

# **RESEARCH PAPER**

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## **Acknowledgements**

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## **Investigating biodegradable polymers as a sustainable alternative to the conventional sanitary pad.**

### **Abstract**

#### **Background**

In developing countries, the amount of pollution derived from synthetic polymers is significant. Sanitary pads, essential for women during menstruation, are made from non-degradable polymers. They add to the large quantities of pollution generated by synthetic polymers (SAP). Women in India often use unsanitary material to control their menstrual cycle, leading to a plethora of diseases. This research aims to find an alternative to this polymer to create a biodegradable pad that will be environmentally and user-friendly.

#### **Result**

I proposed sodium alginate along with carboxymethyl cellulose (CMC) as a possible replacement for Super Absorbent Polymers (SAP) in the principal layer of sanitary napkins. This biodegradable polymer has key advantages related to absorption, fluid retention strength, tensile strength and cost reduction.

## Conclusion

The analysis concludes significant advancement and cost effectiveness for the newly designed prototype. Sanitary napkins without SAP in the core layer would create significant environmental impact along with being more user friendly.

**Keywords:** sanitary pads, biodegradable polymers, super absorbent polymers, biodegradability, sodium alginate , carboxymethyl cellulose

## I. INTRODUCTION

Menstruation is a natural female phenomenon that occurs every month for 2-5 days. The menstrual cycle plays an imperative role in a female's reproductive system. The menstrual cycle starts seeing a high flow rate declining slowly from the second or third day, with a menstrual average blood loss of 35 millilitre (ml) where the blood loss (10–80) ml is considered normal (Nyoni et al. 2014). The menstrual fluid generally contains 50%-60% blood along with mixtures of uterine, cervical and vaginal secretion (Fraizer 2006; Chakwana and Nkiwane 2014). To absorb and retain the menstrual fluid, sanitary pads are the most viable and commonly used product to control bleeding.

Developed first in 1888, a sanitary pad is a menstrual product worn by menstruators that is made of absorbent material to absorb menstrual blood. Originally made of cotton and gauze, and later wood pulp, the material availability declined and a need arose for cost-effective and easily available materials. With the plastic revolution, there was a transformation in the nature of the sanitary pad. Today the entire sanitary pad is made of plastic due to its waterproof capability and the superabsorbent polymer (SAP) which improved absorption, shelf life , as well as cost effectiveness.

Around the world menstruation is a subject that is often overlooked and a topic that is unfortunately discussed in whispers. In India, the topic of the period is a cultural taboo, leading to ignorance of menstrual hygiene compelling women to resort to

absorbents such as sand, muslin cloth, and other homemade and inexpensive solutions. These materials are not only inefficient but unsanitary as they lack absorbing and liquid retention capacity causing a plethora of diseases. As per WHO's data, "India accounts for around 27 per cent of the world's cervical cancer deaths, almost twice the global average —poor menstrual hygiene is partly to blame."

In urban India, there is an increase in the use of menstrual hygiene products especially sanitary napkins because they have been exempted from the ambit of the Goods and Services Tax making them more affordable and accessible to women of all strata. Despite the benefits of using of sanitary pads to a woman's health, a conventional sanitary pad is 90% plastic and a pack of menstrual pads is equivalent to 4 plastic bags adding to the global plastic epidemic . An average person who menstruates discards **200kg of menstrual products in their lifetime**. This poses a problem for the environment. In addition, each sanitary pad takes **500-800 years to decompose** since they are made up of super absorbent polymers which are non-biodegradable and break up into microplastics contaminating the soil, water and air and entering into the food chain. According to a report by DASRA (2017) over one billion non-compostable sanitary pads make their way into the sewage system, and pollute land and water bodies in rural and urban India every month.

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Goel, Ishita. "From Wood Splinters to Menstruation Belt: How Sanitary Napkins Evolved over Time." *The Indian Express*, 23 July 2018, [indianexpress.com/article/lifestyle/health/gst-sanitary-napkins-history-5269817/](https://indianexpress.com/article/lifestyle/health/gst-sanitary-napkins-history-5269817/).

