

## *Experimental Procedure*

### 3. EXPERIMENTAL PROCEDURE

Experimental procedure of this study, deals with the description of the research procedures, techniques and instruments used to carry out the study. The procedure consists of the following headings and the flow chart is presented in Figure – 1.

- 3.1 Collection, Extraction and Processing of *Agave americana* Fibres
- 3.2 Spinning of *Agave americana*, Hemp and Jute fibres, Scouring and Bleaching of Yarns
- 3.3 Fabrication of *Agave americana*, Hemp and Jute Yarns by Weaving and their Processing
- 3.4 Fabrication of *Agave americana*, Hemp and Jute Fibres by Needle Punching
- 3.5 Nomenclature of Yarn and Fabric Samples
- 3.6 Ribbed Woven Fabrics in Cloth tex
- 3.7 Ribbed and Plain Woven Fabrics in Selected Areas of Home tex
- 3.8 Woven and Needle Punched Fabrics as Mulching Sheets in Agro tex
- 3.9 Woven and Needle Punched Fabrics as Screens and Separators for Filtration in Geo tex
- 3.10 Economics of Woven and Needle Punched Fabrics
- 3.11 Evaluation

#### 3.1 COLLECTION, EXTRACTION AND PROCESSING OF *Agave americana* FIBRES

The leaves, of the plant *Agave americana*, were collected and fibres were extracted from them and processed for finding out the salient properties of the fibres.

##### 3.1.1 Collection and Selection of *Agave americana* Leaves

*Agave americana* plants are abundantly available on the road sides of Maruthamalai, Coimbatore (Plates – 1a<sub>1</sub> – 1a<sub>4</sub>). The leaves at different stages of maturity were collected and the fibres were extracted. The fibres were analysed for strength and elongation. The stage, that yielded the strongest fibres, was selected for further study.

Though it was known that the plant was *Agave americana*, through literature reviews, it was confirmed to be the same in the Botanical Survey of India, Tamil

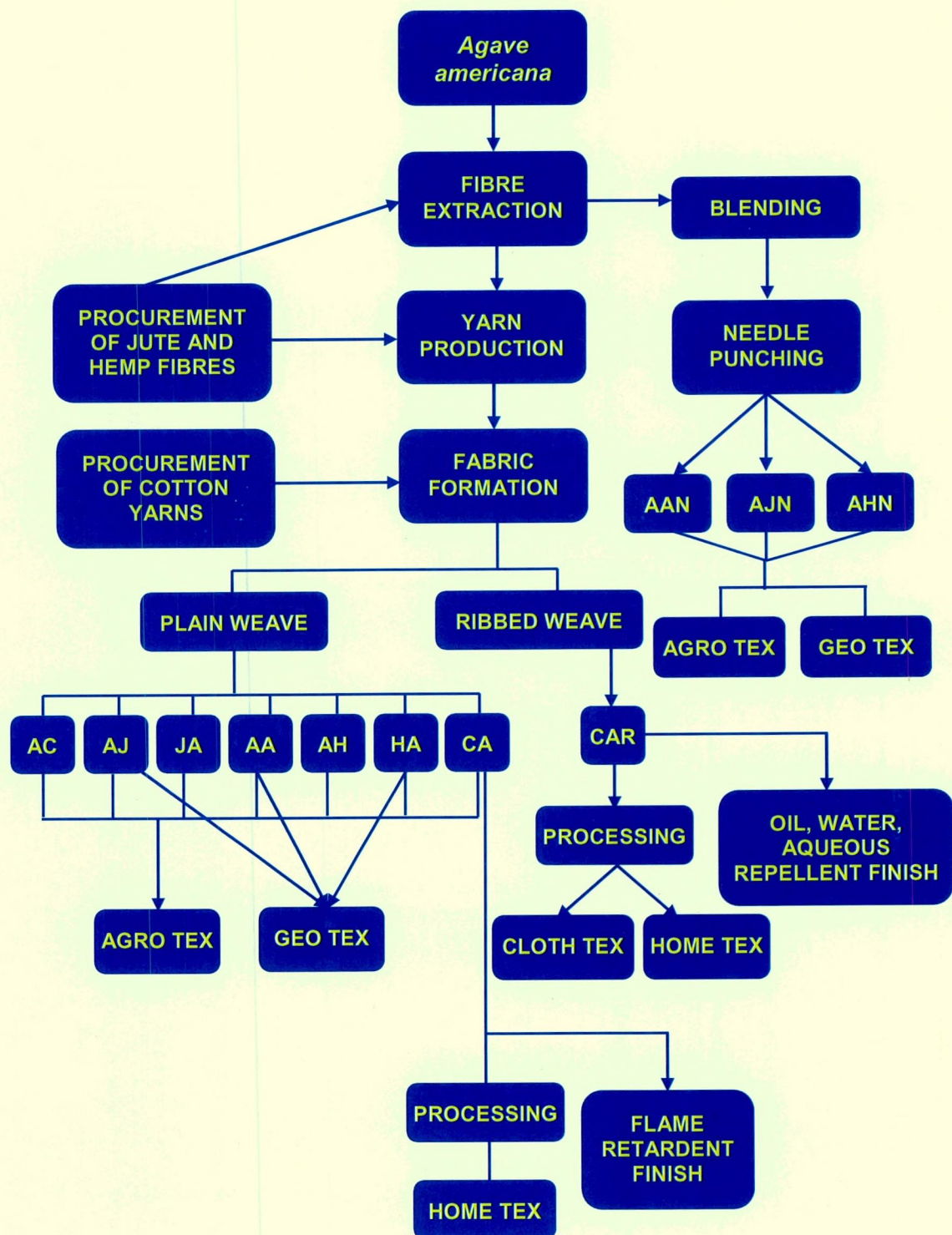


FIGURE – 1  
FLOW CHART OF THE EXPERIMENTAL PROCEDURE

Nadu Agricultural University, Coimbatore, by submitting the specimen of the leaf and flower of the plant. The confirmation certificate is presented in the Appendix – 1.

### 3.1.2 Extraction of *Agave americana* Fibres

Hall (2004) expressed that the leaves are fleshy and require mechanical decortication for separation of the fibres. Hence this method was adopted for extraction of the fibres from the leaves. According to Doraisamy and Chellamani (1993) the leaves of equal length were arranged together and fed into the decorticator (Plates – 1b – 1d). As the drum rotated, three to five leaves were fed between the drum and the backing plate. Owing to the crushing, beating and pulling actions, the pulpy material was removed ; when it was half way through, the leaves were slowly pulled and the other half was fed in the same manner as before. The fibres obtained were washed, dried and combed when slightly wet, using a suitable brush. Combing was done to separate the short fibres from the long fibres. Fibre sample is given in Appendix – 2a.

### 3.1.3 Processing of *Agave americana* Fibres

The decorticated *Agave americana* fibres were scoured and bleached and then assessed for their properties.

#### 3.1.3.1 Scouring

The scouring process is done to remove the nitrogenous matters and to make the operations of bleaching and dyeing efficient, say Modi and Garde (1995). The parameter and the operational range are given in the Table – III.

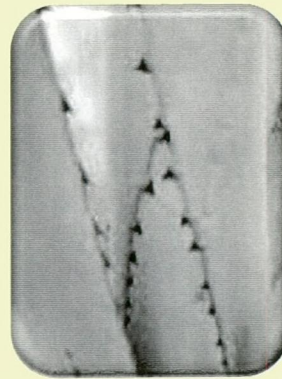
**TABLE – III**  
**RECIPE USED FOR SCOURING OF FIBRES**

S.No.	Parameter	Operational Range
1	Sodium carbonate (%)	2-3
2	Sodium silicate (%)	1.0-1.5
3	Wetting agent (%)	0.1
4	Material to liquor ratio	1 : 4
5	Temperature (°C)	60
6	Time (Hour)	1

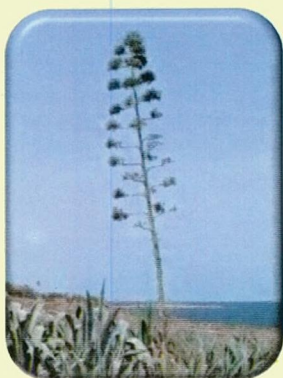
After scouring process, the liquor was drained off and the fibres were washed thoroughly in cold water (Appendix – 2b).



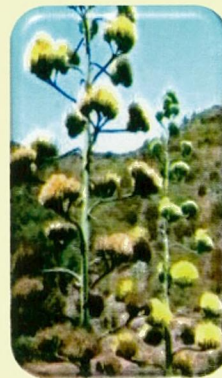
1a<sub>1</sub>. *Agave americana* plant



1a<sub>2</sub>. Spines of *Agave americana* leaves



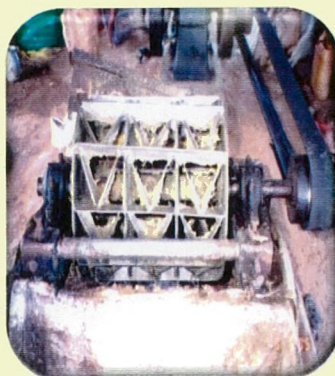
1a<sub>3</sub>. Flowers of *Agave americana* Plant



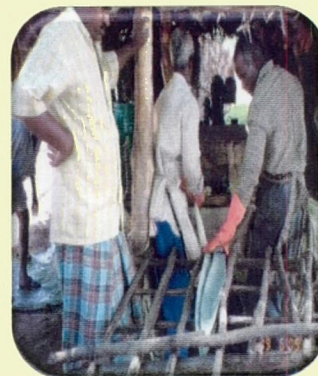
1a<sub>4</sub>. Bloomed flowers of *Agave americana* Plant



1b. Cutting of the leaves from *Agave americana* Plant



1c. Decorticator



1d. Decorticating Process

PLATE – 1  
PLANTS, LEAVES AND FLOWERS OF *Agave americana*  
AND FIBRE EXTRACTION

### 3.1.3.2 Bleaching

Hydrogen peroxide is a universal bleaching agent especially well suited for the bleaching of natural vegetable fibres. It is advantageous because of reasonable costs, with less time consumption as it keeps fibre quality and helps to decrease Chemical Oxygen Demand (COD) (<http://www.degussa.co.n3/downloads/application%20%20textile.pdf>). Bleaching of the fibre was done using hydrogen peroxide as suggested by Ghosh et al. (2005). The recipe used for bleaching is given in Table – IV.

**TABLE – IV**  
**RECIPE USED FOR BLEACHING OF FIBRES**

S.No.	Parameter	Operational Range
1	Hydrogen peroxide (%)	1.0
2	Soda ash (%)	1.0
3	Sodium silicate (%)	1.0
4	Wetting agent (%)	0.1
5	Material to liquor ratio	1 : 20
6	Temperature (°C)	80°
7	Time (Hours)	2

After the bleaching process, the fibres were washed in running tap water and dried at room temperature. The fibres are presented in Appendix – 2c.

## 3.2 SPINNING OF *Agave americana*, HEMP AND JUTE FIBRES, SCOURING AND BLEACHING OF YARNS

The bast fibres namely hemp and jute were procured from a reliable source for the study. The extracted *Agave americana* fibres and procured jute and hemp fibres were spun separately into *Agave americana*, hemp and jute yarns.

### 3.2.1 Spinning of Fibres

The spinning of *Agave americana*, hemp and jute fibres consisted of the following steps.

#### 3.2.1.1 Softening of Fibres

Fritz and Cant (1980) are of the view that oils are often used on fibres as lubricants to help spinning efficiency. Hence, to lubricate and soften, the *Agave americana*, hemp and jute fibres, were cut into suitable length and then treated with Turkey Red Oil and piled up for 24 hours. Then the treated fibres were passed through softener containing eight pairs of spirally fluted cast iron rollers in carriages of two rollers each. Thus the fibres were softened uniformly (Plate – 2a).

### **3.2.1.2 Carding of Fibres**

The softened fibres of *Agave americana*, hemp and jute were carded using breaker and finisher cards.

#### **a. Breaker Carding**

Breaker carding machine is a heavy unit and comprises of steel tubes, a number of rollers with reversing arrangements with one another. The main organs of breaker card which do the carding action are feed roller, cylinder, stripper, weaker, and doffer with the help of which the softened *Agave americana*, hemp and jute fibres were fed one by one in suitable weight to the feed roller, and turned into the form of sliver (Plate – 2b).

#### **b. Finisher Carding**

The construction of finisher carding machine is quite identical with the breaker carding except slight variations in setting, pinning arrangement and speed. Slivers obtained from breaker card were fed into this machine, ten slivers at a time for obtaining uniform slivers of *Agave americana*, hemp and jute.

### **3.2.1.3 Drawing of Fibres**

The slivers obtained from the finisher card were fed into intersecting draw frames of passage I, II and III subsequently for drawing. Two or more slivers from the finisher card were fed into the passage I. This was passed through passage II and passage III of the drawing machines to obtain more regularity and uniformity in the yarns. This was carried out for all the slivers of *Agave americana*, hemp and jute samples (Plates – 2c – 2e).

### **3.2.1.4 Spinning of Fibres**

The machinery utilised for spinning was the one innovated by Brownick, Calculators for spinning. This equipment was utilized for spinning *Agave americana*, hemp and jute fibres.

Spinning process was carried out as explained by Wulfhorst *et al.* (2006), the sliver of *Agave americana*, hemp and jute were first drafted in the flyer drafting field individually which is often designed on a three-roller-two-apron-drafting unit. From the drafting field the drawn sliver is transported over the flyer top into the flyer log which exists at the bottom. A finger guide leads the sliver to the bobbin surface. With this mechanism the sliver obtains one twist on each revolution of the flyer. The

winding itself is caused by a lead of the bobbin against the flyer top. The vertical movement necessary for the winding is accomplished by the bobbin. Because the flyer operates at a constant speed, the vertical movement and the revolution per minute have to be adjusted continuously according to the bobbin diameter. The limit of rotation per minute for the flyer is about 1300 to 1500 rpm. Thus spun yarns of *Agave americana*, hemp and jute were obtained (Plates – 2f and 2h). The spun yarn samples are shown in Appendix – 3a.

