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Research Paper

Development of Eco-Friendly (Biodegradable) Sanitary Napkins by Using Banana fiber

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ABSTRACT

Growing awareness about environmental pollution caused by conventional sanitary napkins has led to increased interest in eco-friendly alternatives. Most modern sanitary napkins contain plastic and superabsorbent polymers, which can take approximately 500 years to decompose. This creates a serious environmental issue, especially considering that an average woman uses around 11,000 pads in her lifetime, most of which end up in landfills. To address this problem, biodegradable sanitary napkins have been developed using natural materials such as banana Fiber, bamboo, and polylactic acid derived from cornstarch. This study explores the feasibility of using these environmentally sustainable products, with a particular focus on cost factors and their environmental impact. The proposed materials offer several advantages, including low cost, high biodegradability, good absorbency, strong tensile strength, and suitability for production in developing regions. The results related to banana Fiber sheet production and its application in sanitary napkins are promising, especially in terms of absorbency, antibacterial properties, and biodegradability. Experimental findings indicate that these biodegradable napkins decompose within a few months, unlike conventional plastic-based products that take several centuries. Although biodegradable napkins are currently more expensive due to higher production costs, efforts such as local sourcing and improved processing techniques are expected to reduce costs over time. Overall, this research highlights the potential of biodegradable sanitary napkins to minimize environmental damage while providing safe, hygienic, and affordable menstrual hygiene solutions. With further development and large-scale production, these products could become widely accessible and sustainable for users worldwide.

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INTRODUCTION

Sanitary napkins, commonly used by women during menstruation, are typically manufactured using materials such as plastics, superabsorbent polymers (SAPs), and nonwoven fabrics. These products have greatly improved menstrual hygiene and comfort over time. In recent decades, the demand for sanitary napkins has grown rapidly across the world. In 2020, the global feminine hygiene market was valued at approximately USD 37.4 billion, with sanitary napkins representing a major portion of this market.

However, despite their benefits, conventional sanitary napkins pose serious environmental challenges. They are mainly composed of non-biodegradable materials like polyethylene, polypropylene, and synthetic adhesives, which do not break down easily. As a result, they contribute heavily to environmental pollution. It is estimated that an average woman uses about 11,000 sanitary pads during her lifetime, most of which are discarded in landfills. Due to their plastic content, these pads can take between 500 to 800 years to decompose, worsening the issue of plastic waste accumulation.

Apart from environmental concerns, the use of synthetic materials in sanitary napkins may also lead to certain health issues. Chemicals present in these products can sometimes cause skin irritation and infections. These risks further emphasize the need to develop safer and more sustainable alternatives.

Biodegradable sanitary napkins offer a potential solution to these problems. However, their affordability remains a concern, especially in developing regions where access to basic menstrual hygiene products is limited. Therefore, there is a strong need for products that are both eco-friendly and economically accessible.

This study focuses on the development and feasibility of innovative biodegradable sanitary napkins, considering both cost-effectiveness and environmental impact. The aim is to explore sustainable options that can replace conventional products while ensuring affordability, safety, and accessibility for women from all socioeconomic backgrounds.

II. MATERIALS USED IN BIODEGRADABLE SANITARY NAPKINS: BIODEGRADABLE ALTERNATIVES TO PLASTICS

Due to the negative environmental effects of plastic-based sanitary napkins, researchers have been actively exploring eco-friendly alternatives. Various natural and biodegradable materials such as bamboo Fiber, banana Fiber, cornstarch-based polymers, and cotton have been studied for their suitability in menstrual hygiene products. These materials are evaluated based on properties like absorbency, biodegradability, and overall performance.

Unlike conventional plastic materials, these natural fibres decompose much more quickly. In addition, they possess hypoallergenic characteristics, making them safer for prolonged contact with the skin.

Banana Fiber

Banana Fiber is obtained from the pseudo stem of banana plants and has emerged as a promising biodegradable material. It is widely available in tropical regions and is known for its good tensile strength, high absorbency, and excellent biodegradability. Being a low-cost and easily accessible resource, banana Fiber is considered a suitable option for manufacturing affordable biodegradable sanitary napkins, especially in developing countries.

Environmental Impact of Biodegradable Sanitary Napkins

Biodegradable sanitary napkins have a significantly lower environmental impact compared to conventional plastic-based products, as they break down more quickly and reduce long-term waste accumulation.

Biodegradability and Decomposition Time

Biodegradable sanitary napkins made from materials such as bamboo, banana fiber, and cornstarch-based polymers can break down within a few months to a few years. In contrast, conventional sanitary napkins require several centuries to decompose. This significant difference helps in greatly reducing the amount of waste generated by menstrual hygiene products.

III. REDUCTION OF CARBON FOOTPRINT

In comparison, the production and disposal of conventional sanitary napkins result in a high carbon footprint due to energy-intensive processes involved in plastic manufacturing and waste management. From production to final disposal, these activities contribute significantly to environmental pollution.