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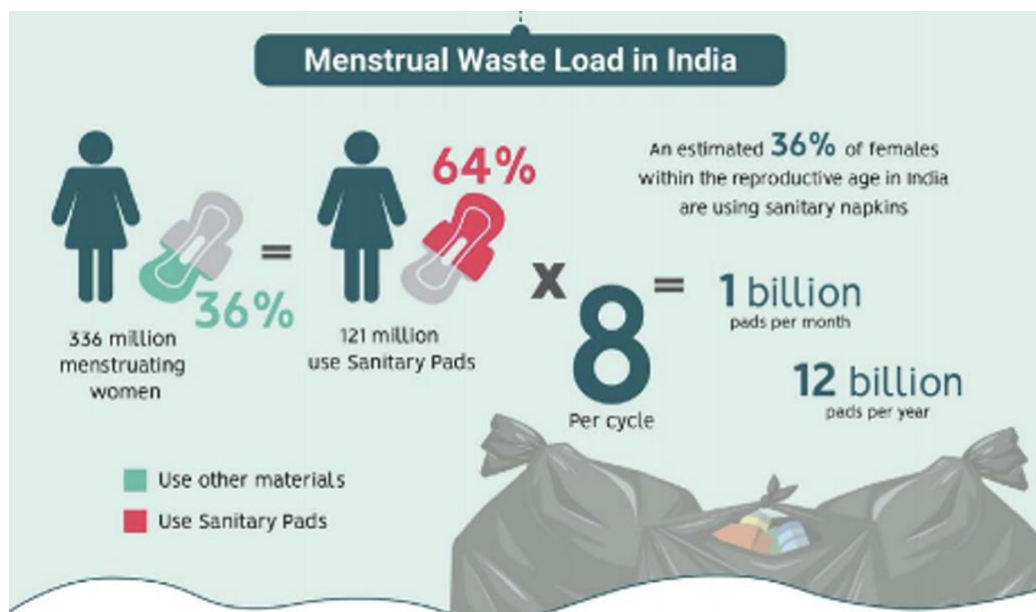


Figure 1: Plastic pollution derived from menstrual waste in India

In India, petroleum-derived synthetic non degradable polymers have caused a lot of environmental pollution due to their resistance to **microbial degradation**, thus adding to huge amounts of land pollution. Efforts have been taken to substitute the core of the sanitary pads with bamboo fibre, cotton and other natural materials. **Sanitary pads made of cotton and like other crops, have pesticides and herbicides are sprayed on cotton crops that can definitely cause harm when they reach the bloodstream.** This exposes a primary gap in research and development related to sanitary pads. While environmentally friendly options exist, more work remains to create a sanitary pad that is environmentally friendly, safe for human use, and economically sustainable.

Hence, this paper will focus on investigating a biopolymer that can be substituted in place of SAP's in the absorbent core layer of the sanitary pad. The key features of the chosen biopolymer will be biodegradability, non-toxicity, and biocompatibility, which will not only be beneficial for the environment but also user friendly. In section II, I review important types of polymers and discuss the materials considered for my product prototype. Further in section III, I will present my proposed solution to the conventional sanitary pad.

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## II. MATERIALS

Polymer materials are solid, non-metallic compounds of high molecular weights. They are comprised of repeating macromolecules, and have varying characteristics depending upon their composition. Each macromolecule that comprises a polymeric material is known as a mer unit. A single mer is called a monomer, while repeating mer units are known as polymers.

Sanitary pads and other personal hygiene products usually have a backing layer that is composed of a film constructed from a liquid-repellent material. This liquid-repellent film commonly uses plastic material such as polyethylene films. Polymer blends of polyolefins exhibit very poor mechanical compatibility, the encapsulation of polyolefins effectively prevents any degradability. In the context of the sanitary pad, it is essential to first understand the benefits of Super absorbent polymers currently present in the core layer of the conventional sanitary pads. After discussing this we will turn to a discussion of alternative biodegradable polymers.

### A) SUPER ABSORBENT POLYMERS

The menstrual pads have three principal layers: the top sheet, the absorbing core of absorbing material and the leaking barrier sheet (Yadav et al. 2016). The absorbent core is integrated with super absorbent polymers (SAP) such as **sodium polyacrylates** along with cellulosic fibre to enhance the absorbency and retention capacity. Super absorbent polymers like **sodium polyacrylates** are integrated into the absorbent core along with the soft cellulosic fibre to enhance the absorbency of the core. The **loosely linked structure** with the polymer chains grants these polymers additional absorbency properties. Even though these super absorbent polymers have this specific benefit of absorbency, they are **petroleum-based polymers** that do not degrade into the earth, and in the long term, exposure has also caused skin infections and toxic shock syndrome (Berkley 1987) to users. SAP's are extremely difficult for bacteria to decompose and hence have become a leading source of pollution. The average woman uses up to 10,000 sanitary pads from menarche to menopause (Verma

& Sambyal, 2018), and all these non-degradable polymers arrive at landfills harm the environment. The proposed solution should also have properties of absorbency in order to fulfil the objective of the sanitary pad in absorbing the menstrual blood.

