**FINAL TECHNICAL REPORT**

**On the**

PROJECT: DEVELOPMENT OF COTTON LAP/CELLULOSE PAD SUBSTITUTE FROM JUTE

Project No: NJB/7.1/MM-IV/JTM 2010, Dt. 02.06.2010

**Sponsored by*:***

**National Jute Board, Ministry of Textiles**

**Govt. of India**

**3A, Park Plaza, 71, Park Street**

**Kolkata 700 016**

**Materials Science Centre**

**Indian Institute of Technology**

**Kharagpur 721302**

March 2013

CONTENTS

**1. Objective and Rationale of Project 2. Literature Survey**

**3. References**

**4. Market Survey and Need Assessment**

* 1. Background
	2. **Gender Hygiene Management Initiatives and Govt. Efforts**
	3. Sample Survey conducted in West Bengal and its report
	4. Sample survey of a particular brand and its market span
	5. Program under National Rural Health Mission (NRHM); Eastern Regional Centre, ICSSR
	6. Mini Gender Hygiene Products **Manufacturing Machinery for decentralized sectors**
	7. Need Assessment Report on baby diapers and gender hygiene products
	8. Baby diapers: Cost economics, marketing potential
	9. Project design for Gender Hygiene Products/Baby Diapers machinery for decentralized units

**5. Methodology of R&D Activities**

**6. Detailed Report on R&D**

6.1. Pretreatment of industrial waste jute (physical and chemical treatment)

6.2. Preparation of super absorbent polymer (SAP)

**7. Results and Outcomes of R&D Activities**

 7.1. Tests done to analyze the physically and chemically treated jute fibers

7.1.1. Water absorption test of jute waste

7.1.2. Water absorbency time

7.1.3. Change of weight of jute after alkali treatment

7.1.4. FTIR study of jute and alkali treated jute waste

7.1.5. Scanning Electron Microscopy (SEM) of jute fiber and commercial baby diaper fiber

7.2. Tests done to analyze the water absorbing and holding capacity of Superabsorbent Polymer (SAP)

7.2.1. Water capture and retention capacity of 1 g polymer

7.2.2. Optimization and standardization of total process and prototype product development

7.2.3. Water uptake of jute super absorbent polymer mixture

 7.3 Polymer synthesized in bulk

 7.4. Biocompatibility Test

 7.5. Biodegradation Test

**8. Product/Process Standardization**

**9. Industrial Field Trial for Product Development**

**10. Cost Analysis/Cost Effectiveness Study Report**

**11. Comparative analysis of hygiene products**

**12. Conclusion**

12.1. Activities completed and efforts towards bulk preparation and technology transfer

**13. Workshop Organized/Participated, Publication, Conference and Human Resource Development**

13.1. Workshops organized

13.3. Human Resource Development

**14. Future Program**

**15. Acknowledgement**

**Project team**

**Prof. Basudam Adhikari, Principal Investigator**

**Manisha Sharma, Junior Research Fellow**

**Sumit Das, Junior Project Officer**

**1. Objective and Rationale of Project**

**Objectives**

1. To develop jute based cellulose laps having high fluid absorbency for baby diapers, sanitary napkins, gauze, wound dressing material, etc.
2. To develop the process of blending various super absorbent polymers (SAP) along with jute based cellulose laps.
3. Testing and standardization of such jute-based SAP blended disposable absorbent products.

**Rationale**

1. Disposable absorbent materials are mainly made up of cotton based cellulose laps. But to cope up with the increasing demand of cotton in textile industry, we have chosen jute, a cellulosic fiber, as a probable substitute for cotton in disposable absorbent materials.
2. Jute is one of the largest celluloses based agricultural product in eastern India, but till date it has not been commercially utilized in the sector of disposable absorbent materials.
3. Flying short fibers of jute (known as caddice) is a waste material of jute mills. In this project work cellulosic fiber was recovered from caddice by chemical treatment to use as substitute of cotton cellulose for absorbent materials.
4. Jute is lower in cost as compared to the cotton and synthetic fibers, and is available in plenty in Bengal region.

**2. Literature Survey**

There is high market demand for absorbent products. Natural cellulosic fibers like cotton, hemp, etc., are used as main constituents in disposable cellulose pad along with suitable super adsorbent polymer (SAP) [1]. Softness and high absorbing property of these natural fibers make them inevitable for this purpose. Increasing demand of cotton in the textile sector paves new path for probable substitute of disposable cotton lap. Till now none of the eco friendly materials have been experimented on commercial basis, hence extensive research in this field is under process. We understand through our ongoing researches that jute may be one of the better replacements of cotton fibers to manufacture cellulose laps used in disposable absorption products (hygiene products), as jute has less cost compared to cotton, contain about 65-70% cellulose and high-water affinity.

**Current status of the work on the issue:**

Cotton fibers having as high as 85-90% cellulose is the first commercial choice as hygienic absorbent material. Since the micro tube structure of cellulose materials have high water absorbing capacity, shrinkage of the material is very much commendable while exposed to fluids. The growing demand for cotton in the textile sector opens scope for research and development for cellulosic substitutes in the absorbent materials. Hemp fiber has also been used as absorbent along with cotton as a blend. Hemp fiber is stronger and more abrasion resistant to cotton, though it is bit rough in surface morphology. Roughness of the hemp fiber can be reduced by further modifications [2]. This fiber resource is unavailable in commercial scale in country like India.

Chitin fiber is a valuable bioactive polymer extracted generally from shells of crustaceans. The products derived from chitin are non-toxic, bacteria and fungi resistant and non-allergic. The three-dimensional network structures give additional softness, super absorbency and flexibility to the chitin-based products, which are essential in manufacturing absorbent medical appliances [3].

Synthetic micro fibers, which are extremely absorbent in nature, are used to make absorbent products, though the lining touching the skin may cause allergic consequences. Synthetic absorbent cellulose fibers like viscose fibers are dominating fiber materials for non-woven absorbent products [4].

Generally, the natural cellulose fibers or pulps absorb fluids through the capillary action as they have tube like core microstructure. This ability of absorbency increases manifold when super absorbent polymers (SAPs) get co-polymerized grafted or blended with cellulose fibers. The crosslinked structure and ionic strength of SAPs and their compatibility of long polymeric chains with water helps them to get additional absorbency [2,5].

The introduction of super absorbent polymers (SAP) in cellulose laps brought a new era in diaper industry in 1980’s. Mainly super absorbent polymers like polyacrylates when introduced into the soft cellulosic natural fiber pulp the combination gives tremendous water absorbency along with sufficient breath ability and flexibility [5].

SAPs having high swelling/gelling properties like poly (vinyl alcohol), poly (ethylene oxide), poly (vinylpyrrolidone), carboxymethylcellulose and polyacrylamide were also introduced as super absorbent core polymers to the baby diapers. In recent times, ultra fine structured SAPs made through electro spinning has also been introduced as a key component of disposable diapers [6].

The healthy production of jute in eastern India facilitates this fiber as a resource of cellulose (65-70 %). Researchers are experimenting with jute and jute waste products for the manufacture of core absorbent cellulose materials (cellulose pads/laps). Jute fiber is having as high as 300-500 MPa tensile strength and approximately 200 % water absorbency. Although the fiber is rough and brittle in nature as it contains approximately 15 % of lignin, the softness and flexibility can be increased with due modifications like scouring, mercerizing-bleaching, activating and then blending with other materials [7]. The additional advantage of jute fibers to cotton is that the fiber length is much shorter in the case of jute easing the preparation of cellulose pulp although the percentage of cellulose content is much lesser in jute. There is a report on the development of fast swelling super absorbent hydrogels [8], where they have reported the effects of cross-linking agents and their concentrations on the porosity and absorption rate. Others have also reported the development of superabsorbent polymer [9] and a review on superabsorbent polymer is also available [10].