### **3.2.2 Scouring of *Agave americana*, Hemp and Jute Yarn Samples**

Yarn may be scoured in hank form or in packages such as cones or cheeses, suggests Trotman (1993).

Hence the investigator scoured the yarns with alkaline chemicals in the form of hanks. All the original yarns of *Agave americana*, hemp and jute were scoured in the same procedure as it was done for *Agave americana* fibres. The scoured *Agave americana*, hemp and jute yarns are shown in Appendix – 3b.

### **3.2.3 Bleaching of Scoured *Agave americana*, Hemp and Jute Yarn Samples**

The scoured yarn samples of *Agave americana*, hemp and jute were bleached in the same method adopted for *Agave americana* fibres. The yarn samples are shown in Appendix – 3c.

## **3.3 FABRICATION OF *Agave americana*, HEMP AND JUTE YARNS BY WEAVING AND THEIR PROCESSING**

The untreated yarns of *Agave americana*, hemp and jute were utilised for weaving. Dalvi et al. (2006) suggest that size is applied to the yarn before weaving to ensure fast and uninterrupted performance on weaving in looms and starch is the most widely used sizing agent. Accordingly, the *Agave americana* yarns alone were sized with starch to minimize the problem due to hairiness and for better performance while weaving.

### **3.3.1 Weaving Process**

Yarn from the spinning frame was removed and converted into cones in cone winding process for subsequent weaving process. Warping involves the preparation of the back beam for slashing and normally requires putting 400-600 ends of yarns onto the beam. The length of individual threads depends on the diameter of the beam and ranks from 20 to 40 thousand yards so that the weight of the beam will be



2a. Emulsion Plant Softener



2b. Carding Machine



2c. Drawing Machine I



2d. Drawing Machine II



2e. Drawing Machine III



2f. Spinning Machine



2g. Cop Machine



2h. *Agave americana*, Jute and Hemp Yarns

PLATE – 2  
SPINNING OF FIBRES

somewhat in the range of 500-1500 lb depending on the yarn count. Sizing of the warp threads was done to *Agave americana* to reduce the effect of friction during weaving. Sized threads were assembled on to a weaver's beam. These were drawn in through the eyes of the headdles and the dents of the reeds. The weft yarns were wound onto the pirns or bobbins, to be inserted into the shuttle to facilitate weaving. Warp and weft threads were interlaced to produce a fabric that was strong and compact with some measure of elasticity (Plates – 3a – 3e).

By this handloom weaving process, mixture fabrics with warp-weft namely *Agave americana*-*Agave americana*, *Agave americana*-jute, jute-*Agave americana*, *Agave americana*-hemp, hemp-*Agave americana*, *Agave americana*-cotton and cotton-*Agave americana* were created. Fabrication was also done using power loom to prepare cotton-*Agave americana*, ribbed structure. Fabric swatches are shown in Appendix – 4a.

### **3.3.2 Processing of Fabrics**

The woven fabrics were scoured and bleached for assessing the important property changes. These fabrics were also dyed for making it suitable for different end uses.

#### **3.3.2.1 Scouring**

Scouring is a pretreatment process that removes the dirt, dust, acquired impurities including batching oil, added in spinning, express Samanta and Ray (2000). All the prepared fabric samples were scoured. The same procedure adopted for the fibres was applied for the fabric also as explained in 3.1.3.1. The fabric swatches are shown in Appendix – 4b.

#### **3.3.2.2 Bleaching**

Mondal (2002)–II suggests that hydrogen per oxide bleach as it is free from chlorine atom unlike chlorine and chlorite bleaching, and it also improves product quality. Hence all the prepared fabric samples were bleached using hydrogen per oxide in the same procedure followed for fibres as explained in 3.1.3.2. The fabric swatches are shown in Appendix – 4c.

#### **3.3.2.3 Dyeing**

Natural dyes were applied for selected fabrics to make them suitable for different end uses. The dyeing procedures are explained under respective headings.



**3a. Cone Winding**



**3b. Warp Preparation I**



**3c. Warp Preparation II**



**3d. Weaving Process**



**3e. Prepared Fabrics**

**PLATE – 3  
WEAVING PROCESS**

### **3.3.3 Opinion about Fabrics**

The prepared fabrics were displayed to obtain the opinion on creating enduses for various fabric samples.

### **3.3.4 Finishing of Selected Fabrics**

The selected scoured fabric samples were given the following special finishes namely aqueous liquid, oil and water repellent and flame retardant finishes in ISO 9001 : 2000 certified company. All the three finishes namely aqueous liquid, oil and water repellent finishes were given to the same sample.

#### **3.3.4.1 Aqueous Liquid Repellent Finish**

The ribbed woven cotton-*Agave americana* scoured fabric sample was treated for aqueous repellent finish. The chemical aquaphobe-SNT- of 40 grams per litre of water was used. The padding method was adopted for incorporating this finish to the fabric. This fabric was cured at 160°C for 2 minutes.

#### **3.3.4.2 Oil and Water Repellent Finishes**

The ribbed woven cotton-*Agave americana* scoured fabric sample was treated with aqualink solution of 10 grams per litre of water. It was padded, dried and cured at 160°C for 2 minutes, to incorporate oil and water repellency.

#### **3.3.4.3 Flame Retardant Finish**

The plain woven cotton-*Agave americana* fabric sample was given flame retardant finish. The fabric was treated using Agnitex-Eco of 350 grams per litre of water. It was incorporated into the fabric by padding technique. The treated fabric was cured at a temperature 140°C, for one minute.

### **3.4 FABRICATION OF *Agave americana*, HEMP AND JUTE FIBRES BY NEEDLE PUNCHING**

The fabrication of *Agave americana*, hemp and jute fibres by needle punching involves the following steps (Plate – 4).

#### **3.4.1 Blending and Preparation of Fibres**

Blending and preparation of fibres were carried out in the following manner.

### 3.4.1.1 Cutting and Blending of Fibres

One can obtain the best fabric for a particular purpose at a suitable price by blending fibres ; blending which is done in various percentages enhances the performance and improves the aesthetic qualities of the fabric ([www.fabric.link.com/blends.html](http://www.fabric.link.com/blends.html)). So the investigator decided to blend *Agave americana* with jute and hemp fibres in 50:50 proportion individually and 100 per cent *Agave americana* fibres as such was also utilised. For this purpose, all the fibres were weighed as required and were cut into small pieces of 25 cms length.

### 3.4.1.2 Hand Batching

The fibres were hand batched for proper mixing of the three different blends namely *Agave americana*-jute, *Agave americana*-hemp and in addition cent per cent *Agave americana*. For softening, the blended fibres were spread out thinly and sprayed with a mixture of oil and water (Plates – 4a and 4b). The mixture was prepared using the recipe as given by Venkatachalam *et al.* (1998) and the same is given in Table – V.

**TABLE – V**  
**RECIPE USED FOR SOFTENING OF FIBRES**

S.No.	Parameter	Operational Range
1	Fibre	1 ½ kg
2	Turkey red oil	8 – 9 litres
3	Emulsifier	40 grams
4	Surfactants	140 grams
5	Rest water	Making up 100 litres

The batch was allowed to stand for sufficient time of twenty four hours. The heat that was generated by bulk, lying of fibres softened the material and made it more pliable. To prevent the heat passing off the batch it was covered with a cloth and weight was placed on the top which prevented the evaporation of the liquid as suggested by Sharp (1998). Thus the fibres were softened, made pliant and workable for the subsequent processes of conversion of fibres into fabric.

### 3.4.2 Fibre Carding

Carding is an essential first step in the processing of all staple textile fibres (<http://www/tft.csiro.au/research/scienpapers.html>). So the fibres were fed into the breaker card machine for carding. When the fibres were passed into the machine, the fibres were cut, carded, parallelised and transformed into thin web of separate fibres

emerging as a fleece which was then condensed into a sliver. This was filled in aluminium cans. The production rate of the card sliver was 40 meters per minute. All the blended fibres namely *Agave americana*-hemp and *Agave americana*-jute, and *Agave americana* (cent per cent) were carded and converted into slivers (Plates – 4c – 4e).

### **3.4.3 Web Formation**

In the web formation phase of non-woven manufacturing process, the prepared fibres were transformed into preferentially arranged layers of lofty or loosely held fibre networks called webs or mats or sheets. The fibre orientation in the web was achieved through the use of machinery (<http://www.swicofil.com/nonwoven.html>).

The prepared slivers were individually laid on the conveying surface. They had been equally distributed into ten aluminium cans and fed into the finisher card machine, where the sliver was made into thin layers and converted to a lap form. On running of the machine, care was taken so that the slivers do not overlap each other. The webs were then layered by the cross-lapper. The cross-lapper took the web from the card, transverse it across a moving bottom lattice and thus built a web in which the fibres were laid diagonally across the width. The production rate of finisher card is 0.6 m/min. Thus the most versatile web-forming system of carding and cross lapping and the most streamlined system of the use of air formers were used for the study. This procedure was adopted for all the samples namely *Agave americana*-hemp, *Agave americana*-jute and cent per cent *Agave americana* (Plates – 5a – 5e).

### **3.4.4 Fabric Formation**

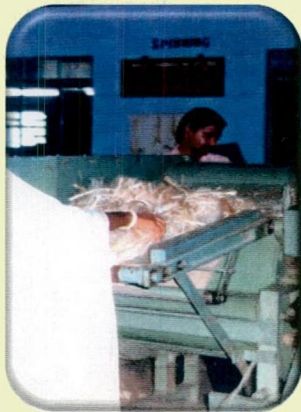
The fabric was formed by a process called needle punching where the web structures were bonded mechanically by interlocking of fibres. The lap was fed into the needle punching machine for the formation of needle punched non-woven fabric. DILO needle punching machine of model OD-11/6 was used for the preparation of the fabric. Single board downward punching loom was used. Punching of the web was done using barbed needles. The needles were spaced in a non-aligned arrangement and were designed to release the fibre as the needle board was withdrawn. The effective operation width was 700 mm. The fabric thickness ranged from 5 mm to 15 mm. The fabric weight of 80-1000 GSM could be produced in the machine.



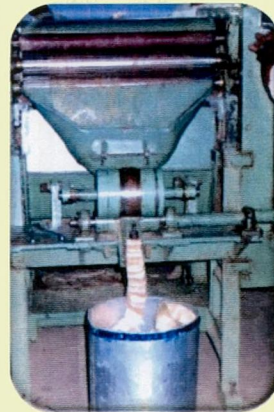
**4a. Spraying Emulsion Over Fibres Using Hand Sprayer**



**4b. Mixing Fibres for Hand Batching**



**4c. Feeding of Softened Blended Fibres into the Breaker Card**



**4d. Card Sliver obtained from Breaker Card**



**4e. Feeding the Card Sliver for Finisher Card**

**PLATE – 4**

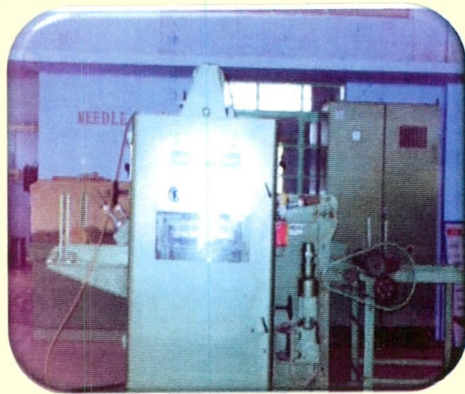
**NEEDLE PUNCHING PROCESS – I**



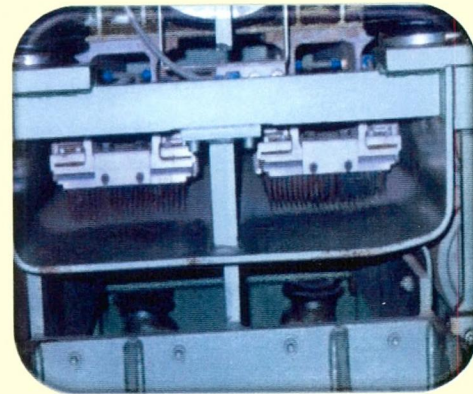
5a. Cross Lapping of the Web in the Finisher Card



5b. Web Formation



5c. Needle Punching Machine



5d. Needles in the Needle Punching Machine

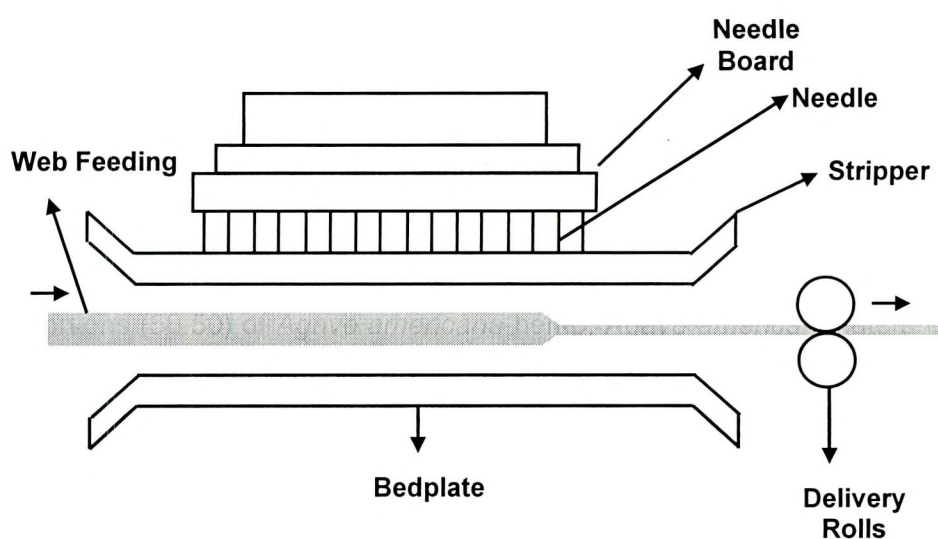


5e. Needle Punched Fabric from Needle Punching Machine

PLATE – 5  
NEEDLE PUNCHING PROCESS – II

The needle loom is basically a very simple piece of machinery. The most common mode of operation is one in which the needles oscillate vertically on a fixed stroke through web material supported between two plates. The plates were drilled with holes to match the pattern of needles in the needle board. The web was supported until it passes into the inlet gap between the two plates. The rollers helped the web to pass into the needling zone. Around 1200 needles were used. The top plate (the stripper) will be inclined so that there is more room at the entry side for the passage of bulky web prior to needling. The bottom plate (the bed) supports these webs during needling. The gap between these plates is adjusted depending on the thickness of the web. The web is made to pass through without any hindrance. The needle punched fabric is drawn away from the needling zone by take-up rollers. The infeed-draw off frequency is adjusted to 0.25 m/min ; stroke frequency to 200 strokes / min and depth of penetration of the needles to 10 mm for the study. The fabric was needle punched on the reverse side also to add strength and to increase the penetrations of the needle. The fabric samples were prepared with equal proportions (50:50) of *Agave americana*-hemp, *Agave americana*-jute and cent per cent *Agave americana* with 60 cms width and around 300 GSM were produced. The swatches of the needle punched fabrics are given in Appendix – 5.

