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Industrial *Cannabis sativa*: Hemp Plastic-Updates

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Abstract

This review paper updates the benefits of using hemp fibre for the production hemp plastic. Traditional fossil-fuel based plastic production emits massive levels of greenhouse gasses, and the material can take hundreds of years to break down. Traditionally, plastics are made from petroleum-based compounds, which release toxic gases into the atmosphere. Petroleum-based plastics and its by-product have a devastating effect on the land, water, and wildlife. Biodegradable plastics are produced using petro-chemicals just like conventional plastics except some additives are included in their manufacturing which helps them in there fast degradation. Hemp plastic is a type of biodegradable plastic made from hemp fibres, which has a sufficiently high cellulose concentration in manufacturing polymers. The resulting material is fully biodegradable and recyclable. It can then be processed into various products, including packaging, consumer goods, automotive parts, and more conventional plastics. Hemp plastic which is 100% biodegradable, can be a better alternative to synthetic plastic. Hemp plastic is also lightweight, with an impressively high density to weight ratio. This makes hemp plastic a potentially good material for making lightweight components in the car and aerospace industry. Conversely, hemp plastic helps to minimize the greenhouse effect. Hemp plastic offers great thermal, UV, and dimensional stability. Some types of hemp plastic are also resistant to flame. Hemp plastic is solely produced using the cellulose extracted from hemp plant and therefore, causes no toxicity during its production.

Keywords: Biodegradable; Bast Fibres; Greenhouse effect; Global warming; Hemp; Plastic; Petroleum; Polymer; Pollution

1. Introduction

Global warming as a result of climate change has become a major concern for people all over the world [1-8]. Anthropogenic greenhouse gas emission has emerged as the most dominating factor for climate change which is liable for an increase of nearly 1° C of global temperature above preindustrial level [1-4]. Traditional fossil-fuel based plastic production emits massive levels of greenhouse gasses, and the material can take hundreds of years to break down. Traditionally, plastics are made from petroleum-based compounds, which release toxic gases into the atmosphere [1-8]. These plastics are non-biodegradable and have negative impacts on land, water, and wildlife. As a consequence, it is gradually decreasing world habitants to extinction by opening vulnerabilities of natural systems [1-4]. Globally, approximately 80% of produced plastic waste has been accumulated in landfills or in the natural environment [2]. The disposal of plastic wastes in terrestrial and aquatic habitats along with the insufficient waste management constitute a significant environmental, financial, and social threat [1-4]. However, while plastic such as polyethylene brings us convenience, and also threatens environmental sustainability and human health [1-5, 43-50]. The negative impact of

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non-degradable composites on the environment has sparked a revolutionary transition to eco-materials and bio-composites [1-5, 43-52]. Polylactic acid (PLA) is the most produced biodegradable plastic [1-7, 43-50]. Due to insufficient recycling efficiency, millions of tons of polyethylene pollutants accumulate in terrestrial or marine environments each year [1-5, 7]. Polyethylene is elastic, chemically stable, and non-biodegradable, and the traditional disposal methods include land-filling and incineration [1-5, 6-8]. These methods are costly, unsustainable, and further increase the burden on the environment [5]. The minimal production cost of plastic is much lower than the recycling cost [1-7, 8 43-50]. This has led to a large accumulation of plastic waste in the natural environment, which has already negatively impacted life on land and in the sea [5, 7, 8, 43-52]. The negative impact of non-degradable composites on the environment has sparked a revolutionary transition to eco-materials and bio-composites [1-5, 43-50]. Most of the conventional plastic today is manufactured using petroleum based compounds and petroleum based products are considered as harmful to the environment [1-5, 43-50]. In the following section, the use and disadvantages of traditional synthetic polymer plastic, role of biodegradable and hemp plastic have been updated and discussed.

