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REVIEW ARTICLE OPEN ACCESS

Benefits and Drawbacks of Bioplastic as an Alternative of Conventional Plastic towards Sustainable Plastic

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Abstract

Plastics have become an integral part of modern life, finding applications in diverse sectors from everyday consumer goods to advanced technologies. However, the environmental concerns associated with conventional plastics, including their non-biodegradable nature and reliance on diminishing petroleum resources, have led to a search for sustainable alternatives. On the other hand bioplastic represent an alternative to conventional petroleum-based plastics. Bioplastics are plastics derived from renewable biomass sources, such as vegetable fats and oils, corn starch, straw, woodchips, sawdust, or recycled food waste. This article explores bioplastics as a potential environmentally friendly substitute for traditional plastics. The present communication enlightened the ecological viability of these materials and presents a comparative analysis between conventional and bioplastics. The comparison encompasses crucial factors such as mechanical properties, moisture resistance, durability, cost-effectiveness, and recyclability. Furthermore, this research delves into the efforts being made to enhance the durability and economic feasibility of bioplastics. The paper also addresses the production, utilization, and sustainability of bioplastics within the Indian context, providing insights into the potential for adoption and implementation in a developing economy. By comprehensively analyzing these aspects, this study aims to contribute to the ongoing discourse on sustainable materials and offer valuable insights into the potential of bioplastics as a viable alternative to conventional plastics in the pursuit of environmental sustainability.

Keywords: Plastic, Bioplastics, Sustainability, Microplastic *etc.*

Introduction

In the face of mounting environmental challenges, sustainable development has become a global priority. Since few decades plastic pollution has emerged as one of the most pressing environmental issues. The ubiquitous use of plastic, coupled with its durability and poor waste management, has led to a global crisis with far-reaching consequences for ecosystems, wildlife, human health, and economies worldwide. Plastics are synthetic polymers of mainly petroleum-based products like polyvinyl chloride (PVC), polyethylene terephthalate (PET), polyamide (Nylon), polytetrafluoroethylene (Teflon) etc. The unique physical structure and morphology offers them a varied range of feasible properties such as flexibility, high tensile strength, durability. Plastics are easily moldable into various shapes and they are water and corrosion resistant and poor conductor of heat and electricity. All these properties along with cheap production cost have made plastic one of the most indispensable commodities of everyday life since the last few decades (Thompson et. al., 2009; Geyer et. al., 2017). From packaging industry to fabric, from construction materials to transportation, from toys and toothbrush to advanced phones, computers and modern-day microchips, plastic has been a vital part. But despite all these grandeurs, with increasing awareness of environmental welfare, steady decrease in the stock of fossil fuel, emission of greenhouse gases during their production, toxicity of the trapped monomers or additives in the plastic, huge amount of non-biodegradable plastic waste in land and oceans and presence of microplastic in food chain, plastic industry has been placed under a scanner and pursuit for an effective alternate has been deployed (Rhodes, 2018).

In this regard, Bioplastics offer a promising alternative to conventional plastics. These are produced from renewable biomass like cellulose, sugarcane, corn, vegetable fats and oils, proteins and lipids obtained from natural sources etc. are under extensive research for their decomposable nature, reduced waste formation, reduced carbon footprint and greenhouse gas emission, as well as preserving sustainability in nature, reduced toxicity and many more (Chauhan *et al.,* 2014; Jeremic *et al.,* 2020). Nevertheless, there is still a long task to achieve before the successful commercialization of bioplastic over the viable conventional plastics due to its cost, poor wet stability in most of the cases, use of first-generation feedstock and more (Varghese *et al.,* 2022). This article enlightened some inspired technology behind the synthesis of novel bioplastics.

