A review of recent research on groundnut shell and saw dust composite materials and structures for industrial Applications

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Abstract

Utilization of naturally generated wastes has tremendous importance towards sustainability. Recently, the critical discussion about investigation for superior properties of engineering products that produced from those natural wastes has led to the renewed focus worldwide, concerning renewable and environmental issues. Meticulous studies have been conducted on the natural waste fillers by both academicians and industrial researchers. There are various types of reinforcements used in the development of bio-composites. Amongst the various types of natural resources, groundnut shell and saw dust have been considerably utilized over the past few years. Theseare unwanted materials that otherwise cause lots of environmental pollutions. However, by utilizing theseas reinforcement materials with different polymers potentially can reduce environmental pollution. Therefore, this review study raises an overview with a specific focus on the improvements made in the scope of groundnut shell and saw dust based reinforced polymer composites in various types of polymer matrices (i.e. thermoplastic, thermoset and natural rubber). An overview of various composite materials reinforced with these bio wastes reported in the literature over the last 20 years is presented in this paper. For the benefit of the readers and researchers, general information regarding structure and function of composites, and various other materials used, are also briefly presented. Different types of bio-composites that are already in use or are investigated for various applications are presented. Specific advantages of using these bio-composites in selected applications are also highlighted. The paper also examines the critical issues and scientific challenges that require further research and development of green composite materials for their increased acceptance in industry.

Keywords
Composite materials, Groundnut shell, Saw dust, Reinforcement and Engineering Applications.

1. Introduction
In recent times, the world's modern industries have demanded materials with criticalfabric properties that conventional materials like ceramics, metals, and polymeric materials cannot meet. This is the major factor that has material scientists and engineers interested in composite materials. Over the past few decades, numerous reinforcing agents have been used to create polymer matrix composites (fibers and particles; Jose et al. 2021; Jose et al 2017) and(Athijayamani et al. 2016). In polymer matrix composites, reinforcing agents can be either natural or synthetic

materials. However, plastic materials can be replaced and used less frequently if reinforcing materials like fibers and particles made from plants, vegetables, fruits, and seeds are used instead. Recent years have seen asextension in the usage of polymer composites reinforced with natural fibers or particles in a variety of technical applications, including automotive, structural, cosmetic, and household goods (Babuet al. 2014; Jose et al. 2021) and (Kiniet al. 2018).
In recent years, biodegradable materials have increasingly been used as reinforcement in polymer composites as fibers, particles, and laminates. Natural fibers outperform synthetic fibers as reinforcement in composite materials due to their numerous technical and ecological advantages. Natural fibers have a number of benefits, including affordability, accessibility, usability, biodegradability, and environmental friendliness, which have piqued the interest of researchers from both the academic and industrial sectors to examine whether they are practical for use as reinforcement and whether they meet the criteria for a good reinforcement in polymer composites for various applications (Jacob et al. 2018).

Groundnut shell is a byproduct created when groundnut seed is removed from its pod, and there hasn't been much interest in using groundnut shell for humankind's advantage (Usman and Momohjimoh 2016).Due to its abundant availability in Northern Nigeria and low interest in other industrial sectors, groundnut shell is a valuable component in the production of composites.To enhance the interaction between the fiber matrix and the thermo-mechanical characteristics of the resulting composite, it was treated with sodium hydroxide.

Due to the rising demand for environmentally friendly materials and the goal to lower the price of conventional fibers like carbon, glass, and aramid reinforced polymer-based composites, new bio-based composites have been created. Natural fiber composites, also known as bio composites, which are made of natural or synthetic resins and reinforced with natural fibers, have attracted the interest of researchers. The primary benefits of natural fibers over conventional reinforcing materials, which also contribute to the rapid rise of the manufacture of natural fiber-polymer composites, are their renewable nature, reduced wear on processing machinery, and low cost. Additionally, they have a low density, producing composites with excellent specific characteristics that are quite lightweight. According to reports, India's agricultural sector alone produced nearly 600 MT of garbage (Patnaik et al. 2022).

