Results and Discussion

4. RESULTS AND DISCUSSION

The findings of the study are presented under the following heads.

4.1 Fibre Analysis – *Agave americana*

4.2 Yarns Analysis

4.3 General Properties of Woven Fabrics

4.4 Analysis of Needle Punched Fabrics

4.5 Evaluation of Ribbed Woven Fabrics as Cloth Tex

4.6 Evaluation of Woven Fabrics as Home Tex

4.7 Evaluation of Woven and Needle Punched Fabrics as Mulch Sheets in Agro Tex

4.8 Evaluation of Woven and Nonwoven Fabrics as Screens and Separators in Geo Tex

4.9 Evaluation of Selected Fabric Structure for Geo Tex

4.10 Economics of Woven and Nonwoven Fabrics

4.1 FIBRE ANALYSIS - *Agave americana*

4.1.1 Physical Tests

The *Agave americana* fibres analysed for physical tests of length, force, diameter and Scanning Electron Microscopic appearance (SEM) are clearly given below.

4.1.1.1 Length

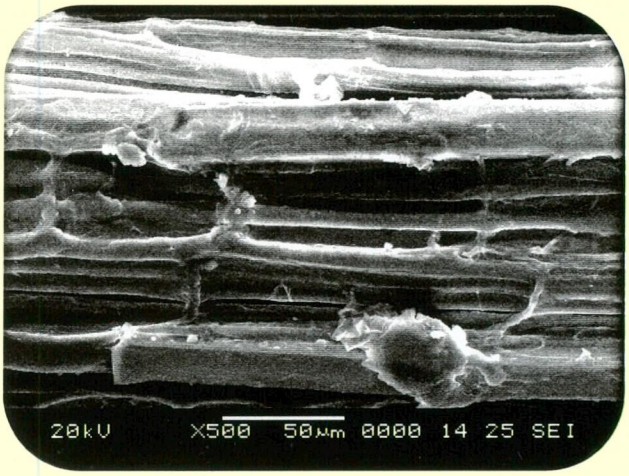
Fibre length is an important physical parameter. The length of the *Agave americana* fibres obtained from the leaves of matured plant was found to be 100-125 centimetres with an average of 110 centimetres.

4.1.1.2 Diameter

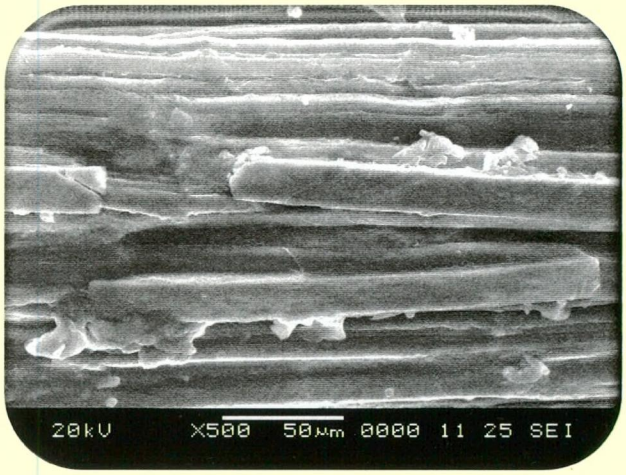
The diameter of *Agave americana* fibres viewed under the projection microscope ranged from 150 μm to 300 μm. The average was found to be 235 μm.

4.1.1.3 Scanning Electron Microscopic (SEM) Appearance

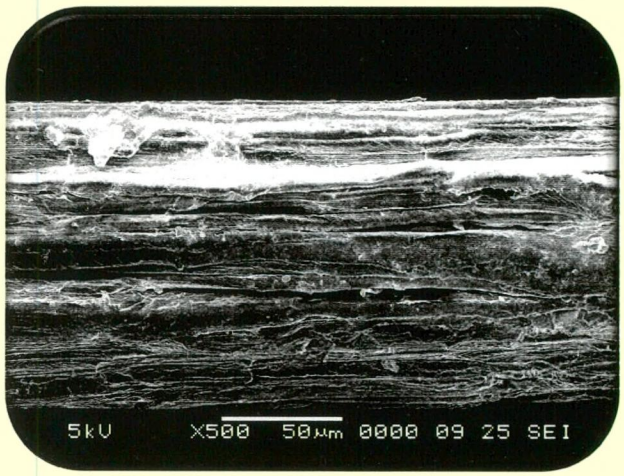
The image of the decorticated fibre in longitudinal section was found to have many cells within one fibre particle. The Scanning Electron Microscopic (SEM) image is given in Plates – 12a – 12c. These fibres were observed to have many fibrils in the original state. The slight swelling of fibres was noted in scoured sample and the bleached samples show a reduction in protruding fibrils.



12a. Decorticated Fibre



12b. Scoured Fibre



12c. Bleached Fibre

PLATE – 12

SEM IMAGE OF *Agave americana* FIBRE

4.1.2 Fibre Characteristics Based on Various Stages of Maturity

Agave americana fibre characteristics based on various stages of maturity namely matured, moderate and tender are given in Table – XII.

TABLE – XII

FIBRE CHARACTERISTICS BASED ON VARIOUS STAGES OF MATURITY

S.No.	Fibres from leaf Stages	Force (gram)			Elongation (per cent)			Time of rupture (seconds)
		Minimum	Maximum	Average	Minimum	Maximum	Average	
1	Matured	857.36	1946.28	1341.38	4.04	7.25	5.89	3.53
2	Moderate	380.47	1003.77	708.72	1.60	5.88	3.92	2.42
3	Tender	207.77	1141.35	658.20	1.20	5.63	3.81	2.34

Table – XII reveals that the force required to rupture the fibres was found to be the highest in matured fibres of 1341.38 grams. The elongation percentage of matured fibres ranged between 4.04 and 7.25 with an average of 5.89 which is the highest among the three samples. The time taken for rupture by the matured fibres was the highest of about 3.53 seconds. Hence matured fibres were proved to be the strongest of all the three.

4.1.3 Chemical Constituents of *Agave americana* Fibres

The chemical constituents of the *Agave americana* fibres were analysed and is given in Table – XIII.

TABLE – XIII

CHEMICAL CONSTITUENTS OF *Agave americana* FIBRES (%)

S.No.	Constituents	Fibres		
		Original	Scoured	Bleached
1	Cellulose	68.36	52.42	52.00
2	Hemicellulose	22.32	27.25	27.00
3	Lignin	3.42	3.41	3.09

From Table – XIII, it is clear that the cellulose content of the original fibre was observed to be 68.36 per cent. On scouring it was reduced to 52.42 per cent and in bleached samples it was 52 per cent. Hemicellulose content was 22.32 per cent in the original sample whereas scoured and bleached samples showed an increase of

hemicellulose content of 27.25 per cent and 27 per cent respectively. Lignin content was reduced on scouring and bleaching processes.

A high hemicellulose content promotes penetration of water and aqueous solutions due to hydrophility of hemicellulose and a high lignin content retards microbiological deterioration, since penetration of water is hindered, stress Balazsy and Eastop (2002). Hence the original samples with highest lignin content were considered for agro and geo textile purposes.

4.2 YARN ANALYSIS

Yarns were analysed subjectively and objectively for various properties.

4.2.1 Visual Assessment of Original and Treated *Agave americana*, Hemp and Jute Yarn Samples

The original and treated yarn samples of *Agave americana*, hemp and jute exhibited for visual evaluation for general appearance, colour, lustre and texture are given in Table – XIV.

TABLE – XIV

VISUAL ASSESSMENT OF ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

S.No.	Sample	Aspects in Percentage											
		General Appearance			Colour			Lustre			Texture		
		G	F	P	B	M	D	G	F	P	S	C	VC
1	AO	10	88	2	26	56	18	8	52	40	0	72	28
2	AS	42	52	6	8	80	12	0	44	56	0	76	24
3	AB	80	20	0	84	12	4	60	40	0	60	40	0
4	HO	44	56	0	20	80	0	12	84	4	52	48	0
5	HS	68	32	0	28	72	0	52	40	8	20	80	0
6	HB	76	24	0	88	12	0	56	44	0	80	20	0
7	JO	44	52	4	8	76	16	0	68	32	44	52	4
8	JS	32	60	8	16	72	12	48	44	8	60	36	4
9	JB	60	40	0	76	20	4	68	32	0	65	35	0

G-Good; F-Fair; P-Poor; B-Bright; M-Medium; D-Dull; S-Soft; C-Coarse; VC-Very Coarse

- **Visual Evaluation of Original and Treated *Agave americana* Yarn Samples**

From Table – XIV, it is clear that the sample AB was rated as good in general appearance by 80 per cent of the judges, bright in colour by the majority of

84 per cent of judges, good in lustre by the maximum of 60 per cent of the judges and soft in texture by the maximum of 60 per cent of the judges. Hence bleaching had improved the quality of the *Agave americana* yarn samples.

- **Visual Evaluation of Original and Treated Hemp Yarn Samples**

Sample HB was rated as good in general appearance by the maximum of 76 per cent of judges. It was also rated as bright in colour, good in lustre and soft in texture by the majority of judges.

Hence, it could be concluded that the hemp yarns were improved in general appearance, colour and texture by bleaching.

- **Visual Evaluation of Original and Treated Jute Yarn Samples**

Sample JB was rated as good in general appearance, bright in colour, good in lustre and soft in texture by maximum number of judges of 60 per cent, 76 per cent, 68 per cent and 65 per cent respectively.

Hence, it could be concluded that the sample JB showed improvement on bleaching.

Moody and Needles (2005) say that lustre is the degree of light that is reflected from the surface of a fibre or the degree of gloss or sheen that the fibre possesses. The bleached samples of all the yarns showed the highest lustre.

4.2.2 Objective Tests

The yarn samples were objectively analysed for various parameters. The original test results obtained from South Indian Textile Research Association (SITRA) are presented in Appendices – 16 and 17.

4.2.2.1 Strength, Elongation and Breaking Tenacity of Original and Treated *Agave americana*, Hemp and Jute Yarn Samples

The strength, elongation and breaking tenacity of original and treated *Agave americana,* hemp and jute yarn samples are given in Table – XV.

TABLE – XV

STRENGTH, ELONGATION AND BREAKING TENACITY OF ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

S.No.	Sample	Strength			Elongation			Breaking tenacity		
		Value (grams)	Loss/ Gain	Loss/ Gain (%)	Value (%)	Loss/ Gain	Loss/ Gain (%)	Value (g/tex)	Loss/ Gain	Loss/ Gain (%)
1	AO	6370.5	-	-	7.22	-	-	11.55	-	-
2	AS	5990.4	380.1	-5.96	7.55	0.33	4.57	13.40	1.85	16.01
3	AB	5251.8	1118.7	-17.55	7.41	0.19	2.63	10.68	-0.87	-7.53
4	HO	5779.0	-	-	2.16	-	-	9.79	-	-
5	HS	5196.9	582.1	-10.07	2.84	068	31.48	10.30	0.51	5.20
6	HB	6110.1	331.1	5.72	3.45	1.29	59.72	9.22	-0.57	5.82
7	JO	6140.0	-	-	2.16	-	-	8.74	-	-
8	JS	5332.4	807.6	-13.15	2.67	0.51	23.61	8.31	-0.43	4.91
9	JB	4618.8	1521.2	-24.77	2.66	0.5	23.14	6.50	-2.24	25.62

- **Strength of Original and Treated Yarn Samples**

Agave americana **:** From the Table – XV, it is clear that scouring and bleaching processes have decreased the strength of the samples. The loss in strength was found to be the maximum of 17.55 per cent in sample AB among other samples. Hence, the scouring and bleaching processes have reduced the strength in *Agave americana* yarn samples.

Hemp : As far as hemp yarn is concerned there was loss in strength of sample HS of 10.07 per cent and increase in strength of sample HB of 5.72 per cent over the sample HO. Hence it could be concluded that bleaching had increased the strength in sample HB and scouring had reduced the strength over the original sample.

