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A review paper on investigation of mechanical and wear properties of polymer composites subjected to environmental degradation

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A R T I C L E I N F O

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A B S T R A C T

Polymer composites have received a lot of attention in a number of industries due to their exceptional mechanical properties and light weight. The goal of the review is to provide detailed information on the erosive behaviour of polymeric composites. The effect of test variables on the erosion wear rate and associated failure causes, such as impact velocity, erodent characteristics, and impingement angle, is the main point of interest. Researchers were interested in polymeric composites because of their erosion resistance, which was improved by the inclusion of different fillers. This essay analyses how damage behaviour is affected by polymer damage processes and relative humidity. More focus is placed on the deterioration of mechanical properties like tensile strength and bending strength as well as the deterioration of wear characteristics like erosion wear rate.

1. Introduction

Researchers from all around the world concentrate on creating novel composite materials, which are formed of natural fibres and environmentally beneficial trash. For a variety of uses, including packaging, outdoor applications, automotive, etc., these composites can take the place of the most widely used synthetic fibres. Natural fibre materials are better suited since they are more readily available, environmentally friendly, and less expensive, have a higher specific strength, and are less dense than synthetic fibres that are not biodegradable. In comparison to synthetic fibre [1] in many industries, the use of bio fibre in composite materials reduces the weight of the material by 10 %, the cost of manufacture by 5 %, and the energy used for making that material by 80 %. Depending on the surrounding environment, the composite materials either entirely release or absorb moisture [2,3]. The presence of hydroxyl groups in the natural fibre, which form hydrogen bonds with water molecules inside the fibre cell, is the only factor contributing to the moisture absorption in the bio-fibre composites [4,5]. By including rice husk particle as reinforcement, polymer matrix composites' moisture absorption behavior was improved [6]. Due to increased voids and celluloses, the moisture content percentage rises as filler loading increases [7]. Additionally, they stated that the interfacial connection between the reinforcement and matrix weakens as a result of moisture absorption, which affects the mechanical properties. The automobile industry is becoming increasingly interested in using natural fibre instead of fiberglass as a reinforcing component in thermoplastic composites. The low mechanical qualities of natural fibres caused by environmental degradation are one of the main obstacles to employing them in the manufacture of vehicle parts [9]. When exposed to temperature, humidity, and ultraviolet (UV) radiation, natural fibre reinforced composites perform less well due to environmental degradation. When exposed to harsh weather conditions, polymer composites utilized in the automotive industry are typically impacted by photochemical reaction [10]. Due to the presence of cellulosic fibres embedded in lignin and pectin matrix, natural fibres can be regarded as natural composites. Due to its arrangement along the fibre length, cellulose gives the matrix its stiffness and high tensile and flexural strengths. A study on the environmental degradability of sisal-based self-reinforced composite was conducted [11]. NaOH was used as a pre-treatment for 1.5 h on the sisal fibres extracted with benzene-ethanol. After that, the fibres were put into a container with benzyl chloride. A benzylated sisal fibre was produced by conducting the benzylation reaction at 115° C, followed by oven drying the material. Hot press molding was used to create the self-reinforced sisal composite, and the resulting samples were submerged in water for a set amount of time. The findings revealed a 15 % decrease in impact strength, flexural strength, and modulus. Investigations were done on how the composites' fibre content affected how quickly they aged in the environment. Based on its good mechanical characteristics, accessibility, thermal stability with PET fibre, and resistance to heat degradation, kenaf fibre was chosen. Several factors, including

