

# Handmade Paper in the Context of Green, Clean And Closed Loop System

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## ABSTRACT

*Handmade paper industry is a sunrise industry. Its performance has been spectacular during the past 7 years. (Table-1)*

*- A record increase of more than 3000% (1990-91, Rs. 6-0 million to Rs. 210 million in 1999-2000) in the export of handmade and value-added items. (Fig. 1&2)*

*- A remarkable increase of about 150% in annual production i.e. from a production worth Rs. 121 million to Rs. 294 millions. (Fig. 3)*

*- Increase in the number of persons directly employed in the industry (7,000 to 10,000). Besides, more than 8,000 people are indirectly employed in the industry for making value-added items from Handmade Paper.*

*- Number of units has increased to 415.*

*- A new breed of educationally qualified and professionally trained entrepreneurs is opting for this industry'.*

*- There are success stories on each of the individual, regional and national level (Table-2).*

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## INTRODUCTION

The handmade paper industry-an ancient craft of India. Though it is claimed that paper was invented in 105 A.D. by Tsai -Lun in Lei-Yang province of China, recent researches have ample evidence to show that the paper was being made in this country as back as 250 B.C. However, that paper could not be accepted by the Indian Society at that time because it was not treated pious for writing religious books. The knowledge of papermaking entered in this country in the 11 century after the invasion of Mahmood Gaznavi. It was a developed craft in 1158 at Kalpi. A number of books written by hand on Handmade paper by eminent authors such as Dhawanyaloklochan by Anand Vardhanacharya in 8 Century, Achar Dinkar by Arya Vardhaman Suri (1411 A.D.), Solah Sanskar (1422

A.D.), Isthuliyabhadragunmala by Suryachandra, Sanganer (1621 A.D.), are available in Rajasthan to speak about the quality of the paper which was made at that time.

The Indian Handmade paper industry was its zenith during Mughal period. However, this flourishing craft received a death blow during the British Ruie because of the import of mill made paper and the policies of alien rulers. The most starting and

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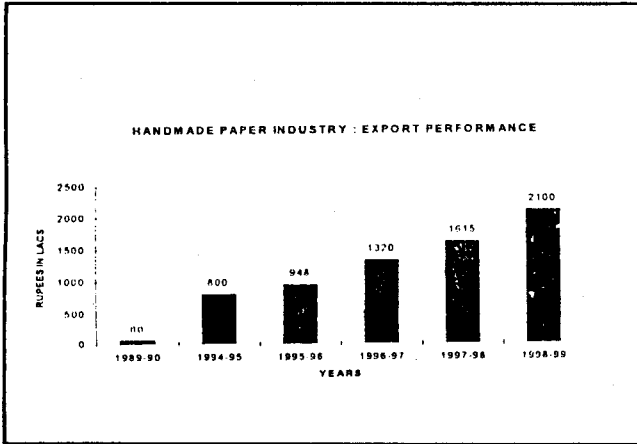
**TABLE-I**  
**PHASE-WISE DEVELOPMENT OF THE HANDMADE PAPER INDUSTRY**

PERIOD	PHASE	NATURE OF DEVELOPMENT	No. of Working Units <sup>(2&amp;3)</sup>	* Installed Capacity (M.T./Annum)	Production in Rs. Lacs <sup>(2&amp;3)</sup>	Sales in Rs. Lacs <sup>(2&amp;3)</sup>	Employment <sup>(2&amp;3)</sup>
1952-53 to 1955-56	I phase	Organisation and assistance to traditional Kagazi	40	520	5.00	5.00	1,000
1956-57 to 1966-67	II Phase	Co-operative societies and registered institutions	149	3870	39.00	36.00	5,000
1967-68 to 1976-77	III Phase	Co-operative societies and registered institutions	201	10,400	156.00	171.00	4,000
1977-78 to 1986-87	IV Phase	Co-operative societies and registered institutions	251	13,000	439.17	463.01	5,000
1987-88 to 1991-92	V Phase	Co-operative societies and registered institutions	344	18,000	1210.39	1238.52	7,000
1992-93 to 1998-99	VI Phase	<p><b>A. Accelerated growth of individual and private Entrepreneurs.</b></p> <p><b>B. Catalytic intervention of UNDP project</b></p> <ol style="list-style-type: none"> <li>1. International Market Survey and Study</li> <li>2. Participation in International Trade Fairs</li> <li>3. Exposure of Indian handmade paper to world market.</li> <li>4. Domestic Market Survey &amp; Study</li> <li>5. National level Workshops</li> <li>6. Participation in exhibitions</li> <li>7. Regional Workshops</li> <li>8. Consultancy</li> <li>9. Dissemination of information</li> <li>10. Organisation of Regional Workshops for Dissemination of technology</li> <li>11. <b>R&amp;D</b> <ol style="list-style-type: none"> <li>i). Alternative raw materials</li> <li>ii). Process development</li> <li>iii). Machinery &amp; equipment development</li> <li>iv). HRD</li> </ol> </li> </ol>	415	32,500	2948.43	3004.27	10,000