On the other hand, biodegradable sanitary napkins have a much lower carbon footprint, as they rely on natural materials and involve less energy-intensive processes, making them a more environmentally sustainable option.

IV. AFFORDABILITY AND ACCESSIBILITY

Cost of Biodegradable Sanitary Napkins

One of the key challenges in the widespread use of biodegradable sanitary napkins is their higher cost. As of 2023, eco-friendly sanitary napkins are typically more expensive than conventional ones due to the increased cost of raw materials and more complex production processes.

However, ongoing advancements in manufacturing techniques and the large-scale production of biodegradable materials are gradually lowering these costs. This is helping to improve the affordability and accessibility of these products for a wider population.

Strategies for Making Biodegradable Napkins Affordable

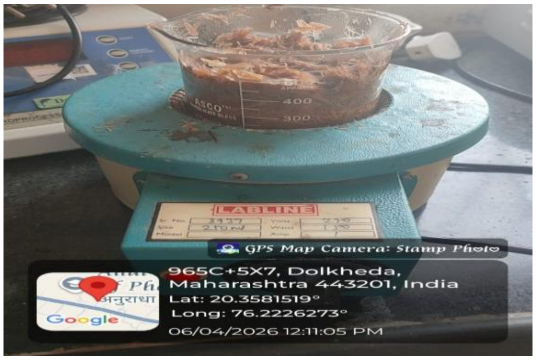
Several approaches are being adopted to reduce the cost of biodegradable sanitary napkins. These include the use of locally available raw materials such as banana fibers, the establishment of community-based production units, and the implementation of government subsidies and policies that support menstrual health and environmental sustainability.

In addition, non-governmental organizations (NGOs) play an important role in improving access by supplying affordable biodegradable sanitary napkins to women in rural and low-income areas.

V. Material and method’s

Preparation of banana fiber sheet Procedure:

The banana stem was rinsed with water and dried using a cloth. Fibers were carefully separated from each stem and collected. These fibers were dried at room temperature for two days. After drying, 50 g of fibers were weighed and cut into small pieces.A beaker containing 400 ml of water was heated, and a 12% NaOH solution was added. The chopped banana fibers were then introduced into the solution and boiled for 4–5 hours.After boiling, the fibers were washed with cold water until neutral pH was achieved. The fibers were then immersed in chlorine water for 2 hours for bleaching. After bleaching, fibers were again washed thoroughly to remove chlorine.The cleaned fibers were ground using a mixer grinder to form pulp. At this stage, cotton pulp was added (in appropriate proportion, e.g., banana pulp : cotton pulp = 70:30) to improve softness and absorbency. During grinding, starch or tragacanth (2 g per 50 g fibers) was added as a binding agent.The combined pulp (banana + cotton) was poured into a mold and evenly spread to form a sheet. The sheet was then dried under sunlight or in a hot air oven



VI. MATERIALS AND METHODS

Absorbency capacity

The absorbency capacity is evaluated in accordance with the EAS 96:2008-Annex C standard. The sample is first weighed in dry state, and then fluid is added until saturation is attained. When the pad reached saturation, a 3.4 kg weight is placed over it, and the excess liquid is wiped off using filter paper and then the pad is weighed. The following formula is used to determine the absorption capacity: Absorption capacity = (W-X) gm. where X is the dry weight of the pad expressed in grams W is the final weight of the pad after saturation underweight expressed in grams

Antibacterial Tests

To provide antibacterial properties to the sanitary napkins, the fabric was treated with boiled water containing extracts of turmeric and neem powder. This method has been supported and validated by several researchers. The antibacterial activity was evaluated using the ASTM E2149 standard method.

For the experiment, separate 250 mL flasks were prepared for neem- and Tulsi-treated samples, along with one untreated control sample. Each flask contained 50 mL of a bacterial suspension with a concentration of 1.5–3 × 10^5 CFU/mL. Nonwoven fabric samples, cut into 1 cm × 1 cm pieces, were added to the flasks. All flasks were loosely covered and placed in a shaking incubator at 37°C and 120 rpm for 1 hour. After incubation, a series of dilutions was prepared using a buffer solution. From each dilution, 0.1 mL was spread onto nutrient agar plates. These plates were then incubated at 37°C for 18–24 hours, after which the number of surviving bacterial colonies was counted. All procedures involving bacterial culture preparation and transfer were carried out under a safety cabinet to maintain sterile conditions. The antibacterial effectiveness was determined by comparing the number of surviving bacterial cells in the treated samples with the control sample using the following equation [19]:

$$\% \text{Reduction} = [(B - A) / B] \times 100$$

Where:

A = Number of viable cells (CFU/mL) in the test sample after 1 hour

B = Number of viable cells (CFU/mL) in the control sample after 1 hour

This method was used to evaluate the antibacterial efficiency of the proposed sanitary napkin formulation.