## **B) BIODEGRADABLE POLYMERS**

In developing countries, the level of environmental pollution by synthetic polymers has resulted in dangerous consequences due to high levels of usage. Petroleum-derived polymers are not easily biodegradable and **resist any microbial degradation** causing them to accumulate in nature. In contrast, biodegradable polymers are defined as material whose chemical and physical characteristics undergo deterioration and completely degrade when exposed to microorganism, aerobic and anaerobic processes.

Scientists and engineers are making the shift easier by fine-tuning the structure and function of these biomaterials while also developing better processing techniques. Biodegradation of polymeric biomaterials involves cleavage of hydrolytically or enzymatically sensitive bonds in the polymer leading to **polymer erosion**, these polymers break down after their use, they can be found naturally as well as derived synthetically. Biodegradable polymers largely consist of **ester, amide** and **ether** functional groups. The property of degradability of these polymers is based on their structures, specifically biodegradable polymers have extremely strong carbon-carbon bonds that are difficult to break. Biodegradable polymers can be divided into natural or synthetic polymers.

Although synthetic plastics are a more economically feasible choice than biodegradable ones, an increased availability of biodegradable plastics will allow many consumers to choose them on the basis of their environmentally responsible disposal and also shift production of synthetic plastics to bio plastics. A range of biodegradable polymers were studied and analysis to name a few: Polysaccharides, lipids, collagen.

### III. MY SOLUTION

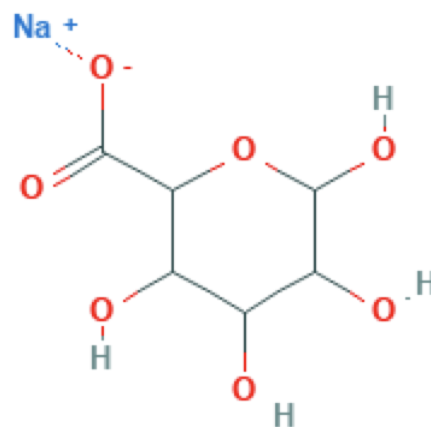
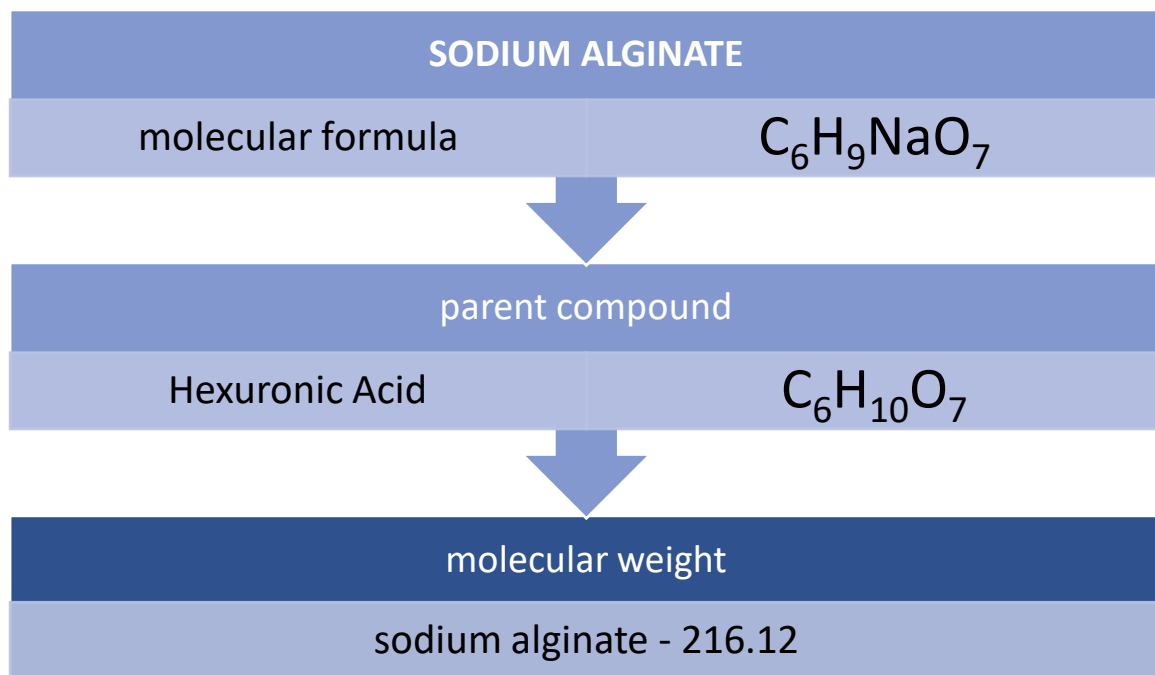
#### PROPOSED ALTERNATIVE