2. Synthetic Polymer Plastic

Plastic is a carbon chained polymer allowing it to be moulded into any shape, and hence they are the most adaptable material [1-5]. The majority of monomers used to make plastics like ethylene and polypropylene are derived from fossil fuel hydrocarbon [1-5]. One of the major components of plastic waste is poly(ethylene terephthalate) (PET), a polymer frequently used in many applications, including textiles and food packaging [1-6]. Plastics are composed of various long-chain polymers from different sources, including natural gas, petroleum, and coal [1-6]. At present, the most widely used plastics are polyethylene terephthalate (PET), polypropylene (PP), polyethylene (PE), polyvinyl chloride (PVC), polystyrene (PS), and polyurethane (PU) [1-6]. As a result, they are neither biodegradable nor easily decomposable; instead, they accumulate in the landfill and the natural environment [1-5]. According to literature, roughly 9% of all plastics produced are recyclable, while the remaining 79% end up in landfills and the atmosphere [1-6]. Petroleum-based plastics and its by-product have a devastating effect on the land, water, and wildlife [1-6]. For this reason, increasing demand has been started in the world for the usage of high-performance bio-based plastics capable of being environmentally friendly and compensating depleting of petroleum resources [1-6]. Plastics are inexpensive, lightweight, strong, durable, corrosion-resistant materials, with high thermal and electrical insulation properties [1-7, 43-50]. The diversity of polymers and the versatility of their properties are used to make a vast array of products that bring medical and technological advances, energy savings and numerous other societal benefits [1-7, 43-50]. Almost all aspects of daily life involve plastics, in transport, telecommunications, clothing, footwear and as packaging materials that facilitate the transport of a wide range of food, drink and other goods [1-7, 8, 43-50]. Conventional plastics contain endocrine disruptors, such as bisphenol A, BPA, which affect the endocrine or hormone system in the human body. When bisphenol A, BPA, gets into human body, it acts like the hormone estrogen, creating a hormonal imbalance that can result in the development of cancerous tumours. Hemp plastic, on the other hand, is non-toxic. Unlike petroleum-based plastics, hemp does not have harmful endocrine disruptors. Hemp also does not release toxic fumes into the atmosphere during its production [1-7, 8, 43-50].

Synthetic polymers shape our contemporary way of life, from packaging to medical masks and numerous other applications [1-7, 48-50]. However, the effects of cumulative plastic pollution on soil, atmosphere, and marine ecosystems have become extremely severe, affecting everyday lives, and are a legitimate threat to future generations [1-7, 48-50]. Over past decades, concerns regarding the adverse effects of plastic pollution on animals, the environment, and human health are motivating the search for biodegradable replacements [1-7, 48-50]. In addition to achieving the desired degradability, there is also growing interest in the development of materials from renewable bio-based resources such as plants instead of non-renewable petrochemical sources to further reduce the environmental impacts of plastics [1-7, 48-50].

The central issue here is relating the types and quantities of additives present in plastics to uptake and accumulation by living organisms [1-7, 43-50]. Additives of particular concern are phthalate plasticizers, bisphenol A, BPA, brominated flame retardants and anti-microbial agents [1-7, 43-50]. Phthalates and bisphenol A, BPA are detectable in aquatic environments, in dust and, because of their volatility, in air [1-7, 8, 43-50]. There is considerable concern about the adverse effects of these chemicals on wildlife and humans [1-7, 8, 43-50]. Discarded plastic also contaminates a wide range of natural terrestrial, freshwater and marine habitats[1-7, 8]. Plastic debris poses a direct threat to wildlife, with many and varied species documented as being negatively impacted by plastic items [1-7, 8, 43-50].

3. Biodegradable Plastic

Biodegradable plastics are produced using petro-chemicals just like conventional plastics except some additives are included in their manufacturing which helps them in there fast degradation [1-7 43-50]. One of the approaches to the development of environmentally friendly polymer materials is the use of substances derived from fauna and flora in composites [1-7 43-50]. Biodegradable plastics do not always break down into harmless substances, sometimes they leave behind a toxic residue and that makes them generally (but not always) unsuitable for composting [1-7, 43-50]. They can be breakdown using microorganisms into water, carbon dioxide and some bio chemical. Some examples of biodegradable plastics are polybutyrate (PBAT), polycaprolactone (PCL), polylactic acid (PLA) and polyhydroxalkanoate (PHA) [1-7, 43-50]. The exploitation of natural fibres to reinforce polymers is a promising practice [1-7, 43-50]. Thus, bio-composites have gained increased attention in automotive, construction, and agricultural sectors, among others [1,43-50]. Fibre-reinforced plastics/polymers (FRP) are well-known, commercially available composites, typically composed of a polymer matrix (usually a resin) reinforced with fibres (e.g., glass or synthetic fibers) [1-7 43-50]. The incorporation of natural fibres, and more generally natural fillers, into polymeric matrices is an alternative strategy to obtain novel, environmentally friendly materials with improved properties and higher biobased and/or biodegradable content [1-7 43-50]. For example, thermoplastic starch can be obtained from the abundantly available polysaccharides through processing with plasticizers such as urea, glycerol, and sorbitol [1-7 43-50]. Polyhydroxyalkanoates are typically synthesized by microorganisms. Although currently made commercially from petrochemicals, polymers such as PBS and PBAT can be made from bio-based monomers [1-7,43-50]. In addition, poly(lactic acid) (PLA) is a commonly used biodegradable polymer whose polymerization monomer can be derived from biomass [1-7, 43-50].