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temperature (thermal degradation), air (oxidative degradation), moisture (hydrolytic degradation), microorganisms (biodegradation), light (photo degradation), high-energy radiation (UV, irradiation), chemical agents (corrosion), and mechanical stress, can cause polymeric materials to degrade in the environment. These factors can also occur individually or in combination [12]. These elements cause the material to undergo irreversible modifications, which typically take place in two phases. Disintegration first involves deterioration of the material's external characteristics (such as colour change), physical and morphological characteristics (such as mass change, crystallinity), or mechanical characteristics (such as embrittlement, fragmentation), before the material eventually completely decomposes into water, carbon dioxide, and other straightforward inorganic compounds (mineralization). The aforementioned causes influence all materials to varying degrees, but what separates environmentally degradable materials from non-degradable ones is how quickly the processes take place. Composites can be made from a variety of multi-component materials. Because they blend material features in interesting ways, composites are fascinating. Composite materials are created when two or more elements come together. In many instances, a rigid, strong, or structural component is immersed in softer, more compliant constituents to form the matrix or continuous phase. A material comprising at least one polymer component is referred to as a polymer composite. Bio fibres, also known as natural fibres, are made of cellulose, hemicellulose, cellulose, sugar, starch, lignin, moisture, oils, and proteins. The push towards bio-based polymers and materials is being driven by benefits to the environment and the economy. Plant-based fibres include seed, bast, fruit, stem, and leaf. The composite can be reinforced with oil, wheat, jute, kenaf, wood, flax, bananas (also known as musa), and other bio fibres. Composites made from plants are more environmentally friendly, light, corrosion-resistant, inexpensive, low density, suitable, high modulus, and biodegradable. Because they are inexpensive and simple to work with, "unsaturated polyester resins" (UPRs) are commonly used as thermoset polymers in composite construction. Glycol and condensed unsaturated dibasic acid are the main components of UPRs. UPRs have been used in construction materials, water tanks, packaging, and automobiles. UPR's thermal and mechanical properties are improved by the addition of inorganic additives [13–15]. Their effectiveness is correlated with the interfacial adhesion between the polymer matrix and the reinforcing material, which is often impacted by a relative incompatibility between the organic and inorganic phases [16]. Temperature, humidity, fluctuating loads, and their combinations can cause polymers to degrade in the environment [17,18]. The majority of polymer composites contain moisture, and the water molecules can act as a plasticizer. Nano clay is one of the most often researched and utilized nanoparticles in polymer Nano composites. Nano clay has been popular among nanoparticles due to its ease of use, benefits for the environment, and accurate chemistry [19]. Superior modulus, cheap cost, low density, and a higher surface area are all characteristics of nano clay. This appears to be crucial for broadening the scope of uses for these Nano composites, particularly in the automotive, marine, building, and home industries. The purpose of this research is to determine whether adding no clay may lessen the effects of water deterioration induced by water uptake and whether drying the water-soaked specimens again can restore the properties of polymer composites. Abhilash Purohit [70] et al in their paper discuses effect of fiber/filler influencing erosion rate also compressive strength is quite different than tensile strength. A Satapathy [71] et al in their paper discusses that by the use of filler content specific wear rate of epoxy-LD sludge based composites is affected. Priyadarshi Tapas [72]et al in their paper found out that during production of steel LD Sludge gets generated which can be used as a filler in polymer matrix composites.it was then observed that if fiber content is increased mechanical property is also increased. Later by Taguchi experiment wear rate of composite is affected by means of adding fiber content. Abhilash Purohit [73]et al in their paper discuses that composite is made up of wood apple dust and epoxy was developed. It was observed that wear rate is affected by four control factors which are normal load, sliding distance, WAD content and sliding velocity. Pabina Kumar Patnaik [74] et al discusses needle punch non-woven viscose fabric reinforced epoxy fabric prepared at constant fabric loading at 30 wt%. Mechanical properties and abrasive wear resistance has been improved under steady state condition. In experimental design through taguchi shows that sliding velocity and silica sand size are the key factors for wear rate.Fig. 1.Fig. 5.1.Fig. 5.2. Table 1.

2. Polymer behavior

Prajapati Naik et al [19] in their paper discusses as natural fibre is hydrophilic, its behaviour is dependent on several environmental factors. In different environmental conditions, such as saline water treatment, steam treatment, and sub-zero temperature, the effects of moisture absorption on the mechanical properties of bio-waste (orange peel) reinforced epoxy composites with different weight percentages (10 %, 20 %, and 30 %), were observed. The studies were conducted by submerging the specimens in the previously mentioned environmental conditions after they had reached saturation. As the filler loadings increase, so does the percentage of moisture content in the produced composite. According to ASTM standards, the mechanical characteristics of composites that have been exposed to the environment were evaluated, and the results were compared to the characteristics of the composite under normal environmental conditions. By using a scanning electron microscope, the fractured surface of the test samples and the morphology of orange peel particles were examined. Analyses using energy-dispersive spectroscopy (EDX) and X-ray diffraction were also used to characterize orange peel particles.