In this project it was proposed to investigate the development of cellulose laps/pads using jute fiber and waste jute (caddice), possibly blended with some super absorbent polymers.

**3. References**

1. Baby diapers: Cost economics, market potential, The Indian Textile Journal, April 2008.
2. M. Pehkonen, why do natural fibers absorb? http:// www.fuzbaby.com/ articles/ diaper-article\_natural-fibers-absorb.htm (2001), (accessed on 10-7-2009).
3. M. Einzmann, J. Schmidt Bauer, B. Schachtner, S. Jary, Tailor made absorbent cellulose fibers for non wovens,Len zinger Berichte, 84, pp 42-49, (2005).
4. European Disposables and Nonwovens Association, 2007. Available from: <http://www.hapco.edana.org/story.cfm?section=|hapco\_publications&story=publications.xml> (accessed November 2008).
5. K. Kirstin, S. Harald, L. O. Jennifer, L. K.Edburga, S. M. Daniel,and N. E. Geetha, Regulatory Toxicology and Pharmacology Volume 53, Issue 2, pp 81-89, (2009).
6. A. Al Ashraf, New generation of super absorber nano-fibroses hybrid fabric by electro-spinning, Journal of materials processing technology 199, pp 193–198 (2008).
7. http://www.jute.org/research\_dvlp.htm, accessed on 2-7-2009.
8. K. Kabiri , H. Omidian, S. A. Hashemi, M. J. Zohuriaan-Mehr, Synthesis of fast-swelling superabsorbent hydrogels: effect of crosslinker type and concentration on porosity and absorption rate, European Polymer Journal Vol 39,p1341–1348 (2003).
9. F. Jiang, W. Li, X. Zhan, G. Chen, J. Zhou , J. Huang, S. Zhang, Preparation and Characterization of Konjac Superabsorbent Polymer, Journal of Wuhan University of Technology – Material Science and Education,(2006).
10. M.J. Mehr, K. Kabiri, Superabsorbent Polymer Materials: A Review, Iranian Polymer Journal, p 451-477 (2008).

**4. Market Survey and Need Assessment**

**4.1. Background**

Global market demand for hygiene absorbent products are in increasing trends. Mainly natural cellulosic fibers like cotton, hemp, etc. are used as main constituents in disposable cellulose pad along with suitable super absorbent polymer (SAP). Softness and high absorbing property of these fibers make them inevitable for this purpose. Increasing demand of cotton in the textile sector paves new path for probable substitute of disposable cotton lap.

Although any other eco friendly materials have yet not been experimented on commercial basis, extensive research is under process. We understand through our basic researches that jute may be one of the better replacements of cotton fibers to manufacture cellulose laps used in disposable absorption products, as jute has about 65-70% cellulose content and high water affinity.

Therefore jute, an agro product of eastern India, can be considered as a source of cellulose (65-70%). Scientists are working with jute and jute wastes for the development of absorbent cellulosic materials. The fiber length of jute being much shorter the preparation of cellulose pulp from jute would be easier although the percentage of cellulose content is less in jute.

**4.2.** **Gender Hygiene Management Initiatives and Govt. Efforts**

The issue of Gender Hygiene Management and its linkage to sanitation facilities and availability of low-cost Gender Hygiene Products has often triggered action by women Self Help Groups (SHGs) working in the sanitation sector.

The Tamil Nadu sanitation program me took the initiative of dealing with these two issues. The successful initiatives were mobilizing and training SHGs for the production of low-cost Gender Hygiene Products and providing incinerators in the girl’s toilets in schools.

The initiative encompasses and focuses on the importance of gender hygiene, the simplicity of the process in setting up low-cost Gender Hygiene Products production units, mechanisms for safe and hygienic disposal in schools and households and the scope of linking this up with total sanitation campaign. The initiative covers how women are benefiting from the process and the innovative marketing techniques being adopted by the groups. The project is supported by UNICEF.

* UNICEF developed the guidance booklet on gender Hygiene Management which serves as a self reference and support girls and women in providing basic factual information about gender and its hygienic management.
* UNICEF took a generous initiative in India by developing association with the State Health Departments (under P & RD) by organizing orientation programmes with the women self help groups to start low cost Gender Hygiene Products production unit and market it to the members of the self help groups.
* Impressed with the low-cost Gender Hygiene Products production and the vending machine installed in schools on an experimental basis, Mr. Gautam Buddha Mukherjee, secretary Tribal Welfare saw its huge relevance in tribal society and schools.
* With 2008 being the International Year of Sanitation (IYS), the total sanitation campaign of the Government of India acquired added importance. The focus on gender Hygiene Management is an essential part of promoting hygiene and sanitation amongst adolescent girls and women who constitute approximately 45 per cent of the total female population.
* The Government of India launched the Total Sanitation Campaign (TSC), a comprehensive national program to ensure sanitation facilities in rural areas, in 1999. Despite a rapid increase in sanitation coverage, the agenda of achieving total sanitation remains incomplete without addressing the sanitation needs of women specially related to gender Hygiene Management (MHM).
* The Department of Rural Development in Tamil Nadu with support of UNICEF has initiated comprehensive action to deal with these issues by engaging NGOs and women Self-Help Groups (SHGs) in creating awareness and building their capacities to manufacture low-cost.
* Gender Hygiene Products, adopting innovative marketing strategies to reach the rural women, involving adolescent girls in providing information and developing mechanisms for safe disposal at the school, household and at community level.

|  |  |
| --- | --- |
|  |  |
|  |  |
|  |  |

**A gender hygiene production unit in Bihar**

In 2010, the Ministry of Health and Family Welfare revealed that it was working on a scheme to provide rural women living below the poverty line with free Gender Hygiene Products. The plan involves supplying 100 Gender Hygiene Products per person per year to 200 million women at a budget of US$ 45m over a three-to-six month period.

When reports of the new Gender Hygiene Products scheme were published, two immediate issues became apparent. One concern was that such a scheme would stifle innovation from enterprises like Jayashree who, though a small player, was providing a necessary social service, inspiring the same spirit of grassroots innovation in local communities and empowering women to take control over their own health.

The second concern to arise from the scheme is its limited scope. It is true that rural women have more restricted access to Gender Hygiene Products, but this issue of accessibility and affordability also exists for lower-income women living in cities. In eastern India alone, 83% of families say that they cannot afford Gender Hygiene Products. The goal should really be universal access for women throughout India, and the new scheme does not promise that.

At present the production of about 900 million pieces are manufactured in India and rest are imported.  Total women in the age group of 15-54 years in India are about 300 million. Total menstrual periods/year is 13 that last for 4-8 days and an average of 3 pieces/day is used. Then consumption would be 58,500 million pieces/year. Present consumption is 2659 million pieces, i.e, 4.5% penetration while in Europe and USA it is well above 73 to 92%. Hence a growth rate well above 18 to 20% is expected in India. The Indian market is quite huge and as per reports available only 35% of India’s requirement is manufactured in India, as of now. A huge market, great potential and excellent profit margin is envisaged in manufacturing of Gender Hygiene Products and baby diapers in India.

In July 2011, a new government program has been launched to improve menstrual hygiene among adolescent girls. The goal was to reach 15 million adolescent girls between the ages of 10 and 19 in 152 districts across the country. The program was first launched in Gujarat, Maharashtra and southern India. It was estimated that only 20% of adolescent girls could afford even a single Gender Hygiene Products, but under this program, a pack of six Gender Hygiene Products would be sold to each girl at schools for INR 1 (~US$0.02). With this new program, accessibility and affordability, as well as hygiene education, were confronted head-on.