Bio-based and compostable plastics such as polylactic acid (PLA), polyhydroxyalkanoates (PHA), polybutylene succinate adipate (PBSA), and polybutylene succinate (PBS) have emerged as alternatives to existing commodity plastics [1-7, 43-50]. Additionally, studies have demonstrated that thin biodegradable plastic films can attain outstanding barrier properties, but they often required the application of additives such as cellulose or nanoclay or specialized techniques such as electron beam-mediated cross-linking [1-7, 43-50]. Researchers have evaluated a range of biopolymers for their usefulness as bio-plastic materials, e.g., cellulose, starch, collagen, casein, plant proteins [1-19, 43-50]. Rutin induced Chitosan/Poly (vinyl alcohol) bioactive films were developed by using solvent casting technique [1-19].

Bioactive films showed strong antimicrobial activity against *E. coli* and *S. aureus* bacteria [8]. The overall migration of components of bioactive films in different food simulants were within the permitted limits of 10 mg/dm^2 [8]. Hence, rutin induced CS/PVA bioactive films have potential to be used for improving food quality and extending the shelf life of food [8]. Rutin (3,3 ,4 ,5,7-pentahydroxyflavone-3-rhamnoglucoside) is a flavonol, abundantly found in plants, such as passion flower, buckwheat, tea and apple [8]. Tea leaves, apples and many more possess rutin as one of the active constituents [8]. Conventionally, rutin is used as an antimicrobial, antifungal, and anti-allergic agent [8]. The exploration of bioactive compounds in food packaging has received increasing attention in recent years due to consumer concerns about the use of synthetic preservatives [8]. The bioactive compounds used for the development of food packaging are mainly nontoxic, used as protective materials to maintain the quality and extend shelf life of food [8-19]. Organic acids, essential oils, fatty acids, fruit and plant extracts such as *Spathodea campanulata* extracts [9], *Phyllanthus reticulatus* anthocyanin[10], *Piper betel* leaves extract [11, 12], *Solanum nigrum* L. leaf extract [14], *Piper nigrum* leaves extract [15], *Basella alba* stem extract [16], turmeric rhizomes (*Curcuma zedoaria*) [18], and *Syzygium cumini* leaves extract [19], and agricultural waste products etc. are all bioactive compounds with effective antimicrobial and/or antioxidant properties useful for preparation of active food packaging films [8-19]. Biopolymers have been widely used for the development of food packaging films as they are excellent vehicles for incorporating a wide variety of additives such as antioxidant, antifungal and antimicrobial agents [8-19, 43-50]. Among the biopolymers, chitosan (CS) is the most interesting for food packaging as it is non toxic, biodegradable and biocompatible [8-19]. Wheat gluten is one of the most important biopolymers due to its low cost and high content of hydrogen bonds in the film [1-8, 9-19, 43-50].

3.1. Hemp Plastic

Industrial *Cannabis sativa*-Hemp is a herbaceous annual plant (family *Cannabaceae*) that has a 4- to 8-month life cycle, is naturally dioecious, reproduces via seed propagation grown for the production of fibre, seeds and oil [20- 42, 51, 52, 53]. Hemp seeds are used as a functional food and medicine since it contains Cannabidol (CBD), and very low levels (0 to 0.3% dry wt) of Λ9-tetrahydrocannabinol (THC) [20- 53].The growth and reproductive cycle progression of hemp is photoperiod-sensitive. Hemp (*Cannabis sativa* L.) is a multi purpose crop that has been investigated for its potential use in phytoremediation of heavy metals, radionuclides, and organic contaminants, and as a feedstock for biochar and bioenergy production [20- 42, 51]. Hemp plants can grow to heights of up to 5 m and can develop a tap root penetrating