\* 1. 60% Utilisation of the installed capacity in HMP units.

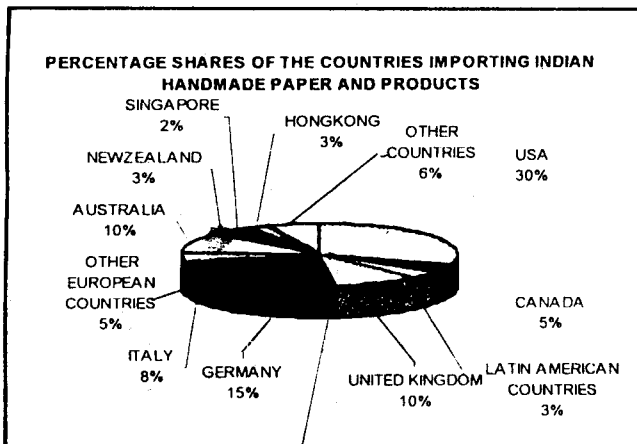
2. In recent years, some of the units have achieved capacity utilisation of more than 90%.

**Fig. 1**



noticeable fact about this craft is that in the Indian subcontinents craft survived only in India though breathing last, whereas in other countries like Pakistan, Mianmar (Burma) and Bangladesh, it almost died. After independence, the programme for revival of this industry was taken by Khadi & V.I. Commission (KVIC) giving support to handful traditional Kagazies, who were still pursuing this craft facing abject poverty. The industry has made a steady progress because of the support of the Government in past four decades. In recent years, it has made its significant place in the world market because of its eco-friendly nature ethnic touch and cost effectiveness.

