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Sustainable menstrual alternatives: The journey so far

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Abstract
Biodegradable materials, eco-friendly solutions, natural products and sustainable resources have become important keywords in today's times, especially since they offer possible solutions to waste-disposal problems. The magnitude of this alarming situation can be understood from the fact that around 1,50,000 tons of sanitary napkin waste is generated every year and these single-use sanitary napkins are composed of more than 90% plastic which do not undergo biodegradation, exhausting landfill sites for another 700-800 years. This article reviews the researches carried out in the past decade, to understand the various biodegradable materials being offered as possible solutions to this increasing waste menace world over. It shall prove to be handy for research studies in the direction of replacing the existing commercial pads with completely biodegradable ones.

Keywords: Eco-friendly solutions, sustainable, landfill, conventional pads, biodegradable napkins

Introduction
Biodegradable materials, eco-friendly solutions, natural products and sustainable resources have become important keywords in today's times, especially since they offer possible solutions to menstrual waste-disposal problems. The magnitude of this problem can be understood from the fact that around 150,000 tons of sanitary napkin waste is generated every year and these single-use sanitary napkins are composed of more than 90% plastic which do not undergo biodegradation, exhausting landfill sites, for another 700-800 years [1].
The review traces significant progress made in the fields of genetic engineering- biodegradable polymers, antibacterial nano-colourants and nano-fibres, cellulose based hydrogels, organic cottons (GMO variety), in order to produce more sustainable alternatives to disposable plastic napkins. Sustainable fibres such as-Soybean, Bamboo, Banana, Milkweed, Water Hyacinth, Jute, Hemp, Wool have been researched in different blend compositions to provide eco-friendly alternatives to disposable plastic pads. Materials like Corn starch have been found to provide leak-proof, sustainable bottom layer against the plastic layer in disposable pads. Herbal Antimicrobial extracts such as Tulsi, Neem, Aloe vera, Curcumin Longa are being successfully used as outer coating on sanitary napkins, to provide skin-friendly napkins. Sustainable Pads are also being created using knitwear industry waste and bamboo wadding fabrics.

Methods
Databases in Google Scholar were searched for articles using keywords such as 'Sustainable Sanitary Napkins', 'Environment and Menstrual Hygiene', 'Biodegradable napkins', 'Nano-fibres for feminine hygiene'. Reports of companies and blogs were also referred for collating data relevant for the research about status of waste menace created by plastic pads and their collection in landfills. The data was reviewed and analysed for progress made over the last one decade in the area of biodegradable menstrual practices.

Results
Plastic pervades modern life- it poses problems, as once it is created, it does not get broken down. The single-use plastic sanitary napkins need to be substituted by more environment friendly and sustainable alternatives.
For better understanding, the different researched biodegradable materials have been divided into various categories:-

1) Biodegradable polymers and novel materials

The biodegradable polymers have offered a possible solution to plastic-disposal problems. Mohanty, Mishra and Hinrichsen reviewed the advances in natural fiber development, from genetic engineering and composite science perspective creating sustainable products from renewable resources. According to them, scientists have the real challenge in finding applications which would consume sufficiently large quantities of these materials to lead price reduction, allowing biodegradable polymers to compete economically in the market [1].

According to Anuradha Barman, Katkar and Asagekar, *Poly Lactic Acid (PLA) fibre* serves as a more biodegradable alternative to the plastic layer used in single-use, disposable sanitary napkins. Additional features of PLA such as anti-bacterial and non-toxicity characteristics pave way ahead for its use in hygiene products. However, research for overcoming high cost aspect of PLA can make it more desirable as an option in commercial sanitary napkins [2].

Further, Banu Ozgen reviews the possibility of using Polylactic Acid (PLA), *Tencel® SUN and Soybean protein fibres (SPF)* in different blend compositions, giving their applications and usage. The effects of fibre types on yarn properties such as-tenacity, fineness, moisture regain are discussed in the review article [3]. Interestingly, Soy protein fibre (SPF) is the only plant protein, man-made fibre, which is manufactured in China. It is a liquefied soy-protein that is extruded from soybean after extraction of oil and is then processed to produce fibres by using bioengineering technology. Reddy and Yang obtained fibres from soybean straw which could be suitable for use in textiles and other applications, as solutions to offer in the direction of sustainable materials [4].

