Standard Operating Procedure (SOP)
For Production of Handmade Paper at Pine Processing Unit using Chir Pine needles
NMHS Project: A Sustainable Approach for livelihood improvement by Integrated Natural Resource Management in the central Himalaya
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In the western Himalaya, economically viable use of pine leaves is one of the possible option for reducing the vulnerability of pine forests to forest fire. Further, it can also supplement livelihood of local youth and women involved in collection and supply of pine leaves. In this context, NMHS has sanctioned various projects on alternate use of Chir-Pine leaves to mitigate the forest fire as well as creating the livelihood option for unemployed youth of the region.

Step 1: Collection of Raw Materials (dry pine needles)

Freshly fallen sun dried Pirul is collected from the Pine forests and cleaned off wood pieces etc.

Step 2: Shredding (Cutting into small pieces)

Dry pine needles cut into small fine pieces by loading into a Rag Chopper Machine

Step 3: Hammering (Grinding of pine needle into finer material)

The fine pieces of pine needle from rag Chopper machine are further grinded in the Hammering Machine which makes this material much finer, smaller and flexible.

Step 4: Cooking (Cooked with NaOH in digester)

The hammered material is now cooked in a Digester (40 kg capacity at RTC) with 10% of caustic soda (NaOH) for 4.5 hours at 1000^{o} C and high pressure which removes the lignin from pine needles.

Step 5: **Washing (Washing with running tap water)**

Cooked material is washed with tap water repeatedly.

Step 6: **Beating (Pulp preparation)**

Pulping process is done in a Beater where cooked material is run for 4-5 hours. Cotton (~15%), starch (~10-12%) and seizing chemicals (Alkyl Ketene Dimer, @2%) are added to pulp to enhance the properties of paper. Sometimes, bleaching of pulp is also done to enhance the quality of products by soaking into a mixture of NaOH and H_2O_2 (4% of total material).

Step 7: **Sheet formation (Formation of sheets in auto vet)**

This pulp is now spread over large trays (Auto vat, using inlet frames) to prepare paper sheets.

Step 8: **Pressing (Pressing under the hydraulic press)**

Paper sheets thus prepared are pressed in a Hydraulic Press to remove water and the sheets are dried in the sun.

Step 9: **Calendaring (Smoothing and straightening)**

Dry sheets are smoothed and straightened into Calendaring Machine and cut to desired size to make final products.

Step10: Making file covers, carry bags etc. then require cloth, islets and finally printing the brand name on these products for ready to sell

Properties of handmade paper made at pine processing unit:

The composition and properties tests of handmade paper were conducted by National Handmade Institute, Jaipur in 2019 (Table 3). Composition of handmade paper (Test Methods IS: 1060 (Part-I): 1960) was determined as: Holo-Cellulose 68.23%, Total lignin 26.5%, Moisture 7.65% and Ash 2.06%. The paper obtained is environment-friendly and rapidly bio-degradable. However, there are certain drawbacks which are observed during the processing. The paper is not conveniently writable and do not have water resistance. However, water resistance problem can be fixed by adding seizing chemical (Alkyl Ketene Dimer, @2%). Pine needle contain higher lignin which results into high bleach chemical demand. Thus instead of bleached variety pine needle can be utilized for production of unbleached craft paper, filler, packing cases and paper board.

Table 1: Processing cost of 30 kg pine needle at pine processing unit to make paper

Material/man power/others	Total cost (Rs.)
Material (pine needle, cotton, starch powder, caustic soda, seizing chemicals etc.)	1368.00
b). Manpower	1625.00
c) Electricity consumption	80.00
Total investment (a+b+c)	**3073.00**
No. of paper sheets produced	90

Estimated cost of a single paper sheet (60x80 cm)	34.13

Table 2: Production cost of various products made out of handmade Pirul paper

Products	Inputs	Total cost (Rs.)
File (Standard size)	a. Material	17
	b. Manpower	5
Total investment		**22**
Meeting folder (standard size)	a. Material	18
	b. Manpower	5
Total investment		**23**
Carry bag (a4 size)	Material	20
	Manpower	05
Total investment		**25**

Table 3: Physico-chemical properties of handmade paper

S. No.	Parameters	Pure pine needle sheet	Cotton mixed pine needle sheet
1	Basis weight (gm/m^2)	533.33	498.28
2	pH	7.2	7.50
3	Moisture (%)	7.65	6.52
4	Tear Index (mN.m^2/gm)	13.35	5.45
5	Burst Index (kPa.m2/gm)	0.65	0.71
6	Caliper (mm)	0.63	0.6685
7	Ash (%)	7.62	5.61

Chir-pine needle processing unit has been established to make 400-500 GSM paper sheet and the paper is being used for making various handmade products like file cover, bags, folder, etc. About 6000 kg pine needle was processed at the unit in the last two years