Few novel synthetic methods in the production of bioplastics:

From starch and cellulose

Starch and cellulose, natural polymers obtained from plants are easily accessible, cheap, completely decomposed in soil and water and thus when incorporated with conventional plastic can infuse biodegradability to the system. Since the last few decades they have gained attention in the wrapping industry (Ozdamar and Ateş, 2018). Thermoplastic starch (TPS) alone is not enough and needs a filler to meet the commercial purpose. The nontoxic mineral clay, which was used in various shapes and forms since the ancient time, is found to be proper choice for filler as well. Also, around the same timeline noteworthy research work has been conducted on Nano composites bio-degradable plastics as the practical alternative tofossil fuel plastics due to their overall advantages and elevated properties. Nano composites consist of a polymer medium strengthened with particles of nano dimension instead of the conservative micro dimensional fillers (Mose and Maranga, 2011). Mose *et al.,* in 2011, published a review paper citing some interesting works on such starch-based nanocomposites. In 2005, Zeng *et al.,* reported that clay particles such as Montmorillonite (MMT), hectorite, saponite and laponite can be effectively used as nanocomposites owing to their exclusive structure and associated properties. These clays significantly augment the mechanical performance of bioplastics, aid their moisture repelling ability and significantly decrease the leaching of plasticizer from starch.

Singh and Mohanty, in 2007 published their work on wood fiber fabricated bacterial bioplastic from dried maple tree wood with the aid of a bacterial polyester polyhydroxybutyrate-co-valerate (PHBV) by the process of extrusion followed by injection molding. The resultant bio-composites exhibited improved tensile strength and flexibility. In 2009, Sarasa *et al.,* studied the comparative data of degree of disintegration of polylactic promising fragmentation under composite condition encouraging their application in plastic manufacture. In 2014, Augustin *et al.,* reported the synthesis of cellulose nano-rod from rice straw with elevated tensile strength and modulus with increasing crystal load as well as better water resistance as tested by moisture acceptance of the cellulose crystal doped films.

From polyhydroxy alkanoate (PHA)

Polyhydroxy alkanoate esters, a wide class of microbial polyesters, are much sought-after as a green alternative for regular plastic (Meereboer *et al.,* 2020). PHA synthesis is aided by multiple microbes by fermentation process. PHA granules reside in a cells cytoplasm and consist of a water-repellant core of helical PHA chains and water as the plasticizer; this core is enclosed by more hydrophilic enzymes and structural proteins. For this unique structure, PHA has other biological roles as well which are still under research (Chee *et al.,* 2010). Owing to their protective function for cells towards harmful effects such as toxic solvents, oxidative stress, heat, UV-irradiation etc. they have received grand attention of bioplastic researchers (Dietrich *et al.,* 2017; Acharjee *et al.,* 2023). PHA based bioplastics have gained popularity in food packaging industry, pharmaceutical purpose as well as owing to their slow carbon release ability, they are utilized in materials to be used in polluted environment to improve bioremediation (Berezina *et al.,* 2015).

In 2020, Smith *et al.,* published their work on synthesizing an agave fiber incorporated PHA composites of different fiber content to study the collaboration effect. They collected the agave fiber from the remains of the bagasse landfill of local industries and blended 15% (wt) and 25% (wt) of the fiber in the PHA matrix. The doping decreased the crystal nature of the PHA and showed an increase in the flexural strength and modulus, increase in impact strength and the tensile modulus. But the tensile strength decreased with the fabrication mainly due to the meager PHA-fiber union. In 2023, Mirpoor *et al.,* reported the formulation of the flavonoid ploretin (a dihydrochalcone) incorporated PHA plastics as an effecting food packaging material with increased tensile strength and elevated antioxidant and antimicrobial properties as tested with apple packaging.

From polylactic acid (PLA)

Polylactic acid is lactic acid polymeric ester which is commercially available and biodegradable. Its main source is polymerized sugar obtained from various agricultural sources. This sustainable thermoplastic is biocompatible, thus suitable for packaging and pharmaceutical industry, aids in carbon dioxide fixation, has modest thermal properties and rigidity. Cheap production cost, non-toxicity and multiple composite forming capabilities has made this polymer as one of the front-runners in bioplastic industry (Naser *et al.,* 2021).

Spiridon *et al.*, in 2014, published their work on the study of the effect of accelerated weathering on the properties of lignin mixed polylactic acid composites. Lignin is a three-dimensional polymer present in plants responsible for the mechanical strength, defense mechanism and water transport in plants. In this study, the produced two types of lignin based (obtained from soft and hard wood) PLA. Both the impact strength and thermal stability of the composites showed better trend. Both the unaltered and the composite lignin-PLA were subjected to elevated weathering, the tensile and impact strength decreased in all samples except for a very slow decrease in the PLA-lignin composite. All composites recorded an increase of water sorption capacity, PLA/LB material having the highest water sorption capacity. The composite also showed least decomposition under UV exposure.