* 1. **Sample survey conducted in West Bengal and its report**

**Hooghly District**

**While doing the survey among the rural adolescents and the women in Hooghly district in West Bengal the following points were collected**

**There is no** gender **hygiene management in the blocks as a programmed with separate fund.**

1. **The P & RD and UNICEF initiated the programmed recently.**
2. **UNICEF is encouraging for setting up units for low-cost Gender Hygiene Products.**
3. **Two NGOs are working in the sanitary management for 20 years.**
4. **There is very little awareness of health hygiene among the women in the villages.**
5. **There is absence of technology in programming low-cost Gender Hygiene Products.**
6. **No proper marketing network has been established for gender hygiene program.**

Balia Gram Unnayan Samity in Hooghlyis an NGO working in RCH (Reproductive Child Heath) for some years. They have adequate experience in gender hygiene management with a low-cost Gender Hygiene production unit in Balia, Hooghly.

**The Project Coordinator Mr. P K Chatterjee’s feedback is as follows:**

* The Samity produces low-cost Gender Hygiene products by self help group members, with a brand name.
* Technology is supported by “Gandhi Grameen Trust” (GGT), Tamil Nadu and the project was approved by Dept. of Science & Technology.
* The components of napkin are wood pulp with gel that is supplied to the NGO by the Trust in Tamil Nadu.
* The other components like Super Absorbent Polymer and a cotton fabric for dimensional purpose are procured locally.
* The NGO is principally operating this particular project in Pandua and Haripal block in **Hooghly** district and in two GPs.
* Marketing of the napkins have been carried out on trial basis by and to the members of SHGs.
* Marketing activity is restricted within sub health centres and sometimes in villages where the NGO meets the women during conducting the RCH meetings.
* The price of each packet is Rs 18 per 10 pcs (standard size). But the cost of the unit pack comes at least Rs 20 per pack. Thus, the product is not techno-commercially viable.
* The raw materials are not available with any agency in West Bengal. Therefore, they have to depend on the trust in Tamandu for regular supply.
* Consumption of Gender Hygiene Products does not exceed 15-20% in the village level.
* Problem in the health awareness, social paradigm; women are not accustomed to purchase a napkin from a chemist shop.
* The financial incapability is one of the major reasons for purchasing a gender hygiene product.
* The quality of MNC products is much better and well suited for custom sizes compared to the local manufacture.
* The prices are not cheaper in comparison to the branded products of MNCs.
* The adolescents and younger women who face heavy discharge, they do not like the product made by the NGO.

**Feedback as per Supervisor of Production, Mr. Tinkori Bandopadhyay**

* The training of napkin making had been conducted by the GGT for 3 months (16 Sept 2010 – 15 Dec 2010). It was a training, trial and observation period.
* The production started on 16th Dec 2010.
* The production unit consists of local SHGs.
* Currently 10 women were involved in production, in two shifts (5 women in each shift)
* Gel content along with the wood pulp was wrapped in two ways using non-absorbent and absorbent (80% non-woven PP, 20% cotton, 17 gsm)
* It is claimed as anti-allergic. Double line sealing using two filaments.
* Raw materials are wood pulp with gel.
* 8 gm of wood pulp and super absorbent polymer (SAP) is used in each piece of napkin
* Wrapper: absorbent and non-absorbent from Chennai.
* A wrapper is locally available of higher gsm, but the production cost is much higher for that.
* Habit of use of proper hygienic napkin has not been established among women.
* Financial reason is not a major issue.

**Feedback from Secretary Mr. Subhash Ch. Pal who looks after sales**

* Sales are undertaken by the SHGs in Pandua and Haripal blocks in **Hooghly** districts. Through SHGs, Primary Health Centres (PHC), ICDS (Integrated Child Development Scheme), sub centres, etc. can be tools for marketing and sales.
* The NGO contacted hospitals, BMOH (Pandua), health workers, did school campaigns and demonstrated local nursing homes.
* The unit participates in Grameen Mela in the districts. Sales are limited in the fares. But awareness is a major issue there.
* Door to door sales to SHG members are undertaken periodically.
* Production capacity at present 50 packs/day.

**Retailers’ Feedback**

* The total sale is 20% - 25% in the district.
* Major cause: rural buyers cannot afford this. They use conventional unhygienic system of homemade pad.
* This area is basically an agriculture based and depends on seasonal economy so they cannot provide to buy.
* The women are apprehensive and hesitative to purchase napkins from the chemists.
* Even they ask for the products, they will ask only brand names. They are unaware of the quality of other products.
* So they cannot compare products from one quality to the other.
* The major players in the market are shown in Table 1.

**Table 1.Various brands of gender hygiene products in the market**

|  |  |
| --- | --- |
| **Brand name** | **Produce** |
| Stayfree | Johnson & Johnson |
| Carefree | Johnson & Johnson |
| Whisper | Proctor & Gamble |
| Kotex | Kimberley-Clerk Lever Pvt Ltd |
| Don’t Worry | Mankind |

Some new companies are there though they are irregular in the market. Therefore, brand biasness has not been established. Customers ask for branded products only. Customers are devoid of knowledge of quality. A new company rarely does the promotions with new products. The new products should be adequately available. There is a need of huge market network, new and small companies are unable to penetrate into the market. The SHGs do not have that management system anyway.

**Howrah District**

Total population of Howrah district: 4,273,009 according to 2001 census. 44% are women, therefore total women population 18, 80,124. 45% of total women population falls between 14-45 years of age. 8, 46,055 of the total women population is the market size of Gender Hygiene Products.

But only 22% of napkins of all brands are sold from retail outlets. 1, 86,132 women uses branded product purchased from market. Therefore, market size for new products is as minimum as 6, 59,922 per month.

**Feedback of Amta II Udayan Mahila Mahasangha (Federation)**

Amta II Udayan Mahila Mahasangha (Federation), Howrah runs a hygiene manufacturing unit with support from PNRD and UNICEF with a brand name “Diya”. Raw materials are procured locally. Total women involved in production are 17. The product details are as follows:

* Cost price per pack (comprising 8 pcs) for Regular: Rs 15.
* Cost price per pack (comprising 8 pcs) for Extra Large: Rs 18
* Sale price per pack (comprising 8 pcs) for regular: Rs 18
* Sale price per pack (comprising 8 pcs) for Extra Large: Rs 20
* Capacity of production: 150 packs per day
* Per head production capacity: 10 packets per day
* Total monthly production: 3750 packs.
* Total sale: 50%
* Target customers: Members of the federation, which is near about 3500 women of 350 Self Help Groups.
* Present users: 1800 women from the groups
* Technical specification: Not found

Potential customer base as studied by the federation: 30,000 women from SHGs across the district, ICDS, Health, Hospitals, Nursing Homes. The market survey for Menstrual Hygiene has been studied in 3 GPs., viz. Khalna, Jaipur and Jhamtia. 300 women in Jhamtia and 620 in Jaypur have been surveyed.

Social feedback: Price is not a big issue. Because women in Amta II block are able to spend Rs 18 per month when they are convinced about the hygiene point. Women do not seek advice from their husbands for choice of napkins.

 Therefore husbands’ approval is not a major issue. Cost break up of each pack of product is shown in Table 2.

**Table 2. Cost break up of one pack of napkin**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Raw materials used** | **Rate** | **Amount used per unit** | **Amount used per pack** | **Cost** **(Rs)** |
| Wood-Gel combined | Rs 47/kg | 8 g | 64 g | 3.04 |
| Wood pulp | Rs 33/kg | 6 g | 48 g | 1.60 |
| Non woven | Rs 7/m |  | 0.5 m | 3.50 |
| Plastic piece | Rs 50/kg |  | 8 gm | 0.40 |
| Adhesive/sticker | Rs 6/m |  | 0.002 m | 0.02 |
| Packing materials | Rs 2 per 10 pcs |  | 1 pc | 0.20 |
| Total material cost |  |  |  | 8.76 |
| Labour cost @ 10% of material cost |  |  |  | 0.90 |
| Overhead cost @ 20% of material cost |  |  |  | 2.00 |
| Total cost |  |  |  | 11.66 |

This cost break up has been derived from the cost taken from the bills and challans of the materials from the federation and actual study in the market.