The schematic diagram of needle punching machine as described by Midha and Mukhopadhyay (2005) is given in Figure – 2.



**FIGURE – 2**  
**SCHMATIC DIAGRAM OF NEEDLE PUNCHING MACHINE**

### 3.5 NOMENCLATURE OF YARN AND FABRIC SAMPLES

The nomenclature used for yarn samples are given in Table – VI.

**TABLE – VI**  
**NOMENCLATURE FOR SPUN AND TREATED YARN SAMPLES**

S.No.	Description	Nomenclature
1	<i>Agave americana</i> Original yarn	AO
2	<i>Agave americana</i> Scoured yarn	AS
3	<i>Agave americana</i> Bleached yarn	AB
4	Hemp Original yarn	HO
5	Hemp Scoured yarn	HS
6	Hemp Bleached yarn	HB
7	Jute Original yarn	JO
8	Jute Scoured yarn	JS
9	Jute Bleached yarn	JB

The nomenclature used for woven and treated fabric samples are given in Table – VII.

**TABLE – VII**  
**NOMENCLATURE FOR THE WOVEN ORIGINAL AND TREATED FABRIC SAMPLES**

S.No.	Combination Warp/ Weft	Nomenclature		
		Original	Scoured	Bleached
1	<i>Agave americana</i> - <i>Agave americana</i>	AA	AAS	AAB
2	Hemp- <i>Agave americana</i>	HA	HAS	HAB
3	Jute- <i>Agave americana</i>	JA	JAS	JAB
4	<i>Agave americana</i> -Hemp	AH	AHS	AHB
5	<i>Agave americana</i> -Jute	AJ	AJS	AJB
6	<i>Agave americana</i> -Cotton	AC	ACS	ACB
7	Cotton- <i>Agave americana</i>	CA	CAS	CASB

The nomenclature used for ribbed and plain woven cotton-*Agave americana* fabric samples are given in Table – VIII.

**TABLE – VIII**  
**NOMENCLATURE FOR THE RIBBED AND**  
**PLAIN WOVEN COTTON-*Agave americana* FABRIC SAMPLES**

<b>S.No.</b>	<b>Description</b>	<b>Nomenclature</b>
1	Cotton- <i>Agave americana</i> Ribbed Woven Original sample	CAR
2	Cotton- <i>Agave americana</i> Ribbed Woven Scoured sample	CARS
3	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached sample	CARSB
4	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished sample	CARSBB
5	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished Madder dyed Original sample	CARSBBM
6	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished Madder dyed Wear studied sample	CARSBBMW
7	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished Lac dyed Original sample	CARSBBL
8	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished Lac dyed and Fragrant finished sample	CARSBBLF
9	Cotton- <i>Agave americana</i> Ribbed Woven Scoured Bleached Biopolished Lac dyed Fragrant Finished and Wear studied sample	CARSBBLFW
10	Cotton- <i>Agave americana</i> Plain Woven Scoured Bleached Biopolished sample	CASBB
11	Cotton- <i>Agave americana</i> Plain Woven Scoured Bleached Biopolished Catechu dyed Original sample	CASBBC
12	Cotton- <i>Agave americana</i> Plain Woven Scoured Bleached Biopolished catechu dyed Wear studied sample	CASBBCW

The nomenclature for needle punched fabric samples are given in Table – IX.

**TABLE – IX**  
**NOMENCLATURE FOR NEEDLE PUNCHED FABRIC SAMPLES**

<b>S.No.</b>	<b>Description</b>	<b>Nomenclature</b>
1.	<i>Agave americana</i> 100%	AAN
2.	<i>Agave americana</i> -Hemp – 50 / 50	AHN
3.	<i>Agave americana</i> -Jute – 50 / 50	AJN

The nomenclature of filtration media and proportions are given in Table – X.

**TABLE – X**  
**NOMENCLATURE FOR FILTRATION PROPORTIONS, MEDIA, SCREENS**  
**AND THEIR COMBINATIONS**

S.No.	Description	Nomenclature	S.No.	Description	Nomenclature
1.	Proportion	P	13.	Woven Hemp- <i>Agave americana</i> as Screen (HA)	S <sub>1</sub>
2.	Media	M	14.	Woven <i>Agave americana</i> -Jute as Screen (AJ)	S <sub>2</sub>
3.	Screen	S	15.	Woven <i>Agave americana</i> - <i>Agave americana</i> as Screen (AA)	S <sub>3</sub>
4.	1:1:1 Gravel / Charcoal / Sand	P <sub>1</sub>	16.	Without screen	S <sub>4</sub>
5.	1:2:3 Gravel / Charcoal / Sand	P <sub>2</sub>	17.	Nonwoven <i>Agave americana</i> -Hemp as Screen (AHN)	NS <sub>1</sub>
6.	2:3:1 Gravel / Charcoal / Sand	P <sub>3</sub>	18.	Nonwoven <i>Agave americana</i> -Jute as Screen (AJN)	NS <sub>2</sub>
7.	3:1:2 Gravel / Charcoal / Sand	P <sub>4</sub>	19.	Nonwoven cent per cent <i>Agave americana</i> as Screen (AAW)	NS <sub>3</sub>
8.	Charcoal	M <sub>1</sub>	20.	Proportion / Media combination	PM
9.	<i>Agave americana</i> fibre	M <sub>2</sub>	21.	Media / Screen combination	MS
10.	Jute fibre	M <sub>3</sub>	22.	Proportion / Screen combination	PS
11.	Coir fibre	M <sub>4</sub>	23.	Proportion / Media / Screen combination	PMS
12.	Hemp fibre	M <sub>5</sub>	24.	Gravel / Charcoal / Sand	GCS

### 3.6 RIBBED WOVEN FABRICS IN CLOTH TEX

The ribbed woven fabric was converted into apparel as per the suggestions given by majority of the judges. These fabrics were scoured and bleached following the same procedure used for *Agave americana* fibres. The samples were then biopolished, lac dyed, fragrant finished, converted into over coat and wear studied. After wear study they were analysed for their basic physical properties namely fabric count, thickness, weight, tensile strength, elongation, stiffness, abrasion resistance and drapability. Comfort properties namely wicking, sinking, air permeability and thermal conductivity were also analysed and compared with the original sample.

### **3.6.1 Biopolishing of Fabrics**

Straathof and Adlecreutz (2000) recommend that, cotton and other natural fibres based on cellulose can be improved by an enzymatic treatment known as biopolishing. The treatment gives the fabric a smooth, and glossy appearance, removes fuzz (without affecting strength), gives superior colour and brightness.

The scoured and bleached samples were biopolished using acid cellulase enzyme as per the procedure given by Ressil Company. The recipe used was for 1 kg fabric, 5 grams of enzyme per litre and 1 litre of water. The fabric was immersed into the solution and the temperature was adjusted to 55°C with pH of 5 for 45 minutes. After this treatment, the fabric sample was given a cold wash.

### **3.6.2 Dyeing of Fabrics**

The fabric was lac dyed using alum as mordant and post mordanting as the technique. The lac dye was made into a paste, and mixed with water. This mixture was boiled for 30 minutes and the fabric was immersed in the dye bath and left for 30 minutes. The material liquor ratio followed was 1:20. Alum, the mordant was mixed in water and boiled. The dyed fabric was then immersed in the mordant solution and left for 60 minutes. This was then washed using cold soft water and dried in the shade. The dyed fabric samples were then analysed for their colour fastness to perspiration, washing, rubbing and light.

### **3.6.3 Finishing of Fabrics**

The biopolished and lac dyed fabric sample was then given a fragrant finish of baby soft "BEBE" to make it more suitable for apparel. The fragrant finishing was done as per the procedure given by Ressil Company. The recipe used was for 1 kg fabric, 1 ml of fragrance BEBE, 1 ml of binder and 5 litres of water. The fabric was immersed into the solution at pH of 5 for 30 minutes. The finished fabric was squeezed, and dried in shade. Accordingly the fabric was fragrant finished, dried and pressed.

### **3.6.4 Wear Study**

The prepared lac dyed and fragrant finished ribbed woven fabric samples were converted into over coat. The investigator selected 30 subjects of age group 15 – 25 years for the wear study based on convenience sampling. The subjects were requested to wear the over coat on alternate days. It was worn (from 10.30 am to

6.30 pm) 10 hours a day. These garments were worn and given ten washes after every successive wear. The fabric swatches are shown in Appendices – 6a – 6f) (Plate – 6). For washing the samples synthetic detergents are those which remove soil by some colloidal chemical process, expresses Shennai (2000). The synthetic detergents are powerful degreases and rapidly removed the grease. Surf excel matic was selected as detergent for the study. Soft water is the most valuable agent used in laundering work, it has excellent solvent power and capable of removing dirt and stain during the steeping process, expresses Dantyagi (1998). Hence soft water was selected for the study.

The detergent solution was prepared using 3 grams of detergent powder in 1000 ml of water. The detergent solution was then mixed with 7 litres of water. The sample was loaded into the fully automatic tumble washing machine. The time taken for full work and four rinse cycle was ninety minutes. The semi dry clothes were removed and dried in shade. This process was repeated for ten washes. This method was adopted for the study.

The wear studied over coat samples were subjectively and objectively evaluated as explained under 3.11.

### **3.7 RIBBED AND PLAIN WOVEN FABRICS IN SELECTED AREAS OF HOME TEX**

The ribbed and plain woven cotton-*Agave americana* fabrics were scoured, bleached and biopolished as mentioned earlier. The ribbed woven fabric was dyed with madder dye and the plain woven cotton-*Agave americana* sample was dyed with catechu dye and utilized for home textile purpose.

#### **3.7.1 Dyeing of Fabrics with Madder Dye**

For madder dyeing, alum was used as mordant. Premordanting technique was used for the study. The madder dye powder was made into a paste, and mixed in water. This mixture was boiled for 30 minutes and the fabric was immersed in the dye bath and left for 30 minutes. The material liquor ratio followed was 1:20. Alum was mixed in water and boiled. The dye dipped fabric was then immersed in the mordant solution and left for 60 minutes. This was then washed using soft cold water and then dried in the shade. The dyed fabric samples were then analysed for the colour fastness to washing rubbing and light. The fabric swatches of the dyed original and wear studied of samples are presented in Appendices – 6g and 6h.



PLATE - 6  
OVER COAT AND ITS WEAR STUDY

### **3.7.2 Dyeing of Fabrics with Catechu Dye**

Catechu dyeing of the fabric was done using Potassium di chromate and copper sulphate as mordants and post mordanting as the technique. The catechu dye powder was made into a paste and mixed with water. This mixture was boiled for 30 minutes and the fabric was immersed in the dye bath and left for 30 minutes. The material liquor ratio followed was 1:20. The mordants were mixed with water and boiled. The fabric was dipped in dye bath and then immersed in the mordant solution and left for 60 minutes. This was then washed using cold soft water and dried in the shade. The dyed fabric samples were then analysed for the colour fastness to washing, rubbing and light (Plate – 7a). The fabric swatches of the dyed original and wear studied samples are placed in Appendices – 6i and 6j.

### **3.7.3 Conversion of the Ribbed Woven Cotton-*Agave americana* Fabrics into Products**

The ribbed woven cotton-*Agave americana* fabrics were converted into table napkins, mats and runners (Plates – 7b – 7f).

### **3.7.4 Conversion of the Plain Woven Cotton-*Agave americana* Fabrics into Products**

The plain woven cotton-*Agave americana* fabric was converted into door mats and rugs.

### **3.7.5 Wear Study of the Prepared Products**

Both the prepared products utilized for home furnishings were wear studied by subjecting them to 10 washes on alternate days. These were then evaluated subjectively and objectively, for colour fastness properties.

## **3.8 WOVEN AND NEEDLE PUNCHED FABRICS AS MULCHING SHEETS IN AGRO TEX**

Materials and methods involved in utilizing the constructed woven and nonwoven fabrics for mulching are given under the following headings.

### **3.8.1 Survey of Farmers**

A survey is a widely used method for gathering scientific information. The purpose of a survey is to determine how people feel about a particular issue, explains McBurney (2002). According to Singh (2001) a sample is that part of the population



7a. Rug



7b. Tea Cup Placemat



7c. Place Mat and Table Napkins



7d. Table Cloth



7e. Table Napkin



7f. Table Runner

PLATE - 7  
HOME TEXTILE APPLICATIONS

which is selected for the purpose of investigation. Convenience sampling is the selection of population element for inclusion based on ease of access. The investigator adopted convenience sampling for the study.

The investigator surveyed 150 farmers to elicit the information regarding awareness about mulching in Coimbatore Uzhavar Sandhai. The tool selected for the study was interview schedule. Pilot study was conducted among the 10 farmers and based on the results the necessary modifications were made in the interview schedule. The final interview schedule used for the survey is presented in Appendix – 7.

