”. Formed composite was compared to the wood particle board and positive result were obtained, flexibility and flexural.

Properties were much better on comparison. The rice straws used in the fabrication were of random sizes and the strength was also same to the others boards, hence sizing cost of the rice straw also is not an issue. The sound absorption coefficient as compared was much better and higher when compared to a wood based material composites. This study showed that one can go for a substitute Pathapulakkal et al.<sup>15)</sup> in 2005 researched on natural fibers by making their properties of more advance using chemical and mechanical means. Result on comparison showed that the fibers treated chemically and mechanically gave much better result in comparison to the one not treated .For chemical treatment he used NaOH as the chemical pulping agent and Orevac CA100 was used as the compatibilizer for the fibers. Mechanically the fibers were cuts, dipped and soaked in water for a night and then air dried and sieved through a 32 mesh tyler screen .End result were obtained from both the virgin polymer and the formed composite from the reinforced .Chemical treatment removed a lot of surface irregularities and the best connection was given by 30% of the wheat straw filled composite.

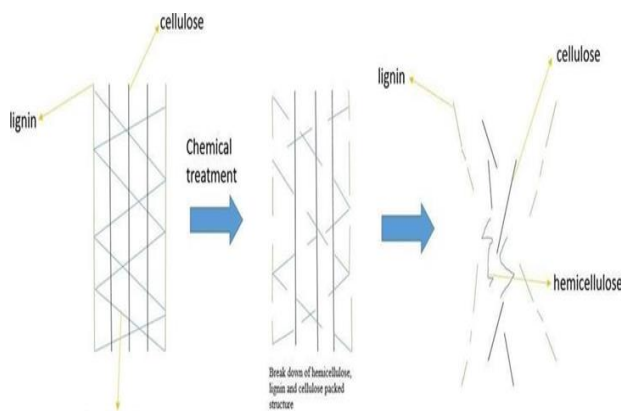


Fig. 6: Shows the effect of chemical treatment on rice straw

In 2005 Yang et al.<sup>16)</sup> studied effect caused by using a compatibilizing agents on various properties such as mechanical and morphological, Rice husk floor was used as the reinforcing material in polypropylene matrix. For making up of the sample various weight % of filler material and weight % of compatibilizing agent were used.

Filler loading %-10, 20, 30, 40

Compatibilizer %- 1, 3, 5

The test result were obtained at various test temperature and various crosshead speed and noted, without any compatibilizing agent tensile strength got decreased and brittleness on its contrary got increased .When a compatibilizing agent is not used the interfacial bonding between the fibers and the matrix tensile strength of the composite remains poor which causes less tensile strength.

Also IZOD test were performed on the composites, the notched and unnotched IZod test result were quite similar whether a compatibilizing material was used or was not used. In another study in 2007 Lei et al.<sup>17)</sup> prepared composite made by high density polyethylene, he used the process of melt blending and compression moulding for the composite and coupling agent type and there concentration effects were studied. Bagasse and pines fibers were used as reinforcement for the composite preparation. Compatibility agent used –MAPE (Maleated Polyethylene) CAPE (Carboxylated polyethylene) TDM (Titanium derived mixture)

All the agents improved the compatibility between the fibers and the matrix. Properties were increased but percentage maxima was reached at about 4.5 % for bagasse composite and for pine composite the maxima was about 2.4 %. While CAPE has very less effect on the mechanical properties .While TDM increases bagasse properties but decreases for pine one. Yao et al.<sup>18)</sup> in 2007 studied Composite panels prepared by using recycled and virgin High density polyethylene natural reinforced composite. In this study he used at least 5 types of natural fibers such as Rice husk, Rice straw Leaf, Rice Straw stem and whole rice straw along with rice fibers, wood fibers were also used. The main purpose of this study was to understand the effect of using different kind of fibers type on the mechanical and loading rate of HDPE crystallization behavior .A cumulative function distribution was analyzed between the length and aspect ratio of the various fibers used, on solving this function a lognormal distribution graph was obtained.When the loading was increased an increase value of moduli and decrease value of tensile and impact value strength was obtained .Comparison between recycled and virgin HDPE strength was done for the composite, recycled HDPE with natural reinforced composite shows much better result on comparison. Vidal et al.<sup>19)</sup> in 2008 went through a new study of understanding the environmental impact of the composite made from polypropylene and high density polyethylene along with rice husk and recycled cotton, life cycle assessment was done.