**Purulia District**

* Total population: 2001 census: 2536516.
* Total female population which is 49% is 1238438.
* 11% use branded Gender Hygiene Products.
* Name of the SHG: Jian Jharna SGSY Cluster, Bundwan, Purulia.
* Product name: “Diya”.
* Technology given by: UNICEF supported by PNRD, Govt. of West Bengal.
* Raw material source: From Howrah Bandhaghat.
* Machineries supplied by PNRD, Govt. of West Bengal.
* No. of women involved in production: 20.
* No. of machines installed: 1 grinding, 1 weighing, 1 cutting, 1 dicing, 1 sealing, 1 trimming, 1 portable trimming, 1 packing.
* Cost price per pack (comprising 8 pcs) for Regular: Rs 16.
* Cost price per pack (comprising 8 pcs) for Extra Large: Rs 19.
* Sale price per pack (comprising 8 pcs) for regular: Rs 20.
* Sale price per pack (comprising 8 pcs) for regular: Rs 22.
* Capacity of production: 250 packs per day.
* Per head production capacity: 12 packets per day.
* Total monthly production: 6250 packs.
* Total sale: 20%.
* Target customers: Members of the federation, which is near about 4000 women of 400 Self Help Groups.
* Present users: 1250 women from the groups.
* Technical specification: Not found.
* Potential customer base as studied by the cluster: 4600 women from SHGs across the district, ICDS, Health, Hospitals. The market survey for Menstrual Hygiene has been studied in 3 GPs., viz. Pukurkata, Paharpur and Kukrudabar. 110 women in Paharpur and 185 in Kukrudabar have been surveyed.

Social feedback: Price is a major issue, because spending Rs 20 per month for the tribal women is a factor. Tribal women are very receptive about new things, but women in the most backward block are never able to purchase a product at Rs 20 per month.

The study suggests that the price with existing product quality will costs about Rs 7, which seems be affordable. Awareness campaign is very poor, thus tribal women are unaware about the health hazards from unsafe use of napkins during periods. There is immense scope of technology intervention at a very low cost. Cost break up of each pack of product is shown in Table 3.

**Table 3. Cost break up of one pack of napkin**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Raw materials used** | **Rate** | **Amount used per unit** | **Amount used per pack** | **Cost** **(Rs)** |
| Wood-Gel combined | Rs 47/kg | 8 g | 64 g | 3.04 |
| Wood pulp | Rs 33/kg | 6 g | 48 g | 1.60 |
| Non woven | Rs 7/m |  | 0.5 m | 3.50 |
| Plastic piece | Rs 50/kg |  | 8 gm | 0.40 |
| Adhesive/sticker | Rs 6/m |  | 0.002 m | 0.02 |
| Packing materials | Rs 2 per 10 pcs |  | 1 pc | 0.20 |
| Total material cost |  |  |  | 8.76 |
| Labour cost @ 10% of material cost |  |  |  | 0.90 |
| Overhead cost @ 30% of material cost |  |  |  | 2.70 |
| Total cost |  |  |  | 12.36 |

Bundwan is most densely tribal populated and among the most backward block of Purulia district. PNRD has had a trail of a production unit in the block; however that unit does not seem to be a commercial one but it may be called a prototype set up. Therefore, it is difficult to draw any techno-commercial report from the study.

**24 Parganas (N)**

**Ramkrishna Mission Lokshiksha Parishad, Narendrapur (RKMLSPNDP)**

Mr. Nirmal Ch Pattanayek, the production head and Mr. Chandicharan Dey, the technical officer of the Gender Hygiene Programme have interacted with the survey agency and shared their statistics in the programme. The study is laid here as follows:

* RKMLSPNDP studied the total sanitation programme including Gender Hygiene Programme in 4 districts in West Bengal.
* They have put a Gender Hygiene Products Production Unit in the Month of May 2011 in East Medinipur near Tamluk.
* The capacity of the unit will be 400 packets of napkins comprising of 8 pieces per pack.
* Lokshiksha Parishad have calculated that sale price of each regular quality packet would be Rs 13.
* They emphasise on the hygiene part of the technology and cost of the product comes second.
* They have a tie up with Gandhi Grameen Trust for raw materials supply. According to RKM the Coimbatore model is the best among others as far as the raw material quality and production system are concerned.
* They have their own lab for testing of materials.
* They will invite new entrepreneurs for market networking under entrepreneurship development programme.
* They have their urban coverage for manufacturing and marketing of napkins. In Bat-tala they have identified 400 women and their families under ICDS programme, they have taken 250 SHG in the mission.

**4.4 Sample survey of a particular brand and its market span**

Company: Mankind.

The product name is “Don’t Worry”.

The price range of the brand is Rs 25, Rs 30, Rs 35, Rs 40 and Rs 50.

All of their products are gel-coated.

Price list of different product lines of Mankind Don’t Worry brand is given Table 4.

**Table 4. Price list of different products of Mankind, Don’t Worry**

|  |  |  |  |
| --- | --- | --- | --- |
| **Product Type** | **Size(s)** | **Pcs per pack** | **Price at the retail outlet (Rs)** |
| Daily | 240 mm | 6 pcs | 25.00 |
| Daily | 240 mm | 8 pcs | 30.00 |
| Daily + Extra Large | 240 mm+ 280 mm | 4 pcs + 4 pcs | 35.00 |
| Extra Large | 280 mm | 8 pcs | 40.00 |
| Extra Large | 280 mm | 12 pcs | 50.00 |

There are two types of pads available in the market. Cotton pad and gel pad. Gel products are more absorbent and give better comfort. Gel pad is best suited for young girls. Demand for the modern gel technology based products is growing among teenagers. Cotton pads are bigger in volume but less absorbent while gel pads are smaller in volume but more absorbent and comfortable. Eastern Regional Centre, ICSSR uses mostly cotton based pads and promotes through several SHGs in different Indian states.

**The market share of different brands**

* By Jhonson & Jhonson (Stayfree & Carefree): 70% occupied
* By Proctor & Gamble (Whisper & Breeze): 20% occupied
* Others Mankind (Don’t Worry), Kimberley & Clerk Lever (Kotex): 10% occupied

Mankind isconducting activities in the rural sector like, campaign in shops (danglers, PoPs, etc.), schools & colleges with free samples and through advertisements in print and electronic media.

**4.5 Program under National Rural Health Mission (NRHM); Eastern Regional Centre, ICSSR**

Paushi, the brand name of cotton lap napkins are produced by several SHGs in West Bengal. Bankura and **Hooghly** are the prominent districts where the technology and the production system have been implemented in commercial level but not in consistent supply assurance, told by Dr Dhrubojyoti Ghosh, Principal Investigator, NRHM project, West Bengal.

The production cost is very low because of the low investment in the machineries, tools and equipments for Paushi. As maximum as Rs 200 is invested for one unit of production of napkins. The manufacturing process is mostly done by hands. Thus the price of the napkin pack, which comprises of 8 units of pads is Rs 16 which is quite affordable by the women in Bankura and **Hooghly** based units. Dr D. Ghosh says that there is no technology intervention so far other than medicated cotton. They do not use any gel or any kind of polymer as SAP substitute. Therefore, raw material is not a big hurdle for them. Only constraint is to establish a system of production consumption chain so that the mission fulfills its objective.