Suryanegara *et al.*, in 2021, fabricated chitosan-ZnO and chitosan-TiO2based novel PLA bio-composites for antimicrobial evaluation which showed elevated antimicrobial property against Gram-positive and Gram-negative bacteria but with decreasing tensile strength. In 2024, Massijaya *et al.*, reported a composite produced by blending polylactic acid (PLA) with thermoplastic starch (TPS). The incorporation of sucrose enhanced the water vapour transmission rate i.e. increased barrier property and degradation property. However, the tensile strength decreased significantly due to the poor PLA to TPS bonding.

From protein

Both tree and animal-based proteins are also under scrutiny for the effective synthesis of bioplastics because of their compatibility with biological form, non-toxic nature as well as complete biodegradability (Jerez *et al.*, 2007; Jones *et al.*, 2015). Yamada *et al.*, in 2020 reported the synthesis of soybean-based bioplastic with the aid of formaldehyde. Degreased soy proteins after oil extraction primarily contains different residual amino acids whose carboxyl and amine group can crosslink with formaldehyde in aqueous solution to form methylene chains. The authors produced formaldehyde cross linked soy protein bioplastic and measured various parameters. With 1% formaldehyde, the bioplastic exhibited bending strength parallel to the conventional polythene as well as satisfactory thermal stability owing to the peptide-formaldehyde crosslinking and biocompatibility and biodegradability.

In 2021, Singha *et al.*, published their work on new bio-degradable plastic derived from single cell protein obtained from potato starch waste. They used glycerol as the plasticizer and the resultant plastics exhibited flexibility, tensile strength and durability compared to polythene. Oxygen permeability of the films was decent and water vapour permeability was similar or even lower than other protein-based bio-composites. Subha *et al.,* in 2024, reported a novel synthesis of bioplastic form hair protein keratin with glycerol, ethanediol and di- and tri-ethylene glycol as plasticizer. They used human waste hair for the purpose and the resultant composites were thoroughly investigated showing tunable mechanical properties with the modification of nature and concentration of the plasticizers as well as sustainability, packaging and biomedical compatibility.

From waste materials

One of the most reflective scientific cultures in today’s work is the study of waste materials generated worldwide and their use in different sectors like energy production, recycling, reuse and more for a future sustainable world (Reno, 2015; Amasuomo and Baird, 2016). Currently research work dedicated for waste management is massive and among them one of vital preferences is the formulation of bio-degradable plastics from waste. Countless sources like agro-waste, food waste, industrial waste, kitchen waste etc. and diverse techniques are deployed for the purpose (Bhatia *et al.*, 2021).

In 2013, Perotto *et al.*, reported a green process to the manufacture of bio-degradable plastic from waste powder of vegetables like carrot, parsley, radicchio and cauliflower by treating them with 5% HCl in water and subsequent dialysis and casting. The resultant films contained the respective natural properties of the vegetables like anti-oxidant properties in case of radicchio plastic. The synthesized materials had mechanical property comparable to polypropylene and starch-based bioplastics. In addition, using a food restorative powder made those plastics safe for food packaging as well as the authors generated a colourful blend of carrot plastic with polyvinyl alcohol with highly satisfactory low oxygen permeability as compared to other conventional plastics. The colourful blended plastic could have their applications in non-toxic cosmetics and bio-electronics.

In 2020, Ebrahimian *et al.,* reported their work on production of polyhydroxyalkanoate (PHA) from organic segment of municipal excess. First, they had pretreated the waste with acetic acid in ethanol solvent followed by enzymatic hydrolysis. The unhydrolyzed residues were then subjected to anaerobic digestion to produce PHA and other biofuels like methane, 2, 3-butanediol, ethanol, acetic acid and biohydrogen.

In 2024, Baltaci *et al.,* published their work on economic manufacture of sustainable plastics from local sugar factory with high carbon content by fermenting the sample with *P. neustonica* NGB15 bacteria cultured under critical condition like high carbon, low sulphur concentration etc. Then produced PHA was categorized as poly-β- hydroxybutyrate (PHB) through FTIR analysis.