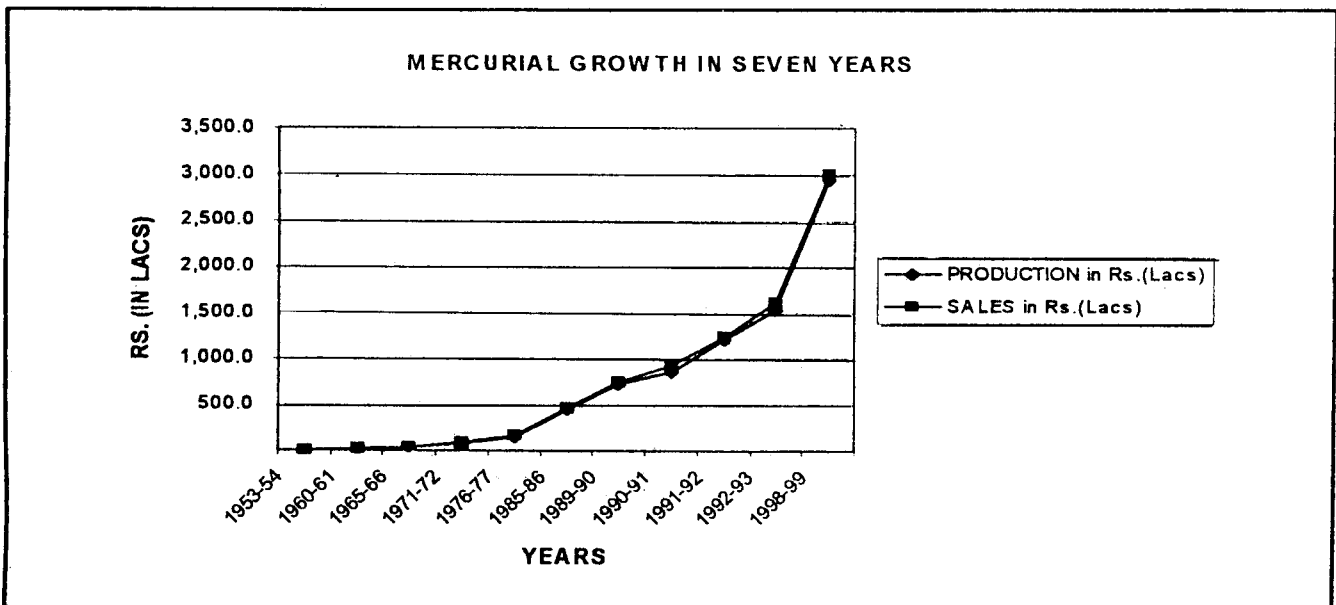
**Fig. 2**



This extraordinary performance is a reflection of continuous, rigorous and collaborative efforts of Kumarappa National Handmade Paper Institute (KNHPI) and Khadi & V.I. Commission (KVIC) in association with United nations Development Programme (UNDP). KNHPI (Annexure-I) is a well-established and world -class institute that emerged in 1991 from the UNDP-assisted Govt. of India project (IND/90/037/A/01/37) titled as "Strengthening the Handmade Paper Industry in India". The institute has now become a centre with the capacity to develop and transfer the technology and to provide services to industry to increase productivity and improve the quality and marketability of Handmade Paper (HMP) products.

As clear from the above facts, Indian HMP industry is flourishing and moving towards a new horizon. It is fast emerging as competent industry. Today, even in the era of the Millenium concept of

**Fig. 3**



**TABLE-2**  
**SUCCESS STORIES OF HMP INDUSTRY AT 3 LEVELS**

	<u>1990-91</u>	<u>1998-99</u>
<b>INDIVIDUAL LEVEL:</b>		
I. An individual unit (Production worth Rs.)	47.0 Lakhs	6.0 Crores
II. Employment including 30% women	60	426
III. Export	Nil	100%
<b>REGIONAL LEVEL:</b>		
I. Area Sanganer		
Kagazis development	3 families	15 families
Entrepreneurs	Traditional	Non traditional too
<b>NATIONAL LEVEL:</b>		
I. Production	Production level (worth Rs. 121 million), which was achieved in 39 years i.e. from 1953 to 1992, has more than doubled within 6 years i.e. worth Rs. 294 million in 1998-99	
II. Export (worth Rs.)	60.0 Lakhs	21.0 Crores
III. Improved capacity utilization		
IV. Enhanced earning & profitability		

a green, clean and closed loop system, HMP industry may remain smiling while the paper mills are under great stress for better utilization of resources and to operate within environmentally compatible limits. The basic fact lying behind its relevance in this context is its inherent nature of ecofriendliness, cleanliness and being green. Besides, there are also some basic differences in the economic and technical considerations for selection of raw materials in a paper mill and a Handmade Paper unit<sup>5&6</sup> (Table-3).

Raw materials used by Handmade Paper Industry include Hosiery cuttings (80%), Cotton rags (15%) and Agricultural residues (5%). The various agro residues, bast fiber, leaf fibers found having tremendous potential for making handmade paper are listed in the Table-4.

Since the raw materials used by HMP industry are easily available either as the waste products of the textile industry or as the fibers from the locally available non-woody annual or biennial plants which can be conveniently grown year after year i.e. which have short renewable cycles, the process of handmade paper making is green.

#### **HAND MADE PAPERMAKING IS CLEAN:**

The usual papermaking process in a mill is highly polluting. The black liquor generated by pulping, bleach effluents and boiler -emissions etc. are great problems for the paper industry and industry invests a lot to reduce their generation and also for their treatments so as to have a safe discharge.

While the handmade paper making is based on such a clean process that it generates negligible or very little pollution. The obvious reason behind the cleanliness of the process of handmade paper making lies in the fact that the cotton rags and hosiery cuttings (most commonly used raw materials) do not require the delignification process at all as they contain mainly the celluloses. They are simply processed in the beater after sorting and cutting. Besides this, pulping processes used for the alternative raw materials, are simple and based on the use of non-polluting chemicals like lime, soda ash, ash lye, NaOH etc. **Open hot digestion**, most commonly used pulping process, is clean itself. The another process termed "**Alkaline Pulping Process (APP)**", which

**TABLE-3**

**FACTORS FOR SELECTION OF RAW MATERIALS**

(PAPER MILLS IN ORGANISED SECTOR V/S HANDMADE PAPER UNITS)