### **3.8.2 Selection of Crop and Experimental Site**

The crop namely Bhendi TNAU hybrid variety CoBhH-1 was utilized for the study. The experiment was conducted in Precision Farming Development Centre, Department of Soil and Water Conservation Engineering, Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Coimbatore, South India. This lies in the Western agroclimatic zone of Tamil Nadu at 11° North latitude and 77° East longitude and at an altitude of 426.70 meters above mean sea level. The soil found here is clay loamy soil with low nitrogen (N), medium phosphorous (P) and high potassium (K) contents. The physical and chemical properties of the soil in which the experiment was carried out are given in Appendix – 8a. The water quality parameters used for the study for irrigating the plants are given in Appendix – 8b.

### **3.8.3 Method of Preparation of Field**

The field was ploughed thoroughly and the beds were formed with depressions at regular intervals. The field was brought to field capacity before planting the seeds.

### **3.8.4 Application of Mulch Fabrics**

The woven samples namely AJ, AH, AA, JA, HA, AC and CA and nonwoven fabric samples namely AAN, AHN and AJN of width 58 cms and length 60 cms were laid over the prepared soil beds with holes pierced on four corners of the fabrics (Plates – 8a and 8b). About three such fabrics of each type were laid on soil bed. The fabrics were placed over the drip irrigation laterals and packed with soil on all four sides. Field layout was done as given in Figure – 3.

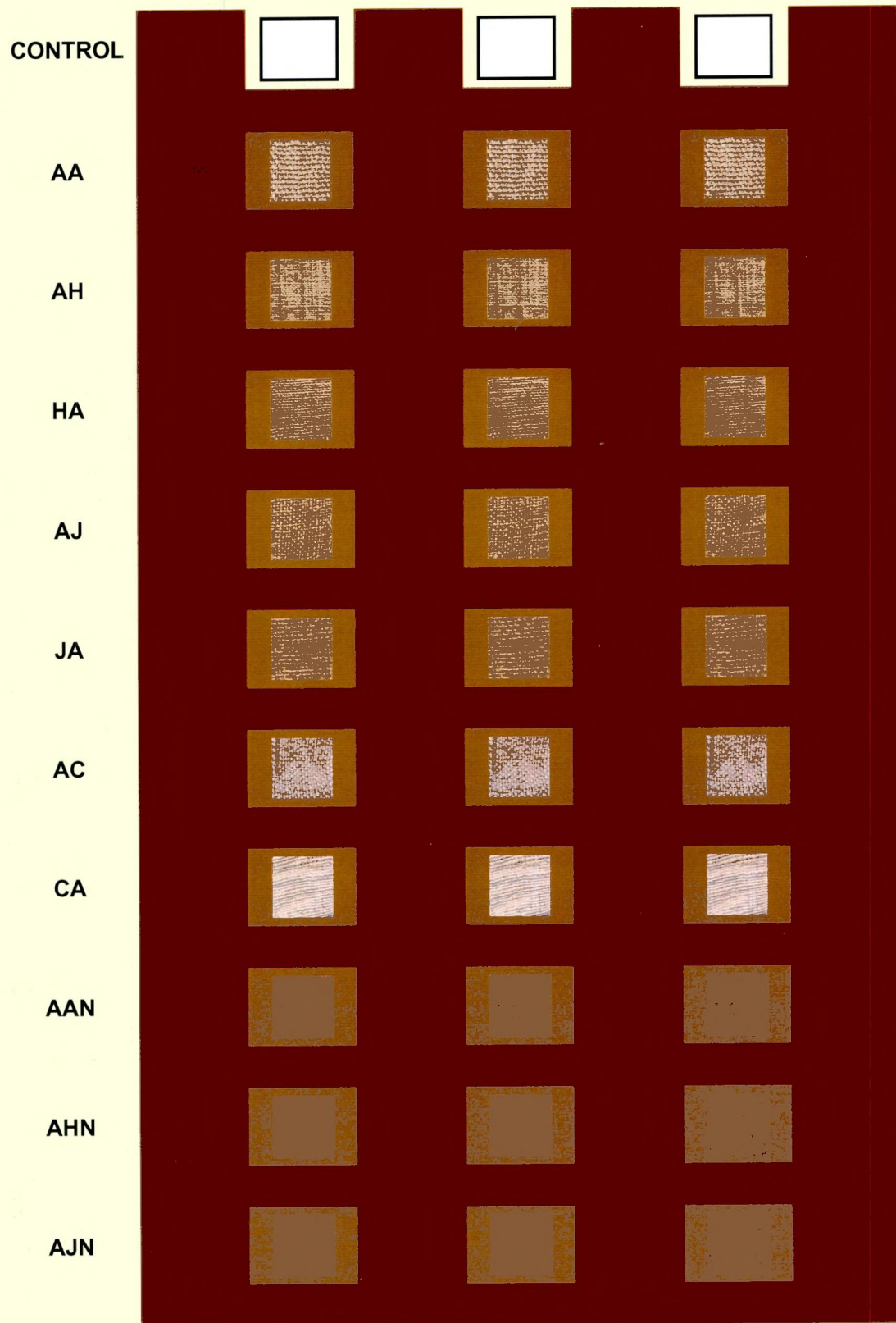


FIGURE - 3  
LAYOUT OF THE MULCH SHEETS LAID ON SOIL BEDS

### **3.8.5 Sowing of Seeds and Cultivation**

The hybrid bhendi seeds were sown in the soil through the pierced holes at a distance of 30 cm as per the recommendation of Tamil Nadu Agricultural University on 15<sup>th</sup> February 2010 (Plate – 8c). The field was kept moist by giving irrigation water daily through drip irrigation. After the germination of the plants, irrigation was given daily through drip irrigation system at cent per cent Cumulative Pan Evaporation (CPE) to meet the crop water requirement. Basal fertilizer dose of NPK 100:100:100 kilogram per hectare at 30 days after sowing was applied in uniform dose over the mulched and unmulched plots through drip irrigation system. The weeds those grew on the control plots were removed manually by women labourers after every 15 days during the crop growth period. The weed count in the mulched and unmulched plots were found, identified and recorded (Plates – 8d – 8f).

### **3.8.6 Collection of Fabric Samples**

The fabric spread for agro textile purpose as mulching sheets were taken from the field after 90 days on 15<sup>th</sup> May 2010 and analysed subjectively.

## **3.9 WOVEN AND NEEDLE PUNCHED FABRICS AS SCREENS AND SEPARATORS FOR FILTRATION IN GEO TEX**

The flow chart for filtration process is given in Figure – 4.

### **3.9.1 Description of the Filtration Equipment**

A sequential filter with three chambers was designed and fabricated to filter out sediments and other impurities in urban storm water and watershed runoff. The size of filter chambers can be adjusted with the help of movable screens, which can be bolted on a slotted rail. Maximum of four chambers can be created with the help of three movable screens and since the present study is concentrated on a 3 layer filtration mechanism, only two screens were used. The water flows through the filter is essentially longitudinal in direction though it moves transversely along the filter depth and come out through the exit pipe. There are provisions for pouring dozed water by means of a funnel and also for back washing the filter at fixed intervals.

The filter is fabricated with 2 mm thick Galvanised Iron (GI) sheets and the screens having 2 mm and 3 mm diameter holes are made up of 1.5 mm thick GI perforated sheet with 3 mm angular iron border. The screens serve as a separation mechanism between various filter media by preventing their mixing up ; they help to



**8a. Laying of Mulch Sheet**



**8b. Packing the Corners of Mulch Sheet**



**8c. Sowing of Seeds**



**8d. Plant Growth in the Mulched plot**



**8e. Weed Growth near the Mulched Plot**



**8f. Plants with Vegetables on Mulched Plot**

**PLATE – 8**  
**MULCHING PROCESS AND PLANT GROWTH**

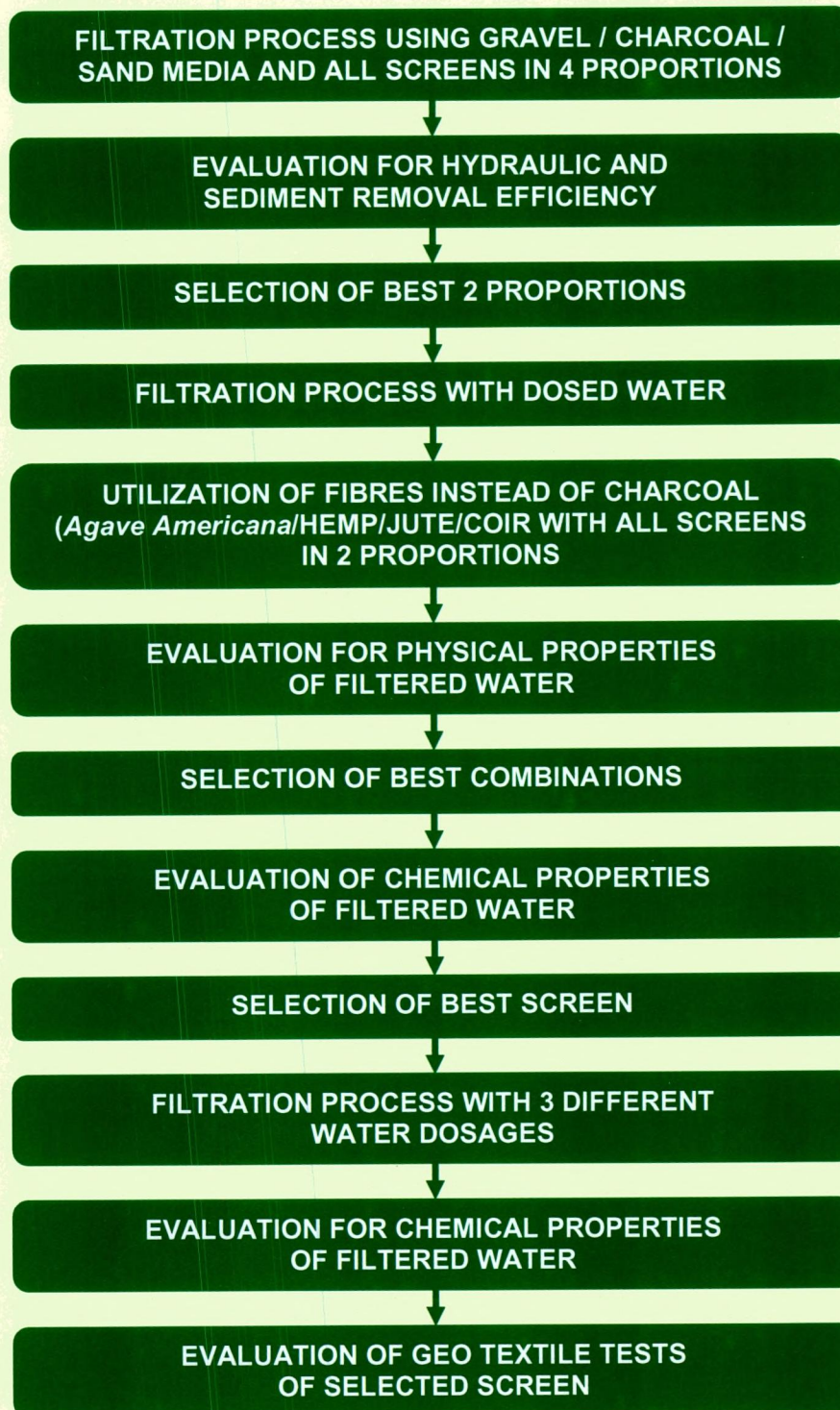


FIGURE – 4  
FLOW CHART FOR FILTRATION PROCESS

retain bigger particles including filter materials and impurities as well. There are also provisions for attaching textile screens in between the filter chambers in place of metal screen. The plan, elevation and side view of the filter are depicted in Figures – 5a and 5b. The internal dimensions of length, width and height of the filter device are 75 cm, 30 cm and 45 cm respectively with a volume of 101.25 litres. The effective volume of the filter chamber subtracting the volume of screens is 93.15 litres. The PVC pipes used for inlet and outlet purposes are 32 mm diameter. Three gate valves are fitted at the inlet, outlet and backwash assembly to control the flow of water. There are also provisions to measure and collect outlet water. A provision for changing the slope of the filter bed is also incorporated. The device is fitted with rubber bushes to enable stable seating on the floor. The filter device is coated with inert paint to avoid rusting and reduce friction with the walls of the filter chamber.

### **3.9.2 Selection of Screen for Filtration**

The fabric filtration screens utilised for the study were woven and nonwoven samples of AA, AH and AJ and AAN, AHN and AJN of the prepared structures. The metal screens of the equipment of 3 mm perforations were substituted by fabric screens.

### **3.9.3 Selection of Media**

Three different types of inorganic materials such as sand, gravel and charcoal as well as organic materials in the form of fibres were selected as media for filtration. The organic materials selected for this study included *Agave americana*, hemp, jute, and coir fibres. The properties of the media used are given in Appendix – 9.

### **3.9.4 Conduct of the Experiment**

The water collected in the sump was pumped by means of a pump set driven by electric motor which can pump slurry/sediment water also. The water was dosed to pre-determined sediment and impurity level and stored in the sump. The rate of flow of inlet water was measured by means of opening a gate valve keeping all other valves closed and by using a measuring jar and stop watch. The manometer fixed at the inlet of the filter measures the head of water entering the device and the manometer at the outlet measures the pressure of water flowing out of the filter. The outlet water was also collected for quality analysis and its rate of flow was measured by means of the measuring cylinder and stop watch. The filtered water was collected in another sump and analysed.