Merits and demerits of bioplastic over conventional plastic

<u>Merits</u>:

Conventional plastic is generally manufactured from liquid monomers obtained from fossil fuel which is a non-renewable energy source with a rapidly depleting stock. Biodegradable plastics, on the other hand utilize renewable sources like food waste, agro and industrial waste, bio-proteins etc. Bioplastic production requires lesser energy than conventional plastic. Bioplastics releases much less greenhouse gases and is non-toxic and most importantly having much insignificant carbon footprint than their synthetic counterpart. Unfettered accumulation of plastic waste in landfills, oceans and their associated hazards of emitted greenhouse gas and toxicity is one of the biggest parameters which are affecting marine life, groundwater sources, damaging the soil and thus hindering the sustainable development goals for our future generation. Some conventional plastic polymer like polyvinyl chloride (PVC) is constituted of carcinogenic monomer unit like vinyl chloride. If some monomer unit is trapped in the polymer matrix and used in household products, slowly it exposes all to the toxicity. Also, when PVC is burned, it produces dioxin, a carcinogen responsible for breast cancer. Bioplastics are biocompatible, biodegradable, non-toxic and the whole process of bio-degradable plastic manufacture is less energy demanding and thus sustainable (Kalia *et al.,* 2000; Gironi and Piemonte, 2011; Gill, 2014)

<u>Demerits</u>:

Despite all those virtues, bioplastics have some demerits like high cost in production, in most cases poor mechanical properties than conventional plastic, low thermal stability, less durability and problem in recycling. Apart from that, exclusive bioplastic production will utilize substantial expanse of land, water, crop, tree resources which can partake an adversative effect on the sustainability. All these reasons and the ignorance of the common people is the reason behind the excessive use of conventional plastics and hampering the environmental balance (Goel *et al.,* 2021; Varghese *et al.,* 2022).

Bioplastic in Indian context

The Ministry of Environment, Forest and Climate Change of The Government of India has revised the Plastic waste management rule, 2016 in August, 2021. The most striking features of the rule is complete ban on single use plastic (SUP) which cause the most hazard on environment including polystyrene and modified polystyrenes as well as direction to increase the thickness of carry bags (Banerjee et. al., 2024). India has an immense availability of massive amount of biomass for effective production of bio-degradable plastic. According to various studies, the bioplastic market in India is expanding at a steady rate. More research work is devoted in the field and hopefully in coming years bioplastics will overcome the present challenges to counter the toxic alternative fossil-fuel plastic (Rafey and Siddiqui, 2021).

Conclusion

As famously quoted by the stalwart physicist Stephen Hawking, “there is no planet B”, plastic wastes are making this world a junkyard and we have no alternative place for relocation. They are filling the lands, the oceans, disrupting the marine life, polluting the air, damaging the soil, imparting health hazard and toxicity. This brief article humbly attempts to discuss the adversity caused conventional plastics, the viability of sustainable plastics, and some new techniques of their production. To accomplish, a strict regulation in the guidelines for reuse, recycle, recovery of conventional plastic and increased awareness towards the viability and sustainability of bio-degradable plastic as well as continuous research for the betterment of the quality and innovative production of them from second and third generation feedstock can address the grave issue for a better and sustainable future.

Reference

Acharjee, S. A., Bharali, P., Gogoi, B., Sorhie, V., Walling, B., Alemtoshi. (2023). PHA-based bioplastic: A potential alternative to address microplastic pollution. *Water, Air, & Soil Pollution* 234(1): 21.

Agustin, M. B., Ahmmad, B., Alonzo, S. M. M., and Patriana, F. M. (2014). Bioplastic based on starch and cellulose nanocrystals from rice straw. *Journal of Reinforced Plastics and Composites* 33(24): 2205–2213.

Amasuomo, E., Baird, J. (2016). The concept of waste and waste management. *J. Mgmt. & Sustainability* 6: 88.

Baltacı, N. G., Baltacı, M. Ö., Görmez, A.,Örtücü, S. (2024). Green alternatives to petroleum-based plastics: production of bioplastic from Pseudomonas neustonica strain NGB15 using waste carbon source. *Environmental Science and Pollution Research* 31(21): 31149–31158.