Mohamad Zaki Abdullah et al [20] depicts that due to their excellent mechanical qualities and resistance to photo degradation, kenaf and PET fibres were chosen as reinforcements. Through compression moulding, the test samples were created. In an accelerated weathering laboratory, the samples were subjected to moisture, water spray, and UV radiation penetration for 672 h. The hybrid composite's tensile strength reduced from 73.8 to 72.5 MPa while the long fibre POM/kenaf (80/20) composite's dropped by only 2 % from 127.8 to 64.8 MPa. This shows that the hybrid composite outperformed the POM/kenaf composite in terms of tensile strength resistance. Similar findings were made for the flexural and impact strengths, which showed that the hybrid composite degraded less than the kenaf fibre composite. The investigation's findings showed that the hybrid composite may be acceptable for outdoor use in the automotive industry since it retained its mechanical qualities better than kenaf fibre composites.

Srinivasarao D [21] in their paper found out modern materials which are frequently utilised combine outstanding mechanical qualities with low density to produce polymer composites, which have a high tensile strength-to-weight ratio. However, materials intended for outdoor usage are adversely affected by environmental variables and lose characteristics to varying degrees. Natural fillers (particulates or fibres) or components, in particular, cause the normally bio-inert matrix of common commodity plastics to become biodegradable.

Achutha Kini [22] in his research article examines how the mechanical and wear characteristics of nonclay-polyester Nano composites (NPNCs) are affected by water soaking and re-drying. The mechanical characteristics of NPNCs are greatly improved by the addition of nonclay in the as-made, water-soaked, and re-dried conditions. Additionally, the percentage of reduced mechanical characteristics under water-soaking conditions was reduced by the inclusion of nonclay. In terms of mechanical property values, re-drying recovers more than 90 % of the original values. However, the mass loss (wear test) of specimens is decreased in all three situations when nonclay is added. Re-dried specimens lose more bulk than as-made specimens while losing less mass than water-soaked specimens. SEM images show how the swelling and plasticization caused by the absorbed water can change the fracture and worn-out surface.

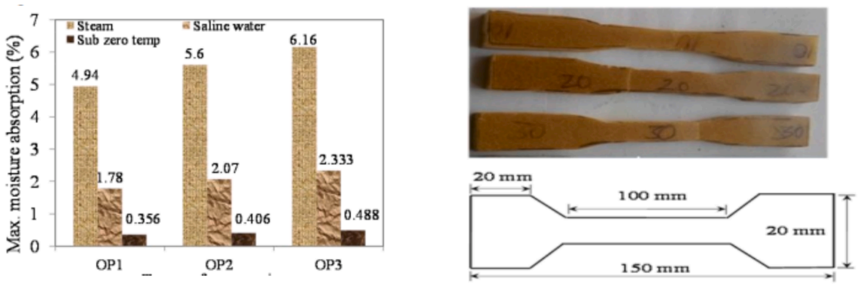

Fig. 1. (a) Tensile test sample; (b) types of composites.

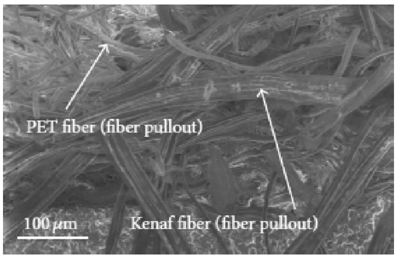

Fig. 5.1. Weathered samples of the hybrid composite.

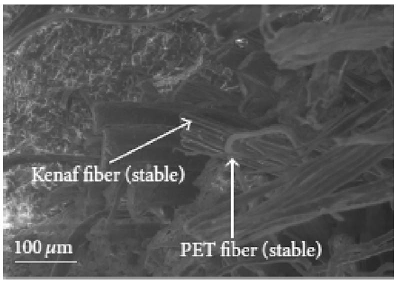

Fig. 5.2. Controlled samples of the hybrid composite.

Table 1
Edx analysis of opp.