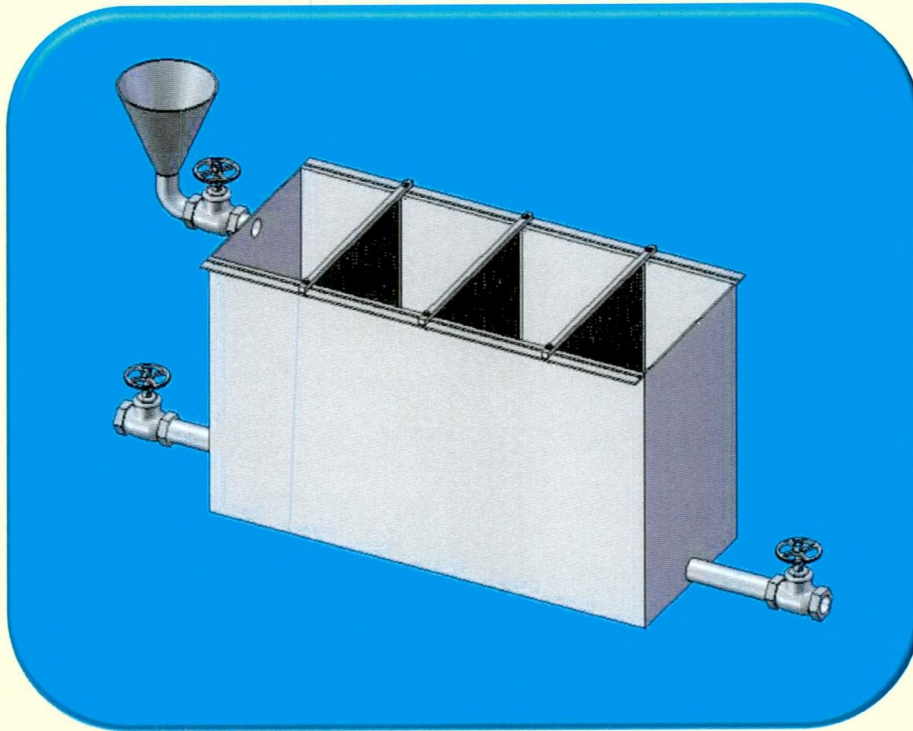


FIGURE – 5a

DIAGRAMMATIC REPRESENTATION OF THE FILTER

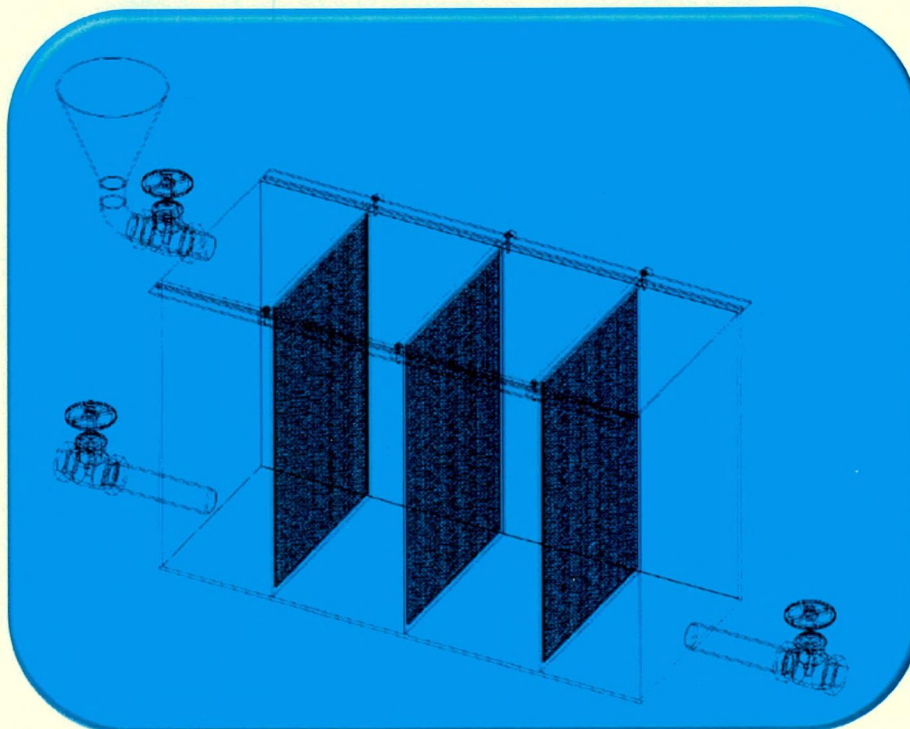


FIGURE – 5b

DIAGRAMMATIC REPRESENTATION OF THE FILTER WITH TRANSPARENCY

### 3.9.5 Selection of Proportion

Four different proportions namely 1:1:1, 1:2:3, 2:3:1 and 3:1:2 were tried for the pilot study with different fabric screens and metal screen utilizing charcoal as media where gravel/charcoal/sand combination was used. The performance evaluation was done and tabulated.

#### 3.9.5.1 Performance Evaluation of Horizontal Flow Filter with various Types of Filter Materials

The Gravel/Charcoal/Sand (GCS) filter combination was first tested in pilot study to find out the best two proportions and screens. Proportions of gravel, charcoal and sand in four different volume ratios were tried 1:1:1, 1:2:3, 2:3:1 and 3:1:2 against 7 different types of screens including metal screen as depicted in Table – XI (a). The experiments were conducted for 28 combinations and corresponding Hydraulic Efficiency (HE) and Sediment Reduction Efficiency (SRE) were calculated. The result of the study based on 2-factor ANOVA analysis is given in Tables – XI (a) and XI (b).

**TABLE – XI (a)**  
**HYDRAULIC EFFICIENCY OF DIFFERENT PROPORTIONS**  
**OF GCS FILTERS AT INFLOW RATE OF 0.05 L/S**

Proportion	Samples							Mean
	AA	AJ	HA	AAN	AJN	AHN	Metal	
<b>1 : 01 : 01</b>	34.6816	27.744	31.72	60.7248	23.59776	32.63152	81.8192	<b>41.845</b>
<b>1 : 02 : 03</b>	30.5496	28.83728	31.56976	75.2	37.67248	53.9696	47.60128	<b>43.628</b>
<b>2 : 03 : 01</b>	82.336	68.8	65.68	75.0752	24.98368	33.71904	80.16	<b>61.536</b>
<b>3 : 01 : 02</b>	10.3630	20.0912	28.72	22.544	11.1872	24.79104	61.29184	<b>25.569</b>
<b>Mean</b>	<b>39.4825</b>	<b>36.36812</b>	<b>39.42244</b>	<b>58.386</b>	<b>24.36028</b>	<b>36.2778</b>	<b>67.71808</b>	<b>43.1450</b>

**TABLE – XI (b)**  
**SEDIMENT LOAD REDUCTION OF DIFFERENT PROPORTIONS**  
**OF GCS FILTERS AT INFLOW RATE OF 0.05 L/S**

Proportion	Samples							Mean
	AA	AJ	HA	AAN	AJN	AHN	Metal	
<b>1 : 01 : 01</b>	59.7561	56.09756	31.09	0	28.12195	31.09756	73.78049	<b>39.992</b>
<b>1 : 02 : 03</b>	0	53.04878	75	100	32.92683	56.09756	36.58537	<b>50.522</b>
<b>2 : 03 : 01</b>	55	0	100	36.6	0	50	25.5	<b>38.157</b>
<b>3 : 01 : 02</b>	0	100	0	20.7317	0	27.5	31.7073	<b>25.705</b>
<b>Mean</b>	<b>28.68902</b>	<b>52.28659</b>	<b>51.5225</b>	<b>39.33293</b>	<b>15.2622</b>	<b>41.17378</b>	<b>41.89329</b>	<b>38.594</b>

From the results of hydraulic efficiency and sediment reduction efficiency, the best two proportions namely 1:1:1 and 1:2:3 were selected focusing on the qualitative parameter of sediment removal efficiency as these two proportions showed the best results in trapping the sediments. Hence these two proportions were selected for further study (Plates – 9a – 9f).

### **3.9.6 Conduct of Experiment with Selected Proportion**

Purchas and Sutherland (2002) say that, in comparison with diatomite or expanded perlite, natural cellulose fibres have certain advantages for precoat filtration as a consequence both of their distinctive structure due to which cellulose fibres are frequently used in combination with other types of precoat either as a preliminary layer or in the form of a mixture.

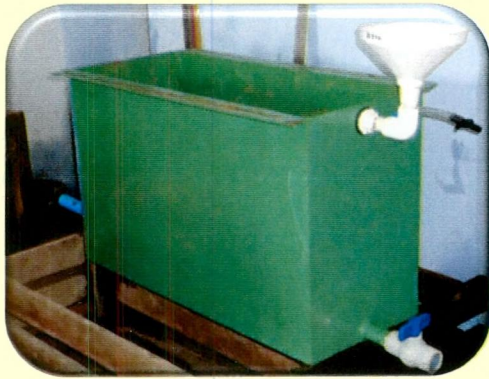
Hence, a total of 56 (4 x 7 x 2) experiments were conducted by substituting and packing the filter with four types of natural fibres such as *Agave americana*, jute, coir and hemp instead of charcoal along with gravel and sand, in two proportions with six different types of fabric screens, namely AA, AH, AJ, AAN, AHN and AJN of both woven and nonwoven structures and one without screen. The rates of inflow, outflow and retention time were observed for each of the filter combinations. The one which was used without screen was considered as control group.

### **3.9.7 Selection of the Best Combination**

Dosing of water was done with sand, silt, super phosphate, urea and K<sub>2</sub>O in the quantities of 2, 2, 0.1, 0.1 and 0.1 grams per litre respectively. The inlet and outlet water samples were analysed for characteristics of hydraulic efficiency, pH neutralizing efficiency, sediment removal efficiency and EC. Out of the 70 (5 x 7 x 2) filter combinations tried, 35 combinations were selected for detailed water quality analysis based on the initial analysis. ANOVA was carried out for determining best screen (Plate – 10a – 10f).

### **3.9.8 Application of the Best Screen, Media and Proportion**

From the above analyses, the best screen was selected for further study. The water was dosed in five different concentrations, passed through this fabric screen and the obtained water samples were qualitatively analysed. Dosing done with 3 different proportions of sand, silt, super phosphate urea and K<sub>2</sub>O and the recipe is presented in the Appendix – 10.



9a. Filter



9b. GCS Filter with Nonwoven *Agave americana*-Hemp Screens



9c. GCS Filter with Nonwoven *Agave americana*-Jute Screens



9d. GCS Filter with Nonwoven *Agave americana* Screens



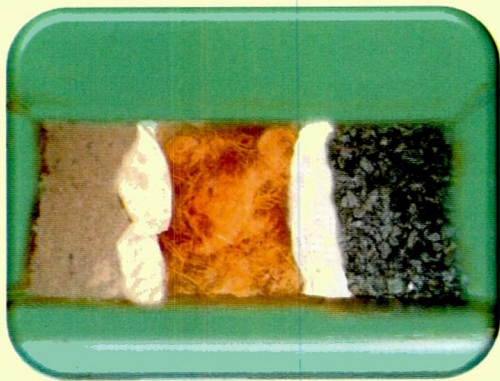
9e. GCS Filter with Woven *Agave americana*-Jute Screens



9f. Gravel / Coir Fibres Sand with Woven Hemp-*Agave americana* Screens

PLATE – 9

FILTER AND FILTRATION PROCESSES IN PROPORTION 1:1:1



10a. Gravel / Coir Fibre / Sand with *Agave americana*-*Agave americana* Screens in Proportion 1:1:1



10b. GCS Filter with Woven *Agave americana*-Hemp Screens in Proportion 1:2:3



10c. GCS Filter with Woven *Agave americana*-*Agave americana* Screens in Proportion 1:2:3



10d. GCS Filter with Nonwoven *Agave americana*-Jute Screens in Proportion 1:2:3



10e. GCS Filter with Nonwoven *Agave americana*-Hemp Screens in Proportion 1:2:3



10f. GCS Filter with Woven *Agave americana*-Jute Screens in Proportion 1:2:3

PLATE – 10  
FILTRATION PROCESS

### **3.10 ECONOMICS OF WOVEN AND NEEDLE PUNCHED FABRICS**

The expenditure involved in the extraction of fibre, spinning and weaving were calculated to assess the value of the fabric. The cost of both woven and needle punched fabrics was estimated.

### **3.11 EVALUATION**

The *Agave americana* fibres, yarns and fabrics of woven and nonwoven structures were evaluated for their basic properties and application oriented characteristics.

#### **3.11.1 Evaluation of *Agave americana* Fibres**

The original and treated fibre samples were tested for essential physical properties of length, diameter, force, scanning electron microscopic (SEM) appearance and chemical constituents.

##### **3.11.1.1 Length**

The length of the fibre was measured as outlined by Jewel (2005) that, length is the distance between the fibre ends when a tension just sufficient to remove the crimp has been applied. Each fibre sample was straightened over a suitable scale and the length was measured directly. This procedure was followed for 50 fibres and the average was taken and recorded as the length of the fibre.

##### **3.11.1.2 Diameter**

Diameter was found using the projection microscope. Samples were mounted one at a time on a slide covered with slide cap and was viewed on the projection microscope. This was repeated for fifty samples. The average of the values obtained was calculated and recorded as the diameter of the fibre.

##### **3.11.1.3 Scanning Electron Microscopic (SEM) Appearance**

Scanning Electron Microscope was used to study the longitudinal view of the original, scoured and bleached fibres. SEM is the imaging system with its wide range of magnification and great depth of focus, remarkably suited to the needs of textile technology. The main reasons for this are, fibres are small but are not microscopic and hence may be imaged easily, clearly and quickly. In the SEM, an electron beam of current is scanned over a specimen's surface. The response of the specimen to this beam is such that the negative charge input from the beam is balanced by the combined effect of charge conduction to ground from the specimen and secondary

emission at the specimens surface, says Kaplan (2001). The SEM appearance obtained are given in the results and discussion.

#### **3.11.1.4 Force, Elongation and Time of Rupture**

Both the extracted and processed fibres were tested for the properties of force, elongation and time of rupture. Techno Statimat 4 Test Standard Tensile Tester was used. It works on the principle of constant rate of extension. The fibre samples were taken randomly and subjected to testing. The gauge length was adjusted to 200 mm and test speed was kept at 208 mm/min. Since it was computerized, suitable keys were pressed for the movements of the jaws. Twenty samples were tested and the readings were automatically recorded in the system and output was obtained. The same procedure was repeated for the fibres at various stages of maturity.