**4.6** **Mini Gender Hygiene Products Manufacturing Machinery for decentralized sectors**

Traditionally, multinational corporations (MNCs) have dominated the manufacturing of feminine hygiene products. The machinery used in manufacturing is expensive to procure and maintain. There is also the additional cost of the raw materials required to make the Gender Hygiene Products.

Inventor Mr. Arunachalam Muruganantham at Jayaashree Industries, a Coimbatore-based company, has found a solution with his mini Gender Hygiene Products-making machine. The low-cost mini machine’s design is based on small-scale production. Jayaashree’s mini machine can be purchased for about US$ 1,680. It is estimated that the mini machine can make 120 Gender Hygiene Productss per hour.

The affordability of the mini machine presents a unique opportunity to expand availability of this necessity while also increasing local employment opportunities. Entrepreneurs or women self-help groups can acquire the machine and set up a business to sell in underserved markets. Such groups can also address the social issues that constrain the uptake of Gender Hygiene Products. Jayaashree’s mini machine has scooped up a host of accolades, including the National Grassroots Innovation Award by Honorable Indian President Pratibha Patil on behalf of the National Innovation Council on November 18, 2009.

**4.7 Need assessment report on baby diapers and gender hygiene products**

Today, the global market for absorbent hygiene products is over US $ 50 billion. The evolution of hygiene products in Europe and the North America has taken 4 to 5 generations. Feminine care was introduced over 100 years ago. Baby diapers were invented 60 years ago. Adult incontinence products appeared 30 years ago. The feminine hygiene products market has evolved over more than 100 years to a more than $ 17 billion in the following category worldwide as referred in Table 5.

**Table 5. Different categories of gender hygiene products**

|  |  |  |
| --- | --- | --- |
| Thick pads | Panty liners | Ultra thin pads |
| Absorbent | Daily use | Wings |
| Dry surface | Tampon back-up | Thin |
| Self sit | Odor control | Comfort |

Per capita consumption of feminine hygiene products is illustrated in Table 6.

Table 6. Worldwide consumption per capita for year 2011

|  |  |  |  |
| --- | --- | --- | --- |
| Country | Population (million) | GDP/Capita US$ | Consumption Hygiene products/capita US$ |
| Brazil | 206.4 | 4,789 | 11.5 |
| China | 1493 | 1,637 | 4 |
| Germany | 90.7 | 36,900 | 26.4 |
| India | 1210 | 798 | 0.14 |
| Japan | 131.1 | 38593 | 41 |
| Russia | 157.3 | 5949 | 9.1 |
| USA | 328.4 | 7479 | 39 |
| Total world | 7105 | 7559 | N/A |

As regards consumption of total hygiene, absorbent products in India, total units consumed in 2007 in India were 2,829 million pieces. Baby diapers comprised 5% whereas adult incontinence, 1% and feminine care share is 94%. Past projections and future projections of women population in category of 15-54 years age is tabulated in Table 7.

**Table 7. Projection of use of hygiene products by women of 15-54 years in India**

|  |  |
| --- | --- |
| Year | Women, million |
| 1995 | 200 |
| 2000 | About 250 |
| 2005 | About 275 |
| 2010 | 300 |
| 2015 | Above 325 |
| 2020 | Above 350 |
| 2025 | Above 375 |

If we see the above projections of women in the category of 15-54 years in India and the details of sales of absorbent hygiene products in India, then the total sales were US$ 213 million in 2007, out of which adult incontinence share was 9%, baby diapers share was 18% whereas feminine care contributed 73%. Thus, in India, the evolution is expected to go quicker.

According to new research report “Indian Baby Care Market Analysis”, the Indian baby care market has experienced sustainable growth during the past few years. The market, which has long been considered as a niche segment in Indian perspective, has now transformed into the potential, full fledged industry, especially in its diapers segment. Diaper market had not grown by leaps and bounds in the past as price continues to be the main impediment. However, diaper brands have been steadily trying to correct the price-value equation and have been offering superior, technology-driven products. Consequently, the Indian diaper is anticipated to grow at a CAGR of over 16% during 2010 - 2013.

Moreover, with large and growing population of India, rise in income levels, stress on convenience, working couples, and higher mobility and competitive price offerings, growth rate is further anticipated to continue in coming years. Changing preference from traditional cloth nappies to disposable diapers, increasing income level, and product innovation are the prime reasons for the prospective growth.

**SAP production in India -** In March 2011, Reliance Industries signed a memorandum of understanding with US specialty chemicals Rohm and Haas to set up an acrylic monomer complex at its special economic zone in Jamnagar, Gujarat, where it is also building the world's largest refinery complex.

The new facility will make 200,000 tonnes/year of acrylic acid that is expected to spur development of super absorbent polymers, used primarily in the manufacture of baby diapers. Essar Chemicals, part of the Essar Group - a Reliance rival - and French chemical company Arkema are also exploring the possibility of setting up a joint venture (JV) plant to manufacture acrylic acid to be used in production of SAPs among other products. The plant was set up in 2010 at Vadinar, adjacent to Jamnagar, where Essar Oil commissioned its refinery late 2009. The chemical plant would use propylene from the refinery to produce acrylics.

According to Carlos Richer of Richer Diaper Consulting Services, India has about 45% more infants than China and almost six times more babies than in U.S. India will be the largest consumer of diapers in the world because of its growing middle class and constantly rising purchasing power parity (PPP).

Japan’s Unicharm enters Indian Gender Hygiene Products market - Japanese FMCG firm Unicharm announced its entry into the Indian feminine care market, which is currently dominated by multinational giants like Procter & Gamble and Johnson & Johnson. The company launched its global Gender Hygiene Products brand 'Sofy', said it aims to capture around 10 per cent of the market in the next three years. "The Indian feminine care market is growing rapidly. However, the penetration of Gender Hygiene Products in India is very low. So, we see that as an opportunity and a big potential for our product," Unicharm Managing Director Yukihiro Kimura told to the media. The company, which already sells 'Mamy Poko Pants' brand baby diapers in India, said it will initially start selling its Gender Hygiene Products in metros and will later move into smaller cities and towns. "Our aim is to establish the brand and we feel that we should at least be able to capture around 10 per cent market share in the next two-three years," the MD said. At present, the Gender Hygiene Products market in India is estimated to be worth around Rs 1,350 crore and is dominated by Procter & Gamble's 'Whisper' and Johnson & Johnson's 'Stay Free'. Unicharm had established a wholly-owned subsidiary in India in 2008. It has a production facility at Neemrana, in Rajasthan.

4.8 Baby diapers: Cost economics, marketing potential

Consumption of hygiene products per capita-Year 2005 is shown at a glance in Table 8.

**Table 8. Consumption of hygiene products per capita - Year 2005**

|  |  |  |  |
| --- | --- | --- | --- |
| **Country** | **Population** | **GDP/Capita, US $** | **Consumption Hygiene** **Products Capita, US $** |
| Brazil | 186.4 | 4,289 | 10.5 |
| China | 1,293 | 1,533 | 3 |
| Germany | 82.7 | 33,800 | 24.2 |
| India | 1,103 | 726 | 0.13 |
| Japan | 128.1 | 35,593 | 39 |
| Russia | 143.2 | 5,349 | 8.3 |
| USA | 298.2 | 41,768 | 35 |
| Total World | 6,465 | 6,879 | N/A |

The Indian market for baby diapers is around Rs 70 crore per annum. Some 24 million babies are born in India every year. If we typically calculate that 25% of these infants in the period between birth and 24 months use at least 28 diapers a week, the theoretically available market for diapers is 8.7 billion pieces per year. It is estimated that the diaper market would grow at a rate of around 5 - 10%. The market estimate of baby diapers and non-woven requirement is given in Table 9.