up to 2 m into the soil [20- 42]. The majority of above ground hemp biomass comes from the tall lignocellulosic plant stalk, which has been used for fibre for thousands of years [20- 42, 51, 52].The hemp stalk has two main fibre types: long bast fibres and short hurd fibres [20- 42, 52]. The outer bast fibres surround the vascular tissue of the hemp stalk, whereas the hurd makes up the woody core[20- 42, 51]. Hemp is a bast fibre, which means fibre is extracted from the stalk of the plant [20- 42, 51, 52].

Cannabis sativa L. (hemp) has received a lot of attention because of its multipurpose usability, short production cycle, low capital demand in cultivation, possibility of carbon-negative transformation and easy carbon sequestering material [1, 20- 42- 53]. Industrial hemp has emerged as a highly successful commercial crop due to its carbon-sequestering property, higher biomass production, and various end-use products. Researchers believed that hemp can be successfully used as a cover crop [1] since it can remediate contaminated soils through phytoremediation and can be produced without pesticides [1, 20- 42]. Even hemp residues can act as botanical insecticides or miticides and inhibitors to soil nematodes and pathogenic fungi [1, 20- 42]. It can replenish the soil by killing and displacing other tiny crops or weeds [1] and absorbing heavy metals from soils [1, 20- 42]. Hemp can be used for insulation and acoustic purpose in the building sector, paper industry [1], medicinal purpose, textile industry [1], biofuel, cosmetics industry [1], food and beverage industry [23], and fibre can be used as reinforcement in polymer matrix composites [1] or in bio-composite as a substitute of glass and carbon fibre [1, 20- 42].

Chemically, the bark fibres of the hemp stalk contain considerably more cellulose and holocellulose, and significantly less lignin than either hardwoods or softwoods [20- 51]. The different fibre types can be used to make a variety of textile and industrial products such as fabric, paper/ pulp, insulation, composite boards, plastic, paint, sealant, biochar and bioenergy [20- 42]. Cellulose fibres are the most common biopolymer in the world [20- 42]. Fossil fuel plastic is made from a non-renewable resource and emits significant greenhouse gasses during its lifecycle [20- 50]. Hemp, on the other hand, is a renewable resource that is actually carbon negative which consumes far more greenhouse gasses than are emitted in its production [20- 42]. Just one ton of hemp can absorb up to 1.6 tons of CO_2, making it one of the best carbon sequestration options on the planet [20- 50].

Conventional plastics or non-biodegradable plastics are mostly chemically inert i.e. resistant to degradation, consequently ends up disrupting the wildlife, oceans and land [1-50]. One of the most destructive impact of conventional plastic is that it is produced by the non-renewable source i.e. petroleum [1-50]. Plastics produced using petroleum compounds are quite cheap and easy to manufacture and on the other hand, the processes involved in the production of biodegradable plastic or specifically hemp plastics are quite expensive and use more effort than the production of conventional plastics [1-50]. The strength of hemp plastic makes it appealing in several industries [1-50]. The automotive, building, and packaging industries are all being turned on to hemp plastic [1-50]. Hemp plastic is also lightweight and has a very high ratio of density to weight [1, 20- 50]. This allows it to potentially be used in aerospace to save weight on heavy structures [1, 20- 50]. Due to its versatility, hemp can be used anywhere for any purpose replacing conventional plastics [1, 20- 50]. Hemp is a fast-growing crop that can be quickly replenished. This makes hemp plastic a more sustainable option than traditional plastic made from non-renewable resources like oil [1, 20- 52]. Producing hemp-based bioplastics requires less energy and emits fewer greenhouse gasses than traditional plastic [1, 20- 50]. This makes it an environmentally friendly alternative. Hemp bioplastic can be produced with a lower energy requirement than traditional plastics [1, 20- 50]. This is because the production process of **hemp plastic** requires lower temperatures and less pressure, which means it requires less energy to produce [1, 20- 52]. Delivering hemp plastic also uses 22-45% less energy than non-renewable energy source-based products [1, 20- 50]. Plastic made from hemp is as durable as traditional plastic. This property enables it to be utilized in aerospace to reduce weight on large structures and manufacture products such as car parts, packaging, and toys [1, 20- 52].