#### **3.11.1.5 Chemical Constituents**

All the cellulosic fibres have several compounds namely, cellulose, hemicelluloses, lignin, pectin and inorganic matters. The cellulose composition and the physical characteristics of the cellulose materials are the most important parameters that influence their processing and application. Chemically cellulose is homogeneous, reports Mishra (2005).

Cellulose forms the main structural basis of vegetable fibre, but is always found to be in association with other cell-wall constituents. The hemicellulose substances in the cell-wall are less resistant to acid hydrolysis than true cellulose, expresses Maulik (2001). Lignin is the fibre constituent responsible for the stiffness of the fibre, say Mishra and Raju (2002).

The chemical compositions namely cellulose, hemicellulose and lignin of fibres were tested in chemistry laboratory at SITRA, using standard procedures.

### **3.11.2 Evaluation of Original and Treated *Agave americana*, Hemp and Jute Yarn Samples**

The yarn samples were assessed subjectively and objectively.

#### **3.11.2.1 Subjective Evaluation**

- **Visual Assessment**

The original and treated yarn samples of *Agave americana*, hemp and jute were kept for visual evaluation. About twenty five judges belonging to Post Graduate

Course of the Department of Textiles and Clothing, Avinashilingam Deemed University for Women, Coimbatore, evaluated the samples. The evaluation was carried out to find the difference in the characteristics of original and treated yarns for general appearance, colour, texture and lustre. The proforma utilized for evaluation is enclosed in Appendix – 11.

### **3.11.2.2 Objective Tests**

The objective tests namely strength elongation, twist per inch, twist direction, yarn hairiness, yarn diameter, U% imperfection and yarn count were found out in a certified laboratory, South Indian Textile Research Association (SITRA).

#### **3.11.2.2.a. Single Yarn Tenacity and Elongation**

Among the various yarn properties, the tensile properties of yarns significantly affect the behaviour of yarns during their conversion into fabrics and the properties of the final structure, say Kothari et al. (2002).

Single yarn tenacity and elongation were analysed using Uster Standard method. The velocity of the equipment was 5000 mm per minute with the clamp pressure of 562 N/cm<sup>2</sup> (50%) and gauge length was 50 cm. The load limit was adjusted to 15 Kgf and elongation was adjusted to 10 per cent. The results were recorded in Gm/tex. Fifty samples were tested and the mean value was found and recorded. Using these specifications the test was carried out for all the yarn samples namely *Agave americana*, hemp and jute.

#### **3.11.2.2.b. Twist Per Inch and Twist Direction**

The twist is a basic feature of a spun yarn, stress Chattopadhyay et al. (2002). Twist of the yarn was tested using microprocessor according to ASTM D 1422-99. The tests were carried out with specimen length of ten inches. The clamp of the twist tester was set at the specified gauge length of +/- 1.0 mm. The yarn specimen was mounted in the twister clamps. One end of the specimen was secured in the non-rotatable clamp and the other end of the yarn was inserted through the rotatable clamp. The extending yarn was pulled through the open clamp until the pointer attached to the non-rotatable clamp has reached the predetermined position for the required tension. At this point the rotatable clamp was tightened and was revolved in the direction which untwist the specimen, releasing the tension as soon as the specimen started to elongate. The rotation was continued in the same

direction, removing the original twist and imparting twist to the specimen in the direction opposite to the original twist. The reinsertion of twist was continued until the indicator returned to its initial position when the specimen was assumed to have its original length and tension. Twenty five samples were tested and the mean was calculated and recorded. This test was repeated for all the yarn samples of *Agave americana*, hemp and jute.

The direction of the twist was also found out.

#### **3.11.2.2.c. U% Imperfection**

The irregularity or unevenness of yarn is commonly defined as the variation in fineness along its length and more appropriately as the variation in mass per unit length along the yarn. It is expressed as U% or CV%. The imperfections are frequently occurring yarn faults, which include thin places, thick places and neps, says Gowda (2003).

Hairiness in yarns leads to fuzzy and hazy appearance of fabric. Fifteen per cent of fabric defects and quality problems stem from hairiness, feels Balasubramanian (2007).

The U% imperfection of the yarn samples was found out as per ASTM D 1425 – 96. The velocity of the equipment was 50 metre per minute with the time of 1 minute. Tension of 100 per cent was applied to the yarn samples. Three samples were tested and the mean was calculated and recorded. The thick places, thin places and the neps were observed and recorded. This test was repeated for all the yarn samples of *Agave americana*, hemp and jute.

#### **3.11.2.2.d. Yarn Diameter**

Image analyzer was utilized for finding the yarn diameter in mm. Twenty samples were viewed and recorded. The mean was calculated. The diameter was recorded in mm. The same was repeated for original and treated yarn samples of *Agave americana*, hemp and jute.

#### **3.11.2.2.e. Yarn Count**

The count of yarn is a numerical expression which defines its fineness. It is also called a yarn number or linear density. According to the definition given by the textile institute, count is a number indicating the mass per unit length or the length per unit mass of yarn. In direct system, the count of the yarn is the number of units of

weights per unit length of yarn. In this system, the count directly expresses the size of the yarn.

Yarn samples were tested as directed in ASTM (2005) test method D 1907 – 01. Samples were randomly selected for testing. Yarn packages were conditioned in standard atmosphere for 3 hours. The yarns were converted into a skein in the automatic wrap reel. The perimeter of the reel was 1.5 yard and 80 wraps were wound to get 120 yards of length. After reeling the skeins were preconditioned before testing, in a standard atmosphere for testing textiles, 21 +/- 1°C (70 +/- 2°F) and 65 +/- 2 per cent relative humidity, until moisture equilibrium was reached, that is until the mass of the specimen increased by not more than 0.1 per cent after 2 hours in that atmosphere. After preconditioning, the skeins were weighed in an electronic balance. Five samples were tested, the findings were recorded and the mean was calculated. The test was repeated for all the yarn samples of *Agave americana*, hemp and jute.

### **3.11.3 Evaluation of the Woven Fabrics**

The woven fabrics were subjectively and objectively assessed.

#### **3.11.3.1 Subjective Evaluation**

Appearance is one of the most important attributes for the quality evaluation of fabrics or garments. Fabric appearance testing mainly relies on manual and subjective assessment and thus the accuracy and reliability is rather doubtful, stress Zhang et al. (2004).

Hence the visual evaluations were done to obtain the opinion and preference of the prepared fabric samples for suitable end use and to evaluate the differences between the original and treated fabrics.

#### **3.11.3.1 Judges Suggestions for Product Preferences for Enduses**

The plain woven fabrics namely AA, AH, AJ, HA, JA, AC and CA and the ribbed woven structure of CA were displayed to obtain the suggestions of 25 judges (students) who belonged to M.Sc. Textiles and Fashion Apparel, Department of Textiles and Clothing, Avinashilingam Deemed University for Women, Coimbatore. The suggestions were obtained for the suitability of fabrics for various enduses namely apparel, curtains, table linens, floor coverings, accessories and package goods as per the proforma in Appendix – 12a.

### **3.11.3.2 Objective Evaluation**

The original and treated fabric samples were objectively analysed for various tests namely, breaking strength and elongation, fabric count, cover factor, fabric weight, fabric thickness, fabric density, dynamic cone drop perforation test, fabric stiffness, abrasion resistance, seam strength, seam efficiency, moisture regain, dimensional stability, wicking, absorbency, sinking test and analysis of fabric samples for biological degradation.

#### **3.11.3.2.a. Breaking Strength and Elongation**

The breaking force is defined as the maximum force applied to a material carried to rupture. Elongation is the ratio of the extension of a material to the length of the material prior to stretching, expressed as per cent (ASTM, 2005). Breaking strength was tested as per ASTM D 5035-2003. The fabrics were tested in both dry and wet conditions using raveled strip method. For preconditioning the samples method ASTM D 1776 was followed. For wet testing the samples were immersed in distilled water at room temperature for one hour, for thorough wetting. Wet sample strength test was completed within two minutes after its removal from the water.

The Eureka Pendulum Type Tensile Strength Tester was used to determine the breaking strength and elongation of the samples. Ten samples of each were cut from the warp and weft directions. Each sample was 35.5 cm in length and 3.8 cm in width. The length wise yarns from the sides of the strip were raveled out up to 0.6 cm from each side of the strip so that 2.5 cm width was maintained. Each sample was perpendicular to the load. The load was applied until the sample was broken. The dial readings in kilograms and elongation in centimeters were noted. Ten readings were taken for each material and the mean value was calculated. The elongation percentage was then found out.

The knowledge of tensile properties of fabrics also helps in predicting the suitability of both the raw material used and the end product. The analysis of tensile behaviour of the woven fabric is therefore extremely important, emphasize Kothari and Chitale (2003).

#### **3.11.3.2.b. Fabric Count**

The fabric samples were tested as directed in test method ASTM D 3775-2003. The fabrics were preconditioned as directed in practice D 1776. Pick

glass with magnifying lens was used to find out the fabric count of all the samples. Pick glass was placed in ten randomly spaced places diagonally across the width of the fabric and number of warp yarns and filling yarns per inch were counted and noted. Ten readings were taken and the mean value was calculated. Randall (2006) expressed that the thread count is calculated by actual number of ends and picks per inch in a woven cloth.

### Calculation

$$\text{Fabric Count} = \text{Warp count } (Q_1) + \text{Weft count } (Q_2) \text{ (Yarns/sq. inch)}$$

#### 3.11.3.2.c. Cover Factor

Kumar (2005) expresses that a number that indicates the extent to which the area of a fabric is covered by one set of threads.

Booth (1996) gives the calculation for cover factor as

$$\text{Cover factor (K)} = \frac{\text{Threads per inch}}{\sqrt{\text{Count}}}$$

$$\text{Cloth Cover factor} = K_1 + K_2 - \frac{K_1 K_2}{28}$$

where  $K_1$  = Warp cover factor ;  $K_2$  = Weft cover factor.

#### 3.11.3.2.d. Fabric Weight

The fabric weight was found according to ASTM test method D 3776 – 2002. The samples were preconditioned as directed in practice ASTM D 1776. The fabric samples were cut with GSM die cutter which is 100 cm<sup>2</sup>. The samples were weighed in an electronic balance. The weight of the sample was measured in grams and multiplied with 100 to get grams per square meter value. Ten samples were tested for each fabric and the average was calculated. The same procedure was followed for all the woven and nonwoven samples.

#### 3.11.3.2.e. Fabric Thickness

Fabric thickness was determined in accordance with test method ASTM D 1777-2002 after preconditioning as specified in practice ASTM D 1776.

The Hungarian thickness tester was used. It has two parts, the anvil and the presser foot, which works under a lever spring action. On the top, a dial indicated the thickness of the sample in the thousand of an inch. Each division on the dial read is

0.01 mm. The sample was placed on the anvil plate and the lever of the presser foot released very slowly and the presser foot pressed the sample. The dial indicated the thickness of the sample. Ten readings were taken from different places of the woven and nonwoven fabric samples and the mean was calculated.

#### **3.11.3.2.f. Dynamic Cone Drop Perforation Test**

The cone drop dynamic perforation test was carried for the fabric samples namely AJ, AA and AH of woven structures. The method EN-ISO-13433-2006 was followed for carrying out the test. This method determines the resistance of geosynthetics to penetration by a steel cone dropped from a fixed height, as a simulation of dropping sharp stones on their surface. The specimen was clamped between two steel rings. A steel cone of 45° tip angle and weight of 1000 g was dropped from a height of 500 mm onto the centre of the specimen. The degree of penetration was measured by insertion of a graduated cone into the hole. A number of five specimens were tested on each face. The results obtained were recorded and expressed as the diameter of the hole in mm to an accuracy of 0.1 mm.

#### **3.11.3.2.g. Abrasion Resistance**

Abrasion resistance is measured by subjecting the specimen to unidirectional, reciprocal folding and rubbing over a specific bar under specified conditions of pressure, tension and abrasive action. Flex abrasion testing equipment was used and test was conducted as per ASTM D 3885 – 04. This machine consisted of balance head and flex block assembly that has two parallel, smooth plates. The balanced head was rigidly supported by a double lever assembly to provide free movement in a direction perpendicular to the plate of the flex block. This head must remain stationary during the test and must be balanced to maintain a uniform vertical pressure from the dead weights. The flex block is capable of reciprocating at 115 +/- 10 double strokes per minute of 25 +/- 2 mm stroke length. The clamps were secured to the front of each plate of the head and flex – block assemblies to permit mounting of the specimen. The clamps have surfaces that prevent slippage of the specimen and permit the specimen after it has been folded over the abradent to be centrally positioned and aligned with its long direction parallel to the reciprocating flex bar. The pressure head weight was 226.8 grams (1/2 pound), Tension weight was 907.2 grams (2 pounds) and the abradent used was type 400. Number of rotations required for rupture of the fabric was observed and recorded. This was repeated for five

samples and the mean was calculated. This was repeated for all the woven fabric samples.

The rubbing was given in warp and weft directions to obtain the values for abrasion.

#### **3.11.3.2.h. Fabric Stiffness**

Basu (2006) is of the opinion that the bending length is a measure of the interaction between fabric weight and fabric stiffness as shown by the way in which the fabric bends under its own weight.

The samples were conditioned in the standard atmosphere as directed in ASTM D 1776. The fabric stiffness has bending length and flexural rigidity was determined as per ASTM test method D 1388 – 2002 cantilever test method was used.

Shirley stiffness tester was used to determine the stiffness of the samples. The sample was cut according to the template size and then both template and sample were transferred to the platform with the material underneath. Both were slowly pushed forward. The strip of the material commenced to drop over the edge of the platform and the movement of the template and the sample was viewed until the tip of the sample viewed in the mirror cut both index lines. The bending length was immediately read from the scale opposite to zero line, engraved on the sides of the platform. Each sample was tested four times at each end and again with the strip turned over. The same procedure was carried out for both woven and nonwoven fabric samples.