<b>PARAMETERS UNITS</b>	<b>LARGE PAPER MILLS</b>	<b>HANDMADE PAPER</b>
<b>A. ECONOMIC CONSIDERATIONS:</b>		
1. Quantity	High	Relatively very small
2. Harvesting	Difficult	Easy (Waste and Residues)
3. Transportation	High	Low
4. Regular Supplies	Uncertain	Assured
5. Processing cost	Economics of mass production	Cheap labour, cheap managerial cost, cheap infrastructure
<b>B. TECHNICAL CONSIDERATIONS:</b>		
1. Removal of non fibrous material	By complex, high tech-process	simple
2. Colour to strength ratio	Important at the cost of strength properties & permanence because of drastic chemical action on fibres	Not important HMP is known for natural/off white colour, strength properties and permanence No drastic chemical action.
3. Yield	Relatively low	Relatively high

incorporates bleaching stage in the pulping process itself, has been found to be attractive for producing TCF paper from the bast fibres.

It would be worthwhile to point out here that in Handmade Paper Industry, the water requirement per ton of paper is about 50m<sup>3</sup> against 100-350m<sup>3</sup> per ton of paper in the mill sector<sup>29</sup> Waste water

generation is also low in the HMP units (30m<sup>3</sup>/ton Vs. 75-200m<sup>3</sup>/ton of paper). The efforts to further reduce the water consumption and generated effluents are there. The effluents of units are well within tolerable limits of BOD & COD and are either recycled or discharged safely to the backyard of the units. The industry is thus creating negligible or far less pollution than a paper mill or any other industry.

**TABLE-4**

**ALTERNATIVE RAW MATERIALS FOR HANDMADE PAPER INDUSTRY**

<b>BAST FIBRES</b>	<b>STALK FIBRES</b>	<b>LEAF FIBRES</b>	<b>WASTE PAPERS</b>
Jute (Raw Jute, Jute Sliver, Jute Caddies)	Wheat Straw (Agro-residues)	Sisal	Shredded currency waste
Aak	Rice Straw ( " )	Banana	Office Records
Kenaf	Bagasse ( " )	Wild Banana	Press Cuttings
Common Hemp	Sabai Grass	Munj	Used Ballot Papers
Moru alba		Pine apple fibre	
Daphne Papyracea			
Wikstroemea Canescen			

**HANDMADE PAPER IN TERMS OF CLOSED LOOP SYSTEM**

A closed loop system is preferred and applicable when the waste stream consists of only auxillary materials because forced enclosure of trash and undesirable additives in the paper has a negative effect both on appearance and strength properties. It is also undesirable from the recycling point of view since all these substances go through the whole system again during the next cycle<sup>10</sup>. On this principle, a HMP unit can easily be set up with the zero-effluent discharge and thus can be closed. The convenience of closing a handmade paper unit is that it contains only diluted waste streams because of the comparatively less aggressive chemical treatments.

**INTRODUCTION OF BIOTECHNOLOGY**

Despite the marvelous achievements of the HMP industry, India is still lagging behind the countries like China which has production level of about 0.2 million tons (i.e. 2.0 lakhs which is about 6.6% of the current paper production of India) against the current level of our production of 20,000 tons. We have miles to go. In the same way, the handmade paper industry although generates comparatively less pollution and is well under the environmentally compatible limit but this does not mean that the industry can fold its hands and become passive because pollution is after all a problem whether to a small or a greater extent. As the environmental laws are becoming more and more stringent, some day the HMP industry can also come under the category of a polluting industry. Therefore the industry is still dynamic and ready to accept modern technologies for further betterment and improvement of its processes. Keeping all this in view, KNHPI has come forward to introduce biotechnology in the world of handmade paper. Biotechnology (the science dealing with technical exploitation of living organisms and/or their products) is the most relevant and promising science of today. The advantages of biotechnological process over the chemical processes are clear from the table.

<b>Biotechnological Processes</b>	<b>Chemical Processes</b>
- Bases on cleaner production techniques	- Highly polluting
- Minimum energy requirement	- Energy intensive
- Require less equipments	- require multiplicity of equipments
- Compatible between stages and over all reduced cost	- Low compatibility between stages

- |   |   |
|---|---|
| <ul style="list-style-type: none"> <li>- Are inherently more selective &amp; specific having the key benefits of reduced side reactions, easy separation and potentially negative environmental effects.</li> </ul> | <ul style="list-style-type: none"> <li>- Are not so selective and have a wide range of side reactions and environmental effects.</li> </ul> |
|---|---|

The recent symposium organized by All India Biotech. Association and Dept. of Biotechnology on "Biotech. Industry - A challenge for 2005 A.D." narrates the awareness about the potential and bright future of this technology even in the developing countries like India.

