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Emissions of Greenhouse Gases from Biobased Diapers with Chemically Altered Protein Superabsorbents

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Abstract

An industrial priority is to transition away from the current mostly fossil-based, throwaway, and non-biodegradable sanitary products and towards sustainable, useful alternatives. Evaluation of suggested biobased alternatives' real effects on greenhouse gas emissions is necessary. Using a biodegradable functionalized protein superabsorbent polymer, we assessed the greenhouse gas (GHG) emissions of biobased newborn diapers, the most often used sanitary product, and compared them to their currently available fossil-based counterparts. Estimated GHG emissions from the production of the biobased components, transportation, and end-of-life combustion of these goods were also considered in the assessment of the diapers. Only a few of the biobased diaper options compared to commercial diapers made of fossil-based materials have lower GHG emissions, research has indicated. Additionally, it was shown that the creation of the bio SAP through chemical alteration of a with 78% of all GHG emissions coming from raw protein, it is the main emitter. With a suggested functionalization agent recycling approach, it was possible to reduce the GHG contribution of the bio SAP production, which resulted in GHG emissions being 13% lower than they would have been had recycling not been done. Overall, we showed that utilising biobased materials, it is possible to produce sanitary articles with reduced and competitive GHG emissions, allowing consumers to continue their current consumption habits while the sanitary business produces disposable products with less environmental impact.

Keywords: Superabsorbent; Diapers; Protein; Sustainability; Circularity

Introduction

The prediction for the entire market value is expected to reach 650 billion USD by the end of 2022. The global market for hygiene products has been growing steadily over the past few decades. Baby and adult disposable single-use diapers make up around 50% of this market [1,3]. The use of these goods increased by about 8% in comparison to 2018 due to the availability of practical and efficient single-use diapers with a liquid absorption capacity over and the growing global population. An outer layer of polyethylene polypropylene film, an inner layer of polyethylene/polypropylene nonwoven, and a middle layer of cellulose pulp combined with a synthetically produced superabsorbent polymer that absorbs are the main components of a traditional single-use diaper and most sanitary products [2,4]. liquid and stop it from leaking With a weight fraction that accounts for almost of the total diaper weight, the SAP in this product engineering context is the component that will have the greatest impact on the diaper's functionality. The charged and partially crosslinked polymeric chains in the SAP account for its high absorbance, which also explains why liquids are retained. However the currently manufactured single-use diapers, whose components are primarily made from the polymerization of monomers sourced from petroleum, have a substantial carbon impact. When creating upscaling methods or processes, consider the high amount of garbage generated that will be used for landfilling or incineration. The environmental impact of these replacements in terms of GHG emissions with respect to the development and production of single-use diapers was assessed in the current study. A perspective from birth to death was evaluated. For a thorough understanding, the 1-min swelling capacity of a reference product SAP made from a commercial diaper and its biobased and biodegradable substitutes were tested experimentally. The study concentrated on using potato protein concentrate and wheat gluten as protein-based sources to create biodegradable SAP substitutes. After that, a GHG emission assessment was done in order to replace the remaining fossil-based diaper components. We were able to present a product configuration in which the GHG emissions from the replacement of various parts could be compared with those of already available commercial products thanks to the many choices for achieving partial or full renewability and biodegradability. The ideas put forth open up a path for creating disposable sanitary products that are efficient and sustainable and adhere to existing standards. Market trends centred on goods that can never be recycled after usage [5,6]. Additionally add to the harm done on the environment. Since disposable diapers are the most popular hygiene item, efforts to evaluate the material choices made are required. As a more sustainable diaper material, some experiments to date have concentrated on replacing the outer layers of fossil-based plastic with counterparts made of biobased polyolefin. To our knowledge, there aren't many researches examining the effects of swapping single-use diapers' SAPs with more environmentally friendly alternatives, despite the SAP's claimed large contribution to these items' carbon footprint when compared to their outer plastic layers[7,8].