#### **3.11.3.2.i. Seam Strength**

The seam strength of all the woven and nonwoven samples were analysed in South Indian Textile Research Association (SITRA) using Instron 5500 R as per ASTM D 434 – 95.

#### **3.11.3.2.j. Seam Efficiency**

Sharma and Lewis (1994), say that the seam efficiency is the ratio of the seam strength to the fabric strength, expressed in percentage. Many specifications require seam efficiency of approximately two per cent.

Accordingly the seam efficiency was found out for both woven and nonwoven structures.

### 3.11.3.2.k. Moisture Regain

Moisture Regain was determined as per ASTM D 629 – 1999 method. The cut samples of approximately one gram was taken, weighed accurately nearest to 0.01 grams in a clean and dry weighing bottle. The weighing bottle containing the test specimen was placed in an oven for one and half hours at a temperature of 105°C to 110°C until the mass is constant to within 0.001 gram. Then the oven dry mass of the specimen was determined using the formula.

#### Calculation

$$\text{Moisture Regain (\%)} = \frac{A - B}{B} \times 100$$

where A = Original mass in grams of the test specimen,

B = Oven dry mass in grams of the test specimen.

### 3.11.3.2.l. Dimensional Stability

The dimensional changes that occur to garments when subjected to repeated automatic laundering procedures commonly used at home are evaluated by this test procedure. A dimensional change is defined in AATCC 2006 as the changes in length or width of a fabric specimen subjected to specified conditions.

As stated in AATCC test method 135-2004, the samples were conditioned in standard atmosphere. Three pairs of bench marks 25 cm long were marked with thread in the warp and weft directions such that they were 12 cm apart and not less than 5 cm from the edge of the test sample. The marked samples were washed in an automatic washing machine with washing temperature of 27°C using the standard detergent. The sample was removed after the final spin cycle and dried on a line. This procedure was repeated four times. The sample was laid without any tension on a horizontal surface and the distance between each pair of bench marks on the warp and weft directions were measured. The dimensional stability was calculated using the formula:

#### Calculation

$$\text{Dimensional Change (DC)} = \frac{B - A}{A} \times 100$$

where A = Original dimension ; B = Dimension after laundering

#### **3.11.3.2.m. Wicking**

The wicking test was conducted as per the procedure given by Saville (2002). A strip of fabric (30 cm x 2 cm) was suspended vertically with its lower edge in reservoir of distilled water. The rate of rise of the leading edge of water was then monitored. To detect the position of water line a dye was added to the water. After 30 minutes, the rise in the water line was noted. The measured height of rise in 30 minutes was taken as a direct indication of the test fabric and recorded in centimetres.

#### **3.11.3.2.n. Sinking Test**

Sinking test is a simple test that helps to measure the wettability of a fabric (Booth, 1996). About ten samples were cut into the size 5 cm x 5 cm square from the mercerized original and the dyed samples. A 1000 ml beaker was filled with distilled water and few drops of wetting agent were added into the distilled water. The sample was dropped on the surface of the water from a standard height. The stop watch was started when the fabric struck the surface of water and stopped when the last corner sank below the water surface and the time required for the sample to sink was noted in seconds. Ten such readings were taken and the mean value was calculated for all the 10 samples. The same method was adopted for original, scoured and bleached samples and recorded separately.

#### **3.11.3.2.o. Absorbency**

As per the AATCC (2008), TM 79 – 2007, the conditioned fabric was spread over an embroidery hoop without wrinkles and kept 9.5 mm below a burette positioned to deliver 15 – 25 drops of water per milli litre. A drop of distilled water was allowed to fall on the cloth. The stop watch was started immediately and the time required for the drop of water to lose its spectacular reflectance and appear as a dull wet spot was noted in seconds. The average of five readings was taken and the shorter the average time the more absorbent the fabric.

#### **3.11.3.2.p. Analyses of Fabric Samples for Biological Degradation**

- **Soil Burial Test**

##### **(A) Burying Fabric in Selected Soil Mixture**

The soil burial test is well known to be a slow process, but it reflects the real, life conditions better than any other test, emphasize Kim et al. (2005). Hence all the fabric samples were subjected to soil burial test.

The woven fabrics namely AA, AJ, JA, AH, HA, AC and CA, and the nonwoven fabrics of AAN, AJN and AHN were cut to 15 cm diameter. These were weighed and buried inside the soil mixture at 3 cm depth individually according to [www.expresstextile.com/20050615/processworld01.shtml](http://www.expresstextile.com/20050615/processworld01.shtml). Red soil, clay and sand taken from Tamil Nadu Agricultural University Campus field were mixed thoroughly and filled in ten different pots. One pot containing the same soil mixture was kept as control sample. This was watered on alternate days and left for 28 days as suggested by Harini et al. (2007).

#### **(B) Collection of Fabric Samples**

After 90 days, the fabric samples were taken out and analysed subjectively by visual assessment and objectively for weight loss and microbial growth to assess the degradation of the fabric samples.

#### **(C) Subjective Evaluation**

##### **Visual Assessment**

The samples were subjected to visual evaluation using proforma (Appendix – 12b) against the original samples for general appearance, colour, lustre, texture and presence of black spots. The ratings were then consolidated and tabulated.

#### **(D) Objective Evaluation**

##### **• Weight Loss**

The fabric samples were washed in distilled water and dried in air for 24 hours. These were weighed using an electronic balance. Then the percentage weight loss was estimated over the original samples as suggested by Kim et al. (2005).

##### **• Enumeration of Microorganisms from Fabric and Soil Samples**

The enumeration of microorganisms was determined as described by Kannan (2002).

##### **Enumeration of Bacterial Colonies**

Ten grams of the fabric samples were weighed and put into 100 ml of sterile distilled water individually and diluted up to  $10^{-9}$ . One milliliter of each dilution of every sample was poured into petri plates followed by 25 ml of sterilized nutrient agar medium (Appendix – 13a) and incubated at 37°C for 24 hours. The well grown bacterial colonies were counted and tabulated.

## **Enumeration of Fungal Colonies**

Fungal strains were isolated by serial dilution technique using sterilized rose Bengal chloramphenicol agar medium (Appendix – 13b). The solidified plates were incubated at 28°C for five days. The fungal colonies were then counted and tabulated.

## **SEM Study**

The fibres namely *Agave americana*, jute and hemp revealed from the woven structures of AA, AJ and AH respectively were studied by Scanning Electron Microscope (SEM) to view the appearance of the fibres.

### **3.11.3.2.q. Evaluation of Finishes**

- **Aqueous Liquid Repellent Finish**

The aqueous liquid repellent finished cotton-*Agave americana* fabric was assessed in ISO 9001 : 2000 certified company as per the standard method AATCC 193-2007. Drops of standard test liquids consisting of a selected series of water / alcohol solutions with varying surface tensions were placed on the fabric surface and observed for wetting and contact angle. The aqueous repellency grade is the highest numbered test liquid which does not wet the fabric surface. The scale ranges from zero to eight with a rating of eight signifying the most repellent surface. Thus the aqueous liquid repellent finished fabrics were tested and rated.

- **Oil Repellent Finish**

The oil repellent finished cotton-*Agave americana* fabric sample was assessed as per the standard method AATCC 118-2007. Drops of standard test liquid consisting of a selected series of hydro carbon with varying surface tensions were placed on the fabric surface and observed for wetting and contact angle. The oil repellency grade is the highest numbered test liquid which does not wet the fabric surface. Thus the fabric finished for oil repellency was tested and the result was recorded.

- **Water Repellent Finish**

The water repellent finished cotton-*Agave americana* fabric sample was assessed as per the standard method AATCC : 22-2005 in ISO 9001 : 2000 certified company. Water sprayed against the taut surface of a test specimen under controlled conditions produces a wetted pattern whose size depends on the relative repellency

of the fabric. Evaluation was accomplished by comparing the wetted pattern with pictures on the standard chart. The standard spray test ratings are 100 – No sticking or wetting, 90 – slight random sticking or wetting, 80 – wetting, 70 – partial wetting, 50 – complete wetting and 0 – complete wetting of specimen face. The treated fabrics were thus tested for water repellency and rated.

- **Flame Retardant Finish**

The flame retardant finished cotton-*Agave americana* fabric sample was evaluated using the standard testing method BS 5867-B. Vertical flame tester was used. The flame was applied on the fabric for 15 seconds. Observations were made for after glow time, occurrence of flaming debris and flame put off time.

### **3.11.4 Analysis of Needle Punched Fabric**

The needle-punched fabric samples were evaluated objectively by laboratory tests for finding various properties of fabric samples. Seam strength weight, thickness, dynamic perforation cone test, stiffness, wickability, sinking, absorbency, moisture content and soil burial tests were conducted in the same procedure followed for woven fabric samples. Few exclusive tests conducted for the prepared nonwoven fabrics were bursting strength, water retention, air permeability and thermal conductivity.

#### **3.11.4.1 Bursting Strength**

Bursting strength was analysed as per ASTM D 3787 – 01. This method described the measurement for bursting strength with a ball burst strength tester of textiles or garments that exhibit a high degree of ultimate elongation. The specimen was placed without tension in the ring clamp and fastened securely by means of the screw or lever device. The machine was started using a pulley clamp speed of 12 +/- 0.5 inch per minute and continued at that speed until the specimen bursts. This was repeated for all the nonwoven samples.

#### **3.11.4.2 Water Retention Capacity**

The water retention capacity was determined according to standard DIN 53814 (25) which expressed the ratio between the mass of water retained in the fabric after soaking for two hours and centrifuging for twenty minutes and the mass of absolutely dry sample at 105°C for 4 hours as described by Kreze and Malen (2003).

#### 3.11.4.3 Air Permeability Test

Air permeability indicates the breathability of clothing fabric. It is the volume ( $\text{cm}^3$ ) of air passing through  $1 \text{ cm}^2$  of fabric per second at a pressure difference of 1 cm head of water. The apparatus consists of means for drawing or forcing air through the fabric of known area, circular orifice of definite known area, provision to hold the fabric without peripheral leakage of air, means for adjusting the pressure drop across the fabric to a known amount, means for measuring the rate of flow of air through the fabric and means of checking the calibration of air flow meter records (ASTM, 2007). TMD737-2004. The specimens were preconditioning as per ASTM D 1776. The test specimen is placed onto the test head of the instrument with sufficient tension to eliminate wrinkles. The vacuum cleaner suction fan was started to force the air through the fabric and adjust the rate of flow of air till pressure drop of one centimeter or 10 mm WG of water head across the fabric. This was achieved by opening the airflow of the rotometers and adjusting the flow rates. The sum of all the rotometer values indicated the rate of flow of air in litres per hour. The test was repeated at ten different places and the mean value was calculated. The air permeability was calculated using the formula :

$$R = \frac{r}{A}$$

where Air permeability (R) – rate of air /  $\text{cm}^2$  of fabric in  $\text{cm}^3 / \text{S}$  ; r = mean rate of flow of air in  $\text{cm}^3 / \text{S}$  and A = area  $\text{cm}^2$  of fabric under test in  $\text{cm}^2$ .

Thus it was conducted for cotton-*Agave americana* ribbed woven and nonwoven samples.

#### 3.11.4.4 Thermal Conductivity

The coefficient of thermal conductivity of the fabric Lee's disc was used as explained by Selladurai (2010). For conducting the experiment, Lee's disc apparatus, steam boiler, bad conductor, stop clock, thermometer, screw gauge, vernier caliper and balance were utilized. The fabric was taken in the form of a disc having dia to that of the metallic disc. The mean thickness of the fabric D was determined with screw gauge. The diameter of the metallic disc was determined with a vernier calipers. The mass M of the disc was found by a balance. The metallic disc was hung from the ring. The specimen of the same size of the disc was placed on it. The steam chamber was placed over the specimen. The two thermometers were placed in

position, one in the disc and the other in the chamber. Steam was passed into the chamber. Thermometers indicate rise in temperature. When the two temperatures were steady for 15 minutes, the readings were noted.

The specimen between the disc and chamber was removed. The chamber was placed directly in contact with the disc. The disc gets heated more rapidly. When its temperature rise about 7° or 8° above the steady state temperature  $\theta_2$ , the steam chamber was removed. The disc was allowed to cool and when its temperature reduced exactly to 5°C above  $\theta_2$ , stop clock was started. The temperature at every 30 seconds was noted till it decrease to 5°C below  $\theta_2$ .

$$\text{Thermal conductivity (K)} = \frac{MS(r+2d)\left(\frac{d\theta}{dt}\right) \text{ at } \theta_2}{\pi r^2 (\theta_1 - \theta_2)(2r + 2d)}$$

$$= \text{wm}^{-1}\text{k}^{-1}$$

where, M = Mass of the disc, S = Specific heat capacity of the material of the disc, d = Mean thickness of disc, 2r = Mean diameter of the disc, r = Mean radius of the disc, D = Mean of fabric thickness and K = Temperature of the steam chamber  $\theta_1$ , Rate of cooling ( $d\theta / dt$ ) at  $\theta_2$ .

The coefficient of thermal conduction of the given fabric is expressed in  $\text{wm}^{-1}\text{k}^{-1}$ . Thus thermal conductivity was found for cotton-*Agave americana* ribbed woven and needle punched samples.

### 3.11.5 Evaluation of Ribbed Woven Fabrics for Cloth tex

The ribbed woven fabrics were subjectively and objectively analysed.

#### 3.11.5.1 Subjective Analysis

- **Visual Evaluation of Original and Treated Fabrics**

The fabrics from the wear studied garment and original fabric samples were placed for subjective analysis by visual evaluation. About twenty five judges belonging to Post Graduate Course of the Department of Textiles and Clothing, Avinashilingam Deemed University for Women, Coimbatore, evaluated the samples. The evaluation was carried out to find the difference in the characteristics of original and treated fabrics for general appearance, colour, lustre and texture. The proforma utilized for evaluation is enclosed in Appendix – 14a.

- **Visual Evaluation of Lac Dyed Original and Wear Studied Samples**

The lac dyed and wear studied samples were evaluated subjectively for the parameters of evenness in dye, brilliancy of colour, texture, lustre, general appearance and fragrance. The proforma is shown in Appendix – 14b.