Jute : Loss in strength was observed in both samples JS and JB with 13.15 per cent and 24.77 per cent respectively over the original sample. Hence, it could be concluded that there was reduction in strength in both the treated samples of *Agave americana* and jute yarns.

- **Elongation of Original and Treated Yarn Samples**

Agave americana **:** The elongation per cent was increased in both the treated samples AS and AB with 4.57 per cent and 2.63 per cent respectively, over original sample.

Hemp : There was a gain in elongation per cent in treated samples HB of 59.72 per cent and HS of 31.48 per cent over the original sample.

Jute : There was an increase in elongation per cent in samples JS and JB of 23.61 per cent and 23.14 per cent respectively.

Hence it could be concluded that elongation of all the yarns namely *Agave americana*, hemp and jute showed the same trend of increase on scouring and bleaching processes.

- **Breaking Tenacity of Original and Treated Yarn Samples**

***Agave americana* :** The breaking tenacity was decreased in sample AB of 7.53 per cent though it was increased in sample AS of 16.01 per cent over the original.

Hemp : The breaking tenacity was increased in sample HS of 5.20 per cent over the sample HO. It had decreased in sample HB of 5.82 per cent.

Jute : The breaking tenacity was decreased in sample JS of 4.91 per cent followed by sample JB of 25.62 per cent over original sample.

Hence it could be concluded that scouring had increased the breaking tenacity in AS and HS but decreased in sample JS. All the bleached samples showed decreased breaking tenacity.

4.2.2.2 Single Twist Per Inch (TPI) of Original and Treated Yarn Samples

The single TPI was analysed for the original and treated *Agave americana*, hemp and jute yarn samples as given in Table – XVI.

TABLE – XVI

SINGLE TPI OF ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

Sample	Single TPI	Loss/Gain	Loss / Gain (%)
AO	3.19	-	-
AS	3.09	-0.1	-3.13
AB	3.33	0.14	4.38
HO	3.26	-	-
HS	3.30	0.04	1.22
HB	3.31	0.05	1.53
JO	3.12	-	-
JS	3.05	-0.07	2.24
JB	3.57	0.45	14.42

Agave americana : From Table – XVI, it is clear that the single twist per inch was increased in sample AB of 4.38 per cent but decreased in sample AS of 3.13 per cent over the original.

Hemp : There was an increase in twist per inch, in samples HB and HS of 1.53 and 1.22 per cent respectively.

Jute : The twist per inch was decreased in sample JS of 2.24 per cent and increased in sample JB of 14.42 per cent over the original.

It could be concluded that there was an increase in single TPI in the bleached samples of all the yarns over the original samples.

4.2.2.3 Direction of Twist in Yarn Samples

The direction of the twist of all the yarns namely *Agave americana*, hemp and jute were found to be in 'Z' direction.

4.2.2.4 Imperfections in the Original and Treated Yarn Samples

The imperfections in the original and treated yarns of *Agave americana*, hemp and jute yarn samples are given in Table – XVII.

TABLE – XVII

IMPERFECTIONS IN THE ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

Sample	Thick place (+50%)	Thin places (-50%)	Nep (+200%)	U% Imperfection		
				Mean	Loss / Gain over original	Loss / Gain over original (%)
AO	987	1418	160	21.39	-	-
AS	960	680	320	19.16	-2.23	10.42
AB	1220	1600	360	22.22	0.83	3.88
HO	1013	800	7	22.31	-	-
HS	1000	980	0	23.70	1.39	6.23
HB	240	180	40	15.50	-6.81	30.52
JO	1187	1867	13	26.80	-	-
JS	680	780	40	21.97	-4.89	18.02
JB	1440	2000	20	27.84	1.04	3.88

Agave americana : From the Table – XVII, it is clear that the thick places in the yarn sample was found to be increased in sample AB of 1220 and decreased in sample AS of 960 over the sample AO of 987. Thin places were found to be increased in sample AB of 1600 whereas it was reduced in sample AS of 680. Neps too were

found to be increased in both the treated samples namely AB and AS of 360 and 320 over the sample AO of 160. Mean U% imperfection was found to have an increase in sample AB of 3.88 per cent.

Hemp : The treated samples of HS and HB showed decrease of thick places in samples HS of 1000, HB of 240 over the original sample. Thin places were increased in sample HS of 980 over the original sample HO. Neps were found to be increased in sample HB of 40 over the original. Mean U% imperfection was increased in sample HS of 6.23 per cent, and decreased in sample HB of 30.52 per cent. Hence, it could be concluded that U% imperfection was reduced drastically in sample HB.

Jute : Thick and thin places were increased in sample JB to 1440 and 2000 respectively over the original samples. Neps were increased in both the treated samples namely JS and JB to 40 and 20 respectively over the original. Mean U% imperfection too was found to be increased in sample JB of 3.88 per cent over the sample JO.

4.2.2.5 Diameter of Original and Treated Yarn Samples

Diameter of original and treated yarns of *Agave americana*, hemp and jute yarn samples were analysed and given in Table – XVIII.

TABLE – XVIII

YARN DIAMETER (mm) OF ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

Sample	Yarn diameter	Loss/Gain over original	Loss / Gain over original (%)
AO	1.01	-	-
AS	0.82	-0.19	-18.81
AB	1.01	0	0
HO	0.96	-	-
HS	1.18	0.22	22.91
HB	1.263	0.30	31.25
JO	1.094	-	-
JS	1.021	-0.073	-6.67
JB	1.081	-0.013	-1.188

***Agave americana* :** Table – XVIII showed that the yarn diameter was decreased in sample AS of 18.81 per cent, whereas sample AB showed the same yarn diameter of the original yarn sample. Hence, the last diameter of *Agave americana* yarn on scouring was regained on bleaching.

Hemp : It is understood that the diameter has increased in sample HB of 31.25 per cent followed by sample HS of 22.91 per cent over the original sample HO. Both the treated samples showed an increase in diameter over the original.

Jute : It is clear that there was a decrease in diameter in samples JS and JB of 6.67 per cent and 1.188 per cent respectively.

Hence, it could be concluded that the diameter of Jute samples decreased on scouring and bleaching and among these treated samples, it was higher in bleached sample than the scoured sample.

4.2.2.6 Yarn Count of Original and Treated *Agave americana*, Hemp and Jute Yarn Samples

The yarn count of original and treated *Agave americana*, hemp and jute yarn samples analysed are given in Table – XIX.

TABLE – XIX

YARN COUNT OF ORIGINAL AND TREATED *Agave americana*, HEMP AND JUTE YARN SAMPLES

Sample	Yarn count	Loss/Gain over original	Loss / Gain over original (%)
AO	1.07	-	-
AS	1.32	0.25	23.36
AB	1.17	0.10	9.34
HO	1.0	-	-
HS	1.17	0.17	17
HB	0.88	-0.12	-12
JO	0.84	-	-
JS	0.92	0.08	9.52
JB	0.83	-0.01	-1.19

***Agave americana* :** From the Table – XIX, it is clear that the yarn count was increased in both samples AS and AB of 23.36 per cent and 9.34 per cent respectively.

Hemp : The yarn count was increased in sample HS of 17 per cent over the original hemp yarn sample.

Jute : The yarn count increased in sample JS of 9.52 per cent over the original. Hence it could be concluded that the scoured samples AS, HS and JS showed an increase in yarn count over their respective originals.

4.3 GENERAL PROPERTIES OF WOVEN FABRICS

4.3.1 Subjective Evaluation

4.3.1.1 Suggestions for Product Preferences of Woven Samples for End Uses

Suggestions for product preferences of fabric samples for end uses given by the judges are presented in Table – XX.

TABLE – XX

SUGGESTIONS FOR PRODUCT END USES

S.No.	Sample	Apparel	Curtains	Table Linens		Floor Coverings	Accessories	Package material
				Mats	Runners			
1	AA	0	0	10	0	60	10	100
2	AJ	0	0	15	0	80	20	100
3	JA	0	0	15	0	80	20	100
4	AH	0	0	16	0	85	25	100
5	HA	0	0	17	0	85	25	100
6	AC	0	0	10	0	15	10	20
7	CA	0	0	95	80	100	10	35
8	CAR	100	100	100	100	0	85	80

The Table – XX, shows that the maximum of cent per cent of judges suggested end uses of sample CAR for apparel, curtain, table linens and floor coverings. Samples AA, AJ, JA, AH and HA were rated by cent per cent of judges for their utilization as package goods. Sample CA was rated by cent per cent of judges for the use of floor coverings.

4.3.2 Objective Evaluation

4.3.2.1 Analyses of Strength and Elongation of Woven Samples in Warp Direction

The analyses of strength and elongation of woven fabrics in warp direction are clearly given in the Table – XXI and Figures – 6a – 6d.

TABLE – XXI

STRENGTH AND ELONGATION OF ORIGINAL AND TREATED WOVEN SAMPLES IN WARP DIRECTION

S.No.	Sample		Strength (Kg)					Elongation (%)				
			Original	Scoured	Loss (%)	Bleached	Loss (%)	Original	Scoured	Loss (%)	Bleached	Loss/ Gain (%)
1	AA	D	113	79	30.08	85	24.77	18	17	5.55	20	11.11
		W	60	32	46.66	35	41.66	17	16	5.88	18	5.88
2	AJ	D	170	148.5	12.64	150	11.76	19	13	31.57	14	-26.31
		W	64	58	9.37	60	6.25	14	13	7.14	13	-7.14
3	JA	D	63	58.5	7.14	60	4.76	19	15	21	16	-15.78
		W	56	49	12.5	53	5.35	18	17	5.55	18	0
4	AH	D	130	128	1.53	129	0.76	15	15	0	13	-13.33
		W	71	66	7.04	60	15.49	15	11	26.66	12	-20.00
5	HA	D	78	76	2.56	52	33.33	20	15	25	18	-10.00
		W	58	49	15.5	51	12.06	19	14	26.34	18	-5.26
6	AC	D	180	150	16.6	157	12.7	20	16	20	17	-15.00
		W	137	100	27	130	5.10	19	15	21	16	-15.78
7	CA	D	58.6	51	12.96	52	11.26	35	30	14.28	31	-11.42
		W	50.5	48	4.95	49	2.97	34	30	11.76	33	-2.94

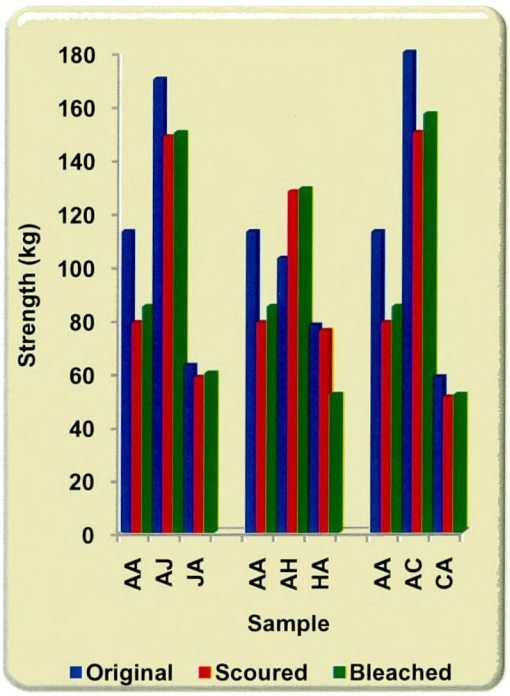
D – Dry ; W - Wet

- **Strength Between Woven Samples in Dry Condition in Warp Direction**

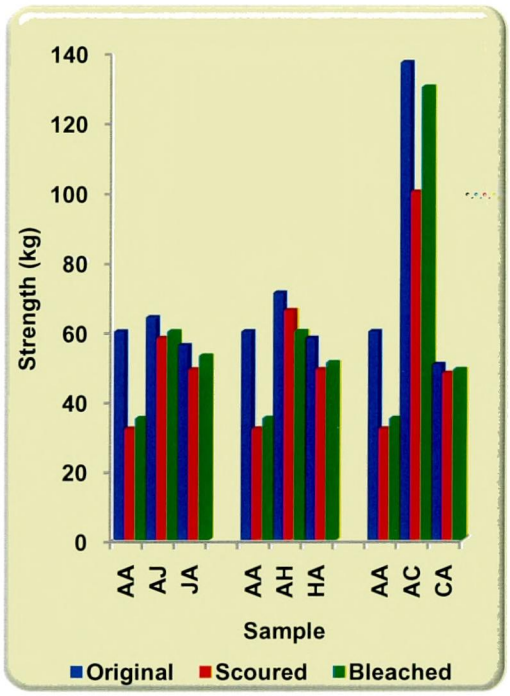
AA, AJ and JA : Among the original samples of AA, AJ and JA, the sample AJ showed the maximum strength of 170 Kg. As for the scoured samples, sample AJ was observed to have the maximum strength of 148.5 Kg. In case of bleached samples also, the maximum strength was noted in sample AJ of 150 Kg. Hence the maximum strength, in both original and treated conditions was observed in sample AJ.