Discussion

This can partly be attributed to the difficulty of locating substitute high-performance absorption materials that are biodegradable, which makes it appear challenging to replace the industrially manufactured SAP due to market tendencies that favour products that are never recycled after use [8,13]. Exacerbate the harm already done to the environment. The most common hygiene item is disposable diapers, so

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it is important to consider the material choices used. Some research to date has focused on substituting biobased polyolefin for the outer layers of fossil-based plastic in diapers to create a more sustainable diaper material [9,11]. Despite the SAP's alleged significant contribution to these products' carbon footprint when compared to their outer plastic layers, to our knowledge, there aren't many studies looking at the implications of replacing them with more ecologically friendly alternativesThis can be partially related to the challenge in finding replacements for high-performance absorbent materials in their processed stages; protein concentrates that are not used to make food are easily accessible as industrial byproducts and offer a wide range in terms of their capacity to promote fluid absorption. Despite being heterogeneous materials, proteins have been shown to be susceptible to simple reactions that alter their ability to swell in liquids [7,12]. As of right now, there have been no studies conducted examining the effects of employing such protein-based SAPs in hygiene products on the environment. Also, there is a drive to learn more about protein-based SAP manufacturing sustainability and then use it as a guiding principle because it is now only manufactured on a lab scale [9,10].

Conclusion

An industrial priority is to switch from the current mostly fossil-based, throwaway, and non-biodegradable sanitary products to sustainable, useful substitutes. Evaluation of suggested biobased alternatives' real effects on greenhouse gas emissions is necessary[14,15]. Using a biodegradable functionalized protein superabsorbent polymer, we assessed the greenhouse gas emissions of biobased newborn diapers, the most often used sanitary product, and compared them to their currently available fossil-based counterparts. Estimated GHG emissions from the production of the biobased components, transportation, and end-of-life combustion of these goods were also considered in the assessment of the diapers. Only a few of the biobased diaper options compared to commercial diapers made of fossil-based materials have lower GHG emissions, research has indicated. Also, it was shown that producing the bioSAP by chemically altering a protein was possible. The main source of GHG emissions, accounting for 78% of all emissions, is raw materials. With a suggested functionalization agent recycling approach, it was possible to reduce the GHG contribution of the bioSAP production, which resulted in GHG emissions being 13% lower than they would have been had recycling not been done. Overall, we showed that utilising biobased materials, it is possible to produce sanitary articles with reduced and competitive GHG emissions, allowing consumers to continue their current consumption habits while the sanitary business produces disposable products with less environmental impact. The use of these goods has increased by about 8% compared to 2018 due to the availability of practical and efficient single-use diapers with a liquid absorption capacity above 20 g/g and the growing global population. The main components of a traditional single-use diaper and the majority of sanitary products are an outer layer of polyethylene/polypropylene film, an inner layer of polyethylene/polypropylene nonwoven, and a middle layer of cellulose pulp combined with a synthetically produced superabsorbent polymer that absorbs liquid and prevents its leakage. The environmental impact of these replacements in terms of GHG emissions with a cradle-to-grave perspective was studied in the current study. Step-by-step replacements of fossil-based components to develop and produce single-use diapers were reviewed. The 1-min swelling capacity of a reference product and biobased and biodegradable alternatives of such a product were experimentally assessed for a thorough understanding. The study concentrated on using potato protein concentrate and wheat gluten as protein-based sources to create biodegradable SAP substitutes. After that, a GHG emission assessment was done in order to replace the remaining fossil-based diaper components. We were able to suggest a product configuration where the GHG emissions from replacing various parts would be reduced because to the numerous choices for attaining partial or complete renewability and biodegradability. Could be contrasted with contemporary commercial goods. The ideas put forth open the door to constructing disposable sanitary products that are both efficient and sustainable and that adhere to current market trends based on goods that cannot be recycled after use. The experimental work to create the superabsorbent protein polymer is outlined in this part, along with recommended production methods to reduce greenhouse gas emissions. The GHG emissions of the suggested product alternatives are also discussed, from the usage of raw materials to the final disposition of the used product.

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None

Conflict of Interest

None

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