**Table 9. The market estimate of baby diapers and non-woven requirements**

|  |  |  |
| --- | --- | --- |
| **Year** | **Baby diapers demand** | **Non-woven demand** |
| **Qty(million pcs)** | **Value(Rs.Cr.)** | **Qty(tonnes)** | **Value(Rs.Cr.)** |
| 2001-02 | 53.85 | 70.00 | 161.55 | 1.78 |
| 2003-04 (Estimated) | 61.65 | 80.14 | 184.95 | 2.03 |
| 2007-08 (Projected) | 80.81 | 105.05 | 242.43 | 2.67 |

**4.9 Project design for Gender Hygiene Products/Baby Diapers machinery for decentralized units**

A model project profile is designed for decentralized sector in Tables 10-13.

**Table 10. Machine and infrastructure details**

|  |  |
| --- | --- |
| Production  | 350 pcs/ min per machine at 100% efficiency and capacity |
| Efficiency | 80% |
| Waste | 1.5-3.0 % |
| Power  | 110 Kw |
| Man power | Operator 1, Helper 10 |
| Automation | Semi automatic |
| Cost | Rs. 0.8-0.9 crore |
| Building size | 600 sq m per machine |
| Product | Gender Hygiene Products/baby diaper |

**Table 11. Raw material cost for approximately 8 gm regular Gender Hygiene Products**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sl no** | **Raw material** | **Qty per piece** | **Rate in Rs/kg** | **Unit cost** |
| 1 | Non-woven fabric | 1.1 g | 140 | 0.15 |
| 2 | Cellulose pulp | 4.5 g | 40 | 0.18 |
| 3 | Super absorbent polymer | 0.6 g | 100 | 0.06 |
| 4 | Polypropylene back sheet  | 0.96 g | 116 | 0.11 |
| 5 | Silicon paper of 25 micron 45 gsm | 0.67 g | 1125 | 0.75 |
| 6 | Hot melt seal | 0.45 g | 142 | 0.06 |
| 7 | Hot melt positioning seal | 0.14 g | 149 | 0.02 |
|  | **Total material cost per piece** |  |  | **1.33** |

**Table 12. Raw materials and their suppliers**

|  |  |  |  |
| --- | --- | --- | --- |
| **Sl No** | **Material** | **Composition and specification** | **Supplier** |
| 1 | Non-woven fabric | a) permeable top layer of 12 to 18 GSM is normally a spun bond fabric made of polypropyleneb) Impermeable polyethylene/non-woven film is the bottom layer. | Ginni Filaments, Supreme Nonwoven, Pantex, Fiber Web, Union Industries, PVD Plastic, India |
| 2 | Cellulose pulp |  | Wayerhaesder – Switzerland, Rayonier-UK, Tembee Tartas – France, Stora Enso-Italy |
| 3. | Super absorbent | Sodium acrylate, potassium acrylate, alkyl acrylate. | China, Korea |
| 4. | Polyethylene back sheet |  | Exten-Switzerland, Plastik-Italy, Huhtamaki-Germany |
| 5. | Silicon Paper |  | MCS-Switzerland, ICA-Italy, Rossella-Italy |
| 6. | Hot melt seal and positioners |  | Savare, National Henket-Italy |
| 7. | Packaging |  | India and other countries |

The super absorbent polymer is basically acrylic based polymer that forms gel after absorbing liquid. By this it can hold water up to 30 times its weight. This absorbent pad is attached to permeable top sheet made of nonwoven, mainly spunlace fabric. Then the same is attached to non-permeable bottom sheet made of polyethylene. The three layers/ components are glued and sealed to prevent leakage by using heat or ultrasonic vibrations. The content of absorbing pad composite will vary for different types of napkins.

**Table 13. Capacity and business**

|  |  |
| --- | --- |
| Speed of coating machine | 350 pieces/min (Average speed considering for single side: 360 m/h, for two passes |
| Working capacity | 300 pieces/min @ 85% efficiency |
| Production for 300 working days for 24 h/day at 100% capacity utilization | 12.96 crores pieces/annum. |
| Production for 300 working days for 12 h/day at 80% capacity utilization | 10.37 crores pieces/annum. |

Note:

1. Land & building cost is not considered in the project.
2. Capital subsidy schemes are not considered while calculating the profit.
3. Overhead expenses are not calculated in the scheme.

**Details of raw materials in a diaper**

* Surgical cotton rolls or cellulose fluff pulp and super-absorbent polymer for preparation of absorbent core.
* Web lint tissue paper/spun lace non- woven .
* Polystyrene sheet/spun-bond non-woven (polyethylene or polypropylene base) boarding the empanelled polystyrene/poly-ethylene/polypropylene sheet with lint tissue papered cotton lap.
* Elastic tapes, waist band or hot melt adhesive and fastening tapes, frontal tapes, pre-laminated tapes, leg elastic, etc.
* Super absorbent polymers.

**Process of manufacture of baby diapers**

* Preparation of cotton lap/cellulose pad.
* Wrapping the cotton lap in lint tissue paper and pasting.
* Cutting the lint tissue papered cotton lap to required size.
* Cutting the pieces of polystyrene sheet or polyethylene sheet or spun bond non-woven.
* Enchannelment of elastic strip on the length sides of sheet.
* Bonding the elastic empanelled polystyrene piece or polyethylene piece or spun-bond non-woven

piece with the lint tissue papered cotton lap.

* Finishing and packing.

**Major converting plant & machinery equipment for diaper production**

* Raw material un-winder.
* Pulp grinder.
* Fluff drum forming system.
* Fluff processing.
* Super absorbent polymer applicator.
* Fluted elastic waist band applicator.
* Fluff leg cuff applicator.
* Hot melt glue applicator.
* Tape detector.
* Compressing unit.
* Poly-cutting system.
* Stacker unit.
* Mini scutcher.

**Automatic diaper making machine manufacturer**

1. M/s M D Viola, Italy.
2. M/s Diatec Srl, Italy.
3. M/s BHT Bicma, Germany.
4. M/s Caldiroli, Italy.
5. M/s Fameccanica, Italy.

**Raw material supplier**

* Unimin India Ltd, Village Kadayia, Daman Industrial Estate, Near Daman 396 210.
* Fibre Web, Behind Unimin India Ltd, Village Kadayia, Daman Industrial Estate, Near Daman 396

 210.

* Brisk Surgicals Cotton Ltd 62, GIDC Estate, Kalol 382 725, Dist.Gandhinagar. Tel: (Off) 02764-

 227888, (Res) 02764-224994. E-mail:briskgroup@yahoo.com

* Ruby Surgicals & Allied Products (P) Ltd A-43, 44, MIDC Area, Ajanta Road, Jalgaon 425 003.

**Plant specification**

**Table 14. Plant capacity and utilization**

|  |  |  |
| --- | --- | --- |
| Rated plant capacity | No. of working days | No. of shifts |
| 1,00,000 pieces/day (3 crore pieces of baby diapers/annum) | 25 days/month = 300 days/annum | 1 per day; One shift : 8 hours |

**Table 15. Plant economics (fixed cost) at a glance**

|  |  |
| --- | --- |
| **Heads** | **Cost (in INR crores)** |
| **Land & Building:** Total land required 1200 sq m @ Rs 3000/sq m 0.36 Built-up area 1,000 sq m | 10.86 |
| **Plant & Machinery:** Total plant & machinery for diapers (approx.) | 3.00 |
| **Installation cost for electricity:** 130 KVA transformer 0.015 | 23.015 |
| **Office equipment, project preparation, lab, etc.** | 0.025 |
| **Preliminary expenses** | 0.030 |
| **Total** | 30.055 |

 **Methodology of R&D Activities**

1. Materials selection and procurement
2. Physical and chemical pretreatment of industrial waste jute(Caddice)
3. Preparation of cellulose laps from jute
4. Preparation of super absorbent polymer: Laboratory optimization completed followed by successful preparation of the polymer of a 2 kg batch size done.
5. Blending of cellulose laps with super absorbent polymer
6. Test for biocompatibility of our jute polymer blend
7. Necessary fine tuning of super absorbent polymer preparation and conversion of jute caddice so that maximum water uptake capability can be obtainable from an optimum ratio of polymer to jute fiber in the final superabsorbent cotton lap material
8. Final cost calculation based on the cost of bulk raw material and optimized process cost
9. Prototype product development and market testing
10. Pilot scale trial

**Detailed Report on R&D**

**6.1. Pretreatment of industrial waste jute (physical and chemical treatment)**

Industrial waste jute (caddice) was used for the treatment. Different chemical and physical treatments were done for proper defibrillation and fiber surface modification, intended for increasing water absorption and hopefully better bonding with the SAP.