Balancing the need for absorbency and biodegradability, my research led us to discover alginate. A polysaccharide derived from brown seaweed, alginate that has been proposed as an alternative is sodium alginate. Alginate can be processed easily in water as chitosan and is fairly non-toxic and non-inflammatory. It has been proved that alginate is biodegradable, it has controllable porosity, and may be linked to other biologically active molecules.

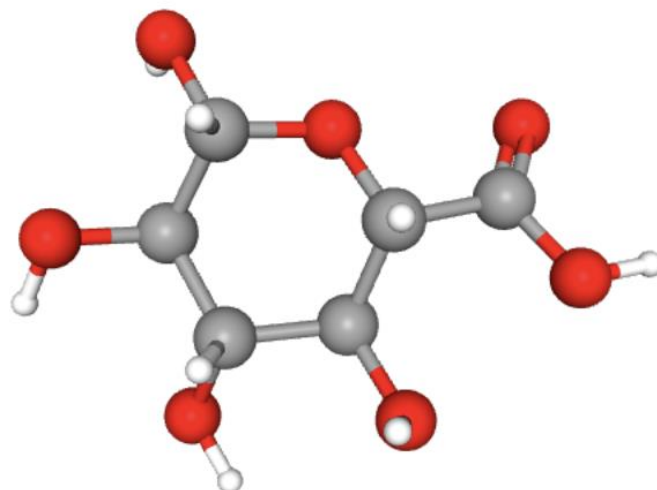
**Sodium alginate** was proposed as an alternative. The core absorbent layer boost requirements such as absorption, fluid retention strength, softness and cost reduction. Sodium alginate and carboxymethyl cellulose (CMC) offer a possible replacement for SAP. Algin is the compound found in algae, and sodium alginate is the salt formed when it comes in contact with sodium or some other metal. Carboxymethyl cellulose has been added because it thickens the polymer. Viscosity refers to how thick a material is, essentially, how runny it is. Polyalginate on their own are viscous materials that need to be thickened by a viscosity modifier like CMC in order to see use.

The consequential advantage of the selection of sodium alginate and cellulose-based hydrogels for the development of sanitary napkins over SAP lies in their biodegradability and environmentally friendly nature. Sodium alginate is an acidic polysaccharide composed of linear block copolymer 1–4 bound  $\beta$ -mannuronic acid and  $\alpha$ -guluronic acid (Bardajee et al. 2008). On the other hand, CMC comprises hydrophilic carboxylate units in its polymeric structure that can consume lots of water. The higher number of negative ( $\text{COO}^-$ ) charges of CMC in gels eventually enlarge the molecular chains of repulsion, leading to an increase in mesh size and assistance in the uptake of water (Tang et al. 2014). Several scientists have earlier documented the biodegradability and biocompatibility of sodium alginate and CMC and it is a common perception that these biopolymers are beneficial to the environment and to personal health (Hubble et al. 2013).

The cost effectiveness of sodium alginate was also taken into consideration while coming to a conclusion to choose this for the sanitary pad. Compared to other biopolymers the cost of sodium alginate granules are relatively small compared to other biopolymers. This would make it feasible for industries to shift their raw material to this new alternative. In addition, high sodium alginate content and CMC incorporate excellent hydrophilic characteristics, resulting in an increase in water absorption capacity within a very short period of time



In Figure 2 we see the 2D Structural model of sodium alginate



In Figure 3 we see the 3D model of sodium alginate

If a team and myself work on the development of the pad the following tests will have to be carried out which will allow to verify my results.

### **Tensile testing**

Tensile strength is the ability of a material to withstand a pulling (tensile) force and refers to the breaking strength of a material when applying a force capable of breaking many strands of the material simultaneously, at a constant rate of extension/load. It is customarily measured in units of force per cross-sectional area. The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used for structural applications. The sanitary pads physical attribute of tensile strength can be verified by taking samples and running them on an Instron machine to get stress-strain curves to see how durable the material is.