Final result shows a great reduction in environmental impact when compared to conventional virgin thermoplastics made. Favardo et al.<sup>20)</sup> in (2008) made composite from polyethylene (PE) with various concentration of rice husks .Rice husk was first prepared

by NaOH and then it was treated by acetyl 5 to 10 % , treated fibers was used in making of composite ,SEM process was done for the morphology analysis,Silvia used injection moulding technique for preparation of composite .Mercerization of fiber was done which removed natural fats ,waxes, lignins and hemicellulose as a result of this the reactive OH group gets reveals on the outer surface ,Hence it improves the acetylation process greatly .Positive result were obtained in this study,the final IZOD test of composite have 35 % more strength as compared to the virgin matrix. Kim et al.<sup>21)</sup> in 2008 studied mechanical Properties of polypropylene and natural fibers. He compared cotton fibers and wood fibers combination as reinforced in the composite .Maleic anhydride was used as a Compatibilizer to improve the hydrophilic and hydrophobic nature between the fiber and the composite. He also studies that with increase in the quantity of the cotton the strength got increased. This occur because of the property that cotton fibers get entangled with each other hence which gives a more compact reinforcement to the composite .But for wood fibers the result were opposite ,that is with increasing quantity strength got decreased.

Zouet al.<sup>22)</sup> in 2008 studied the use of long fibers of wheat straw length which was upto 10 cm and he used polypropylene for matrix to fabricate matrix, his purpose was to fabricate composite comparable to jute composite with same density. Idea was that if the properties are comparable to that of jute one can use wheat straw fibers for production of products similar to that of jute.Basta et al.<sup>23)</sup> studied the possibility in preparing high performance, agro based composite formed from rice straw using ecopoly alcohol polymers based system. He used “Corn Starch” as natural polymer with polyvinyl alcohol .Percentage of the additive combined ,Starch material used,bonding temperature and the time for it were optimized and controlled for better result outputs.The organic adhesive which was synthesised was compared with polymer based synthesis ,such as urea formaldehyde,Comparison was mainly done on the basis of bond strength ,Mechanical and physical properties.Results obtained were positive ,eco adhesive gave good bond strength but further research needs to be done in this domain. This study was complete organic in nature and comparison was made with polymer based , a good result can help in developing of complete biodegradable composite.In 2010 Rahman et al.<sup>24)</sup> worked on chemical treatment on rice husk composite reinforced with polyethylene Composite .Benzene diazonium salt was used in this research in three medium such as alkali medium, acidic medium and neutral medium along with variable percentage of rice husk .Final composed composite was compared with each other and observation were made on the effect of different medium on the rice husk.In same year Satapathy et al.<sup>25)</sup> worked on jute epoxy Composite

reinforced with SiC derived from rice husk through Plasma processing method, This new reinforcement lead to many new advantage in properties.

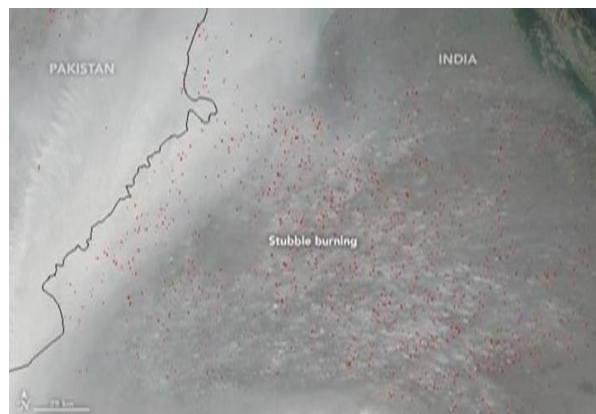
Also in the same year Reddy et al.<sup>26)</sup> focused his research on wheat straw clay composites, results obtained showed increase in flexural strength of the composites but weak for water absorption property. Clay formed composites showed less strength. Zaho et al.<sup>27)</sup> in 2011 treated rice straw with methyl methacrylate as a monomer in the admicellar polymerization for the fibers. This helps the fibers to have better compatibility with the matrix used in the composite. For the thermal analysis thermogravimetric analysis was done for thermal analysis of the polymer. In 2012 Liu et al.<sup>28)</sup> studied cornstarch biodegradable composite research work with Rice Straw.