The various biotechnological applications showing potentials for the Paper industry included barking, deinking, depitching, biopulping, biobleaching, decolourization of the effluents, improving the drainage of secondary fibers, retting etc<sup>13-16</sup>. There are so many applications but biobleaching is the only process that has been most successful commercially and that too in some of the developed countries only. This is not new & surprising at least for a microbiologist or biotechnologist because he/she knows that it often takes time to "convert a biotechnology breakthrough into a commercial venture".

This is because a large number of technical and also important commercial and legislative criteria is to be satisfied in order to achieve commercial success. These include development of efficient process technology package through scale up studies, starting from shake flask level along with inputs from molecular biology, optimization of unit operation protection of the technology package & issues related to practicing the process on commercial scale when recombinant organisms are used.

This is what the biopulping consortium<sup>17</sup> (formed in April 1987 by including FPL, universities of Wisconsin & Minnesota & up to 22 Pulp & Paper-related companies) is actively engaged in. The overall goal of the consortium research is to evaluate the commercial & economic feasibility of biomechanical pulping. The consortium has already shown that biopulping works but it is facing difficulties for the commercialisation.

**TECHNOLOGICAL CONSTRAINTS IN ADOPTING BIOTECHNOLOGICAL PROCESSES IN THE MILL SECTOR**

Major problems are the ones that come while

upscaling any biotechnological process for its commercialization. As per the recent reports of biopulping consortium,

- a. The processes of steaming, cooling and fungal inoculation of wood chips are to be carried out in a continuous manner, contrary to their batchwise operation in laboratory studies.
- b. The commercial levels of the process need to be about 200-2000 tonnes or more per day of wood chips processed, representing a  $10^3$  increase in the scale used at laboratory (1.5Kg. wood chips on O.D. basis). The larger scale with a 2-week treatment time would require the routine storage of 28,000 tons of wood for a 2000 ton per day plant which is a pile  $160,000\text{m}^3$  in volume. To put the amount of chips in perspective, it would be a pile of chips from 100m long, 40m wide & 40m high. The decontamination and inoculation (with sufficient amount of suitable fungus) of such a huge pile of wood chips maintenance proper incubation conditions (temperature, pH, aeration, humidity etc.) for the long period of at least 2 weeks. This seems difficult for a paper mill.

Biobleaching is comparatively easy to implement in a mill as xylanases can be easily applied & require essentially no capital expenditure because of the enzymatic reaction takes place during the storage of brown stock in the high density tower. The minor but important problems are:

- To use cellulase - less mutants (enzyme xylanase should be free of cellulase).
- Proper mixing of enzyme solution with the pulp.
- Maintenance of proper pH & temperature for the required retention period of about one to two hours. A mill employing large amount of pulps, requires a rather high amount of enzyme and acid (for pH adjustment, if required ) as well. So installation of two tanks connected to high density tower would be required for the storage of acid and enzyme.
- Sufficient amount of enzyme. The enzyme is to be imported in India so it is costly and its use does not seem economical in terms of money until and unless we have the indigenous production of the enzyme.

## ADVANTAGES FOR HANDMADE PAPER INDUSTRY:

Fortunately what are the difficulties for the mill-sector can prove boon for a HMP unit since handmade papermaking process utilizes batch processes & operates on small -scales so it is very easy to incorporate biopulping in the existing process. Neither, there would be any problem of scale up nor of making the process continuous. The most important point is just to evaluate the potential in the specific context of handmade papermaking.

The biopulping economics<sup>21</sup> estimated (through two 50 tons each, outdoor chip-pine trials) by the scientists of the consortium reveals an operating cost of 9.44US \$/ton of O.D. pulp besides the capital cost of  $5.7 \times 10^6$  US\$ (for 600 tons per day pulp) for biopulping. As far as HMP industry is concerned, this cost would definitely be much lesser because firstly the maximum capacity of a HMP unit is 0.5tpd so the capital cost would be reduced respectively and secondly the operating cost shall also be reduced drastically because neither there will be the need of ventilation blowers (as a small pile of raw materials could be mixed manually) nor the specific equipment (consisting of screw conveyors) would be required as suggested for the mill-sector<sup>(18, & 22)</sup>. The whole thing appears to be rather simpler for a HMP unit. However, this all requires the proper work to be done for its implementation.