Hemp bioplastic**,** in particular, has been gaining attention as a promising alternative to traditional plastics [1, 20- 50]. Hemp plastics are becoming more popular as the push for sustainable packaging continues [1, 20- 50]. Many manufacturers are searching for renewable resources that can replace the fossil fuels and other materials used to create plastics [1, 20- 50]. Hemp seems to be a viable alternative for these manufacturers, especially those who deal with short-term and single-use plastics [1, 20- 50]. Hemp plastic is fairly new to the packaging industry, there are plenty of reasons to start embracing hemp packaging. Regular plastic materials can take decades to fully decompose, and that is only if the right conditions are present to speed up the process [1, 20- 50]. Hemp plastic, like many other bioplastics, is able to decompose within three to six months, which makes it a better alternative for single-use plastics and short-term packaging [1, 20- 50]. There are clusters of plastic waste forming in the ocean that cause damage to our ecosystems. Because plastic has become such a problem, there is a global push to find more sustainable options for packaging and other areas where plastic is in high demand [1, 20- 50]. Hemp plastic is one of the alternative options that has recently come to light [1, 20- 50]. The process of making hemp plastic does not required the use of fossil fuels like other plastics [1, 20- 50]. Fossil fuels have to be excavated in ways that damage the environment, such as fracking [1, 20- 50]. Other

renewable materials such as wood and cotton are also used to make plastic, but hemp provides an environmental benefit over these when it comes to water consumption [1, 20- 50]. Compared to cotton, hemp requires 50 percent less water to farm. Processing cotton also uses up to four times as much water compared to hemp processing [1, 20- 50]. Hemp has around 65 to 75 percent of cellulose, which makes it an excellent choice for plastic manufacturers [1, 20- 50].

Hemp plastic is made from cellulose that is derived from the stalk of hemp plant. This plant has a high cellulose count that is required for the plastic manufacturing [20- 53]. There are several different types of hemp plastic, including conventional plastics fortified with hemp fibers and 100% hemp plastic made fully from the hemp plant [20- 50]. Hemp plastic offers great thermal, UV, and dimensional stability [20- 50]. Some types of hemp plastic are also resistant to flame [20- 50]. In fact, hemp plastic is about 2.5 times stronger than polypropylene (PP) plastic. Hemp can replace a wide range of building materials, including plastic, concrete, and plasterboard [20- 50]. The fact that hemp plastic is safer and sturdier than fibreglass make it a great replacement for building components that are made from conventional plastic [20- 50]. Hemp fibre made plastic influenced the development of the automotive industry from the very beginning. They were used in the first cars to produce structural elements [20- 50]. The fibres of hemp plant were tested as a component in the production of car bodies by Henry Ford in 1941 and by Lotus Cars [20- 50]. Plant-based materials were first used to make vehicle components in the 1940's by Henry Ford [20- 50]. Today, many car manufacturers are considering using natural products in the place of plastic and metal components [1, 43-50]. Cars that have hemp-based components are carbon neutral [20- 50]. They are also fuel-efficient as they are about 30% lighter [1, 43-50]. The fact that hemp is biodegradable, these cars will not be a menace to the environment when they become old [20- 50]. It is worth noting that car manufacturers like Ford, Chrysler, Nissan, GM, Honda, Mercedes, BMW, and Saturn are currently using hemp composite door panels, headliners, trunks, among other components [20- 50]. Hemp was also used to create laminates for any type of construction [1-50]. Researchers dealing with the subject of hemp-containing materials postulate that hemp-based materials are extremely durable and at the same time have a high biodegradability potential [20- 50]. Many specialists presented hemp as a natural material that is stronger than that obtained from other sources of natural cellulose fibres such as coconut, bamboo or jute [20- 50]. The prospect of biomaterials that make up motor vehicles is promising due to the high cost of storing old cars and a strong impact on the natural environment [20-50].