These rice straw fibers were treated with NaOH for better compatibility this composite formed was completely environment friendly and made from biodegradable products such as adhesive of corn starch. With the increase in the starch the water absorption got increased and the density got decreased, further more research can be conducted on this topic. In the same year Montaña-Leyva et al.<sup>29)</sup> researched for the first of its kind biocomposite from wheat by products that is wheat gluten as well as wheat straw fibers. These by-products were made into composite by using Thermomechanical processes. Different sizes of wheat straw were made by grinding them into small sizes by milling process such as cut, impact and ball milling. Initially Rice husk was used for preparing and manufacturing of composite, Rice straw began to be matter of interest for researchers all over the world. In 2014 Khandanlou et al.<sup>30)</sup> made composite material from rice straw and polyprolactone, different loading of the fibers were taken XRD, SEM, Fourier Transform infrared Spectrography (FT-IR) thermogravimetric analysis and mechanical properties were calculated. EL Shazly et al.<sup>31)</sup> works on the effect of weathering on various properties of HDPE and Rice straw composite. Different weight loading such as (20, 35, 50 %) were examined, PE wax and UV stabilizer were added to analyse its effect. U.V Stabilizer has negative effect on polymeric properties of the composite formed. In 2017 Xu et al.<sup>32)</sup> developed a composite rice straw residue biocomposite, by using nano crystalline cellulose from rice straw and chitosan. Various physiochemical properties and evaluation of interfacial compatibility. Chitosan used in this research is an amino polysaccharide and is most abundant in nature Cellulose and chitosan form hydrogen bonding then without using any kind of chemical coupling agent or modification. This paper gives a further future gap for understanding the mechanism of electrostatic interaction and formed layer thickness for interfacial bonding by different kind of modifications in properties of the composites.

Zhang et al.<sup>33)</sup> in the year 2017 researched mainly on Mechanical and resistant properties of board made by composite from rice straw and soy protein adhesive as matrix. This board produced may act as an alternative to wood board and the effect of NaOH content and addition of soy protein isolates were studied and reported. Making an alternative to a wood board from this study would reduce a lot of stress on our wood fiber resource. Basta et al.<sup>34)</sup> studied about the bonding behaviour changes by dewaxing and deashing of Rice Straw fibers by eco urea formaldehyde. The deashing and dewashing were done by various means. The benefit of this project was done by calculating the strength and water resistance properties of the produced agro composites from the untreated ones. Result showed that the produced board strength has value as that of a board from resin bonded R.S particle. Low et al.<sup>35)</sup> in 2017 worked on the influence of crosslink chemicals on mechanical strength and also on water absorption of composite made by Rice straw based reinforcement. Cross link chemicals used were mainly Vinyltrimethoxysilane, dicumyl peroxide, dibutyl dilaurate. Review was given that by properly regulating the cross link chemicals one can develop biocomposite with some better mechanical properties. Xia et al.<sup>36)</sup> in 2018 worked on the residue left after producing biogas from rice straw. From this residue he prepared a composite. In anaerobic condition Rice straw gets fermented maximum within 10 days, during this fermentation the non-contents in the rice gets digested. Finally composites were prepared from rice straw as well as residue of the fermented rice straw. After evaluating the result it was seen that the biogas residue formed has much better tensile and flexural properties as compared to that of untreated rice straw. Jiang et al.<sup>37)</sup> in 2018 used modification of rice straw by in situ polymerization of ammonium polyphosphate (APP) polyelectrolyte. This modification helped grafting of ammonium polyphosphate into the rice straw surface. Composite were made from HDPE and modified rice straw and flame retardancy of the following composite made was compared. A char layer was formed on composite during flame test, This formed layer has more thermal stability hence it improved the retardancy test. Zandi et al.<sup>38)</sup> in 2019 worked on rice straw by chemically reacting and alkali pulping and benzylation reactions the inter and intramolecular hydrogen bonding got destroyed, also the cellulose part of the rice husk got separated from the lignin part. Two outputs were obtained such as benzylated pulp (BP) and pulping liquor (PL) rich in cellulose both were mixed with PLA (polylactic acid). The composite made were done for soil biodegradation test, on PLA sheets as well as PLA biocomposite, in final result degradation occurrence were seen in biocomposites. Wahyuni et al.<sup>39)</sup> prepared composites with polypropylene (PP) and rice straw as filler in it PP gives a great property in heat retention. The composite were made by melt mixing and