AA, AH and HA : Among the original fabric samples of AA, AH and HA, the sample AH showed maximum strength of 130 Kg. In the scoured and bleached samples also, the sample AH showed the maximum strength of 128 Kg and 129 Kg respectively. Hence the maximum strength in both original and treated conditions was observed in sample AH.

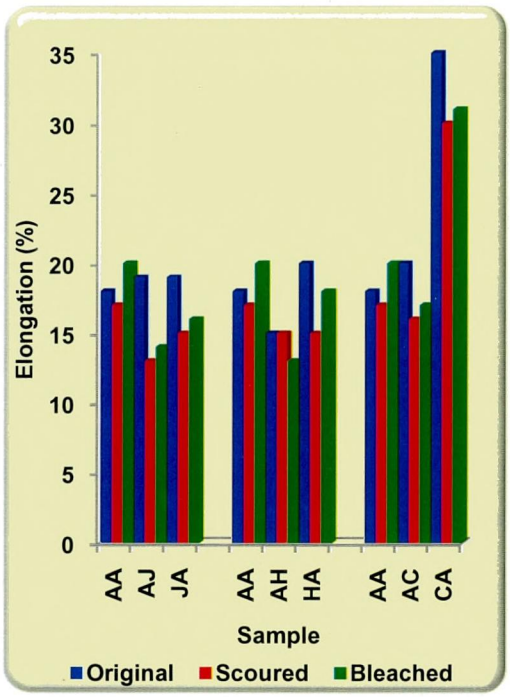
AA, AC and CA : Among the original fabric samples of AA, AC and CA, the maximum strength was noted in sample AC of 180 Kg. In case of scoured samples, the maximum strength was observed in sample AC of 150 Kg. In the case of bleached samples also, the maximum strength was noted in sample AC of 157 Kg.



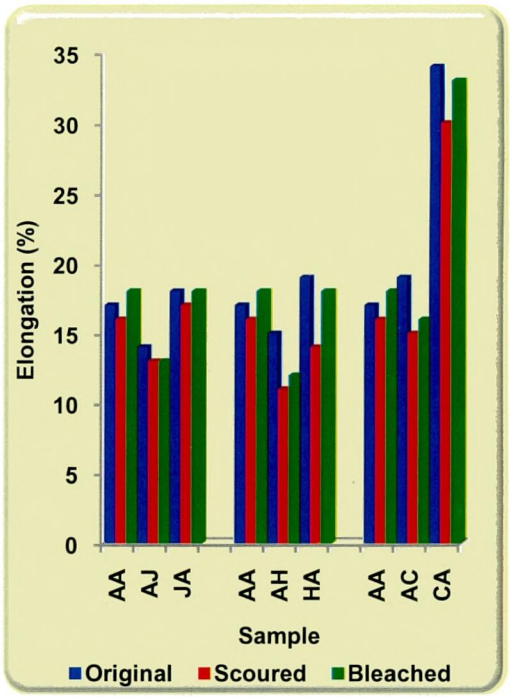
6a. Strength in Dry Condition



6b. Strength in Wet Condition



6c. Elongation in Dry Condition



6d. Elongation in Wet Condition

FIGURE – 6

STRENGTH AND ELONGATION OF ORIGINAL AND TREATED WOVEN SAMPLES IN WARP DIRECTION

The maximum strength in both original and treated conditions was observed in sample AC. Hence it could be concluded that in warp direction, in dry condition, the samples AJ, AH and AC exhibited the highest strength among other samples in both original and treated states; among these samples the sample AC showed the highest strength and strength loss was found to be minimum in sample AH.

- **Strength Between Woven Samples in Wet Condition in Warp Direction**

AA, AJ and JA : Among the original samples of AA, AJ and JA, sample AJ was observed to have the maximum strength with 64 Kg. In the scoured samples, sample AJ had the maximum wet strength of 58 Kg. In the case of bleached samples also, the sample AJ was observed to have the maximum strength of 60 Kg. Hence the maximum wet strength in both original and treated conditions was observed in sample AJ.

AA, AH and HA : Among the original samples of AA, AH and HA, sample AH had the maximum strength of 71 Kg. In the scoured and bleached samples also, the sample AH showed the maximum strength of 66 Kg and 60 Kg respectively. Hence the maximum strength in both original and treated conditions was observed in sample AH.

AA, AC and CA : The comparison between samples AA, AC and CA, sample AC showed the maximum strength of 137 Kg. Among the scoured and bleached samples also, the sample AC showed the maximum strength of 100 Kg and 130 Kg respectively.

Hence the sample AC showed the maximum strength in both original and treated conditions.

Samples AJ, AH and AC exhibited the highest strength among all samples in both original and treated states. Among these samples, the sample AC showed the highest strength. Strength loss was found to be minimum in the scoured sample AH (7.04%) and in bleached sample AC (5.10%).

- **Strength of Woven Samples Between Dry and Wet Conditions in Warp Direction**

In warp direction, a slight loss of strength was observed in the samples in wet condition over dry condition in original, scoured and bleached samples.

Cotton is stronger when wet than in dry, which was proved in the bleached samples of CA, with cotton as warp expressing higher strength (Carr, 1995).

- **Elongation Between Woven Samples in Dry Condition in Warp Direction**

AA, AJ and JA : The elongation per cent was higher in both samples AJ and JA with equal values of 19 per cent than sample AA. Among the scoured samples, it was noted that sample AA had the maximum elongation of 17 per cent. In the case of bleached samples also, the maximum elongation was observed in sample AA with 20 per cent.

AA, AH and HA : Among the original samples, HA showed the maximum elongation of 20 per cent. In the scoured and bleached samples, the sample AA showed the highest elongation values of 17 per cent and 20 per cent respectively.

AA, AC and CA : Among the original samples of AA, AC and CA, the elongation per cent was noted to be the maximum in CA of 35 per cent. In the case of scoured and bleached states also the sample CA showed the highest elongation of 30 per cent and 31 per cent respectively. Hence the maximum elongation was observed in sample CA.

- **Elongation Between Woven Samples in Wet Condition in Warp Direction**

AA, AJ and JA : Among the original samples, the elongation was observed to be the maximum in sample JA of 18 per cent. In the case of scoured samples the elongation was noted to be the maximum in sample JA of 17 per cent. As for the bleached samples, both the samples AA and JA had same elongation values of 18 per cent in wet condition whereas sample AJ had an elongation of 13 per cent.

AA, AH and HA : In the comparison of original samples, the elongation per cent was observed to be the maximum in sample HA with 19 per cent. Among the scoured samples, the elongation was noted to be the maximum in sample AA of 16 per cent. As for the bleached samples, both the samples AA and HA showed equal values of 18 per cent in wet condition.

AA, AC and CA : In the comparison of original samples, the sample CA had the maximum elongation of 34 per cent. As for the scoured and bleached samples also, the maximum elongation was noted in sample CA with 30 per cent and 33 per cent respectively. Hence the maximum elongation was noted in sample CA in both original and treated states.

- **Elongation of Woven Samples Between Dry and Wet Conditions in Warp Direction**

The elongation per cent value decreased in all the scoured samples over the original fabric samples. Though slight increase in elongation in bleached samples,

over scoured samples was observed it was found to be lesser than the original samples except in sample AJ (13%) in wet condition and sample AH (13%) in dry condition.

Balazsy and Eastop (2002) explain hysteresis that water acts as a plasticizer in fibres considerably making them more elastic, due to which the physical properties vary in wet and dry conditions. Few samples in the study satisfied the above statement. Chemically treated fibres showed a considerable decrease in tensile properties and this decrease is attributed to the substantial delignification and degradation of cellulosic chains during chemical treatment as reported in http://www.thefreelibrary.com/pretreatments - natural fibres - application - reinforcing.

4.3.2.2 Analyses of Strength and Elongation of Original and Treated Woven Fabrics in Weft Direction

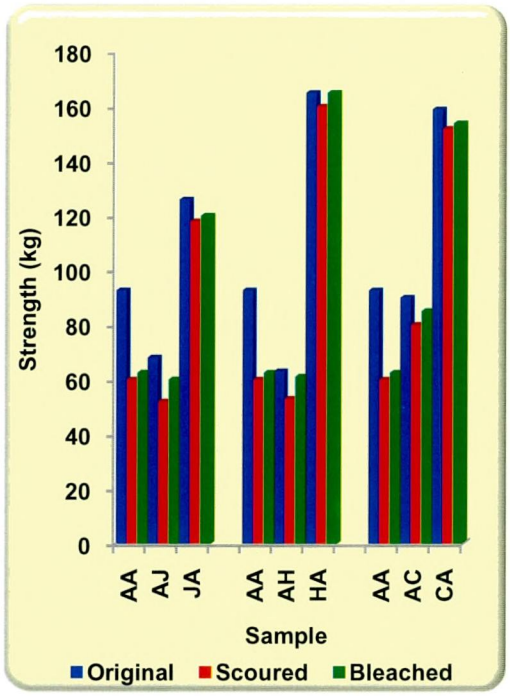
The original and treated samples of woven fabrics were analysed for strength and elongation in weft direction in both dry and wet conditions is given in Table – XXII and Figures – 7a – 7d.

TABLE –XXII

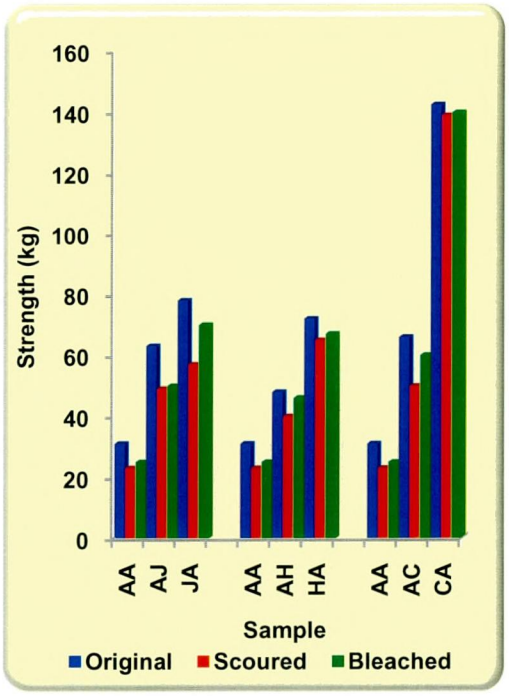
STRENGTH AND ELONGATION OF ORIGINAL AND TREATED WOVEN SAMPLES IN WEFT DIRECTION

S.No.	Sample		Strength (Kg)					Elongation (%)				
			Original	Scoured	Loss (%)	Bleached	Loss (%)	Original	Scoured	Loss (%)	Bleached	Loss/ Gain (%)
1	AA	D	92.6	60	35.20	62.5	32.50	17	14	17.64	15	-11.76
		W	31	23	25.80	25	19.35	16	11	31.25	12	25.00
2	AJ	D	68	52	23.52	60	11.76	19	14	26.31	16	-15.78
		W	63	49	22.22	50	20.63	15	13	13.33	14	-6.66
3	JA	D	126	118	6.34	120	4.76	14	12	14.28	13	-7.14
		W	78	57	26.92	70	10.25	16	15	6.25	16	0
4	AH	D	63	53	15.87	61	3.17	20	16	20	17	-15.00
		W	48	40	16.66	46	4.16	19	13	31.57	15	-21.05
5	HA	D	165	160	3.03	165	0	23	20	13.04	22	-4.35
		W	72	65	9.72	67	6.94	15	13	13.33	14	-6.66
6	AC	D	90	80	11.11	85	5.55	24	23	4.16	24	0
		W	66	50	24.24	60	9.09	21	17	19.04	20	-4.76
7	CA	D	159	152	4.40	154	3.14	16	13	18.75	15	-6.25
		W	142.5	139	2.45	140	1.75	15	12	20	14	-6.66