Hemp fibre reinforced plastics are materials that are composed of polymer and hemp fibres from which the composite receives the strength [1- 43-50]. Hemp fibre reinforced plastics are mainly used in automobile industry for interior, but also exterior applications and also for the production of furniture and other consumer products [1- 43-50]. Hemp plastic material favorable mechanical properties such as rigidity and mechanical properties such as strength and rigidity in combination with low density with no sharp edges [1- 43-50]. The majority of currently produced applications are manufactured using thermoplastics and thermoset compression moulding for which the natural fibres fleece and the polymer material are heated and pressed [1- 43-50]. Hemp is not only used to make products that benefit man but also products that benefit animals like dogs and cats [1-50]. A company by the name Honest Pet Products uses sustainable hemp and organic wool to make pet toys [1-50]. Hemp fibres are spread more randomly when compared to conventional plastics [1-50]. This enhances their strength in all directions [1-50]. This increased strength makes hemp plastic ideal for use in many industries. The construction, packaging, and automotive industries are embracing hemp plastic [1-50]. Conversely, hemp plastic helps to minimize the greenhouse effect [20- 50]. Hemp does this by absorbing carbon dioxide from the atmosphere and converting it into oxygen [1-50]. Moreover, hemp plastic releases non-toxic by-products. Hemp plastic is completely plastic-injectable [1-50]. In this process, a hopper is filled up and then melts the raw material before expelling into a mould cavity where it is solidified [1-50]. This process is highly efficient and can be used to manufacture complex items at a low cost [1-50].

Conventional plastic has contributed to the death of millions of wildlife [1-50]. According to a study by the Commonwealth Scientific and Industrial Research Organization and Imperial College of London, 60% of today's seabirds have plastic in their gut [1-50]. This number could shoot to 99% by 2050 [1-50]. Plastic normally disintegrates into tiny pieces when exposed to sunlight. Marine animals end up ingesting these tiny pieces of plastic, which result in various detrimental effects and eventual death of the animals [1-50]. Conversely, hemp plastic is biodegradable and non-toxic. So, instead of piling up water bodies with harmful petrochemical plastics, sustainable initiatives should be developed to recycle hemp plastic safely [1-50]. Duroplasts are the last group of the polymeric materials with conspicuous additives [1-50]. One of the most commonly used thermosets is unsaturated epoxy resins [1-50]. It is this polymer that is one of the most modified with hemp derivatives [1-50]. As a result of the addition of fibres, the tensile, compressive and bending strengths increased. It is logical because the fibres perfectly transfer stresses in materials in which they are active fillers [1-50].

There is growing interest in biodegradable and bio-based materials that can replace conventional plastics in applications such as packaging [48]. Polymers based on 2,5-furandicarboxylic acid (FDCA) have been proposed as bio-based analogues for polymers based on terephthalic acid [48]. However, they tend to be brittle, exhibit limited biodegradability, and there are few examples of bio-composites from these polymers [48]. Incorporation of aliphatic dicarboxylic acids facilitated blending of the copolymers with hemp powder, with up to 30 wt% hemp incorporated into the polymer containing 60:40 FDCA:Sebacic acid [48]. Incorporation of hemp did not substantially alter the thermal properties but increased the moduli of the composites [48]. The copolyesters were susceptible to degradation by *Rhizopus oryzae* lipase, with the sebacic acid-containing polyester having higher degradability than the succinic acid-containing polyester [48]. Overall, the results of this study demonstrated the promise of the copolyester-hemp blends for applications where they can replace conventional non-degradable plastics [48].

Hemp plastic which is 100% biodegradable, can be a better alternative to synthetic plastic [1-7, 43-50]. The cellulose of the hemp plant is rated 60–70%, which can be extracted for making a different range of plastics, including rayon, celluloid and cellophane [1, 43-50]. While 100% hemp-based plastic is still a rarity, composite bioplastics made from hemp and other plant source are already in use [1-7, 43-50]. Though it is by definition a composite, in reference to dimension and end-uses, researchers often use hemp plastics as distinguished terminology [1, 43-50]. One of the study developed short industrial hemp fibre-reinforced wheat gluten plastics and found that hemp fibre-reinforced wheat gluten plastics with 20% fibre content exhibit double tensile strength and ten times young's modulus in comparison to the pure wheat gluten plastics [1-7, 20-50]. Another study developed hemp fibre-reinforced bio-plastics by using cellulose acetate and cellulose butyrate as bio-resin and revealed that hemp fibre-reinforced bioplastics showed better mechanical properties than the non-renewable polypropylene- based hemp fibre-reinforced plastics [1-7, 43-50]. Hemp-based plastics can be used for packaging and technical purposes [1-7, 43-50]. They are particularly suitable because of their strength, lightweight and environmental compatibility [1-7, 43-50]. According to recent report, an eco-friendly hemp-fibre-reinforced recycled HDPE composites were successfully prepared by melt mixing [1, 43-50]. This process proved satisfactory in providing adequate dispersion of the fillers in the polymer matrix and appropriate to prepare materials with filler concentrations up to 75% wt [1-7, 43-50]. Overall, the use of compatibilizers had a beneficial effect on the properties [1, 43-50].

