Mount HIRA Matriculation School

Nellikuppam

STUDENT NAME

O.ZAINAB

CLASS

GRADE 8

PROJECT TITLE

CREATING A BIODEGRADABLE DIAPER FROM NATURAL RESOURCES

Introduction

This research project focuses on designing a biodegradable diaper made from natural resources such as bamboo fiber, banana fiber, hemp, and organic cotton. The aim is to prove that natural fibers can provide comfort and absorbency while ensuring faster decomposition and minimal environmental impact. If successful, this project can offer a model for eco-friendly baby care products, contributing to the reduction of plastic pollution.

2. Selection of the Problem and Background Information

The problem of disposable diaper waste is both environmental and health-related. Parents and caregivers choose disposable diapers for convenience, yet very few consider their long-term environmental impact. In India alone, an estimated 2–3 billion diapers are used annually, with almost all ending up in landfills.

Apart from the waste problem, disposable diapers are often associated with skin rashes, allergies, and discomfort caused by synthetic chemicals, perfumes, and dyes. Studies have reported traces of harmful dioxins, volatile organic compounds (VOCs), and phthalates in conventional diapers, raising concerns about infant health.

In contrast, natural resources such as **bamboo and banana fibers** have unique properties:

- Bamboo fibers are **antibacterial, breathable, and highly absorbent**.
- Banana fibers are **strong, lightweight, and biodegradable**.
- Hemp and cotton are **soft, durable, and renewable**.

By combining these natural fibers into a layered diaper structure, it is possible to create a product that is safe, effective, and environmentally sustainable.

3. Objectives

The project is designed with the following objectives:

1. To create a diaper prototype entirely from natural and biodegradable resources.
2. To test and compare the absorbency and leakage resistance of natural fibers.
3. To examine the biodegradability of the materials under soil/compost conditions.
4. To evaluate comfort and skin-friendliness of natural fiber linings.
5. To estimate the production cost and feasibility for mass use.
6. To highlight the environmental benefits of shifting to biodegradable alternatives.

Healthier for Babies: The natural, gentle materials are safer for delicate skin and can help prevent diaper rash and irritation.

Environmental Responsibility: By using renewable resources and promoting faster decomposition, these diapers significantly lower the environmental impact of diaper use. To practically create a biodegradable diaper, source materials like bamboo, organic cotton, or hemp for absorbency and a soft, chemical-free top layer, assemble them with a waterproof, plant-based backing, and integrate components like seeds in the absorbent core to add value and ensure full biodegradability.

Reduced Plastic: Eco-friendly diapers use less plastic and avoid oil-based plastics in their construction. Chemical-Free: The process eliminates harsh chemicals, synthetic fragrances, and chlorine, which are often found in traditional diapers.

Biodegradability: Materials are chosen to decompose more rapidly in landfills or compost sites, reducing waste accumulation.

Guiding Principle

The guiding principle of this project is based on the idea that **natural plant-based fibers and biodegradable films can be assembled into layered structures that mimic the absorbency and leakage control of commercial disposable diapers, while ensuring complete biodegradability in soil or compost conditions**.

1. Layered Structure Concept

Conventional disposable diapers rely on three functional layers:

1. **Inner Layer (comfort layer):** soft, non-irritating fabric that touches the baby's skin.
2. **Absorbent Core:** superabsorbent polymers and cellulose that hold large volumes of liquid.
3. **Outer Layer (barrier):** waterproof plastic sheet that prevents leakage.

The biodegradable diaper follows the same principle but replaces synthetic materials with **natural resources**:

- **Inner Layer:** Organic cotton fabric provides softness, breathability, and prevents rashes. Cotton and bamboo are known for their **skin-friendly, hypoallergenic qualities**, which make them ideal for prolonged contact.
- **Absorbent Core:** Natural fibers like **bamboo, banana fiber, or hemp** are chosen because of their **hollow structures** and **high water retention capacity**. For example, bamboo fiber can absorb liquid up to **three times its weight**, while banana fiber provides structural strength and resilience. The combination of fibers ensures both **absorbency and durability**.
- **Outer Layer:** Instead of petroleum-based plastics, a **biodegradable film (PLA/PHA)** or **wax-coated cotton** is used. This layer acts as a barrier against leakage while remaining breathable. PLA (polylactic acid) is derived from corn starch and decomposes under composting conditions, aligning with the project's eco-friendly goals.

2. Natural Fiber Absorbency Principle

Absorbency depends on **capillary action and fiber porosity**. Plant fibers like bamboo and banana have microscopic pores and capillary channels that allow them to absorb and lock in moisture. Unlike superabsorbent polymers, which swell into gels, natural fibers hold water through their cellulose structure, making them **biodegradable and non-toxic**.

By increasing the **number of layers** of these fibers, the diaper's absorbency can be adjusted. The guiding principle here is **layer optimization**: finding the right thickness that balances comfort, absorbency, and biodegradability.

3. Biodegradability Principle

The guiding idea is that all chosen materials must be capable of decomposing naturally into **organic matter, water, and carbon dioxide** when exposed to soil microbes. Unlike plastic diapers that remain intact for centuries, cotton, hemp, bamboo, and banana fibers break down within weeks to months. PLA films also degrade under composting conditions, reducing long-term waste.