* The industrial waste jute was soaked in detergent for 24 h for the removal of dust, oil, foreign particles and other water-soluble components of jute caddice
* To dissolve out hemi-cellulose, other carbohydrates, amino acids, lignin partially and to increase the surface area of fiber, alkali treatments have been done using different concentrations of alkali at different time intervals and ambient conditions
* Jute caddice was taken and kept in sodium chlorite and acetic acid solution (pH 4) for 48 h. Next the fibre was treated with sodium hydroxide solution for 24 h.
* Next it was washed, neutralized and bleached using detergent solution

|  |  |
| --- | --- |
| **6.2. Preparation of super absorbent polymer (SAP** |  |
|  |  |
|  |  |

Outlines of the preparation of super absorbent polymer are shown in Schemes 1 and 2.

|  |
| --- |
| Acrylic monomerAlkaliMonomer precursorPolymerization/Cross linkingDry super absorbent polymerBlend with bleached jute |
| **Scheme 1. Preparation of superabsorbent polymer** |

|  |  |
| --- | --- |
| Industrial waste juteCleaning, shear reduction/softening of fiber length/diameter and bleachingBleached jute with activated fiber surfaceBleached jute blended with super absorbent polymerJute polymer blend packed into diapers  |  |
| **Scheme 2. Detail flowchart of the process** |

Some photographs of laboratory scale chemical treatment of jute caddice, cellulosic pulp prepared from jute caddice and a packed absorbent pad containing jute caddice cellulosic pulp and our SAP

|  |  |  |
| --- | --- | --- |
|  |  |  |

**Figure 2. Chemical treatment of jute caddice, cellulosic pulp from jute caddice and an absorbent pad with cellulosic pulp and SAP**

**7. Results and Outcomes of R&D Activities**

**7.1 Tests done to analyze the physically and chemically treated jute fibers**

* Measurement of weight percentages (loss or gain due to exclusion of components of jute fiber except cellulose, etc. or inclusion of moisture, water molecules, etc.) of fiber as a result of different treatments.
* Study of changes in functional groups through FTIR spectroscopy after alkali treatment.
* Study of moisture absorption capacity of industrial waste jute.
* Study of fiber surface by Scanning Electron Microscopy (SEM) after different treatments.

**7.1.1 Water absorption test of jute waste**

Water absorption test was carried out by immersion of industrial waste jute in water for 24 h and was found to be 190 ± 11 %.

**7.1.2** **Water absorbency time**

Water absorbency was carried out according to IS: 2369 – 1967 method. The water absorbency is expressed as the time taken by the jute samples to be completely immersed in water. The water absorbency of industrial waste jute was compared with other fibers as shown in Table 16.

**Table 16. Time required for wetting of jute by water**

|  |  |  |
| --- | --- | --- |
| Sl. No | Fibre | Time taken to absorb water |
| 1 | Industrial waste jute | 90 min |
| 2 | Jute felt | 8 min |
| 3 | Treated jute waste | 19 sec |
| 4 | Surgical cotton | 4.5 sec |

**7.1.3 Change of weight of jute after alkali treatment**

Jute samples were treated with varying concentrations of NaOH solution (1 %, 2 %, 3 %, 4 % and 5 %) and the weight loss after 4 h was measured at room temperature (33 oC) after neutralization of excess alkali from jute surface and oven drying at 60 oC for 5 h as shown in Table 17.

**Table 17. Change of weight after alkali treatment**

|  |  |  |
| --- | --- | --- |
| Sl. No | NaOH (%) | Weight loss (%) |
| 1 | 1 | 0.083 |
| 2 | 2 | 0.118 |
| 3 | 3 | 0.152 |
| 4 | 4 | 0.155 |
| 5 | 5 | 0.164 |

**7.1.4 FTIR study of jute and alkali treated jute waste.**

FTIR spectrum of untreated jute and alkali treated jute was recorded from 400 cm-1 to 4000 cm-1 (Figure 3). From the spectrum, it was found that the intensity of the peak at 1736 cm-1 attributed to the C=O stretching of hemicellulose of untreated jute felt gradually decreases with increase in concentration of alkali.

|  |
| --- |
|  |
| **Figure 3. FTIR spectra of jute fibres (untreated, alkali treated and bleached)** |

**7.1.5 Scanning Electron Microscopy (SEM) of jute fiber and commercial baby diaper fiber**

The surfaces of the jute and baby diaper fibers are shown in Figures 4a and 4b.

**7.2 Tests done to analyze the water absorbing and holding capacity of the super absorbent polymer(SAP)**

**7.2.1 Water capture and retention capacity of 1 g polymer**

1 gm of the grafted SAP was kept in water and its water capture and retention capacity was studied. The gradual swelling capacity of the SAP is shown in Fiure 5a-

**Figure 5. Water capture and retention capacity of 1 g SAP developed in our laboratory**

**7.2.2 Optimization and standardization of total process and prototype product development**

**Blending of treated jute and super absorbent polymer**

Synthesized SAP and bleached jute were blended together in a mixer. Ratio of the weights of bleached jute and SAP has been optimized to obtain maximum water holding capacity of the processed jute-SAP blend. As per our investigation and analysis with our developed material as well as with commercial products, this ratio can differ with the nature of product, viz., diaper and sanitary napkin. The fluid absorption capacity of sanitary napkin can be kept at lower level than that of diaper.

**7.2.3 Water uptake of jute super absorbent polymer mixture**

Treated jute and powdered SAP were blended in different ratios and their water absorption was studied. **Amount of water absorbed by** **1.0 g SAP is 180 ml** **and water absorbed by 1.0 g processed jute is 12 ml**. Water absorbed by 1.0 g jute-SAP blends in different ratios is shown in Table 18.

**Table** **18. Water absorption of jute polymer mixture**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Sl.No | Jute:Polymer ratio(dry mix) | Jute (%) | Polymer (%) | Water absorbed (ml/g) of jute-polymer blend | Water absorbed (ml/g) of SAP-cotton blend (Pamper) |
| 1 | 1:1 | 50 | 50 | 96 | 140 |
| 2 | 1:2 | 33 | 67 | 124 |
| 3 | 1:3 | 25 | 75 | 138 |
| 4 | 1:4 | 20 | 80 | 147 |
| 5 | 2:1 | 67 | 33 | 68 |
| 6 | 3:1 | 75 | 25 | 54 |
| 7 | 4:1 | 80 | 20 | 46 |
| 8 | 5:1 | 83 | 17 | 40 |
| 9 | 2:3 | 40 | 60 | 113 |
| 10 | 3:2 | 60 | 40 | 80 |

It is found that water uptake by treated jute and polymer mixture in the ratio 1:4 is similar to that of the polymer used in baby diaper available in the market (Figure 6a-

**7.3 Polymer synthesized in bulk**

About 8 kg of polymer was synthesized in bulk using acrylic acid, natural polymer, cross linker and initiator. Acrylic acid was neutralized with sodium hydroxide in an ice bath. Calculated amount of natural polymer was added into the above neutralized monomer solution. The mixed solution was stirred under nitrogen atmosphere. An oxidative initiator and cross linker were then added into the solution and the reaction was allowed to continue for 15-20 min. The synthesized polymer was allowed to mature overnight. The product was then dried and ground into granular samples. The photograph of the reactor used for bulk synthesis of the absorbent polymer is shown in Figure 7.

|  |
| --- |
|  |
|  |

**7.4 Biocompatibility test**

**Cytotoxic assay**

Cytotoxic effect of the as developed diaper materials on NIH-3T3 cells (mouse fibroblast American type culture collection) was determined by conventional MTT assay. Briefly, NIH-3T3 cells in the exponential growth phase were seeded in 96-well flat-bottom culture plates at a density of 2.5 × 103 cells per well in 0.1 ml DMEM complete medium. The cells were allowed to adhere and grow for 24 h at 37 °C in an incubator (Heraeus Hera Cell, Germany), after which the medium was aspirated and replaced with 0.1 ml fresh medium containing the test materials.