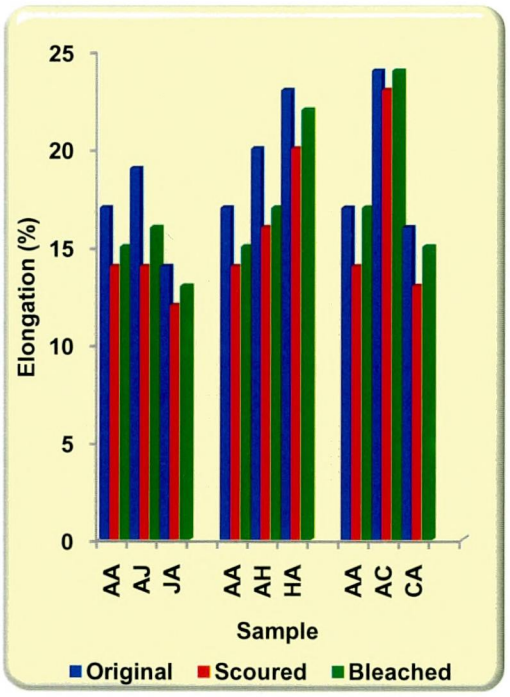
D – Dry ; W – Wet



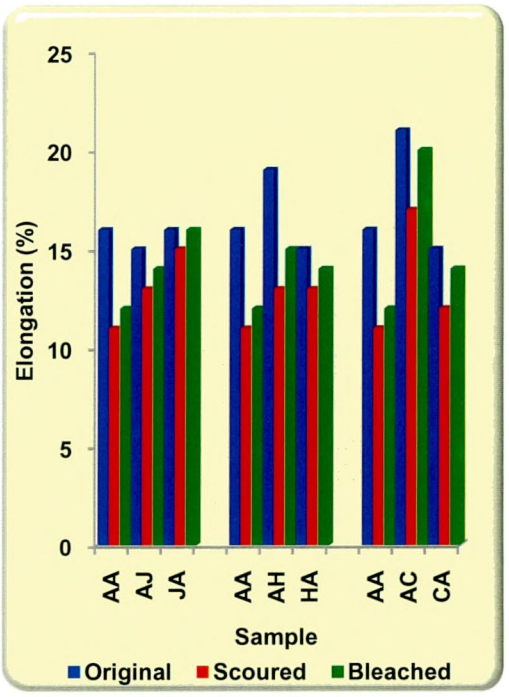
7a. Strength in Dry Condition



7b. Strength in Wet Condition



7c. Elongation in Dry Condition



7d. Elongation in Wet Condition

FIGURE – 7

STRENGTH AND ELONGATION OF ORIGINAL AND TREATED WOVEN SAMPLES IN WEFT DIRECTION

- **Strength Between Woven Samples in Dry Condition in Weft Direction**

AA, AJ and JA : Among the original samples, sample JA showed the maximum strength of 126 Kg. As for the scoured and bleached samples also, the sample JA showed the maximum strength of 118 Kg and 120 Kg respectively. Hence sample JA showed the maximum strength among both original and treated samples.

AA, AH and HA : In the comparison of original samples, the sample HA showed the maximum strength of 165 Kg. In the scoured and bleached samples of AA, AH and HA also, the sample HA had the highest strength of 160 Kg and 165 Kg respectively. Hence it could be concluded that sample HA had the maximum strength in both original and treated conditions.

AA, AC and CA : Among the original samples, the sample CA was found to have the maximum strength of 159 Kg. Among scoured and bleached samples also, the sample CA showed the highest strength of 152 Kg and 154 Kg respectively. Hence sample CA showed the maximum strength in both original and treated samples.

It could be concluded that the samples JA, HA and CA showed the highest dry strength in both original and treated samples in all the three sets of comparisons respectively. Among these samples the maximum dry strength and minimum loss of strength were observed in sample HA.

- **Strength Between Woven Samples in Wet Condition in Weft Direction**

AA, AJ and JA : Among the original samples, the samples JA had the highest wet strength of 78 Kg. In the case of scoured and bleached samples, also the same trend was observed with sample JA exhibiting the highest wet strength of 57 Kg and 70 Kg respectively. Hence it could be concluded that among original and treated woven samples, the sample JA had the maximum strength in weft direction in wet condition.

AA, AH and HA : Between original samples, in weft direction in wet condition, it was observed that sample HA had maximum strength of 72 Kg. As for the scoured and bleached samples also, the sample HA exhibited the maximum strength of 65 Kg and 67 Kg respectively. Hence it could be concluded that sample HA had good strength in weft direction even after scouring and bleaching processes.

AA, AC and CA : Among the original samples, the sample CA showed the maximum strength of 142.5 Kg. In case of scoured and bleached samples also the same trend was noted as sample CA had maximum strength of 139 Kg and 140 Kg respectively.

In wet condition, the samples JA, HA and CA exhibited the maximum wet strength in both original and treated conditions among all the samples. The sample CA had the maximum wet strength and minimum loss in strength.

- **Strength of Woven Samples Between Dry and Wet Conditions in Weft Direction**

A loss in strength was observed in both original and treated fabric samples in wet state over the dry state.

- **Elongation Between Woven Samples in Dry Condition in Weft Direction**

AA, AJ and JA : Among the original samples, the sample AJ had the maximum elongation of 19 per cent. In the case of scoured samples, the sample AA and AJ showed the same value in elongation of 14 per cent. In the bleached samples, the maximum elongation was observed in samples AJ of 16 per cent. Hence it could be concluded that sample AJ showed the maximum elongation in weft direction in dry condition in original as well as treated states.

AA, AH and HA : Among original samples, the maximum elongation was noted in sample HA of 23 per cent. In the case of scoured and bleached samples also, the maximum elongation was noted in sample HA of 20 per cent and 22 per cent respectively. Hence it could be concluded that sample HA showed the maximum elongation in weft direction in dry condition in original as well as treated states.

AA, AC and CA : In the comparison between original samples the maximum elongation was observed in sample AC in original, scoured and bleached states of 24 per cent, 23 per cent and 24 per cent respectively. Hence it could be concluded that sample AC showed the maximum elongation in weft direction in dry condition, in original and treated states among other samples.

- **Elongation Between Woven Samples in Wet Condition in Weft Direction**

AA, AJ and JA : Among the original samples, the elongation per cent was noted to be 16 per cent in both samples AA and JA. In the scoured and bleached samples, the highest elongation was observed in sample JA of 15 per cent and 16 per cent respectively. Hence it could be concluded that sample JA showed the maximum elongation in weft direction in dry condition.

AA, AH and HA : In the comparison between the original samples, the elongation per cent in wet condition was noted to be the maximum in sample AH of 19 per cent. Among the scoured fabric samples, both the samples AH and HA showed same

elongation of 13 per cent. In the bleached samples, the sample AH showed the highest elongation of 15 per cent. Hence it could be concluded that sample AH showed the maximum elongation in weft direction in dry condition in original as well as treated states.

AA, AC and CA : In the comparison between original samples in wet condition, the sample AC showed the maximum elongation of 21 per cent. Among the scoured and bleached samples also, the sample AC showed the highest elongation per cent of 17 per cent and 20 per cent respectively. Hence it could be concluded that sample AC showed the maximum elongation in weft direction in dry condition in both original and treated samples.

- **Elongation of Woven Samples Between Dry and Wet Conditions in Weft Direction**

The elongation per cent value decreased in all the samples in wet condition over dry condition in original, scoured and bleached states except in bleached JA sample.

Hence the above findings prove the statement given in www.indiantextilejournal.com, that strength and elongation are lost by alkali treatment of the cotton samples.

4.3.2.3 Fabric Count and Cloth Cover Factor of Original and Treated Woven Samples

The fabric count and cloth cover factor of original and treated woven samples are given in Table – XXIII.

TABLE – XXIII

FABRIC COUNT AND CLOTH COVER FACTOR OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Sample	Fabric Count (Yarns/ sq.inch)			Cloth Cover Factor (K)		
		Original	Scoured	Bleached	Original	Scoured	Bleached
1	AA	17	19	20	14.37	15.73	16.37
2	AJ	20	20	21	16.11	16.12	16.77
3	JA	21	22	22	16.32	16.88	18.08
4	AH	19	21	22	16.40	17.03	17.68
5	HA	20	21	24	16.37	17.01	18.86
6	AC	23	24	25	12.58	13.48	14.43
7	CA	38	38	40	18.05	17.33	18.96

- **Fabric Count of Woven Samples**

AA, AJ and JA : Among samples AA, AJ and JA, the maximum count was noted in sample JA in original and treated samples.

AA, AH and HA : Among these samples, the sample HA showed the highest fabric count in original and bleached samples, as in scoured sample both HA and AH showed the same count of 21 yarns per square inch.

AA, AC and CA : The sample CA exhibited the maximum fabric count. The scoured and bleached samples also showed the same trend. Fabric count increased on processing over original sample.

- **Fabric Count Between Original and Treated Woven Samples**

The fabric count was increased in the scoured samples of AA, JA, AH, HA and AC over original samples whereas the samples AJ and CA showed the same fabric count of their originals after scouring also. On bleaching, the fabric count was further increased in samples AA, AJ, AH, HA, AC and CA whereas in the sample JA it was the same as scoured.

- **Cloth Cover Factor of Woven Samples**

AA, AJ and JA : The maximum cover factor was observed in sample JA of 16.32. In the sample JA, the maximum cloth cover factor was 16.88 and 18.08 in scoured and bleached samples respectively.

AA, AH and HA : The sample AH exhibited the maximum cover factor in both original and scoured samples. As for the bleached samples, the sample HA showed the highest cover factor.

AA, AC and CA : The sample CA showed the highest cover factor in all states of original, scoured and bleached of 18.05, 17.33 and 18.96 respectively.

Cloth Cover Factor Between Original and Treated Woven Samples

The cloth cover factor showed an increase in values on both scouring and bleaching over original samples.

There is a slight increase of fabric cover factor after scouring and bleaching processes, express Mangovska et al. (2004) which is proved in this study also.

4.3.2.4 Weight (GSM) of Original and Treated Woven Samples

The weight of the samples are given in Table – XXIV (a).

TABLE – XXIV (a)

WEIGHT (GSM) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Samples	Original	Treated			
			Scoured	Loss (%)	Bleached	Loss (%)
1	AA	525	521	0.76	519	1.14
2	AJ	491	483	1.62	463	5.7
3	JA	577	575	0.34	549	4.85
4	AH	544	465	14.5	402	26.10
5	HA	552	524	5.07	507	8.15
6	AC	434	424	2.30	409	5.76
7	CA	649	570	12.17	444	31.58

The statistical analysis of weight of woven samples is presented in Table – XXIV (b).

TABLE – XXIV (b)

ANALYSIS OF VARIANCE OF WEIGHT OF WOVEN SAMPLES

S.No.	Samples	Original	Scoured	Bleached
BETWEEN THE WOVEN SAMPLES – 'F' VALUES				
1	AA / AJ / JA	775.487**	446.316**	343.504 **
2	AA / AH / HA	22.105**	190.411**	718.929 **
3	AA / AC / CA	1131.220**	606.801**	428.152 **
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES				
4	AA	8.7633*		
5	AJ	63.3341*		
6	JA	34.8484*		
7	AH	933.0059*		
8	HA	77.5301*		
9	AC	23.9491*		
10	CA	930.7723*		

** Significant at 1 per cent level. * Significant at 5 per cent level.

- **Weight Among Woven Samples**

Among the fabric samples of AA, AJ and JA, the sample JA had the maximum weight of 577 GSM. In the comparison of samples AA, AH and HA, the highest weight was noticed in sample HA of 552 GSM. Among the fabrics AA, AC

and CA, the maximum weight was observed in sample CA of 649 GSM. In the case of scoured and the bleached samples also, the same trend was observed with maximum weight in samples JA, HA and CA in all the three sets of comparison respectively.