Cellulose is the one of the most abundant natural polymers, found in nature as the main constituent of plants. Besides, *Cellulose-based hydrogels* are known to be superabsorbent materials as these are known to swell immensely and absorb water and other aqueous fluids. According to Bashari, and Shirwan *et al*., this has enabled widespread use of cellulose hydrogels at commercial levels. Some applications discussed in the paper include cellulose hydrogel being used for hygiene products such as diapers, tampons, panty liners, etc. [5].

Shibly H and Hossain M et.al have drawn a comparison of different aspects like absorbancy, wickability, etc for biodegradable materials such as *soya fabric, poly fabric and bamboo fabric* blended with natural fibres. Interestingly, *carboxy methyl cellulose* (CMC) had been experimented for layering purpose within these blended napkins. Different tests revealed that absorbancy gets greatly enhanced with such composition where *Sodium Alginate and CMC* are used in combination in the napkins. Further, coating the napkins with *Neem extract* yielded SAP free sanitary napkins, which provides an environmentally safe solution [6].

Sathish Kumar, Aarthi, M, *et al.* developed biodegradable, quality sanitary pads at affordable prices for schoolgirls and women. The highlight was use of *waste of loom* i.e., *Cotton fluff.* Cotton web hence made, showed a very high absorbancy of 470%. '*Neem and orange peel based nano colorants'* were coated on the sanitary pads to enhance the anti-bacterial characteristics [7].

Chandra S. S and his team from the Department of Chemical Engineering, IIT Hyderabad, used *nano-fibres* of *cellulose acetate biopolymer*, as core of sanitary napkins. Testing revealed that the napkins showed enhanced absorption, due to a greater surface area [8]. According to research findings as reported by Yadav S and team "these cellulose acetate (CA) nano fibers provide a better alternative to achieving enhanced absorbency even without adding SAP layer to sanitary napkins. The conclusion of the study was that these nano-fibre sanitary napkins without SAP can offer a safe solution to the sanitary waste disposal problem" [9].

Anuradha B, Katkar P.M and Asagekar S.D have suggested the use of the *Organic Cotton* in sanitary napkins. According to the team, this not only serves as a sustainable raw material, but also is skin-friendly and highly absorbant. *Organic cotton* is grown in a pesticide-free environment, which further helps to restrict the use of chemicals and paves way towards an environment friendly production process. As cotton fibre comes directly from nature, it degrades when disposed. The team also researched on Lenzing Company's *Lyocell fibre*, which is completely biodegradable and hydrophobic in nature with extra softness, for use as top sheet. The paper suggests that due to its enhanced moisture uptake there is reduced bacteria growth, hence making it a good choice in sustainable sanitary napkins [2].

Woollen fabric, as a backing material, has been used by women, for time immemorial, to absorb menstrual waste. When compared with fleece, it is less waterproof, however it is a strong backing option for those women who want a more natural fabric. However, wool is known to show felting shrinkage if not delt with care and certain skin types are found allergic to the woollen fabrics [10].

2) Miscellaneous fibres and their blends

Sparkle Sanitary napkins recommends the use of *Corn starch, Banana fibres and Bamboo fibres* for some interesting reasons**.** *Corn starch layer* in napkins, functions as a sustainable anti-leak bottom layer and a compostable alternative to plastic. Conventional pads use polyethylene plastic as bottom-layer in order to provide for the leak-proofing, which makes these napkins non-biodegradable. Another sustainable material for napkins as suggested by Sparkle, is the use of *Banana fibres*, which is procured from bark of the tree that had been earlier treated as an agro-waste. [11]. Studies suggest that Banana fibres are highly absorbant and use less fertilizers as compared to other natural fibres. Ishika Ghosh and team have reported in their review article, development of cheap and hygienic pads for rural ladies, using *Banana fibers* [12].