Banerjee, M., Singh, A., Shanthakumar, S. (2024, June). India on Track to Plastic Waste Management–A Diversity of Challenges and Regulatory Innovations. IN NDIEAS-2024 International Symposium on New Dimensions and Ideas in Environmental Anthropology-2024 (NDIEAS 2024) (pp. 405-438). *Atlantis Press*.

Berezina, N., Yada, B., Lefebvre, R. (2015). From organic pollutants to bioplastics: insights into the bioremediation of aromatic compounds by Cupriavidus necator. *New biotechnology* 32(1): 47–53.

Bhatia, S. K., Otari, S. V., Jeon, J. M., Gurav, R., Choi, Y. K., Bhatia, R. K.,Yang, Y. H. (2021). Biowaste-to-bioplastic (polyhydroxyalkanoates) Conversion technologies, strategies, challenges, and perspective. *Bioresource Technology* 326: 124733.

Chauhan, K., Kaur, R., Chauhan, I. (2024). Sustainable bioplastic: a comprehensive review on sources, methods, advantages, and applications of bioplastics. *Polymer-plastics Technology and Materials*. DOI: 10.1080/25740881.2024.2307369.

Chee, J. Y., Yoga, S. S., Lau, N. S., Ling, S. C., Abed, R. M., Sudesh, K. (2010). Bacterially produced polyhydroxyalkanoate (PHA): converting renewable resources into bioplastics. *Current research, technology and education topics in Applied Microbiology and Microbial Biotechnology* 2: 1395–1404.

Dietrich, K., Dumont, M. J., Del Rio, L. F., Orsat, V. (2017). Producing PHAs in the bio-economy—Towards a sustainable bioplastic. *Sustainable production and consumption* 9: 58–70.

Ebrahimian, F., Karimi, K., Kumar, R. (2020). Sustainable biofuels and bioplastic production from the organic fraction of municipal solid waste. *Waste Management* 116: 40–48.

Geyer, R., Jambeck, J. R., Law, K. L. (2017). Production, use, and fate of all plastics ever made. *Science Advances* 3: e1700782.

Gill, M. (2014). Bioplastic: a better alternative to plastics. *Int. J. Res. Appl. Nat. Soc. Sci.*2: 115–120.

Gironi, F., Piemonte, V. (2011). Bioplastics and petroleum-based plastics: strengths and weaknesses. *Energy sources, part a: recovery, utilization, and environmental effects* 33(21): 1949–1959.

Goel, V., Luthra, P., Kapur, G. S., Ramakumar, S. S. V. (2021). Biodegradable/bio-plastics: myths and realities. *Journal of Polymers and the Environment* 29: 3079–3104.

Jeremić, S., Milovanović, J., Mojićević, M., Škaro-Bogojević, S., Nikodinović-Runić, J. (2020). Understanding bioplastic materials-current state and trends. *Journal of the serbian chemical society* 85(12): 1507–1538.

Jerez, A., Partal, P., Martínez, I., Gallegos, C.,Guerrero, A. (2007). Protein-based bioplastics: effect of thermo-mechanical processing. *Rheologica Acta* 46: 711–720.

Jones, A., Mandal, A., & Sharma, S. (2015). Protein-based bioplastics and their antibacterial potential. *Journal of Applied Polymer Science* 132(18).

Kalia, V. C., Raizada, N., Sonakya, V. (2000). Bioplastics. *Journal of Scientific and Industrial Research* 59: 433–445.

Massijaya, S. Y., Laksana, R. P. B., Nissa, R. C., Nurhamiyah, Y., Irmayanti, M., Ningrum, R. S., Karlinasari, L. (2024, June). Enhancement of PLA-based Biopolymer Composite Physical Properties with Addition of Sucrose. *In IOP Conference Series: Earth and Environmental Science*. 1354(1): 012033.

Meereboer, K. W., Misra, M., Mohanty, A. K. (2020). Review of recent advances in the biodegradability of polyhydroxyalkanoate (PHA) bioplastics and their composites. *Green Chemistry* 22(17): 5519–5558.