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## **Absorbency capacity**

An absorbent capacity test is used to assess a material's ability to absorb a liquid and how quickly it does this, defined as its speed of absorption. It is a common test used to assess the absorbency of materials such as diapers, sanitary pads etc. once the proposed material is produced this test can be undertaken which will verify the results. For evaluating absorbent capacity of developed sanitary napkin, saline solution was used as a substitute of blood.

To further verify this material the tests that can be taken are :

- Strike through test: Strike through penetration time is a measure of the speed at which the liquid has been transported from the surface of the pad to the inside.
- Retention capacity test : Retention capability for sanitary napkin is a very important characteristic that usually measures the pad's ability to manage menstrual fluid before leakage.
- Wicking height test: Wicking is an absolutely fundamental quality of sanitary pads as they allow the blood to be distributed throughout the pad's entire structure while allowing the accumulated blood to be retained and distributed in the pad, thereby reducing leakage.

## RESULTS AND ANALYSIS

I proposed sodium alginate along with carboxymethyl cellulose (CMC) as a possible replacement for Super Absorbent Polymers (SAP), in the principal layer of sanitary napkins. This biodegradable polymer further boosts requirements such as absorption, fluid retention strength, tensile strength and cost reduction. The only shift in the product would be the change in the raw material from super absorbent polymers to the biodegradable polymers. Furthermore through the analysis of the chemical structure and the absorbency of sodium alginate it makes this shift viable to reduce plastics and at the same be user friendly. The loosely linked structure of the polymer chains grants this polymers additional absorbent properties , hence fulfilling its purpose of balancing biodegradability with being user friendly.

## V. CONCLUSION AND DISCUSSION

The proposed alternative greatly reduce plastic generation associated with sanitary pads. Through this research paper I am proposing this idea for a product that will be socially beneficial as well as environmentally and economically viable achieving the triple bottom line. My research is a step towards a more sustainable planet, however testing of the sanitary pad is still required as well as developing the product for testing. An extension to my research could be making the product samples and conducting rewet or wet back tests and retention capacity tests as well as the wicking height test. The finding of this research suggests prospective implementation of biopolymer as a substitute for SAP in the absorbent napkin to provide better health conditions during menstruation. Most of the materials and chemicals used in this study are environmentally friendly, not only reducing the health risks associated with the use of SAP, but also making disposable women napkin items more environmentally friendly. further I have discussed the effect on the industries and the cost effective of this product. An extension to my research would be implementing to produce this sample product and studying the usefulness of the prototype. I have also gone to talk

about the industrial impacts and external factors that boost the relevance of my proposed sanitary pad.

Figure 4 shows the Projected Indian market growth of sanitary pads:



Source: [www.expertmarketresearch.com](http://www.expertmarketresearch.com)

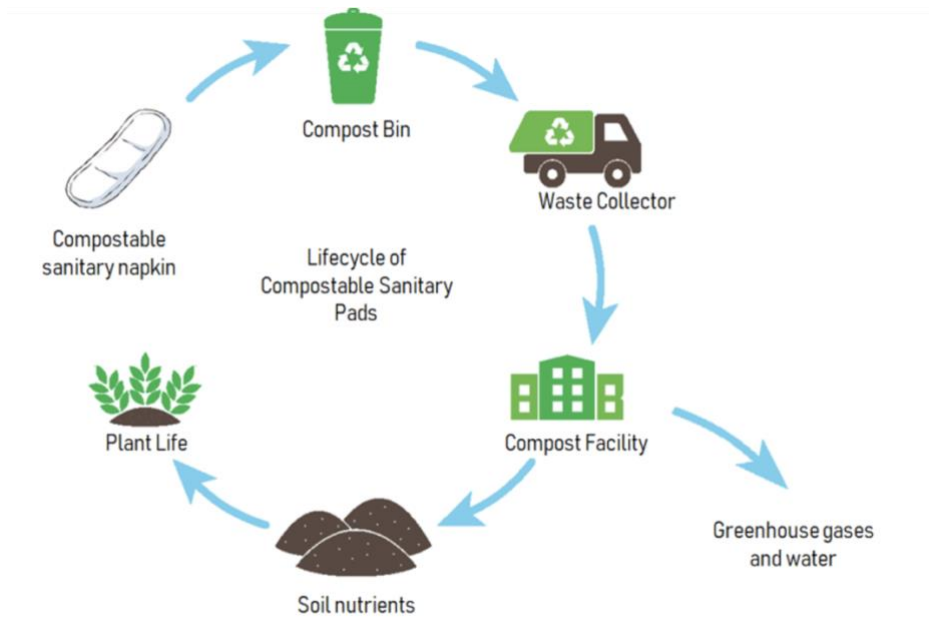


This means that the usage of sanitary pads is going to increase hence the number of users will increase thereby implying the levels of plastic pollution increasing making the shift to biodegradable sanitary pads imperative.