- **Weight (GSM) of Original and Treated Woven Samples**

From the Table – XXIV (a), it is obvious that in sample AA the weight was observed to decrease in scoured and bleached samples of 0.76 per cent and 1.14 per cent respectively.

The weight of the fabric AJ had decreased on scouring and bleaching of 1.62 per cent and 5.7 per cent respectively over original samples. The sample JA showed a decrease in scoured and bleached samples of 0.34 per cent and 4.85 per cent respectively.

The sample AH the weight was found to decrease in scoured and bleached conditions of 14.5 per cent and 26.10 per cent respectively. The sample HA expresses a decrease of 5.07 per cent and 8.15 per cent in scoured and bleached samples respectively.

A reduction in weight was observed in sample AC of 2.30 per cent and 5.76 per cent due to scouring and bleaching respectively. In sample CA there was a reduction in weight of 12.17 per cent and 31.58 per cent in scoured and bleached samples respectively. Hence it could be concluded that on processing, the weight, of all the fabric samples was reduced.

From statistical Table – XXIV (b), it is clear that one per cent significant difference exists in the comparison made within the original, scoured and bleached samples. There was five per cent significance observed between original, scoured and bleached samples within each woven structure.

As found by Wallenberger and Weston (2004), that fabrics increased in strength with an increase in fabric weight, from Tables – XXI and XXII it is proved among treated and untreated samples.

Moore et al. (2003) are of the opinion that jute woven geo textiles used for soil erosion control and vegetation establishment are of weight 500 g/m^2 for the products namely geo jute, soil saver and antiwash. The weight of almost all the original samples were more than 500 g/m^2 except samples AC and AJ. Hence these samples could be used as geo textiles.

4.3.2.5 Thickness of Original and Treated Woven Samples

The thickness of fabric samples are given in Table – XXV (a).

TABLE – XXV (a)

THICKNESS (mm) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Samples	Original	Treated			
			Scoured	Loss (%)	Bleached	Loss (%)
1	AA	2.45	2.02	17.55	1.94	20.8
2	AJ	1.88	1.74	7.44	1.70	9.57
3	JA	2.05	1.84	10.24	1.81	11.70
4	AH	1.90	1.69	11.05	1.65	13.15
5	HA	1.91	1.77	7.32	1.62	15.18
6	AC	1.58	1.56	1.26	1.53	3.16
7	CA	1.79	1.59	11.17	1.43	20.11

Statistical analysis for thickness of woven samples is given in Table – XXV(b).

TABLE – XXV (b)

ANALYSIS OF VARIANCE FOR THICKNESS OF WOVEN SAMPLES

S.No.	Samples	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC SAMPLES – 'F' VALUES				
1	AA / AJ / JA	1785.233**	397.911**	214.003**
2	AA / AH / HA	721.764**	386.369**	430.613**
3	AA / AC / CA	1847.345**	622.233**	733.932**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES				
4	AA	1532.8719**		
5	AJ	195.7209**		
6	JA	238.9752**		
7	AH	253.2578**		
8	HA	283.5102**		
9	AC	7.0457**		
10	CA	358.4305**		

** Significant at 1 per cent level.

- **Thickness among Woven Samples**

Among the three sets of original fabric samples namely AA, AJ and JA ; AA, AH and HA ; AA, AC and CA, the maximum thickness was observed in sample AA of 2.45 mm. Within the scoured and bleached samples also the samples AA showed the highest thickness values.

- **Thickness Between Original and Treated Samples**

The processed samples showed a reduction in thickness over the original sample. There was a slight reduction in thickness in scoured samples and higher reduction in thickness in all the bleached samples. The maximum loss in scoured and bleached samples were observed in fabrics AA and CA respectively. The sample AA exhibited the maximum thickness in both original and treated samples.

From the Table – XXV (b), it is obvious that there was one per cent significance between the fabric samples between original, scoured and bleached categories of the same structure and among the fabric samples of each tretament.

4.3.2.6 Dynamic Perforation Cone Drop Test of Woven Samples

Dynamic perforation cone drop test of woven samples are given in Table – XXVI.

TABLE – XXVI

DYNAMIC PERFORATION CONE DROP TEST OF WOVEN SAMPLES (mm)

S.No.	Samples	Hole Diameter
1	AA	7.6
2	AH	8.8
3	AJ	8.8

From the Table – XXVI, it is clear that the cone drop test of the woven samples showed higher hole diameter in both samples AJ and AH of 8.8 mm than sample AA with 7.6 mm. Hence it could be concluded that cent per cent *Agave americana* sample AA exhibited better perforation resistance than the other samples.

The dynamic perforation through cone drop test for transportation geo textiles, the range for moderate to high is between 18 mm and 12 mm (www.alyaf.com/ geotextiles%20in%20Transportation%20applications). But findings showed still lesser values for all the woven samples. It is clear that lesser hole size proved to have higher strength of fabrics showing the potentiality to be utilized for geo textile purpose.

4.3.2.7 Abrasion Resistance of Woven Sample

The flex abrasion resistance of the woven samples of *Agave americana*, hemp and jute tested in both warp and weft directions are given in Table – XXVII.

TABLE – XXVII

ABRASION RESISTANCE OF WOVEN SAMPLES

S.No.	Samples	Abrasion (No. of rotations)	
		Warp	Weft
1	AA	2304	906
2	AJ	914	408
3	JA	379	1137
4	AH	663	295
5	HA	297	1306
6	AC	2003	68
7	CA	50	2091

From Table – XXVII, it is observed that sample AA required the maximum number of rotations of 2304 to abrade the sample along warp direction among all woven samples. Among the fabrics AA, AJ and JA, in weft direction it was observed that the sample JA required the maximum rotations of 1137 to abrade the sample.

Between samples AA, AH and HA in weft direction it was observed that the sample HA showed the maximum abrasion resistance of 1306 rotations. Among the fabric samples AA, AC and CA in the weft direction, the sample CA showed the maximum abrasion resistance of 2091 rotations. As for abrasion resistance of woven samples, CA could withstand the maximum rotations of all the samples in weft direction.

4.3.2.8 Stiffness of Original and Treated Woven Samples

The stiffness of the woven samples tested in warp and weft directions for original and treated samples are presented in Table – XXVIII (a).

TABLE – XXVIII (a)

STIFFNESS (cm) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Sample	Original		Treated							
				Scoured				Bleached			
		Warp	Weft	Warp	Loss (%)	Weft	Loss (%)	Warp	Loss (%)	Weft	Loss (%)
1	AA	9.2	8.9	8.6	6.5	7.7	13.48	7.45	19.02	6.2	30.3
2	AJ	7.59	6.43	7.26	4.34	4.07	36.7	6.8	10.4	3	53.3
3	JA	5.53	9.01	3.8	31.2	8.5	5.6	3	45	8	11.2
4	AH	8.01	5.86	7.3	8.86	4.2	28.3	6.9	13.85	4.0	31.7
5	HA	4.97	9.8	3.6	27.5	8.8	10.2	3.2	35.6	8.3	15.1
6	AC	8.85	2.4	8	9.6	2.1	12.5	7	20.90	1.8	25
7	CA	2.9	10.04	2.6	10.34	9.7	3.3	2	31.03	9	10.35

The statistical analysis for stiffness of woven samples is given in Table – XXVIII (b).

TABLE – XXVIII (b)

ANALYSIS OF VARIANCE FOR STIFFNESS OF WOVEN SAMPLES

S.No.	Samples	Warp			Weft		
		Original	Scoured	Bleached	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC SAMPLES – 'F' VALUES							
1	AA/AJ/JA	4972.996**	16688.7849**	8572.328**	3424.043**	5346.493**	8903.285**
2	AA/AH/HA	2576.1489**	5570.271**	6548.238**	2027.310**	519.558**	4153.523**
3	AA/AC/CA	8962.916**	5804.5677**	6385.787**	7967.917**	9317.020**	1128.133**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES							
4	AA	1087.6130**			2808.6630**		
5	AJ	217.9667**			14474.7258**		
6	JA	6141.6827**			167.7680**		
7	AH	243.6966**			1873.5623**		
8	HA	2262.8461**			304.4361**		
9	AC	363.1937**			544.2379**		
10	CA	903.0316**			89.6210**		

** Significant at 1 per cent level.

The Table – XXVIII (a) reveals that among all the fabric samples in warp direction, the sample AA exhibited the maximum stiffness of 9.2 cm.

In weft direction among samples AA, AJ and JA, the maximum strength was observed in sample JA with 9.01 cm. Among the fabric samples of AA, AH and HA in weft direction, the highest stiffness was observed in sample HA with 9.8 cm. Among the fabric samples of AA, AC and CA in weft direction, the highest stiffness was observed in sample CA of 10.04 cm.

The woven samples showed reduction in stiffness over their respective originals along warp direction and the maximum of 31.2 per cent was observed in sample JA on scouring. After bleaching, the samples showed further reduction in stiffness over original and the maximum reduction was observed again in sample JA of 45 per cent.

The woven samples showed reduction in stiffness over their respective originals along weft direction also, and the maximum of 36.7 per cent loss was observed in sample AJ on scouring. After bleaching, all the samples showed further

reduction in stiffness over original and the maximum reduction was exhibited in the sample AJ of 53.3 per cent.

Hence it could be concluded that among all the fabric samples in warp direction maximum stiffness was observed in sample AA in original as well as treated samples and in weft direction it was observed in sample CA.

The analysis of variance by 'F' value done for stiffness values proved that the differences, within the original, scoured and bleached samples along warp and weft directions, were found to be significant at one per cent level in each group of samples. The 'F' value further showed that the differences between the original and treated samples in warp and weft directions too were significant at one per cent level in each woven structure.

4.3.2.9 Seam Strength, Strain and Seam Efficiency of Woven Samples

The seam strength, strain and seam efficiency of woven fabric samples are given in Table – XXIX.

TABLE – XXIX

SEAM STRENGTH, STRAIN AND SEAM EFFICIENCY OF WOVEN FABRIC SAMPLES

S.No.	Samples	Maximum Load (Kg f)		Tensile strain (%)		Seam Efficiency (%)	
		Warp	Weft	Warp	Weft	Warp	Weft
1	AA	36.16	31.10	22.00	17.33	32	33.58
2	AJ	28.17	27.66	23.33	18.67	16.57	40.67
3	JA	26.93	29.68	24.67	19.33	42.74	23.55
4	AH	30.41	28.58	22.67	23.33	23.39	45.36
5	HA	24.66	27.08	21.33	20.00	31.61	16.41
6	AC	31.50	23.06	38.00	18.00	17.5	25.62
7	CA	22.12	30.27	19.00	37.00	38.13	19.03

Among all the samples, the sample AA was observed to withstand the maximum load of 36.16 Kg f in warp and weft directions.

In warp direction, among samples AA, AJ and JA the maximum strain was noted in sample JA of 24.67 per cent. Between samples AA, AH and HA the maximum strain was observed in sample AH of 22.67 per cent. Among the fabric samples AA, AC and CA, the sample AC had the maximum strain of 38 per cent.

In weft direction, among the samples AA, AJ and JA in weft direction, the sample JA showed the highest strain of 19.33 per cent. In the comparison between samples AA, AH and HA the sample AH had the maximum strain of 23.33 per cent. Among the samples AA, AC and CA the sample CA exhibited the maximum strain of 37 per cent.

