Can biodegradable textiles lead us to a hopeful path of a sustainable textile industry? - A Review.

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Introduction

Excessive consumption of short-lived textile goods has led to an increase in post-consumer textile waste (PCTW), which has resulted in impacts like climate change and increased pollution that has caused a decline in human and environmental health (Geyer et al., 2017). Despite several possible methods to recycle and reuse, most PCTW often ends up in landfills due to the lack of viable options at the end of their life. The complex separation process in blended textiles, low-quality products, higher recycling costs compared to virgin materials, volume, collection, sorting, and transportation costs involved are to name a few of the many issues causing landfilling of PCTW not to mention the recycling process can only handle a small percentage of textile waste (TW) (Soyer & Dittrich, 2021). Textiles in the apparel industry commonly consist of a blend of fibers which complicates TW processing due to their differing degradation and recycling pathways.

Many of the complexities in these end-of-life processing methods cause the landfilling of PCTW. The ways in which these wastes interact with the environment must be carefully understood to identify their impact on our ecosystem. In light of this problem, biodegradable polymers are receiving a lot of interest lately as they can potentially help encounter the issue of PCTW accumulation. This state-of-the-science multidisciplinary literature review analyzes the possibility of textile polymer biodegradation as a pathway for PCTW accumulation. While the majority of published studies in the polymer biodegradation area focus on synthetic polymers, the plastic industry, and biopolymers (Jönsson et al., 2021). We found that there is a dearth of peer-reviewed literature focusing on the biodegradation of textiles and their environmental impact. This review offers a broader understanding of the textile polymer biodegradation mechanism, factors affecting the rate of textile biodegradation, and related environmental impacts as these wastes are left to sit in landfills and break down into the environment. Also, this knowledge will be valuable to several stakeholders of the textile industry including but not limited to textile manufacturers, consumers, policymakers, and regulatory authorities.

Methodology

The initial literature search included 5 key phrases, “biodegradable textiles”, “biodegradable fibers”, “textiles in landfill”, “textile biodegradation” and “biodegradable polymers”. The search was performed in the web of Science (WOS) database and was limited to

the studies published between 2013 to 2023 and yielded 120,622 results in total. This was further narrowed down by filtering our search criteria by "original research articles", "review papers", and "refereed book chapters", which resulted in a total of 284 publications. At this stage, we read the abstract, and conclusion of each paper to select relevant articles and further narrowed our search by excluding articles that didn't meet all of the four criteria listed below:
1. The study must have a well-defined research question/objectives/hypothesis.
2. The study must focus on investigating the biodegradation of solid textile waste in a published original research article or a review paper.
3. The study must be published in a peer-reviewed and reputable journal or book.
4. The publication must be indexed in the web of science.
In the end, a total of 48 publications were synthesized in this literature review that met all 4 criteria listed above.

Key knowledge gaps, and concluding remarks

As sustainable approaches to combat PCTW accumulation have increasingly become an area of interest among academic researchers and the industry. An urgent need to minimize the environmental impact of TW and encourage circularity through policymaking, laws, and regulations are sensed by this review paper. It is anticipated that stringent regulations for PCTW management will be stipulated in the near future and thereby more cost-effective and feasible solutions are urgently needed and discussed in the future research directions of this paper.
We analyzed several pieces of information around novel techniques such as torrefaction, pyrolysis, and enzymatic hydrolysis that can manage PCTW accumulation by creating value-added products and biomass in this review. However, these methods are not energy negative (Podgornik et at., 2021). Therefore, textile production and consumption rates must be kept in check. Efforts should be made in increasing the service period of textile products in contrast to the current fast fashion trends. Also, textile product designers must prioritize the longevity and circularity of the products through their design. Increased sustainability through new textile material innovation and recycling strategies also requires parallel adaptation of consumer behavior and waste-minimizing practices to curtail the accumulation of TW in the first place. Textile sustainability must be researched with a holistic viewpoint and find more cost-effective, practical, and eco-friendly solutions to tackle PCTW in mind. Viable solutions are needed to promote circular manufacturing and improve the overall sustainability of the textile industry. In conclusion, a balance must be found between the three pillars of sustainable development often denoted by the 3Es: Environmental impact, Equity, and Economic gain for a balanced economy, production, and consumption. To do that, all stakeholders including producers, policymakers, governmental bodies, manufacturers, retailers, and consumers must collaborate to achieve a sustainable future for the textile industry.

Future research direction

To advance the textile industry's sustainability through biodegradation, research efforts in 3 main directions are needed.

1. Firstly, there has been an emphasis on developing textile polymers that can degrade efficiently in controlled/industrial microbial environments such as anaerobic digestion and composting. Biopolymers that deliver the performance and function of synthetic textiles and at the same time have the biodegradability and renewability of natural fibers can help tackle the accumulation of PCTW.
2. Second, the promotion of recycling and circular manufacturing by developing biobased circular manufacturing technologies that convert textile polymers back to monomers is being explored. However, due to the loss of a fiber's mechanical properties from use and the lack of technology, fiber-to-fiber recycling of PCTW is not possible. More rigorous research efforts are needed to derive solutions for true fiber-to-fiber recycling to make the processes of textile manufacturing circular.
3. Thirdly, efforts to reduce the harm caused by releasing PCTW into the natural environment are being made. The wastes being released into the natural environment must be able to biodegrade without negatively impacting the biosphere in the long term (Hou et al., 2013).

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