EDX analysis of OPP		
Environmental conditions	% C	% O
Normal sample	73.91	17.56
Saline water	55.80	24.81
Steam Water	50.37	48.25
Sub-zero Temp	52.85	44.93

Shubhendu Prashant singh [23] The current work intends to investigate how temperature, alkalinity, and loading rate affect the mechanical properties of glass fibre/epoxy composites. Experimental materials included glass fibre reinforced polymer (GFRP) with simple epoxy and GFRP with a 1–2 % nonclay variant. Flexural testing of the specimen was carried out using GFRP and epoxy with the recommended percentage of nonclay, and pre-stretching of GFRP using plain epoxy and GFRP with the recommended percentage of nonclay was then carried out. It was investigated how temperature, alkali, and moisture together affect how glass fibre reinforced polymers degrade in various settings. The behaviour of the GFRP composite specimen, pure epoxy, and nonclay reinforced epoxy exposed to various hydrothermal loads has also been studied on a macroscopic and microscopic level. The behaviour of GFRP composites at the microscopic level was investigated using a scanning electron microscope (SEM). Additionally, an X-ray diffraction examination of epoxy with additions of 1 %, 2 %, and 3 % nonclay was carried out. Additionally investigated were specimens tested under tensile and flexural loads at various orientations, including 0°, 30°, 45°, 60°, and 90°. Prior to hygrothermal loading, maximum average flexural strengths of 2 % nonclay/glass fibre reinforced polymer and plain glass fibre reinforced polymer were observed at 0° orientation to be 295.04 MPa and 481.69 MPa, respectively. Prior to hygrothermal temperatures, the maximum flexural strength of plain glass fibre reinforced polymer at 46.7 MPa and 2 % nonclay/glass fibre reinforced polymer at 147.52 MPa were both observed at 20 % and 50 % loading circumstances. In a NaCl environment, the 2 % nonclay/glass fibre reinforced polymer showed the greatest tensile strength decrease (384.78 MPa at 50 % loading). In comparison to mixing 0 % and 2 %, adding 1 % of nonclay to pure epoxy resulted in lower tensile strength. Tensile strength is lower for specimens containing 2 % nonclay in pure epoxy as compared to 0 % and 1 % mixing. Moisture and mechanical pressure on the glass composites modified their tensile strength. When exposed for shorter periods of time, glass fibre reinforced polymer Nano composite showed less degradation and a considerable increase in tensile strength; however, when exposed for longer periods of time (3000 hr), tensile strength dramatically decreased. SEM study of a glass fibre reinforced polymer Nano composite at pre-stretching of 20 % and 50 % loading was carried out after degradation in four different conditions (four tanks) for 30 days at a time. SEM analysis clearly showed that at 50 % loading, there is significant damage to the glass fibre reinforced polymer Nano composite and the formation of voids of epoxy. At 20 % loading, there is less damage to the glass fibre reinforced polymer Nano composite with the formation of small irregular lumps.

In the realm of research, studies into environmental factors and their influence on the characteristics of renewable materials are gaining substantial traction, particularly for natural fibres and the composites made from them. The hydrophilic character of natural fibres makes them susceptible to water absorption, which has an impact on the overall mechanical properties of natural fibre-reinforced composites (NFRCs). Additionally, NFRCs are mostly based on thermoplastic and thermosetting matrices, which can be employed as lightweight materials in automotive and aerospace components. Therefore, these components must be able to withstand the highest temperatures and humidity levels seen in various parts of the world. This research critically explores the effects of environmental variables on the impact performance of NFRCs based on the aforementioned elements and through a current review. In addition, by emphasising moisture ingress and relative humidity in the impact damage behaviour of NFRCs, this research critically evaluates the damage mechanisms of NFRCs and their hybrids. Keywords: impact performance; environmental factors; moisture content; damage mechanisms; natural fibre reinforced composites (NFRCs); hybrids.

3. Characteristics

Dilbag Singh Mondloe [24] in his review paper discusses that natural fibres are versatile components that can take the place of composite materials made with glass fibre. Natural fibres are reinforced into a matrix to create natural fibre-based hybrid composites because of their many advantages, such as low cost, light weight, high strength, and low wear rate. Bio composites have good mechanical qualities, such as being non-abrasive and bio-degradable, in addition to being environmentally benign. In order to determine whether using a hybrid banana-coir-epoxy composite is feasible for tribological purposes, the current study looks at this. In the current study, a hybrid composite made of banana and coir was created by manually combining bio fibres and epoxy resin. Epoxy resin has been employed for binding purposes, and sodium hydroxide (NaOH) alkali treatment is applied for better adhesion. In order to characterize banana coir epoxy-based hybrid composites' tensile strength properties and particular wear rate, pin on disc equipment is used. The test technique and necessary calibration were carried out in accordance with ASTM standards. The best banana-coir epoxy hybrid composite for tribological purposes is determined by this study. The findings show that BBBB (0 % coir, 40 % banana, and 60 % epoxy) has the maximum mechanical strength whereas BBCC (20 % coir, 20 % banana, and 60 % epoxy) offers the lowest specific wear rate.