As far as the seam efficiency was concerned in warp direction among samples AA, AJ and JA, the efficiency was the maximum in sample JA of 42.74 per cent. Among the samples AA, AH and HA, the highest efficiency was noted in sample AA of 32 per cent. Between samples AA, AC and CA, the sample CA showed the maximum seam efficiency of 38.13 per cent.

In weft direction, among samples AA, AJ and JA in weft direction, the seam efficiency was the maximum in sample AJ of 40.67 per cent. In the comparison between samples AA, AH and HA, the highest seam efficiency was observed in sample AH of 45.36 per cent. Among the samples AA, AC and CA, the seam efficiency was highest in the sample AA of 33.58 per cent.

Hence it could be concluded that in all samples seam strength was found to be the maximum in samples AC, AH, AA and AJ along warp direction whereas it was maximum in samples JA, HA and CA in weft direction. This may be due to the running of *Agave americana* yarn in that particular direction.

4.3.2.10 Moisture Regain of Original and Treated Woven Samples

The moisture regain of original and treated woven samples are given in Table – XXX (a).

TABLE – XXX (a)

MOISTURE REGAIN (%) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Samples	Original	Treated			
			Scoured	Loss (%)	Bleached	Loss (%)
1	AA	10.3	10.1	1.94	10	2.91
2	AJ	9.3	9.0	3.22	8.9	4.30
3	JA	8.1	8	1.23	7.9	2.46
4	AH	14	13.7	2.14	13.5	3.57
5	HA	8.3	8.2	1.20	8	3.61
6	AC	8.77	8.6	1.93	8.5	3.07
7	CA	8.39	8.25	1.66	8	4.64

Statistical analysis for moisture content of woven samples is given in Table – XXX (b).

TABLE – XXX (b)

ANALYSIS OF VARIANCE FOR MOISTURE REGAIN OF WOVEN SAMPLES

S.No.	Samples	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC SAMPLES – 'F' VALUES				
1	AA / AJ / JA	1360.716**	1045.893**	692.661**
2	AA / AH / HA	2252.597**	2702.196**	3141.891**
3	AA / AC / CA	409.918**	326.197**	388.649**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES				
4	AA	24.8275*		
5	AJ	35.9254*		
6	JA	7.1833*		
7	AH	14.4802*		
8	HA	14.5835*		
9	AC	6.7973*		
10	CA	17.2451*		

** Significant at 1 per cent level. * Significant at 5 per cent level.

AA, AJ and JA : Among the original woven samples of AA, AJ and JA, the maximum moisture regain was observed in sample AA with 10.3 per cent. Among the scoured and bleached samples also, the same trend was noted with maximum moisture regain in sample AA of 10.1 per cent and 10 per cent respectively.

AA, AH and HA : In the comparison of original samples of AA, AH and HA, the maximum moisture regain was noted in sample AH with 14 per cent. When a comparison was made between scoured and bleached samples, the moisture regain was noted to be the maximum in sample AH of 13.7 per cent and 13.5 per cent respectively.

AA, AC and CA : Among the original fabric samples of AA, AC and CA, the maximum moisture regain was noted in sample AA of 10.3 per cent. In the case of scoured and bleached samples also, the maximum regain was observed in sample AA of 10.1 per cent and 10 per cent respectively.

Hence it could be concluded that on scouring the moisture regain capacity was reduced in all samples and the loss per cent ranges from 1.2 per cent to 3.22 per cent. Of all the fabric samples the maximum moisture regain was observed in original sample of AA and treated samples of *Agave americana*-hemp mixture. The

maximum loss in moisture regain was observed in scoured and bleached samples of AJ and CA respectively.

Statistical data proved that the differences in moisture regain within original, scoured and bleached in each group of woven samples, were significant at one per cent level. The differences between the original, scoured and bleached samples were significant at five per cent level.

4.3.2.11 Dimensional Change

The dimensional change of samples in warp and weft directions is presented in Table – XXXI.

TABLE – XXXI

DIMENSIONAL CHANGE (%) OF FABRICS IN WARP AND WEFT DIRECTIONS

S.No.	Sample	Change					
		Warp			Weft		
		Original	Scoured	Bleached	Original	Scoured	Bleached
1	AA	-5.0	-2.0	0	-5.2	-3.3	-1.0
2	AJ	-5.2	-3.5	-1.2	-5.6	-3.4	-1.4
3	JA	-4.6	-3.7	-1.7	-5.4	-3.2	-1.0
4	AH	-5.5	-2.8	-1.0	-5.5	-2.6	-1.8
5	HA	-5.7	-3.2	-1.5	-5.0	-2.0	-1.3
6	AC	-4.7	-3.3	-1.8	-5.0	-3.8	-1.7
7	CA	-5.9	-4.0	-1.9	-4.2	-3.0	-1.6

- **Dimensional Change of Woven Samples in Warp Direction**

Among samples of AA, AJ and JA, sample AJ showed the maximum reduction of 5.2 per cent in dimension in warp direction. On scouring, lesser change in dimension was observed over original samples. On bleaching, the same samples showed still lesser change in dimension along wrap direction. The value zero in sample AA in bleached condition showed a stability in dimension. This same trend was observed in both the sets of samples namely, AA, AH and HA and AA, AC and CA.

- **Dimensional Change of Woven Samples in Weft Direction**

The samples showed change in dimensions in original, scoured as well as in the bleached samples. Among the samples AA, AJ and JA, the samples showed minimum change in dimension on scouring and bleaching in sample JA of 3.2 and 1.0 over the unwashed samples. The least change in dimension was noted on

scouring in sample HA of 2.0 per cent and on bleaching in sample AA of 1.0 per cent. As for the samples AA, AC and CA the dimensional change was observed to be the minimum on scouring in sample CA of 3 per cent and on bleaching in sample AA of 1.0 per cent along weft direction.

4.3.2.12 Wicking of Original and Treated Woven Samples

The wicking of original and treated woven samples is given in Table – XXXII (a) and Figures – 8a and 8b.

TABLE – XXXII (a)

WICKING (cm) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Sample	Original		Treated							
				Scoured				Bleached			
		Warp	Weft	Warp	gain (%)	Weft	gain (%)	Warp	gain (%)	Weft	gain (%)
1	AA	3	3	4	33	4	33	9	200	9	200
2	AJ	3	3	5	66.6	4	33.3	6	100	5	66.6
3	JA	3.3	5.3	4.2	27	6.1	15	6.1	84	7.4	39.6
4	AH	5	3.2	6.4	28	4.3	34.3	7.7	54	5.7	78
5	HA	5	8.3	6.9	38	9	8.4	7.4	48	10.5	26.5
6	AC	5.5	4.3	6	9	5.4	25.5	7.3	32.7	6.9	60
7	CA	6	6.8	6.7	11.6	7.4	8.8	7.3	21.6	8.2	20.5

Statistical analysis for wicking of woven samples is given in Table – XXXII (b).

TABLE – XXXII (b)

ANALYSIS OF VARIANCE FOR WICKING OF WOVEN SAMPLES

S.No.	Samples	Warp			Weft		
		Original	Scoured	Bleached	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC MIXTURES – 'F' VALUES							
1	AA/AJ/JA	367.996**	584.009**	4404.922**	4787.330**	9756.637**	4794.3222**
2	AA/AH/HA	2412.545**	2842.685**	467.412**	16950.532**	7533.532**	3026.053**
3	AA/AC/CA	2720.062**	2132.255**	428.000**	4267.734**	2268.633**	501.181**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES							
4	AA	41114.058**			69196.4286**		
5	AJ	6835.9375**			2868.0688**		
6	JA	3255.1727**			1296.4863**		
7	AH	1917.1385**			3624.9354**		
8	HA	1612.4489**			579.8077**		
9	AC	555.8150**			1558.5483**		
10	CA	297.6563**			272.9407**		

** Significant at 1 per cent level.

- **Wicking Among Woven Samples in Warp Direction**

AA, AJ and JA : Among original fabric samples AA, AJ and JA, the maximum wicking was observed in sample JA. In the case of scoured samples, the sample AJ showed the maximum wicking of 5 cm. Among the bleached samples, the sample AA showed the highest wicking of 9 cm.

AA, AH and HA : In the comparison between the original samples AA, AH and HA, the samples AH and HA showed higher wicking capacity of 5 cm than sample AA with 3 cm. Among the scoured fabric samples, sample HA showed the maximum wicking of 6.9 cm. In the bleached samples, the sample AA showed the maximum wicking of 9 cm.

AA, AC and CA : Among the original fabric samples AA, AC and CA, the sample CA showed the highest wicking to 6 cm. In the scoured samples, the sample CA showed the maximum of 6.7 cm wicking capacity. As far as the bleached samples are concerned, the maximum wicking was observed in the sample AA with 9 cm.

- **Wicking Among Woven Samples in Weft Direction**

AA, AJ and JA : Among fabric samples AA, AJ and JA, the maximum wicking was observed in sample JA of 5.3 cm. Among the scoured fabric samples, the maximum wicking was noted in the sample JA of 6.1 cm. In the case of bleached samples the sample AA showed a maximum wicking height of 9 cm.

AA, AH and HA : The comparison between samples AA, AH and HA, the sample HA showed higher wicking capacity of 8.3 cm. In case of scoured and bleached samples also, the sample HA showed the maximum wicking of 9 cm and 10.5 cm respectively.

AA, AC and CA : Among the original and scoured samples of AA, AC and CA, the sample CA showed the highest wicking of 6.8 cm and 7.4 cm respectively. In the case of bleached samples, the maximum wicking was observed in sample AA with 9 cm height.

- **Wicking Between Original and Treated Woven Samples**

Table – XXXII (a) highlights that there is an increase in wicking heights in all the samples after scouring and subsequent bleaching. The same trend was observed in all the fabric samples.

Absorbency of fabric is influenced by their wicking ability, express Patnaik et al. (2006). The increase in wickability of all samples shows the increase in absorbency of the fabric.

Statistical data proved that the differences in wicking capacity of woven samples present within original, scoured and bleached of the three sets were significant at one per cent level. The differences between the original, scoured and bleached samples also showed a significance of one per cent level in both warp and weft directions.

4.3.2.13 Sinking of Original and Treated Woven Samples

The results of samples analysed for sinking are presented in Table – XXXIII (a) and Figure – 9.

TABLE – XXXIII (a)

SINKING (SECONDS) OF ORIGINAL AND TREATED WOVEN SAMPLES

S.No.	Samples	Original	Treated			
			Scoured	Loss (%)	Bleached	Loss (%)
1	AA	10	5	50	3	70
2	AJ	13	10	23.07	6	53.8
3	JA	20	15	25	7	65
4	AH	20	14	30	6	70
5	HA	21	15	28.5	6	71.42
6	AC	25	12	52	6	76
7	CA	23	10	56.52	7	69.56

Statistical analysis for sinking of woven samples is given in Table – XXXIII (b).

TABLE – XXXIII (b)

ANALYSIS OF VARIANCE FOR SINKING TEST OF WOVEN SAMPLES

S.No.	Samples	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC MIXTURES – 'F' VALUES				
1	AA / AJ / JA	22681.596**	8720.930**	4791.743**
2	AA / AH / HA	4281.581**	9891.304**	4694.835**
3	AA / AC / CA	4243.432**	3567.834**	5225.080**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES				
4	AA	18714.0115*		
5	AJ	14149.1396*		
6	JA	12776.0721*		
7	AH	8875.0300*		
8	HA	10863.3505*		
9	AC	10273.3510*		
10	CA	7244.9252*		

** Significant at 1 per cent level. * Significant at 5 per cent level.

- **Sinking of Original and Treated Woven Samples**

AA, AJ and JA : Among the original fabric samples of AA, AJ and JA, the sample AA took the minimum time for sinking of 10 seconds. Between the scoured samples, the sample AA took the least time of 5 seconds. In the case of bleached samples also the same trend was observed, with sinking time of AA as 3 seconds.

AA, AH and HA : The comparison of original samples of AA, AH and HA, the minimum sinking time was noted in sample AA of 10 seconds. In the case of scoured samples also the time taken by sample AA (5 seconds) was the least. As for the bleached samples the sinking time of AA still got reduced to 3 seconds.