SR No	component	Raw Material	Function
1	Top sheet	1 layer of muslin cloth	A liquid-permeable surface layer that allows fluid to pass through easily while remaining gentle on the skin.
2	Softness one	Cotton 3layer	Provides cushioning and enhances overall softness.
3	Absorbent core	1 layer of banana fiber	Acts as a biodegradable material that effectively absorbs fluid.
4	Back sheet	1bailayer of parchment paper	Serves as a moisture-resistant layer that prevents leakage.

Leakage Test

According to EAS 96:2008, Annex B, the leakage test is conducted to assess the effectiveness of the barrier layer. A barrier sheet measuring approximately 6.5 mm is cut, weighed, and shaped into a cone. This conical sheet is then placed inside a funnel.

A total of 20 mL of test fluid (water) is poured into the funnel. The setup is left undisturbed for 24 hours. After this period, the funnel is examined for any leakage by determining the difference between the final weight and the initial dry weight of the barrier sheet.

Degradation Study

The samples were subjected to soil degradation studies to assess their degradability. Test specimens measuring 2 × 2 cm2 were buried in the soil, and their weight was recorded on a weekly basis. The weight loss was calculated and is depicted in Equation (2).

Weight reduction =<u>weight of napkin before degradation- weight of napkin after degradation</u> ×100

Actual weight of the napkin

Biodegradation Test

In this experiment, both types of napkins were cut into small pieces and placed in a container filled with soil. After specific time intervals of 3, 6, and 8 months, the shredded samples were removed from the soil, rinsed again with distilled water, dried, and weighed.

Wetback Test

The wetback test was conducted to assess the ability of the pad to prevent fluid from returning to the surface after being absorbed through the top layer. In this method, 20 mL of test liquid was poured onto the sample. A pre-weighed filter paper was then placed on top of the sample, and a pressure of 3.4 kg was applied for 3 minutes. After the specified time, the filter paper was removed and weighed again. The increase in the weight of the filter paper was recorded as the “wetback,” which indicates the amount of fluid that returned to the surface.

RESULT AND DISCUSSION

SR No	Mechanical and Physical properties	Details
1	Density(g/cm3)	1.25-1.45
2	Tensile Strength (MPa)	515-795
3	Elongation (mm)	2.2.4
4	Fiber Diameter (m4)	54-224
5	Chemical Properties of cellulose (%)	58-61
6	Hemicellulose (%)	5-8
7	Lignin	4-7

Absorbency capacity

SR No	No of time tested the same sample	Napkin size	Before weight	After weight	Liquid absorbency
1	Frist time	Regular	16.13 gm	42.33gm	20ml
2	Second time	Regular	42.33gm	68.63gm	40ml

Leakage Test

SR No	Barrier sheet length	Barrier sheet width	Water ml	Time (Hrs)
1	6.5cm	6.5cm	20ml	24 hrs

Leakage Resistance of the biodegradable material chosen for the sanitary pad's barrier layer has been tested to see how well it can prevent leaks. When the barrier sheet was folded into a cone shape and left with fluid for 24 hours, it is found that there is no evidence of leakage.The test results demonstrate good liquid resistance of the barrier sheet.

Wet back test

Napkin Size Filter paper weight (dry) Filter paper weight (wet) Filter paper weight (wet) 1.100g 2.620g 1.520g

Sr.no	Napkin Size	Filter paper weight (dry)	Filter paper weight (wet)	Wet back Level
1	Regular	1.050g	2.480g	1.430g

The results of the Wet back characteristics of samples are shown in fig 3 shows satisfactory values of wet back test

Wet back value= Wet filter paper weight - Dry filter paper

Lower wetback value means better the sanitary pad performance.

VII. COST OF DEVELOPED PAD SAMPLE

SR No	Raw material use to develop napkin	Cost
1	1 layer of muslin cloth	0.1
2	cotton 3 layers	1.25
3	1 layer of banana fiber sheet	2.0
4	1 bilayer of parchment paper	0.50
	Total cost	3.85Rs

CONCLUSION

Biodegradable sanitary napkins made from banana fiber are an innovative and sustainable solution for menstrual hygiene management. Banana fiber, a natural by-product of banana plants, is highly absorbent, biodegradable, and easily available, making it an ideal raw material for eco-friendly sanitary products.

These napkins provide good absorption capacity, breathability, and comfort while being completely free from harmful chemicals and plastics. As a result, they are safe for skin and help reduce problems such as irritation, rashes, and infections. Additionally, since banana fiber is biodegradable, these napkins decompose naturally within a short period, significantly reducing environmental pollution compared to conventional sanitary pads. The use of banana fiber also supports waste utilization and promotes rural employment, especially in agricultural regions where banana cultivation is common. However, factors like production cost, lack of large-scale manufacturing, and limited awareness may affect their widespread adoption.

In conclusion, banana fiber-based biodegradable sanitary napkins are an effective, eco-friendly, and economically beneficial alternative, contributing to both environmental sustainability and improved women's health.

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