Muneer Ahmed Musthaq [25] in his review paper studies into environmental factors and their influence on the characteristics of renewable materials are gaining substantial traction, particularly for natural fibres and the composites made from them. The hydrophilic character of natural fibres makes them susceptible to water absorption, which has an impact on the overall mechanical properties of natural fibre-reinforced composites (NFRCs). Additionally, NFRCs are mostly based on thermoplastic and thermosetting matrices, which can be employed as lightweight materials in automotive and aerospace components. Therefore, these components must be able to withstand the highest temperatures and humidity levels seen in various parts of the world. using the aforementioned elements.

Mahavir Choudhary et al [26] examines the impact of barium sulphate content on the fixed glass fibre reinforced epoxy composites' physical, mechanical, dynamic mechanical, and erosion wear qualities. By using the vacuum assisted resin transfer moulding (VARTM) process under regulated pressure conditions, composites containing 0 to 30 wt% barium sulphate were created. The physical, mechanical, dynamic mechanical, and erosion wear parameters of the produced composites were assessed using computational and experimental analyses. Physical characteristics included density, void content, and hardness. Mechanical characteristics included tensile, flexural, and inter-laminar shear strengths. The density, void content, hardness, interlaminar shear strength, and fracture toughness of the composites increase with increased barium sulphate content, according to experimental results, while tensile and flexural properties decrease above 10 wt% barium sulphate content. The semi-ductile character of the composites is demonstrated by the erosion findings, which showed that the maximum wear rate was obtained between the ranges of 45° and 75° impingement angle. In order to validate the numerical results by comparing the acquired experimental results for validation, computational fluid dynamic (CFD simulation by ANSYS Fluent) analysis was also applied to compute the erosive wear rate, erosion scar, and then monitor the particle paths. The erosion efficiency of the suggested particle loaded composites was then estimated as a function of impact velocity, and eroded samples were examined under a scanning electron microscope to see how the composites wear.

Ganesh R [28] in his review paper mentioned that research has focused on combining natural fibre reinforcement with composites and adding fillers to improve the thermal and mechanical thermal behaviour of composites. These biopolymers with natural fibre reinforcement serve as partially eco-friendly products. It increases the requirement for hybrid composite material design databases. In the current work, hybrid composite laminates with basalt and jute fibre reinforcements were created utilising the hand layup technique, along with 5 %, 10 %, and no silicon carbide. Along with five stacks of alternative fibre layers and five stacks of basalt and jute fibre reinforced polymer composite laminate with 5 % and 10 % SiC filler, six hybrid composite laminates were created. To examine mechanical behaviours including tensile, flexural, and wear qualities using ASTM standards, all such composite laminates are compared with five stacks of five layered composite laminates built of individual Basalt and Jute fibre. Results were assessed, and a scanning electron microscope was used to investigate cracked surfaces.

Ganesh Chauhan [29] in his paper focuses on creating hybrid composites with steel sheet and glass fibre embedded in epoxy resins. The creation of hybrid laminates using the hand lay-up technique. When spring steel sheet is used, the volume fraction of epoxy resin is kept constant at 40 %, 0, 5, 10 %, and 50, 55, and 60 %. Investigated were mechanical characteristics such flexural, impact, and tensile strength. Analyses were also done on the dry and sliding wear behaviour of hybrid laminates. The ideal parameters for the wear performance were found using the Taguchi technique. The findings demonstrate that the steel sheet has better qualities in the middle, when it occupies positions with 50 % glass fibre and 10 % steel sheet. The ideal parameters were determined to be a sliding distance of 1000 m, a load of 80 N, and a 10 % volume fraction of steel sheet.