AA, AC and CA : The comparison between original samples of AA, AC and CA, the minimum time was noticed in sample AA of 10 seconds. In the scoured samples also the same trend was noted with AA having lowest sinking time of 5 seconds. As far as the bleached samples the sample AA showed minimum time of 3 seconds.

- **Sinking in Fabric Sample Between Original and Treated Samples**

On comparison of sinking in fabric sample between original and treated samples it is understood that all the samples showed an improvement in absorbency. The reduction in sinking was the highest in the cotton mixed samples of CA and AC.

Cavaco-Pawlo and Gubitz (2003) feel treatment of cellulosic fibres with caustic soda induces inter crystalline swelling of cellulose, for improved properties of fibre strength, dye uptake, brightness and hydrophilicity. Findings also prove the same.

The Table – XXXIII (b) reveals that there was one per cent significance between the woven samples. The comparison between original, scoured and bleached samples were significant at five per cent level as per the 'F' values observed.

4.3.2.14 Absorbency of Woven Samples

The absorbency results of woven samples are presented in Table– XXXIV (a) and Figure – 10.

TABLE – XXXIV (a)

ABSORBENCY (SECONDS) OF WOVEN SAMPLES

S.No.	Sample	Original	Treated			
			Scoured	Loss / gain (%)	Bleached	Loss / gain (%)
1	AA	8.6	6.9	19.76	5.3	38.37
2	AJ	23.1	11.2	51.5	10.3	55.41
3	JA	21.3	13.7.	35.68	9.7	54.46
4	AH	18.5	12.4	32.97	6.5	64.86
5	HA	20.3	14.6	28.07	10.6	47.78
6	AC	24.1	10.5	56.43	9.6	60.16
7	CA	21.2	15.5	26.88	12.2	42.45

Statistical analysis for absorbency of woven samples is given in Table – XXXIV(b).

TABLE – XXXIV (b)

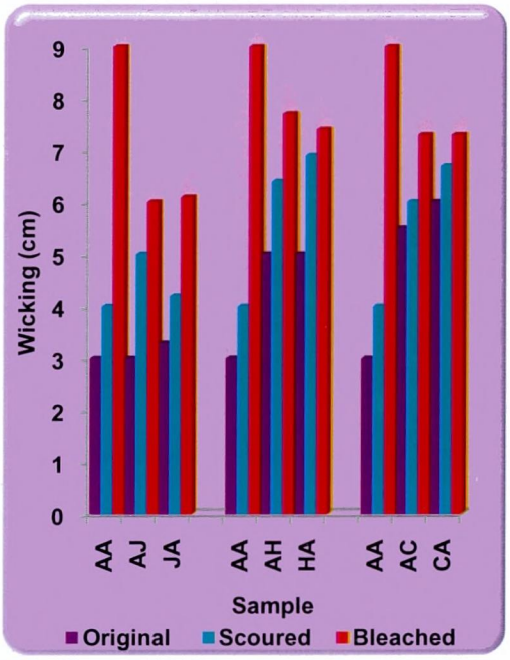
ANALYSIS OF VARIANCE FOR ABSORBENCY OF WOVEN SAMPLES

S.No.	Samples	Original	Scoured	Bleached
BETWEEN THE WOVEN FABRIC MIXTURES – 'F' VALUES				
1	AA / AJ / JA	33442.885**	4779.798**	3395.750**
2	AA / AH / HA	5252.643**	5502.237**	4752.802**
3	AA / AC / CA	4946.443**	3909.955**	5161.154**
BETWEEN THE ORIGINAL AND TREATED SAMPLES – 'F' VALUES				
4	AA	4592.9839**		
5	AJ	19695.1100**		
6	JA	9891.3043**		
7	AH	7658.6542**		
8	HA	4138.2713**		
9	AC	7545.8837**		
10	CA	1926.0032**		

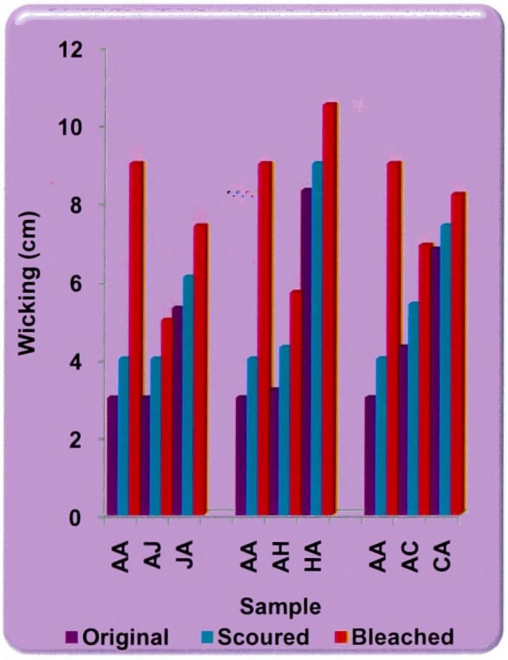
** Significant at 1 per cent level.

- **Absorbency within Woven Fabric Samples**

AA, AJ and JA : In the comparison made between original samples of AA, AJ and JA the sample AA took minimum time of 8.6 seconds for absorbing water into the fabric. In the scoured and bleached samples also, the sample AA took minimum time of 6.9 seconds and 5.3 seconds respectively.



8a. Warp Direction



8b. Weft Direction

FIGURE – 8

WICKING OF ORIGINAL AND TREATED WOVEN SAMPLES

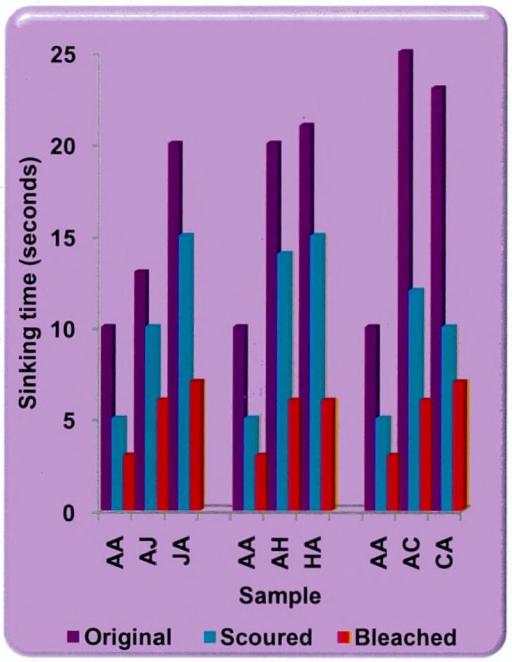


FIGURE – 9

SINKING OF ORIGINAL AND TREATED WOVEN SAMPLES

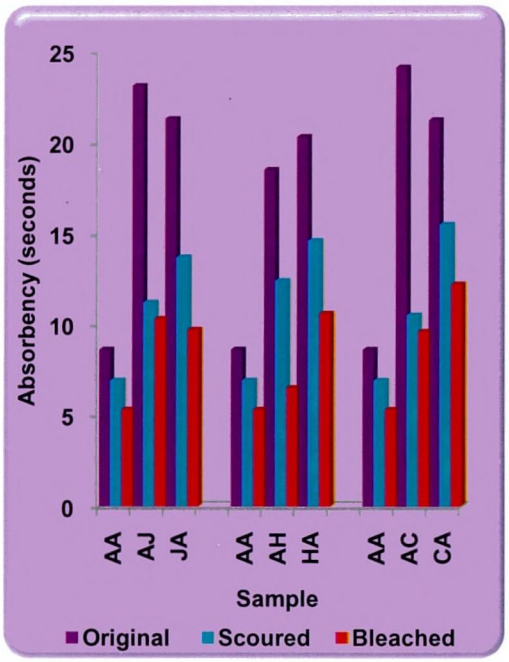


FIGURE – 10

ABSORBENCY OF WOVEN FABRICS

AA, AH and HA : Between these samples, the sample AA took the minimum time of 8.6 seconds for absorbing water. As for the scoured and bleached samples, the same trend was noted.

AA, AC and CA : Among these samples also, the sample AA required the minimum time for absorbing water in original, scoured and bleached conditions.

- **Absorbency Between Original and Treated Woven Samples**

The absorbency between original and treated woven fabric samples showed that the scouring and the bleaching treatments improved absorbency of the fabric to a very great extent.

Hence it could be concluded that the rate of absorbency was the fastest in original, scoured and bleached samples of AA. The maximum time reduction was observed in scoured and bleached samples of AC and AH respectively.

From the statistical data, it is clear that the differences in absorbency within original, scoured and bleached samples of the three sets of woven structures were significant at one per cent level. The differences between the original, scoured and bleached samples were also significant at one per cent level, highlighting the fact that the pretreatments have an impact on absorbency of the samples.

4.3.2.15 Analyses of Fabric Samples for Biological Degradation

The results of fabric samples analysed for biological degradation are given below.

(a) Subjective Analysis

Visual Assessment : The visual assessment of the soil buried fabric samples exhibited black spots on the surface of fabric samples which showed the development of microorganisms. All the samples showed reduction in lustre and became very soft in texture.

(b) Objective Analysis : The objective analysis on weight loss and microbial presence on the soil buried fabric samples are given below.

(i) Weight Loss : The loss in weight observed in the fabric samples is expressed in Table – XXXV.

TABLE – XXXV

WEIGHT (GSM) LOSS OF SOIL BURIED WOVEN SAMPLES

S.No.	Samples	Weight		Weight Loss (%)
		Original	Final	
1	AA	525	420	20
2	AJ	491	382	22
3	JA	577	444	23
4	AH	544	451	17
5	HA	552	463	16
6	AC	434	329	24
7	CA	649	486	25

The weight loss was observed in all the fabric samples. The maximum loss of 25 per cent was observed in sample CA. The hemp mixed samples of AH and HA showed a minimum loss in weight of 17 and 16 per cent respectively over the original samples.

(ii) Bacterial and Fungal Colonies in Control Soil Sample and Woven Fabric Buried Soil Samples

The number of bacterial and fungal colonies in control soil sample and woven fabric buried soil samples are presented in Table – XXXVI.

TABLE – XXXVI

BACTERIAL AND FUNGAL COLONIES

S.No.	Samples	Bacterial Colonies									Fungal Colonies								
		10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}
1	Control	30	29	27	23	17	15	12	9	6	21	19	17	16	13	12	11	8	2
2	AA	32	30	28	25	23	20	18	14	7	23	20	19	18	16	14	13	9	4
3	AJ	31	30	29	26	20	17	15	12	7	22	20	19	18	15	13	13	9	3
4	JA	34	33	33	30	19	17	15	11	7	22	20	19	18	16	14	13	10	4
5	AH	31	30	29	27	25	18	17	10	8	22	20	18	17	15	13	12	9	3
6	HA	32	31	30	25	18	17	15	10	8	22	20	18	17	15	13	12	9	3
7	AC	34	31	29	26	20	18	14	10	9	23	21	19	19	17	15	14	10	4
8	CA	33	31	30	27	19	17	15	12	8	23	21	19	19	17	15	14	10	4

From the above Table, it is obvious that the fabric buried soil samples showed higher bacterial and fungal colonies over the control soil sample. This may be due to the degradation of the fabric samples. A decrease in bacterial and fungal colonies was noted after each dilution in all the samples (Plates – 13a and 13b).

(iii) SEM Study

The SEM images given in Plates – 13c – 13e of the *Agave americana,* jute and hemp fibres removed from the woven structures of AA, AJ and AH exhibited damage of the fibres. Fibre fracture was observed in hemp fibres.

4.3.2.16 Evaluation of Finishing of Selected Fabric Samples

A. Aqueous Liquid Repellent Finish : From the test results, it was observed that the ratings of treated fabric for aqueous liquid repellency was 8 whereas the untreated sample showed zero repellency.

B. Oil Repellent Finish : The results of cotton-*Agave americana* fabric treated for oil repellency showed a rating of 6 whereas the scoured fabric sample showed zero value. The comparison of oil repellency between treated and untreated fabric sample is expressed in Plates – 14a and 14b.