neat polypropylene and were put into various fractions. In this paper various research was mainly done on finding the effects of weight fraction, There sizes and pretreatment on their thermal conductivity. Composite made from fine particles gave lower thermal conductivity and much more of tensile strength as compared to that of coarse particles. Inayati et al.<sup>40)</sup> in 2019 used rice straw along with chitosan and plasticizer as additives to the bioplastic being researched Glycerol was being added to it as a plasticizer and with variation upto 25, 30, 35 %. Made composite were later experimented by water swelling, oil Swelling, UTM and FTIR were performed on the composite. In result it was found that more the glycerol was added more was the water swelling but less in the case of oil swelling test. Jamaludinand Bahari<sup>41)</sup> worked on rice straw and bagasse in preparation of binderless particleboard (BPB). Two ratio 50:50 and 40:60, MOE (Modulus of elasticity), MOR (Modulus of rupture), Internal Bonding, water absorption and thickness swelling properties were determined and compared. Bagasse alone gave better values of the tested result and rice straw gave the minimum value of MOR, MOE and IB values. In this research it was also found that if rice was kept more than 3 months then it becomes brittle hence its properties were changed so it must be used in fresh form. Wang et al.<sup>42)</sup> fabricated Nano TiO<sub>2</sub> modified foamed wheat straw, he used hot extrusion method for the fabrication of composite. The size, crystallinity and composite were analysed through laser particle size analyser. The main purpose of TiO<sub>2</sub> was to improve the U.V shielding and the mechanical strength of the composites. Bhattacharjee et al.<sup>43)</sup> in 2020 made a bio composite by using melt extrusion method. In study rice straw in the form of rice straw flour with poly butylene succinate was used, dicumyl peroxide was used as a cross linking agent in the formation of the composite. Various properties of the made composite was tested such as morphological, thermal, mechanical and rheological behaviour were calculated and results were given. Raj et al. in 2019<sup>44)</sup> explored the performance of rice straw poly propylene composites for vibration isolation, Fibers sizes was controlled and vibration damping was measured best damping factor of 370. Composite with 600 micrometer fiber size was obtained, This research was much different from others as it allows the use of green composites into various industrial purposes where vibration is a problem. Pandey Arunabh and Kumar Brind<sup>45)</sup> in 2020, IIT BHU studied the potential use of rice husk ash and microsilica in rigid pavements. Various combinations were studied, positive results were seen in the strength of the concrete rice straw husk increased the strength upto 7% and microsilica increased the strength upto 24 %. Also this amalgamation increased the protection of the following concrete against water absorption, chloride ion, acid attack and ACC accelerated carbon curing. This study is breakthrough for increasing many properties of the

composites. Bhuvaneshwari et al.<sup>46)</sup> in 2018, Studied a review on crop residue burning in India, its policy changes and potential solution. They gave a full-fledged data about the quantity of rice husk produced. A complete stats about how much the rice is burned and smoke is produced. Which gases are produced and what effect does it causes.