Control wells were treated with equivalent volumes of material free media. After 24 h of incubation, the culture medium was removed, and 100 μL of 1 mg∕ml MTT reagent in PBS was added to each well. After 4-5 h incubation, the unreduced MTT solution was discarded. Then DMSO (100 μL) was added into each well to dissolve the purple formazan precipitate which was reduced from MTT by active mitochondria of viable cells. Plates were shaken and formazan dye was measured spectrophotometrically using a benchmark microplate reader. The assay was performed in triplicate. The cytotoxic effect of each treatment was expressed as percentage of cell viability relative to the untreated control cells. Percentage control was defined as: {[OD treated cells at 550 nm] ∕ [OD control cells at 550 nm]} × 100.

|  |
| --- |
| **Graph1** |
| **Figure 8. Biocompatibility of the product compared to the commercial product** |

Cytotoxicity is indicated by malformation, degeneration and lysis of cell under and around the test material. Direct contact between the NIH-3T3 cells and the above samples did not evoke any such adverse effects. Figure 8 shows the results obtained during the MTT assay of treated jute, SAP and jute-SAP blend products developed in this project. From Figure 8 it is evident that the product developed in our laboratory has similar cell viability as that of commercial Diaper Material (Pampers) and hence may be considered as biocompatible material.

**7.5 Biodegradation test**

Biodegradation of the hygiene product is necessary as these products are disposed in the environment after use. It was assessed through soil burial test according to the standards. It was observed that the samples degraded within 60 days (Figure 9a-c).

**A) Process development (laboratory scale batch process) and product testing**

* For this particular project industrial waste jute caddice was procured from market and used for the development of hygiene product.
* Optimized the process of cleaning and bleaching of jute caddice by varying the proportion of different ingredients in the batch.
* Superabsorbent polymer synthesis process was optimized.
* The treated industrial waste jute caddice was blended with our SAP in different proportions as per the market needs.
* The jute cellulose-SAP was packed in nonwoven polypropylene films.

**Achievement from laboratory scale process**

1. Improvement in the physical and chemical properties of industrial waste jute
2. Synthesis of superabsorbent polymer and its blending with the treated jute caddice
3. Good water absorption as well as water retention capacity of the final product
4. The final product is biocompatible
5. Biodegradation of the product undergoes easily

**Recommendation:**

The process of treatment of industrial waste jute and synthesis of superabsorbent polymer is feasible at industrial level with minor modifications of machineries and techniques which will depend upon the area of application.

**8. Product/Process Standardization**

The process of treatment of industrial waste jute and synthesis of SAP has been standardized. Few necessary modifications are being made to the set up so that we can get a thin film of SAP which can be easily dried and grinded.

**9. Industrial Field Trial for Product Development**

Sufficient quantities of SAP and processed cellulose from jute have been prepared for supply to the Baliagram Unnayan Samity (NGO). This NGO will prepare sanitary napkins and distribute to the users for testing. M/S Jayasree Industries, Coimbatore has been contacted for sanitary napkin product making.

**10. Cost Analysis/Cost Effectiveness Study Report**

Cost of 1 kg cellulosic pulp from jute caddice is Rs.120

Cost of 1.0 kg super absorbent polymer is Rs.125

Cost of 1.0 kg polypropylene sheet is Rs.114

**11. Comparative analysis of hygiene products**

Cost of jute cellulose-SAP based absorbent product was calculated taking the calculated cost of components mentioned in Section 10. The cost comparison of such jute cellulose-SAP product (developed in this project) with commercial absorbent products are shown in Table 19. As is seen from Table 19 the cost of jute cellulose-SAP based absorbent product is cheaper than the commercial absorbent products in terms of water uptake capacity and the weight of the absorbent materials.

**Table 19. Comparative data on the cost and water absorption capacities of various commercial hygiene products with the product developed in our laboratory**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Baby Diaper (Pampers)****(Fibre:SAP ratio unknown)** | **Sanitary Napkin (Stayfree)****(Fibre:SAP ratio unknown)** | **Sanitary Napkin (Whisper: ultra thin)****(Fibre:SAP ratio unknown)** | **Jute-SAP absorbent product developed in our laboratory\*****(Fibre:SAP = 5:1)** |
| Cost | Rs 24 (2 pcs) | Rs 22 (8 pcs) | Rs 70 (8 pcs) | Rs 11.68 (8 pcs)  |
| Total weight of 1 piece (g) | 26.0  | 8.7  | 6.0 | 11.32 |
| Total weight of fiber & SAP in 1 piece (g) | 13.7 | 6.8 | 3.8 | 10  |
| Water holding capacity of 1 piece (ml) | 350 | 60 | 55 | 400 |

**\*The cost of the product will vary according to the ratio of jute cellulose and SAP.**

**12. Conclusion**

**RECOMMENDATION AND FOLLOW UP ACTION**

**12.1. Activities completed and efforts towards bulk preparation and technology transfer**

1. Laboratory R&D on the development of cellulose pad substitute from Industrial waste Jute has been completed.
2. Baliagram Unnayan Samity (NGO) and M/S Jayasree Industries, Coimbatur has been contacted for sanitary napkin product making.
3. M/S DiponEd BioIntelligence has approached us and showed interest for taking our technology of diaper materials

|  |
| --- |
|  |

**12.2. Observations on pilot scale trial**

We have successfully synthesized about 8 kg of polymer in bulk using acrylic acid, natural polymer, cross linker and initiator and we are looking forward to a pilot scale trial of our product.

**13. Workshop Organized/Participated, Publication, Conference and Human Resource Development**

**13.1. Workshops organized**

**Workshop 1: Technology Transfer Seminar**

The second workshop organized by National Jute Board, during 8-9 November, 2011 at Hotel Stadel, Kolkata. In this workshop IIT Kharagpur participated actively in the “Technology Transfer Seminar” and presented the progresses of all the JTM projects assigned to IIT Kharagpur.

|  |
| --- |
|  |

**13.2 Presentation in International Conference**

We shall soon present our work in the forthcoming International Conferences**.**

**13.3 Human Resource Development**

Project Scholar: One project scholar and one Junior Project Officer were involved in this developmental research.

**14. Future Program**

1. Generating liaison between user/trader and interested diaper manufacturer.
2. Both administrative and financial supports of NJB in the form of project are required to see the commercial success of the project.
3. Venture investors may also be encouraged.
4. The investigator will continue to extend technical support to any entrepreneur interested for commercial production of diaper products.

**15. Acknowledgement**

The project team acknowledges with thanks the National Jute Board, Ministry of Textiles, Govt. of India, Kolkata for funding this project work and Indian Institute of Technology Kharagpur for providing necessary infrastructure facility for carrying out the project work. We also thank the organizations who helped in market feedback and for supplying chemicals relevant to the project.