Increased erosion wear rate is caused by erodent particle velocity and impact energy. Impact or impingement velocity is a word used to describe how quickly an erosive particle (erodent) strikes the target material and has a significant impact on erosion. The degraded surface experiences plastic deformation as the velocity rises, and particle impact causes subsurface cracking to be visible. High particle velocities may even cause melting at the surface that is being affected. On the other hand, at low speeds, the impact stress is inadequate to cause plastic deformation, which leads to surface fatigue and wear. Events with low impact velocities can be categorised as quasi-static. Depending on how much damage is caused, impact velocities are categorised. Delamination and matrix cracking are characteristics of low impact velocity, whereas penetration that results in fibre breaking is a characteristic of high impact velocity. Knowing the type of failure mechanism is crucial since it provides details on the structural residual strength.

4. Applications

A review paper by Mihai Brebu [30] mentioned that due to their excellent material qualities, fibre-reinforced polymer (FRP) composites are revolutionising the world's manufacturing industries. The aerospace, marine, and civil industries are paying increasing attention to FRP's mechanical performance at various temperatures. At ambient temperature or lower than the polymer matrix's glass transition temperature, these composites are tested for a variety of mechanical characteristics. The problem arises when components manufactured of these composites are exposed to various temperature settings, which occurs under actual service circumstances. When a component is subjected to lengthy service time, thermal strains caused by the rise in cutting temperature at the tool-work piece contact might result in catastrophic component failure.

Thuraya Abdulrahim Basudan [31,32] et al have extensively done the research and based on that he suggested effectiveness of different dental composites and advancements in dentistry, with several positive results. The most frequently reported and utilised composites in clinical contexts among the variously reported composites are hybrid ones. The materials and environmental conditions that these composites may be exposed to, however, have a significant impact on how they behave. Environmental elements like temperature, moisture, chemical reactions, and impact may have a significant impact on dental composites. Additionally, improving the materials' quality by employing more adaptable strategies might improve their quality in producing better results. Additionally, research in this field should focus on enhancing the capabilities of dental composites and raising the standard of living for associated patients.

One of the fillers used in polymer composites that has been researched by certain scientists is marble dust. About 66 % of it is calcite.

During cutting, the marble stone industry produces stone slurry as waste, which pollutes the environment. Reusing waste materials has therefore been highlighted. Ceramic tile production may use marble slurry as a raw material. Erosion investigations on marble dust filled aramid fibre epoxy composites were reported by Choudary et al [33]. It had been discovered that adding filler caused the impingement angle to change from 45° to 60°, indicating that composite materials are semi-brittle. Sharma et al. [34] discovered a similar erosion behaviour of marble dust using jute fibre/epoxy composites. Subrajith et al. [35] examined the addition of marble dust in glass/epoxy composites. In order to determine the best process variables for achieving the lowest erosion rate, an artificial neural network approach was used. The stated results made it clear that filler content has a more significant impact than other elements. Hard and irregularly shaped shattered particles were present due to the preponderance of composite wear with marble dust [36].

Another type of industrial waste produced during the smelting process to recover copper is copper slag. Kalusuraman et al.[37] studied the erosion characteristics of polyester composites reinforced with jute fibre and copper slag particle materials. Their findings demonstrate that copper particles up to 10 % weight percent strengthened the connection between the matrix and fibres, preventing composite degradation. The bonding deteriorates above 10 wt%. The synthetic composites revealed their fragile nature. The outcomes that were described agreed with those of Biswas et al [37]. Sandhyarani Biswas investigated the inclusion of copper slag in bamboo fibre/epoxy composites [38]. With 15 wt% of filler content, a lower erosion rate was seen. Such composite materials were suggested to offer potential in wear applications such industrial fans, low-cost housing, helicopter fan blades, and pipes delivering coal dust, among others.