Bast fibres, which are typically evaluated as reinforcing agents for polymer matrices are commonly obtained from the outer cell stem's layers of several plants, mainly flax, jute, kenaf, and hemp [1-7, 43-50]. Some of the most desirable characteristics of natural fibres are their low density and specific weight, acceptable strength, toughness and stiffness, and biodegradability, accompanied, of course, by their green character [1-7, 43-50]. Hemp fibres (HF) are one of the dominant classes of bast fibres, commonly isolated from the hemp plant (*Cannabis sativa* L.) [1-7 43-50]. The common features of natural fibres along with the inherent mechanical, thermal, and acoustic properties of hemp fibres render them promising components for reinforcements in polymer composite materials [1-50]. Since hemp fibres are waste from the agricultural industry, they are inexpensive and available in important quantities, thus lowering the cost of the final products [1-50]. Consequently, the revalorization of by-products from industries or agro-forestry to prepare composites similar to wood/plastic composites (WPC) supported the circular economy and creates a path for sustainability [1, 43-50].

The biggest challenge in the preparation of composite materials is the successful interface adhesion between the filler and the polymer matrix [1, 43-47]. When it comes to natural fibers, compatibilization and adhesion with the polymer matrix are even more challenging due to the highly hydrophilic nature of the fibres, composed mainly of cellulose and lignin, compared to the polymeric matrix, which is rather hydrophobic, especially in polyolefins [1, 43-50]. Therefore, surface modification of the fibres and/or the polymer is a currently an active field of research in polymeric composites with natural fibres [1, 43-50]. There are, of course, other limitations linked to the use of natural fillers, such as the intrinsic variability of all bio-based compounds, higher moisture absorption, lower thermal stability, lower durability, lower fire resistance, etc.; nevertheless, the main difficulty remains obtaining satisfactory adhesion [1, 43-50]. In case of hemp fibers, chemical treatment, such as treatment with alkali, silanization, or surface-initiated polymerization, as well as physical treatments such as stretching, thermotreatment, and electric discharge have been proposed and studied as possible means to ameliorate the adhesion with the polymeric matrix [1, 43-50]. On the other hand, hemp plastic is solely produced using the cellulose extracted from hemp plant and therefore, causes no toxicity during its production [1, 43-50].

Bioplastics from hemp can be produced by extracting cellulose from the stalks and fibres of hemp and converting it into a polymer that can be moulded into various shapes and forms**.** Hemp plastics can be processed using existing equipment and techniques, making it a cost-effective and scalable solution for plastic manufacturers and users [1, 43-53]. One of the most significant benefits of hemp plastic is its biodegradability. Unlike traditional plastic, which takes centuries to decompose, this plastic can biodegrade within six months to a year, depending on the environmental conditions [1, 43-

53]. Production costs of all bio-plastics have seen a gradual decrease with an increase in yearly production volumes [1, 43-50]. Despite this, they remain more costly alternatives to commonly used commodity plastics [1, 43-53]. This could be offset by exploiting more of the zero-burden resources obtained from agricultural waste to prepare low environmental impact papers [1, 43-49]. With an emerging alternative to polylactic acid (PLA), there is a chance to adapt biodegradable composites with hemp material to meet the needs of specific applications [1, 43-50]. Considering the presented results, bioplastics with hemp powder are very promising materials for paper laminate production in a variety of food packaging applications [1, 43-49, 50]. The use of hemp and its derivatives in the new materials sector also showed promise for the development of environmentally friendly polymer products [20- 50]. The polymer industry, contributing to each of the main sectors of the economy, can draw from this green source of many active phyto substances, oils and fibres [1, 43-50]. The pro-ecological aspect of hemp cultivation, low soil and water requirements and the possibility of processing and using 100% of plants with cheap production allowed to be optimistic about the development of this production department and related science activities [1, 43-53]. There is also a lack of basic knowledge in the use of other cannabis derivatives in the polymer industry [1, 43-50]. Hemp cellulose is mixed with plasticizers and plastic additives to enhance the final product properties [1, 43-50]. The mixture then goes under heat pressure treatment to produce the hemp plastic desired. The exact process of making hemp bioplastics may vary depending on the manufacturer and the intended use of the final product [1, 43-50].