**Fig. 7** Stubble burning in Punjab India Nov 6, 2015<sup>47)</sup>

kaur<sup>48)</sup> Punjab Agriculture university Ludhiana (2017) gave an extensive review about the crop residue generated particularly in Punjab agriculture. He studied the burning activities and all other methods to reduce it. In Hyderabad a study was conducted the burning of a tonne of straw releases 3 kg particulate matter, 60 kg carbon monoxide, 1460 kg carbon dioxide, 199kg ash and 2 kg sulphur oxide in the air, also this burning causes major losses in nutrients in the soil by killing many bacteria and other micro level organisms. Lila et al.<sup>49)</sup> (2018) Studied the effects of recycling done on composite made by using bagasse fibers with polypropylene as matrix. Recycling was done many times and further studies were conducted in order to check various properties such as tensile, crystallinity, aspect ratio etc. This study gave good understanding about recycling property of the formed composite as a result it was concluded that the recycled polymer material preserves the characteristics without any further addition of a virgin polymer. Smaradhana Feby Dharu et al. studied about a progress on nano cellulose as binders for natural fibers. Can be obtained by two ways as described in the paper firstly using nano fibrillated cellulose and other by synthesizing from bacterial cellulose. The final cellulose obtained can be used to make coated fibers or reinforcements for the preparation of nano composite. This nanocellulose product is developed to be binder for the natural fibers used, it increases the mechanical properties of the composites<sup>45-50)</sup>. Raharjo p Wahyu et al performed a research to study and understand the overall improvement of zallaca fibers when they are treated through NaHCO<sub>3</sub>, 10 % NaHCO<sub>3</sub> was used for treatment of fibers, and a time range of 24, 120, 240 hrs were taken. Analysis of the Fiber content and FTIR showed an



increment in the quantity of cellulose while a decrement in the quantity of hemicellulose and lignin content. An increment in the crystals was observed by performing XRD analysis. Final results showed that 120 hrs of treatment gave the best results for the tensile strength and elastic modulus<sup>50-58</sup>).

Mahyudin Alimin et al studied the effect of percentage on mechanical properties and the biodegradability of the composite prepared by using polypropylene along with the addition of banana and taro starches. For the preparation of the composite hand layup method was used and the fiber was added in various percentages. The strength strain and the modulus of elasticity were compared between the manufactured composites. The result showed that 3% of the fiber addition gave the best result for the mechanical properties calculated. SEM was also performed to understand the voids and cavities distribution in the sample<sup>59-64</sup>. Siasati Harini et al mixed natural fiber kenaf with glass reinforced with polypropylene and made a hybrid composite with different fiber loading. Fiber content effects were calculated on the tensile properties. It was observed that inhomogeneous distribution of the added fiber resulted in formation of voids and due to which end results of the formed composites were hampered and less tensile properties were seen<sup>65-69</sup>).

Kabir Sarower et al understood the effect of a heat resistance coating on the drilled hole for a hybrid fiber reinforced polymer. In the study it was made by glass, carbon fibers and epoxy. Vacuum infusion process was used for the preparation of the composite. Drilling performance was tested on the coated and non-coated composite manufactured. The results were positive and less delamination was observed in the coated composite was observed<sup>70-75</sup>).

### Challenges

After reviewing through many papers the main challenges are as follows:

- Absence of good interfacial bonding between the rice straw (natural polymer) and the composite matrix used, this is because of the water absorbing nature of natural fibers. Hence this decreases its potential to be a reinforcement.
- Natural fibers are mainly hydrophilic in their nature, while all matrix thermoplastics are mainly hydrophobic in nature hence a proper chemical treatment has to be done in order to make both of them compatible.
- Variable quality of the reinforcement used also hampers the quality of the composites formed.
- Limited mechanical properties obtained from use of natural fibers is also a disadvantage, research is still being done in order to increase them.
- Water absorption after the formation of the composite is still a problem, for this the fibers are treated with chemicals.

- Low thermal stability of the composites formed by using natural fibers.

### Conclusions

- Rice straw being from the family of fibers which are from non-wood category, using them as a reinforcement in composite one can easily decrease the use of petroleum and wood fibers and reduce stress on our non-renewable resources.
- They are similar to the wood fibers in terms of chemical and physical nature. But using rice straw as a natural is not easy because of the water absorption capacity of these fibers, hence they need chemical treatment for modification to improve on this problem. These chemicals are termed as compatibility agent such as silane, NaOH. These chemical treatments increase the amount of cellulose exposed for better mechanical interlocking.
- There is a huge chance of using natural fibers in the future for various purposes such as using them as vibration damper, sound absorption, thermal reflector etc. A lot of startups are also being run and creating wealth out of waste.
- Hence proper use of rice straw can help in increasing the income of our rural India by using waste material and producing something worth from it. But for this a further research is needed to improve the mechanical and morphological properties of the green composite prepared.

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