Mirpoor, S. F., Patanè, G. T., Corrado, I., Giosafatto, C. V. L., Ginestra, G., Nostro, A., Pezzella, C. (2023). Functionalization of Polyhydroxyalkanoates (PHA)-based bioplastic with Phloretin for active food packaging: characterization of its mechanical, antioxidant, and antimicrobial activities. *International Journal of Molecular Sciences*, 24(14): 11628.

Mose, B. R., & Maranga, S. M. (2011). A review on starch based nanocomposites for bioplastic materials. *Journal of Materials Science and Engineering*. B 1(2B): 239.

Naser, A. Z., Deiab, I., Darras, B. M. (2021). Poly (lactic acid)(PLA) and polyhydroxyalkanoates

Reno, J. (2015). Waste and waste management. *Annual Review of Anthropology* 44(1): 557–572.

Rhodes, C. J. (2018). Plastic pollution and potential solutions. *Science Progress* 101(3): 207–260.

Sarasa, J., Gracia, J. M., and Javierre, C. (2009). Study of the biodisintegration of a bioplastic material waste. *Bioresource technology* 100(15): 3764–3768.

Shubha, A., Sharmita, G., Anita, L. (2024). Production and characterization of human hair keratin bioplastic films with novel plasticizers. *Scientific Reports* 14(1): 1186.

Singha, S., Mahmutovic, M., Zamalloa, C., Stragier, L., Verstraete, W., Svagan, A. J., Hedenqvist, M. S. (2021). Novel bioplastic from single cell protein as a potential packaging material. *ACS Sustainable Chemistry & Engineering* 9(18): 6337–6346.

Smith, M. K., Paleri, D. M., Abdelwahab, M., Mielewski, D. F., Misra, M., Mohanty, A.K. (2020). Sustainable composites from poly (3-hydroxybutyrate)(PHB) bioplastic and agave natural fibre. *Green Chemistry* 22(12): 3906–3916.

Spiridon, I., Leluk, K., Resmerita, A. M., Darie, R. N. (2015). Evaluation of PLA–lignin bioplastics properties before and after accelerated weathering. *Composites Part B: Engineering* 69: 342–349.

(PHAs), green alternatives to petroleum-based plastics: a review. *RSC advances* 11(28): 17151–17196.

Özdamar, E. G., & Ateş, M. (2018). Rethinking sustainability: A research on starch based bioplastic. *Journal of Sustainable Construction Materials and Technologies* 3(3): 249–260.

Perotto, G., Ceseracciu, L., Simonutti, R., Paul, U. C., Guzman-Puyol, S., Tran, T. N., Athanassiou, A. (2018). Bioplastics from vegetable waste via an eco-friendly water-based process. *Green Chemistry* 20(4): 894–902.

Rafey, A.,Siddiqui, F. Z. (2023). A review of plastic waste management in India-challenges and opportunities. *International Journal of Environmental Analytical Chemistry* 103(16): 3971–3987

Suryanegara, L., Fatriasari, W., Zulfiana, D., Anita, S. H., Masruchin, N., Gutari, S., Kemala, T. (2021). Novel antimicrobial bioplastic based on PLA-chitosan by addition of TiO2 and ZnO. *Journal of Environmental Health Science and Engineering* 19: 415–425.

Thompson R. C., Swan S. H., Moore C. J., Saal F. S. vom. (2009). Our plastic age. Phil. Trans. *R. Soc.* B364: 1973–1976.

Varghese, S., Dhanraj, N. D., Rebello, S., Sindhu, R., Binod, P., Pandey, A., Awasthi, M. K. (2022). Leads and hurdles to sustainable microbial bioplastic production. *Chemosphere* 305: 135390.

Varghese, S., Dhanraj, N. D., Rebello, S., Sindhu, R., Binod, P., Pandey, A., Awasthi, M. K. (2022). Leads and hurdles to sustainable microbial bioplastic production. *Chemosphere* 305: 135390.

Yamada, M., Morimitsu, S., Hosono, E., & Yamada, T. (2020). Preparation of bioplastic using soy protein. *International Journal of Biological Macromolecules* 149: 1077–1083.

Zeng, Q. H., Yu, A. B., Lu, G. Q., and Paul, D. R. (2005). Clay-based polymer nanocomposites: research and commercial development. Journal of nano-science and nanotechnology 5(10): 1574–1592.

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