- **Feedbacks of Wear Studied Over Coat**

The feedbacks from the subjects about general appearance, comfort, stiffness, pricking, dye bleeding on wash and fragrance persistent were obtained and recorded after every wear and wash. The profoma utilized is enclosed in Appendix – 14c.

### **3.11.5.2 Objective Tests**

Tensile strength, elongation, fabric count, weight, thickness, abrasion resistance, stiffness, wicking and sinking tests were carried out similar to the procedure adopted for fabric samples as explained in pages 67-72. Colour fastness tests were also performed for the dyed apparel fabrics. Drapability test was also carried out for the apparel fabric.

#### **3.11.5.2.1 Drape**

Drape is the term used to describe the way a fabric hangs under its own weights. Measurement of a fabric drape is meant to assess its ability to hang in graceful curves, says Saville (2002).

The Eureka Drapemetre was used for characterizing the draping properties of fabrics. A brown paper of 31 cm diameter was cut using a template and weighed (P). A circular sample of the same size was cut using the template and was draped over a disc of 18 cm diameter. A light source and lens located below the disc projected image of the draped sample on the brown paper, which was placed over the glass lid. The outline of the projected image was carefully traced out. The paper was cut along this outline and weighed (Wpa). The area of the supporting disc was cut away from the actual projected area and then weighed again (Wsda). The drape coefficient percentage was calculated using the formula :

$$F = \frac{Wpa - Wsda}{P} \times 100$$

where F = Drape co-efficient percentage ; P = Weight of annular ring of paper ; Wpa = Weight of the projected area of paper and Wsda = Weight of the supporting disc area of the paper.

IS (2000), TS 83 57 – 1977, defines drape coefficient as the area covered by the shadow of the draped specimen expressed as a percentage of the area of the annular ring. Thus the drape coefficient of each sample was calculated. The mean value was calculated for five readings and recorded.

#### **3.11.5.2.2 Colour Fastness**

The important property of a dyed material is the fastness of the shade according to the AATCC, TM 15- 1997, colour fastness is defined as the resistance of the material to change in any of its colour characteristics, to transfer of its colourant (s) to adjacent materials or both as a result of the exposure of the material to any environment that might be encountered during the processing, testing, storage or use of the material. Bhattacharya and Raja (2000), comment that it has been possible to compare the loss of colour or staining or any hue irrespective of depth.

- **Colour Fastness to Light**

Colour fastness to light is the resistance of a material to a change in its colour characteristics as a result of exposure of the material to sunlight or an artificial light source. Colour fastness to sunlight test was done by AATCC test method 16 option – 6 – 2004.

After the test exposure, the fabrics were conditioned in a dark room at standard conditions for testing textiles as directed in ASTM D 1776. The samples were conditioned for four hours in an atmosphere of 21 +/- 1°C (70 +/-2°F) and 65 +/- 2% relative humidity by laying each test specimen separately on a screen or perforated shelf of conditioning rack. A comparison was made with exposed and unexposed portion of the specimen. The colour change was quantified using AATCC grey scale and recorded.

- **Colour Fastness to Crocking**

As stated in AATCC (2006), TM 8-2005, crocking is defined as a transfer of colorant from the surface of a coloured yarn or fabric to another surface or to an adjacent area of the same fabric principally by rubbing.

The crock meter was the standard device for this test. Each test sample was cut to a size of twenty six centimeter length and twenty one centimeter width and mounted on the flat base of the crock meter. A square white material was wrapped around the rubbing finger and held in position with a ring. Each sample was given

twenty rubs, after the number of rubs to be given was standardized. The white square cloth was removed from the rubbing finger and the colour transfer was assessed using a gray scale.

For wet crocking, damp white material was wrapped around the rubbing finger. The rest of the procedure was the same as that of dry crocking. The above mentioned method was used to determine the colour fastness to both dry and wet crocking for all the samples.

- **Colour Fastness to Washing**

Colour fastness to laundering was done by AATCC (2006) test method 61-2003. The dyed test specimen were cut in 2 inch X 4 inch of its size for testing. Bleached cotton test fabric was cut in the same size and attached together with the test specimen by edge stitching.

SASMIRA launderometer was used for laundering. The soap solution was prepared with five grams of detergent powder/ one litre of soft water. The solution was thoroughly mixed and used. Each specimen was soaked in soap solution with material liquor ratio 1:20 in each canister separately and lid was tightly closed. The canisters were fixed in launderometer. The launderometer was set to operate for forty five minutes, at the speed of 40 +/- 2 rotations per minute. After washing the specimens were thoroughly rinsed three times with soft water and air dried. The dried specimens were conditioned in a standard atmosphere for one hour before evaluation. Both colour change and staining were evaluated for the laundered specimens and attached white test fabric using the gray scale for colour change and the gray scale for staining and their values were recorded.

- **Colour Fastness to Perspiration**

The test method AATCC TM 15 – 2009 as explained in [www.aatcc.org/Technical/Test-Methods/Scopes/tm15.cfm](http://www.aatcc.org/Technical/Test-Methods/Scopes/tm15.cfm)., was used to determine the fastness of coloured textiles to the effects of perspiration. Perspiration may be acidic or alkaline in nature. The samples were therefore tested for the colour change in both acidic and alkaline solutions using the perspirometer. Two specimens measuring 5 x 10 cm were cut from each of the original samples and sandwiched between desized white cotton material stitched on three sides and numbered. The acid and alkaline solutions were prepared according to the ISO 2002, IS 105 – C06 – 1994.

The acid solution was prepared with 2.65 grams per litre of sodium chloride, 0.5 grams per litre of L-histidine monohydrochloride monohydrate and 2.2 grams per litre of sodium di hydrogen orthophosphate with pH 5.5. The alkaline solution was prepared with 5 grams per litre of sodium chloride and 0.5 grams per litre of L-histidine monohydrochloride monohydrate with pH 8.

Acetic acid and sodium bicarbonate were added to get the required pH value in acidic and alkaline solutions respectively. The prepared test samples were saturated with the respective solutions and kept for 30 minutes. The samples were then removed from the respective solutions, squeezed and mounted on the instrument by placing each in between the plastic plate. The weight was then replaced on this set up and the entire instrument was kept in the oven at 60°C for four hours. The samples were removed and evaluated for colour change and staining using the gray scale. This procedure was followed for the dyed samples used for cloth tex.

#### **3.11.6 Evaluation of Woven Fabrics Utilized for Home Tex**

The prepared samples were subjectively and objectively evaluated to find its application for home tex.

- **Subjective Evaluation**

The visual assessment was done for the cotton-*Agave americana* ribbed woven scoured bleached and madder dyed and cotton-*Agave americana* plain woven, scoured, bleached and catechu dyed samples before and after wear study for the parameters of general appearance, brilliancy of colour, lustre, texture and evenness in dye. The proforma used is presented in Appendix – 14d.

- **Objective Evaluation**

Colour fastness to light, crocking and washing were done in the same way as they were done for apparels. The wear studied samples were subjectively analysed as explained in 3.11.5.1.

The madder dyed and catechu dyed samples were analysed for various parameters of tensile strength, elongation, fabric count, stiffness, weight, thickness, wicking, sinking and absorbency for original, scoured, bleached, biopolished, dyed and wear studied in the same procedure as explained above.

### 3.11.7 Utilisation of Woven Fabrics as Agro Tex

The analysis was carried out for the soil moisture content, soil temperature, plant growth, soil nutrient content, and weed count.

#### 3.11.7.1 Soil analyses

The soil samples from each of the mulched and unmulched plots were analysed for moisture content, temperature, macro and micro nutrients and weed count.

##### A. Soil Moisture Content

The soil moisture content was analysed at every seven days interval during the cropping period. The soil from the centre portion of the three mulched plots and unmulched plot were taken at 15 cm depth with the help of screw augers. Screw auger ranges from about 2 ½ to 4 cm in diameter. The screw auger is about 15 cm in length and the distance between flanges is out the same as the diameter, describes Padhyay (2007).

The soil taken with the help of screw auger from each of the mulched and unmulched plots were analysed for the moisture content using gravimetric method. The procedure utilized was as per Gupta (2007)–II and the percentage of the soil moisture content was computed by the formula (Plates – 11a – 11c).

$$\text{Percentage of the soil moisture content} = \frac{Y - Z}{Z - X} \times 100$$

where X = Weight of empty moisture can ; Y = Weight of moisture can + Moist soil ; Z = Weight of moisture can + Oven dry soil ; Y – Z = Moisture content in soil and Z – X = Weight of oven dry soil.

##### B. Soil Temperature

Soil temperature was measured using soil thermometer. The soil thermometer is an instrument that comprises of sensor rod and electronic display unit which shows the temperature of the soil when the sensor touches the soil. The temperature of the soil under the mulch at two different depths of 15 cm and 30 cm was taken with soil thermometer. Three such readings from different portions of mulched and unmulched plots were taken and recorded. The temperature was taken at every seven days interval and recorded. The weather data stating the maximum and minimum temperature, relative humidity and rainfall for the period of cropping

from 21<sup>st</sup> February to 28<sup>th</sup> April 2010 was obtained from the Meteorology Department, Tamil Nadu Agricultural University, Coimbatore, the same is shown in Appendix – 15 (Plate – 11d).

### **C. Soil Analysis for Presence of Macro and Micro Nutrients**

The soil samples collected before the start of the experiment from 15 cm depth were analysed for the presence of macro nutrient contents namely available nitrogen (N), phosphorous (P) and potassium (K) present in the soil. The micro nutrients and pH were also analysed and recorded. All the tests were repeated after harvest in both mulched and unmulched plots.

#### **3.11.7.2 Assessment of Weeds**

The weeds were assessed after every fifteen days by counting the number of weeds in the mulched and unmulched areas. The count was done in 3 different areas of the plot and mulched plots and the average was taken and recorded. Weed suppression per cent was calculated and the obtained results were tabulated (Plate – 11e).

#### **3.11.7.3 Analysis of Plant Growth**

The biometric parameters of plants namely shoot length, root length, germination percentage and vigour index were evaluated. The plant height was measured from the base to the tip of the longest leaf stretched. The growth of number of leaves, the count and length of vegetables were also measured and recorded after 70 days of the growth on 26<sup>th</sup> April 2010 for all the plants in both mulched and unmulched plots for comparison.

As studied by Dutta and Gupta (2006), germination and seedling growth are recorded after 4 days from the starting of the experiment. Same way after 4 days period, the seedling germination was assessed. The germination percentage was calculated as per the formula.

$$\text{Germination (\%)} = \frac{\text{Total number of seedlings}}{\text{Total number of seeds}} \times 100$$

as expressed by Kishore and Sharma (2006).

Bose (2008) narrates that, early seedling growth and vigour index are important traits under dry environment particularly in sandy soils that have poor moisture holding capacity. Vigour index = Root length + Shoot length x Seed



11a. Removal of Soil with Screw Augar for Testing



11b. Placing Soil Samples in Oven



11c. Weighing of Oven Dried Soil Samples



11d. Soil Temperature Measurement



11e. Weed Assessment

PLATE – 11  
SOIL TESTING AND WEED ASSESSMENT

germination (%). Accordingly vigour index was calculated. Yield parameters of the plant namely number of vegetables and length of vegetables were also assessed and recorded.

#### **3.11.7.4 Visual Evaluation of the Fabric Samples Laid as Mulching Sheet**

The samples utilized as mulching sheets which were removed after 90 days and subjected to visual evaluation using the same proforma used for evaluating soil buried fabric samples which is presented in Appendix – 12b. It was evaluated for general appearance, colour, lustre, texture and presence of black spots.

#### **3.11.7.5 SEM Appearance of Fabric Samples Laid as Mulching Sheet**

SEMs have been a valuable resource for viewing samples at a much highest resolution and depth with three dimensional appearance, emphasize Sattler (2010). So the samples utilized for mulching were subjected to SEM study to assess the damage of the fibres in the fabric structures after its laying period of 90 days.

#### **3.11.8 Evaluation of Woven and Nonwoven Fabrics for Geo Tex**

##### **3.11.8.1 Analysis of Water**

The filtered water obtained by filtration through various proportions, media and screens of woven and nonwoven structures were evaluated qualitatively and quantitatively.

##### **(a) Quantitative Analysis**

The rate of flow of inlet water was measured by means of opening the gate valve keeping all other valves closed. The water flow was measured using measuring jar and stop watch. The outlet water was collected and its flow rate was also measured by the same method.

Filtration efficiency was calculated using the formula

$$\text{Filtration efficiency} = \frac{\text{Value of outlet water} - \text{Value of inlet water}}{\text{Value of inlet water}} \times 100$$

##### **(b) Qualitative Analysis**

The original and filtered water were qualitatively analysed for its essential qualities of appearance, odour, turbidity, electrical conductivity, pH, total alkalinity, total hardness, calcium, magnesium, sodium, potassium, manganese, ammonia, nitrate, sulphate and phosphorus in Tamil Nadu Water Supply and Drainage Board (TWAD) and the results were obtained.

The results obtained by quantitative as well as qualitative methods were analysed by ANOVA and the best proportion, media, screen and combinations were determined.

### **3.11.9 Analyses of Selected Screen and its Filtration Ability**

#### **(a) Water Analyses**

The three different dosed water samples were passed through the combinations of sand, fibre, gravel with selected screen. The unfiltered and filtered water were analysed and compared.

#### **(b) Screen Analyses**

The selected screen was evaluated for further important geo textile parameters in Bombay Textile Research Association (BTRA) for the mass in gm / m<sup>2</sup> as per ASTM D : 5261:2009, thickness (mm) as per ASTM D : 5199-2009, trapezoid tear strength (W) as per ASTM D 4533 : 2004 in warp and weft directions, widestrip tensile strength (KN/m) according to ASTM D : 2599 : 2009 in both warp and weft directions and CBR puncture strength (N) as per ASTM D 5261 : 2009.

These results obtained were tabulated and discussed in the chapter on Results and Discussion.