Consideration that "the sophisticated science of biotechnology is difficult to be accepted by the general mass of the Handmade Papermakers (who are not so highly educated)" shall be wrong definitely. On the contrary, Biotechnology will not be new for the Handmade Papermakers because they had been using it unknowingly in one or the other way from the very beginning<sup>23</sup>.

- The Arabs used to disintegrate linen rags by placing them in heaps saturated with water and allowing a fermentation to take place.
- The Asiatic papermakers covered their papers with a thin coating of rice or wheat paste for sizing.
- For using bamboo, the Chinese used to strip off the leaves and shoots of canes, tied them into bundles and steeped in a pond until the green outer skin or bark could be removed After splitting, the bamboo placed in layers with

alternating layers of lime in a sunken pit (filled with water), were allowed to soak thoroughly for several months. Then after washing and beating, paper was made out of them.

Even today, extraction of jute fibre from green jute plants (i.e. retting) is done by steeping the plants in water for the sufficient time<sup>24</sup>.

Thus, it was the unrefined form of biotechnology, where the handmade papermakers were somehow exploiting the action of existing microbes by manipulating the conditions of their processes. This all, implies that the potential of biotechnology has greater horizons and more hopes for the handmade paper industry.

### CONCLUSION

In view of the above facts, Biotechnology is going to prove a boon for the HMP industry. On one hand, where paper mills in India, may take time to switch over the biotechnological applications specially in pulping and bleaching; the handmade paper industry can be immediately switched. The need is to have collaborative arrangements for the intensive study with different institutes of the country as well as abroad, working in this area.

### ACKNOWLEDGEMENT

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### IMPACTS AND ACHIEVEMENTS OF THE KUMARAPPA NATIONAL HANDMADE PAPER INSTITUTE

The catalytic intervention of UNDP project "Strengthening the Handmade paper industry in India" has really strengthened the industry and the project has taken the shape of an R&D institute, KNHPI. The major achievements of the institute are:

- Development of a technology for making tissue paper (for the conservation of manuscripts and other ancient documents) from the banana fibre. Indian Conservation Institute, Lucknow has regarded its standard equivalent to the international standard of tissue papers.
- Recycling of the shredded currency waste of Reserve Bank of India (RBI) and development of stationary to be supplied back to RBI. Thus the institute is creating national wealth from the

national waste.

- Making the high quality paper from *Calotropis procera* which has been regarded as Indian Xuan paper by Dr. Marlfed Judt due to its equivalence to the Chinese Xuan paper<sup>25</sup> (Xuan paper is known as "Precious Rose" of these handmade paper).
- Development of Chemical Free Paper from *Daphne papyracea*. Instead of any conventional chemical, cooking liquor (ash lye) used here is generated by boiling wood ash in water
- Development of TCF quality paper from jute wastes, jute caddies/sliver {National jute programme and National Centre for Jute Diversification (NCJD)}
- Evaluation of the new agroresidues and locally available bast fibers for their potential to be used for making HMP.
- Development of Alkaline Peroxide Pulping (APP) and Neutral Oxalate Pulping (NOP) processes for the pulping of bast fibres.
- Training imparted to 378 entrepreneurs from different parts of the country and from abroad too under the orientation and specialised operator course programme of the institute.

Thus the Institute has a wide impact on the Handmade Paper Industry as evident from the wonderful growth of the industry after its foundation. The institute is wholly devoted to its philosophical commitment: "*Sustainable Rural Industrialisation Without Disturbing Environment, Social And Community Harmony, Revitalisation of Ancient Arts And Crafts With Modernisation At Affordable Cost*". To further modernise the Handmade Paper Industry institute has been making sincere efforts for adopting Bio-technological Applications. The initiatives taken by the institute are:

- a microbiologist already appointed.
- Collaboration with Birla Institute of Scientific Research (BISR), Jaipur till the institute has its own biotechnology laboratory and other infrastructural facilities.
- The institute is in touch with other institutions like Institute of Microbial Technology (IMTECH), Chandigarh; Thapar Centre for



Industrial Research & Development (TCIRD), Patiala, Central pulp & paper Research Institute (CPPRI), Saharanpur and Biocon India Ltd., Bangalore for sharing information and experiences on areas such as Biopulping and Biobleaching.

- Work already started on Biobleaching
- Biotechnology laboratory is proposed to be set up.

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