Because of their environmental friendliness, light weight, and superior mechanical qualities, natural fibres like plant fibres predominate in the manufacturing sector [39,40]. Natural fibres compete with synthetic fibres, notably glass fibres, for their superior qualities, such as specific modulus and elongation at break, despite having a few drawbacks including water absorption and a limited maximum processing temperature [41,42]. Age of the plant, soil parameters, weather, and harvesting all affect the NFRCs' mechanical properties [43,44]. Plant fibres have unique characteristics that are influenced by natural conditions like water, sunlight, soil, and air. All of them share the same elements despite having different compositions [45]. 40–70 % of the cellulose found in plant fibres such hemp, flax, kenaf, and jute [46] is cellulose. Due to its semi-crystalline structure, cellulose is hydrophilic and has superior mechanical properties [47]. Hemicellulose, on the other hand, is an amorphous polysaccharide with five or six carbon rings. The network of cellulose or hemicellulose is made up of cellulose micro fibrils. Lignin also enhances thermal stability and lessens water absorption [48]. Plant fibres have been successfully used in semi-structural and non-structural applications more recently [49]. It did not, however, fully satisfy the needs of structural applications [50]. Perhaps the bast fibres' low breakdown temperatures (less than 200 ^{0}C) are a result of their poor moisture absorption, rendering them particularly susceptible to structural use [51]. Numerous studies have discovered that including coupling agents and compatibilizers or other chemical alterations might reduce the ability of NFRCs to absorb moisture [52–54]. Additionally, Dhakal et al. [53] observed that other aspects, such as fibre breaking, matrix cracking, and fibre pull-out, that may be difficult to evaluate the natural-fibre-reinforced composites subjected to impact testing. In structural applications, NFRC environmental conditions are a major problem. The higher temperatures cause natural fibre components like cellulose, hemicellulose, and lignin to breakdown, changing the mechanical properties of the composite. Therefore, a thorough analysis is required to comprehend the environmental circumstances in which natural fibres and the composites made from them are subjected to impact behaviour.

Alkaline chemical treatments are frequently employed in NFRCs to eliminate undesirable components from the surface of the fibre, such as wax, lignin, and oil material, and to increase the fibber's toughness by significantly increasing its capacity to lock with the matrix [55,60]. To further offer excellent interfacial bonding with the fibre and the matrix, various coupling agents are also utilised as a medium [61]. The matrix is a crucial component of NFRCs because it shields the surface of the fibre from mechanical wear and acts as a barrier against unfavourable environmental factors [62]. Thermoset and thermoplastic polymer matrices are the most widely utilised matrices in NFRCS [63–65]. Because the NFRCs are often thermally unstable up to a 200 ^{0}C threshold, the choice of matrix in natural fibre is constrained by temperature. Due to temperature limitations, the thermoplastic matrix softens at lower temperatures and is easily recyclable. Thermoset matrices, in contrast to thermoplastic matrices, are simple to use yet difficult to recycle and contain hazardous compounds [68]. Based on the resins utilised, the thermoset matrices in NFRCs require high curing temperatures. The structural integrity of the component is significantly at danger of burning if the temperature rises above the 200 ^{0}C maximum threshold [69]. At the moment, researchers are focussing more on the impact test, specifically on the topics of vehicle crashworthiness, runway debris, and hand tools hitting composites. Delamination can also happen to composite laminates. However, with NFRCs, water absorption on the fibber's surface can result in delamination and be the cause of a number of things. Natural fibres' weak ability to attach to organic polymeric matrices is due to two factors: (a) a poor interface between the hydrophilic natural fibres and the hydrophobic organic polymeric matrices; and (b) the waxy nature of natural fibres' surface energy.

5. Conclusion

In the current study, the effects of water intake quality and thickness swelling on generated composite samples' mechanical properties have been examined. After being exposed for 672 h in an accelerated weathering room, the composites for all formulations underwent an environmental degradation test. The samples were subjected to water sprinkling, moisture, and UV ray penetration. The samples were taken out of the test chamber and put through tensile, flexural, and impact testing. Advances in materials science and engineering. Tensile test findings revealed a noticeable loss in tensile strength. Nano nitrile butadiene rubber particles are used to improve the abrasive wear characteristics of epoxy glass fibre composites. Several factors, including temperature (thermal degradation), air (oxidative degradation), moisture (hydrolytic degradation), microorganisms (biodegradation), light (photo degradation), high-energy radiation (UV, irradiation), chemical agents (corrosion), and mechanical stress, can cause polymeric materials to degrade in the environment. These factors can also occur individually or in combination. This experimental analysis of the mechanical and wear behaviour of a unique hybrid composite made of banana coir and epoxy yields a number of important and ground-breaking conclusions.

CRediT authorship contribution statement

Pramod H. Sahare: Writing – review & editing, Writing – original draft, Software, Methodology, Data curation, Conceptualization. **Lalit P. Dhole:** Visualization, Supervision, Investigation. **S.W. Burande:** Validation, Software.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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