Sugarcane bagasse, paddy, wheat straw and husk, waste from food production, tea, oil extraction, jute fiber, groundnut shell, timber mill waste, coconut husk, cotton stalk, and other agricultural wastes are among the primary quantities produced (Sengupta 2002) and (Bledzkiand Gassan1999). Recent developments in the utilization of natural fibers like flax, cellulose, jute, hemp, straw, sisal, kenaf, and bamboo in composites have been studied by a number of authors (Mishra et al. 2002) and (Patnaik et al. 2022).

Since 1908, when paper or cotton were utilized as reinforcement in phenol resins to make sheets in large quantities, natural fibers have been used instead. In the early 19th century, hemp was the most important crop grown for its fibers, but as synthetic fibers became more popular, hemp's use began to wane.Natural fibers frequently exhibit significant non-uniformity in the majority of properties, including chemical composition.

In industries including the automotive and building industries, natural cellulose fiber is currently being investigated because it has the potential to be an alluring substitute for synthetic fiber. These fibers are also a plentiful source and offer excellent application. Natural fibers are superior to synthetic fibers because they are renewable, inexpensive, biodegradable, and simple to chemically modify (Gibson 2010).

The term "hybrid composite" refers to a composite that has two or more reinforcements added to the matrix. The use of reinforcement materials improved the composite's mechanical properties, such as hardness and tensile strength.

1.1 Objectives

This study is designed to provide a concise overview in the area of saw dust and groundnut shell composites research and development and the scientific theory behind these composites.
This review also intended to identify gaps in the existing studies for potential future research.

2. Literature Review

2.1Composite Structure: Ground Nut shell and Sawdust reinforced composites

Because of the complexity of the structures, the selection of the fabrication materials, as well as the fabrication process itself, which is crucial to achieving the desired functional capabilities while maintaining the predetermined structural functions, makes designing and fabricating multifunctional composite materials a challenging task. (Li et al. 2020) A composite structure that is suited for a variety of applications may be created by combining ground nut shell with sawdust in a multifunctional material. The usage of ground nut shell in creating diverse composite constructions is therefore remarkable.

In Table 1 shows how many composite structures could have already been developed by using ground nut shell.

Table 1. Illustrates the summery of various uses of ground nut shell composite materials.

Composite structure	Investigator name
Recycled High-Density Polyethylene Filled with Groundnut Shell Powder	1. (Jacob et al. 2019) 2. (Jacob et al. 2018) 3. (Usman et.al 2016)
Groundnut shell particle reinforced epoxy	1. (Raju and Kumarappa 2011)
Natural Hybrid Filler reinforced epoxy polymer	1. (Aenuguet al. 2011) 2. (Mausam et al.2021)
Natural rubber filled with groundnut shells, both treated and untreated	1. (Gumel et al. 2014)
Polymer Metal Matrix reinforced with Groundnut Shell	1. (Dwivedi et al. 2020) 2. (Naidu et al. 2013) 3. (Venkatesh et al.2019)
Epoxy Reinforced with Tamarind and Groundnut Shell Particles	1. (Goudar and Shetty 2017)
Epoxy Polymer Hybrid reinforced with Luffa Fiber and Ground nut	1. (Panneerdhass et al. 2014) 2. (Panneerdhass et al. 2016)
Epoxy Hybrid with reinforcements of Raffia Palm Fibre/Groundnut Shell	1. (Nyior et al. 2018)
Roofing Sheet Material utilizing particles of Groundnut Shell and Epoxy Resin	1. (Sarker and Islam 2018)
Lightweight Metakaolin-based Geopolymer Development Employing Groundnut Shell Powder	1.(Nemaleu et al. 2020)
Jute–Epoxy Hybrid employing the application of Groundnut Shell Particulate	1. (Patnaik et al. 2022)
Polyester reinforced by discarded Ground nut shell	1. (Prabhakar and Song 2015)

However, Bio waste like ground nut shell has a great impact on developing polymer matrix composites. Sawdust is another adaptable, affordable, and easily accessible bio-waste that can provide yield convenient materials for sustainable remediation solutions. (Mallakpour et al. 2021)

Table 2. shows how many composite structures could have already been developed by using sawdust