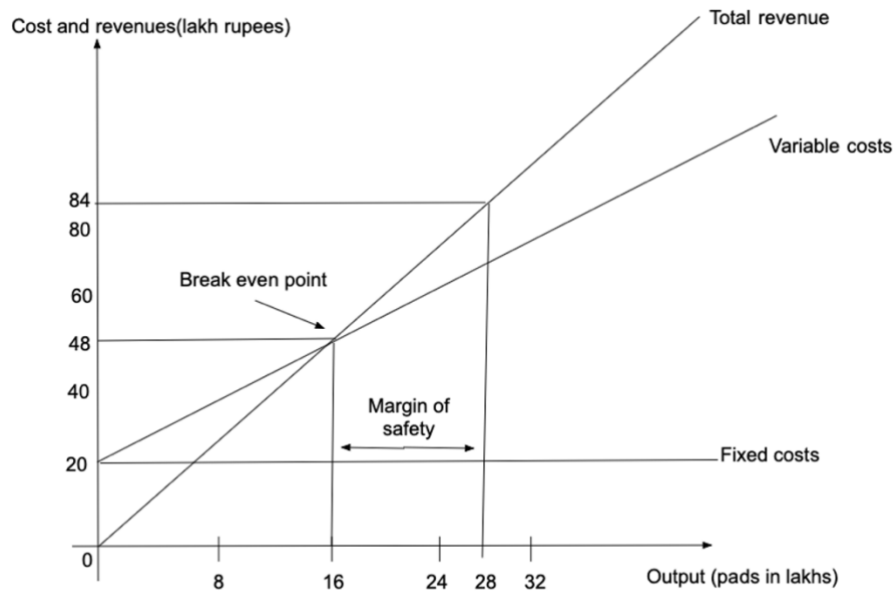
**The product design :**



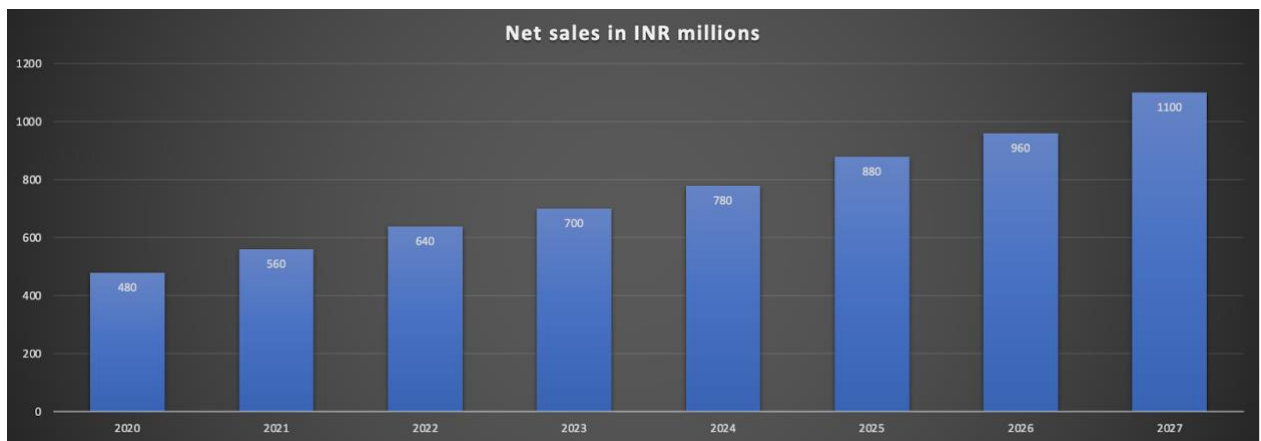
**Figure 5 indicates The lifecycle of the biodegradable sanitary pad**



**Figure 6 Describes the Cost analysis of the biodegradable pad through the study of the break-even analysis .**



**Profitability of the product**



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