Thus, the guiding principle ensures that **nothing in the diaper contributes to non-biodegradable waste**. Every component—fiber, film, elastic, or fastener—is chosen with decomposition in mind.

4. Comfort and Safety Principle

Infants' skin is sensitive and prone to irritation. Conventional diapers often contain **dyes, perfumes, and chemical gels**, which can cause rashes. The guiding principle of this project is to ensure **safety and comfort through natural fibers**:

- Organic cotton and bamboo naturally resist bacterial growth, reducing diaper rash.
- Breathable materials keep skin dry and minimize discomfort.
- Absence of chemicals ensures hypoallergenic properties.

5. Environmental and Economic Sustainability

The project is also guided by the principle of **using locally available natural resources**. Banana fiber and hemp, for instance, are agricultural by-products and can be obtained at low cost. This reduces dependence on imported synthetic materials and promotes **local cottage industries**.

By designing a diaper from **renewable and abundant materials**, the project supports both **environmental sustainability** and **economic feasibility**.

4. Hypothesis

My hypothesis is that a diaper made entirely from natural resources such as bamboo fiber, banana fiber, hemp, and organic cotton will demonstrate adequate absorbency and leakage resistance for practical use, while showing faster biodegradability compared to conventional plastic diapers.

5. Materials

The following materials are required to construct and test the biodegradable diaper:

- **Fibers and fabrics:** Organic cotton (inner lining), bamboo fiber sheets, banana fiber, hemp fabric.
- **Outer protective layer:** PLA (polylactic acid) biodegradable film or wax-coated cotton.
- **Fastening materials:** Biodegradable elastic bands, Velcro or cloth ties.
- **Testing materials:** Synthetic urine (prepared using water, salt, and urea), measuring cylinders, weighing balance, stopwatch.
- **Biodegradation setup:** Compost or soil-filled containers, thermometer, and moisture monitor.
- **Tools:** Sewing machine, scissors, fabric pins, adhesives (non-toxic and eco-safe).

6. Methodology

a) Prototype Development

1. Cut an inner layer of organic cotton for softness.
2. Prepare absorbent core layers using bamboo and banana fibers, layered to increase thickness.
3. Add hemp or cotton as secondary absorbent reinforcement.
4. Use PLA film or waxed cotton as the outer waterproof layer.
5. Sew the layers together, adding elastic edges and fastening straps.

b) Absorbency Test

1. Weigh the dry diaper.
2. Pour 50–150 mL of synthetic urine on the inner surface.
3. Record the time taken for liquid absorption.
4. Measure the weight of the diaper after absorption to calculate absorbency.
5. Apply pressure using a weight to simulate sitting and check rewetting.

c) Leakage Test

- Tilt the diaper and apply pressure to check for seepage.
- Record the volume at which leakage occurs.

d) Biodegradability Test

1. Bury small samples of cotton, bamboo, banana fiber, hemp, and the finished diaper in compost/soil.
2. Record initial mass.
3. Retrieve samples at intervals of 2, 4, 8, and 12 weeks.
4. Measure weight loss and record visible signs of decomposition.

7. Variables

Independent Variables

- Type of natural fiber used (bamboo, banana, hemp, cotton).
- Thickness of absorbent layer.
- Type of outer waterproofing (PLA vs waxed cotton).

Dependent Variables

- Absorbency capacity (mL).
- Leakage resistance (time/volume).
- Comfort (softness, irritation, breathability).
- Biodegradation rate (% mass loss).

8. Data Collection and Analysis

Data will be collected systematically:

- **Absorbency:** measured in mL retained per gram of material.
- **Leakage:** time and volume until seepage occurs.
- **Rewet:** amount of liquid expelled under pressure.
- **Biodegradation:** percentage weight loss over weeks.

Graphs will be plotted to show:

- Absorbency vs. type of fiber
- Biodegradation percentage vs. time.

9. Risk Factors and Safety

- Use only synthetic urine for hygiene.
- Handle scissors, sewing needles, and hot sealing equipment with care.
- Compost containers should be handled with gloves to prevent contamination.

BIBILOGRAPHY

Al-Salem, S. M., Lettieri, P., & Baeyens, J. (2009). Recycling and recovery routes of plastic solid waste (PSW): A review. *Waste Management, 29*(10), 2625–2643.

Gajra, B., Pandit, A., & Singh, H. (2017). Biodegradable superabsorbent polymers for sanitary napkins and diapers. *Journal of Applied Polymer Science, 134*(31).

Nair, L. S., & Laurencin, C. T. (2007). Biodegradable polymers as biomaterials. *Progress in Polymer Science, 32*(8–9), 762–798.

Szefer, E., et al. (2019). Eco-diapers: Development of biodegradable diapers using natural fibers and biopolymers. *Journal of Cleaner Production, 223*, 554–562.

UNEP. (2021). *Single-use diapers and their alternatives: Recommendations for policymakers*. United Nations Environment Programme. Retrieved from: https://www.unep.org

Environmental Paper Network. (2020). *The environmental impact of disposable diapers*. Retrieved from: https://environmentalpaper.org

ScienceDirect. (2022). Articles on biodegradable diapers and sustainable materials. Retrieved from: https://www.sciencedirect.com

National Geographic. (2019). *What's the environmental impact of disposable diapers?* Retrieved from: https://www.nationalgeographic.com