3.1.1. Disadvantages of Hemp Plastic

- Hemp based plastic is still a relatively new material and needs to be widely available in the market. This can make switching to hemp as a raw material is challenging for businesses [1, 43-50].
- Hemp-based plastics are currently more expensive than traditional plastics. This cost difference is mainly due to the limited availability of hemp as a raw material and its relatively high processing cost.
- Although hemp plastic is biodegradable, it can be challenging to recycle if the material is mixed with some additives to enhance its quality. This is because hemp bioplastic requires a specific composting process, and not all recycling facilities have the necessary infrastructure to compost plastics.
- Plastic from hemp have a shorter shelf life than traditional plastics. It is more prone to degradation and can break down faster when exposed to heat and moisture.

3.2. Hemp Plastic Future Prospective

Hemp derived bioplastics can have a significant positive impact on the environment [1, 43-50]. Industrial hemp requires less water and fewer pesticides than traditional crops, making it a more sustainable option for producing plastics [1, 43-51]. Additionally, since bioplastics from hemp are biodegradable, they do not contribute to the pollution of oceans and landfills, which can have long-term consequences for the health of our planet [1, 43-52]. **Hemp based plastics** offer a positive future for plastic manufacturers and consumers alike [1, 43-50]. This will reduce reliance on petroleum-based plastics by choosing hemp-based plastics and contribute to a more sustainable and environmentally friendly future [1, 43-50]. Choosing **hemp plastics** is beneficial for the environment and can also be an intelligent business decision. With consumers becoming more conscious of their environmental impact, offering products made from sustainable materials like hemp bio-plastics can attract environmentally conscious customers and help to differentiate brand from competitors [1, 43-50]. Overall, the Pros of **hemp bioplastic** outweigh the Cons [1, 43-50]. Hemp plastic biodegradability, renewability, versatility, strength, and cost-effectiveness make it a promising alternative to traditional plastic. However, it is essential to note that this bio-plastic is not a perfect solution, and there are still some barriers to its adoption. Therefore, continue searching for more sustainable alternatives to traditional plastic, hemp bio-plastic should be considered a viable option [1, 43-52].

4. Conclusion

Traditional fossil-fuel based plastic production emits massive levels of greenhouse gasses, and the material can take hundreds of years to break down. Traditionally, plastics are made from petroleum-based compounds, which release toxic gases into the atmosphere. These plastics are non-biodegradable and have negative impacts on land, water, and wildlife. As a result, they are neither biodegradable nor easily decomposable. However, they accumulate in the landfill and the natural environment. Biodegradable plastics are produced using petro-chemicals just like conventional plastics except some additives are included in their manufacturing which helps them in there fast degradation. Hemp plastic is made from cellulose that is derived from the stalk of hemp plant. Hemp plant has a high cellulose count that is required for the plastic manufacturing. Hemp plastic which is 100% biodegradable, can be a better alternative to synthetic plastic. Hemp plastic is also lightweight, with an impressively high density to weight ratio. This makes it a potentially good material for making lightweight components in the car and aerospace industry. Conversely, hemp plastic helps to minimize the greenhouse effect. Hemp plastic offers great thermal, UV, and dimensional stability. Some types of hemp

plastic are also resistant to flame. Due its versatility, hemp can be used anywhere for any purpose replacing conventional plastics. In fact, hemp plastic is about 2.5 times stronger than polypropylene (PP) plastic. Hemp plastic is solely produced using the cellulose extracted from hemp plant and therefore, causes no toxicity during its production.

Compliance with ethical standards

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No conflict of interest to be disclosed.

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