Composite structure	Investigator name
Sawdust and recycled plastics	1. (Najafi et al.2006) 2. (Najafi et al. 2007)
Polypropylene—sawdust	1. (Suarez et al. 2003)

Wood sawdust and gypsum	1. (Dai et al. 2015)
Polypropylene and sawdust	1. (Sombatsompop et al. 2005)
Poly vinyl chloride (PVC) and sawdust	1. (Sombatsompop et al. 2003)
Sawdust, steel dust, graphite silicon carbide and epoxy resin	1. (Lawal et al. 2017)
Sawdust and polyurethane foam	1. (Atuanya and Obele 2016) 2. (Tiuc et al. 2019)

From Table 2 is clear that bio-waste like sawdust nowadays is used for high-performance composites fabrication. However, ground nut shell &sawdust can also be a good bio waste material to develop a matrix polymer-based composite. Both of these materials can be used together in a matrix to develop ahigh-performance bio based composite structure which convert both of these natural cheap and abundance waste materials into different special bio based composite structures.

2.2 Applications

2.2.1 Groundnut Shell

The current study has emphasized the merits of employing ground nut husk powder as a filler for polypropylene, and the findings indicate that this filler may considerably expand the range of applications for polypropylene with powdered ground nut husk incorporated as filler (Onuegbu et al. 2013). Alternative materials for use in car interior panels, such as boot liners, side and door panels, rear storage shelves, and roof covers, can be produced utilizing Raffia Palm Fiber/Groundnut Shell Reinforced Epoxy Hybrid Composites (Nyior et al. 2018).

The high impact strength of groundnut shell and rice husk reinforced epoxy composites is a crucial quality in bumper design. A sample of EGSC containing 12.5% groundnut shell was created and utilized to make the back bumper for Bajaj tricycles (Olaitan et al. 2022).

End products for non-structural applications in building started to show up. Groundnut shell have been used in the creation of a lightweight geopolymer composite based on metakaolin. (Nemaleu et al. 2022).

Ground nutshell reinforced polyester composites made from bio waste may be utilized to make sporting goods, technological packaging, and interior car parts (Probhakar& Song 2015).

2.2.2 Sawdust composite

A significant amount of sawdust and wood shavings goes into the production of Particleboard in the United States of America. Between 2000 and 2017, the production of timber-based panels, such as plywood, oriented strand boards (OSBs), and particleboard, rose by 125% globally.

Sound-absorbing materials are made from a mixture of sawdust and polyurethane foam(Tiuc et al. 2019). Lightweight Sawdust Concrete is made from waste materials like sawdust. Wood aggregate, such as sawdust, could be aviable substitute component for the creation of lightweight concrete and warmcover building composites due to its low density andhigh thermal insulation. Sawdust is fruitfully employed to create normal weight and lightweight concrete with specialized fracture qualities that are both environmentally friendly and thermally efficient (Ahmed et al. 2018)It was found that a combined design of coarse aggregate, sand, and cement, with varying doses of sawdust as a partial substitute for sand created typical, lightweight concrete that was both ecologically sound and efficient in terms of thermal energy usage.To create sawdust/recycled polyethylene composite board, sawdust and recycled polyethylene (RLDPE) were combined and then heat pressed(Atuanyaet al. 2016).

3. Conclusions

Researchers are focusing their attention on the prospect of using natural bio waste particles as reinforcement to enhance the characteristics of polymer matrix composites owing to the availability of biowaste materials, their lightweight, affordable, and simplicity of refining.In polymer composites, the inclusion of biowaste material as reinforcing agents improves all of the composites' qualities. For the purpose of enhancing the physical, mechanical,

chemical, and thermal characteristics of composites, these biological waste materials were also employed as fillers with natural or manmade fiber reinforced polymer composites.In addition to offering a report on the research and development undertaken to enhance the attributes of bio waste particle reinforced polymer composites, this study also examines how these composites are used in varying engineering and technological domains.Mostly Groundnut shell and saw dust are used separately in composite making but they did not applied jointly. Based on literature reviewed a new bio composite can be developed with these wastes together as reinforcement and mechanical, electrical, thermal properties can be found for future applications.

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