Further, *Bamboo fibres* are well known for their natural property of sterilization and bacteriostasis. This helps it to find wide usage as sanitary products, hygiene products etc. It is for this reason that, the finished bamboo products need not be added with any artificial synthesized antimicrobial agent, so it does not cause skin allergy, and at the same time, it also has competitive prices in the market**.** Rathod and Kolhatkar, have proposed in their research the use of bamboo fibres in different combinations for sanitary napkins. Properties of 100% bamboo & bamboo – cotton (50:50) blended yarn fabrics for sanitary pads were analysed. Overall, their experimental results indicated higher breaking strength, higher elongation, better tearing strength and overall better performance for 100% Bamboo fabric, though cover factor for Bamboo-Cotton (50:50) blended yarn was higher than other prototypes [13]. Willis, S. in her blog has proposed, *bamboo fleece* as an excellent absorbent yet thin material for core of cloth pad. She further suggests the use of Hemp fleece, due to its absorbent characteristics. However, it has a tendency to become stiff and uncomfortable while in use and develops an unpleasant odour over time [10].

Ishika Ghosh and team have drawn comparison of different aspects of sanitary pads made with Water Hyacinth and Hemp. Pads have also been developed using *Water hyacinth***,** which is a kind of weed. The fibre is extracted from its stem. They sanitary napkins hence created had been found to be cost-effective and biodegradable. Sustainable and absorbent Sanitary napkins have also been developed using Hemp, in the above study [12].

Kumar R et.al has tapped useful properties of Milkweed and its blend with Cotton in sanitary napkins. In the study, it was found that the *Milkweed fibre* shows very high absorption index. The napkins with the Milkweed fibre core were made using polyethylene and polypropylene as bottom and top layer respectively [14]. *Jute fibre* is a natural, eco-friendly fibre has also become popular for use especially in the barrier layer and absorbant core to make sanitary napkin layers super absorbent. The paper by Agbaku C. A, *et al*., sheds light on the aspect of Jute fibres characteristic as the most affordable natural fiber, second only to cotton in its production and uses [15]. In a research work done at IIT Kharagpur by Barman, Katkar and Asagekar, Jute fibre was used to substitute a cotton core sanitary pad which had 65-70% cellulose content and high water affinity. Further the advantages of having a jute core include, lower price and abundance availability especially in North East India [2].

3) Novel finish coatings on pads

Burman A, Katkar P and Asagekar S.D researched to produce herbal coated biodegradable sanitary napkins. The paper focuses on developing sanitary napkins, in varying blend compositions of natural fibres. These napkins were further coated with herbal layers of -*Curcuma longa and Azadirachta indica* [2]. Shibly M.M.H, *et al*. in their research, developed sanitary napkin samples with cheap raw materials and a coating of natural antimicrobial agents such as *Tulsi and Aloe Vera*. The napkins produced were both eco-friendly and economical [6].

4) Sustainable Pads developed form industrial wastes etc

Owing to the huge waste generated by textile industry and following the principles of sustainability, Uddin M, Tushar S.I and Sakib S constructed sanitary pads from *cotton knitwear industry waste.* The choice of material was such because affordable sustainable napkins could be created for under-privileged women in Bangladesh [16].

Lakshmi Murthy, Ph.D. scholar, IIT, Mumbai has discussed the *sustainable Uger fabric pads*. In her paper, Murthy researches the menstrual products used by women in South Rajasthan. For assessing sustainability, the PASS diagram has been used. There were two styles of pads developed- for light flow and heavy flow. Uger pads were found to be satisfactory as it looked into aspects of environment as well as livelihood, as the pads are handmade generating employment within the community [17]. Foster, J studied the menstrual practices and their management in low and middle income countries. Research had been carried out with materials which are both sustainable and low in cost -cotton terry cloth, hemp cloth and *bamboo wadding*. According to the researcher, bamboo wadding had high absorption and its easy availability in these countries, makes it a cheap source, however, with further research, extraction process once simplified can prove beneficial in its usage in sanitary napkins [18].

Conclusions

The progress over the past decade clearly indicates that sustainable alternatives are the way to move ahead in future, once the commercialization of the same takes place.

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