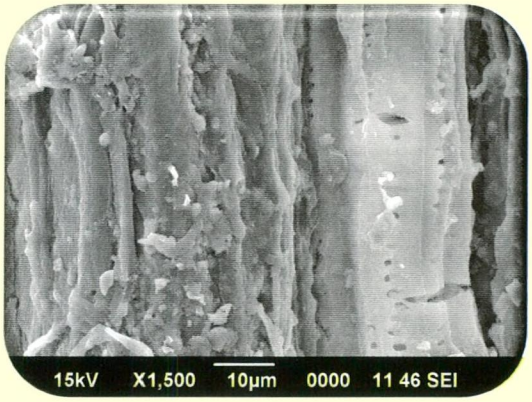
C. Water Repellent Finish : From the test results, it was observed that the ratings of treated fabric for water repellency was 100 indicating no sticking or wetting the highest rating whereas the scoured sample showed zero value indicating complete wetting of specimen face. The comparison of water repellency between treated and untreated fabric samples is expressed in Plates – 14c – 14e.

D. Flame Retardant Finish : The treated plain woven cotton-*Agave americana* fabric was reported to meet the conditions of the test standard 5867, B as in the treated fabric, after flame glow time was 'Nil' no occurrence of any flaming debris was observed and the flame did not reach the edge of the fabric. But in the case of untreated fabrics, complete burning of the sample occurred.

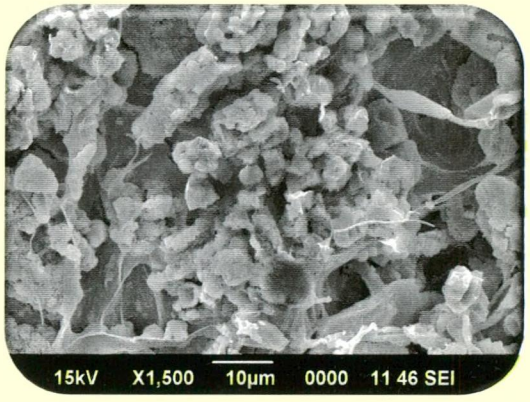
Hence it could be concluded that the cotton-*Agave americana* ribbed woven fabric lends itself for special finishes namely water, oil and aqueous liquid repellent finishes. The plain woven cotton-*Agave americana* fabric lends itself for the flame retardant finish. So the above finishes could be applied to these mixture fabrics and utilized in the field of technical textiles. The fabric swatch and results are presented in Appendices – 18a – 18c.

13a. Bacterial Colonies at 10^{-5} dilution

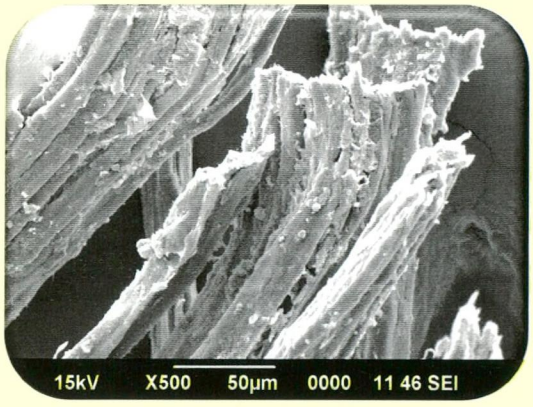
13b. Fungal Colonies at 10^{-4} dilution



13c. SEM Image of *Agave americana* Fibre from Soil Buried Woven AA Sample



13d. SEM Image of Jute Fibre from Soil Buried Woven AJ Sample



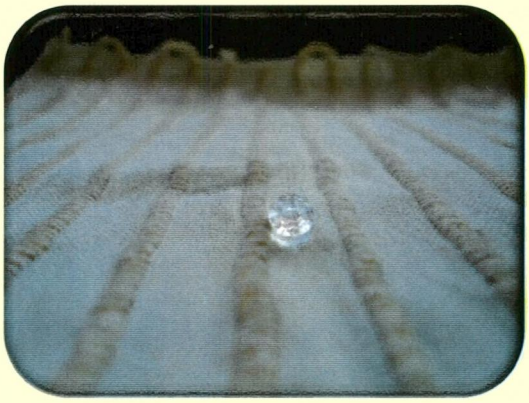
13e. SEM Image of Hemp Fibre from Soil Buried Woven AH Sample

PLATE – 13

EVALUATION OF SOIL BURIED SAMPLES

14a. Oil Drop on Treated Fabric

14b. Oil Drop on Untreated Fabric



14c. Water Drop on Treated Fabric

14d. Water Drop on Untreated Fabric

14e. Water Droplets on Treated Fabric

PLATE – 14

REPELLENCY ON TREATED AND UNTREATED CAR SAMPLES

4.4 ANALYSIS OF NEEDLE PUNCHED FABRICS

4.4.1 Bursting Strength of Needle Punched Samples

The bursting strength of needle punched fabrics samples are presented in Table – XXXVII.

TABLE – XXXVII

BURSTING STRENGTH (kg/sq.cm) OF NEEDLE PUNCHED SAMPLES

S.No.	Samples	Bursting Strength
1	AAN	16.3
2	AJN	7.4
3	AHN	8.0

From Table – XXXVII, it is seen that the bursting strength was the maximum in sample AAN of 16.3 kg/sq.cm followed by sample AHN of 8.0 kg/sq.cm and AJN of 7.4 kg/sq.cm. Hence, it could be concluded that sample AAN had the highest bursting strength among the three samples.

4.4.2 Dynamic Perforation Cone Drop Test on Needle Punched Samples

The Table – XXXVIII reveals the dynamic perforation cone drop test on nonwoven samples.

TABLE – XXXVIII

DYNAMIC PERFORATION CONE DROP TEST OF NONWOVEN SAMPLES (mm)

S.No.	Samples	Hole Diameter
1	AAN	7.2
2	AJN	*
3	AHN	21

* No perforation took place instead damage was observed near the clamps

From the Table – XXXVIII, it is observed that sample AHN had the bigger hole diameter of 21 mm then sample AAN it was lesser of 7.2 mm. This shows that the sample AAN had the maximum strength. The perforation created in same AAN was only 7.2 mm which was lesser than the range suggested for transportation geo textiles as 18 mm to 12 mm for moderate to high (www.alyaf.com/Geotextiles %20in%20 Transportation%20applications-Meccai and Hasan, 2004).

4.4.3 Seam Strength, Strain and Seam Efficiency of Needle Punched Samples

Table – XXXIX presents the seam strength, strain and seam efficiency of needle punched samples.

TABLE – XXXIX

SEAM STRENGTH, STRAIN AND SEAM EFFICIENCY OF NEEDLE PUNCHED SAMPLES

S.No.	Samples	Load (Kg f)		Tensile strain load (%)		Seam Efficiency (%)		ANOVA 'F' Values	
		Md	Cd	Md	Cd	Md	Cd	Md	Cd
1	AAN	51.93	20.76	52.67	20.67	719.25	198.85	31757.891**	4371.411**
2	AJN	24.63	23.09	35.33	26.67	324.93	182.96		
3	AHN	23.43	11.03	40.67	24.67	268.38	86.57		

Md – Machine Direction ; Cd – Cross Direction.

** Significant at 1 per cent level.

- **Seam Strength of Needle Punched Samples Between Machine and Cross Directions**

The seam strength of sample AAN was found to be the higher in machine direction of 51.93 Kg f than in cross direction of 20.76 Kg f.

In sample AHN also the seam strength was more in machine direction of 23.43 Kg f than in cross direction which was 11.03 Kg f. In sample AJN also the seam strength was more in machine direction of 24.63 Kg f than in cross direction which was 23.09 Kg f.

- **Seam Strength Between Fabric Samples in Each Direction**

Among different fabric combinations of needle punched samples, the maximum seam strength in machine direction was observed in sample AAN of 51.93 Kg f. As for the cross direction, the maximum seam strength was noted in sample AJN with 23.09 Kg f.

- **Tensile Strain of Needle Punched Samples between Machine and Cross Directions**

The tensile strain was observed to be higher in all samples of AAN, AJN and AHN in machine direction than in the cross direction.

- **Tensile Strain Between the Fabric Samples in Each Direction**

The tensile strain in machine direction was observed to be the maximum in sample AAN of 52.67 per cent among the three samples. As far as the cross direction is concerned, the maximum strength was noted in sample AJN of 26.67 per cent.

- **Seam Efficiency of Needle Punched Samples between Machine and Cross Directions**

The seam efficiency was noted to be higher in all the needle punched fabric samples in machine direction than in cross direction.

- **Seam Efficiency Between the Fabric Samples in Each Direction**

In machine direction, the maximum seam efficiency was noted in sample AAN with 719.25 per cent among all the three samples. In cross direction also the same trend was observed with maximum efficiency in sample AAN with 198.85 per cent.

Analysis of Variance Between Needle Punched Fabric Samples

The statistical data proved that the differences in the needle punched samples were significant at one per cent level in both machine and cross directions.

4.4.4 Fabric Weight and Thickness of Needle Punched Samples

The weight and thickness of needle punched samples are given in Table – XL.

TABLE – XL

FABRIC WEIGHT AND THICKNESS OF NEEDLE PUNCHED SAMPLES

S.No.	Samples	Weight (GSM)	Thickness (mm)
1	AAN	1090.2	4.49
2	AJN	774.4	3.52
3	AHN	783.2	3.74
ANOVA 'F' Values			
4	AJN / AAN / AHN	4773.330**	563.843**

** Significant at 1 per cent level.

From Table – XL, it is clear that the weight was maximum in sample AAN of 1090.2 gms per square meter among the three samples. The thickness too was the maximum in sample AAN of 4.49 mm of all the three samples.

Fabric weight increases with increase in thickness, due to the increase in number of fibres, say Debnath and Madhusoothanan (2010). The above findings prove the same.

Wallenberger and Weston (2004) inform that, fabrics generally increased in strength with an increase in basis weight. Tables – XXXVII and XL prove this. Hence, it could be concluded that sample AAN had the maximum weight and thickness of the three samples.

Analysis of variance done between needle punched samples proved that the differences were significant at one per cent level in both the cases namely weight and thickness.

4.4.5 Stiffness of Needle Punched Fabric Samples in Machine and Cross Directions

The Table – XLI presents the stiffness of needle punched fabric samples in machine and cross directions.

TABLE – XLI

STIFFNESS OF NEEDLE PUNCHED FABRIC SAMPLES IN MACHINE AND CROSS DIRECTIONS (cm)

S.No.	Samples	Stiffness	
		Machine Direction	Cross Direction
1	AAN	8.9	9.4
2	AJN	6.9	6.8
3	AHN	7.0	7.4
ANOVA 'F' values			
	AJN / AAN / AHN	927.449**	742.077**

** Significant at 1 per cent level.

- **Stiffness of Needle Punched Samples between machine and Cross Directions**

In the comparison made between the machine and cross directions of the needle punched fabric samples, it is observed that among all the three samples, AAN and AHN showed higher stiffness in cross direction than machine direction.

- **Stiffness Among Needle Punched Samples in Each Direction**

The stiffness in machine direction was the maximum in sample AAN of 8.9 cm of all the samples. In cross direction also the stiffness was the maximum in sample AAN of 9.4 cm.

Analysis of Variance Between the Nonwoven Samples for Stiffness

Analysis of variance proved that the differences between the samples AAN, AJN and AHN are significant at one per cent level both in machine and cross directions.

4.4.6 Water Absorbency and Retention Capacity of Needle Punched Samples

Findings of water absorbency and retention capacity of needle punched fabric samples are presented in Table – XLII.

TABLE – XLII

WATER ABSORBENCY AND RETENTION CAPACITY

IN NEEDLE PUNCHED SAMPLES

S.No.	Test	Samples			ANOVA 'F' values
		AAN	AJN	AHN	AAN / AJN / AHN
1	Wickability (cm)	1.8	1.0	1.3	13822.573 **
2	Sinking (seconds)	4	6	5	1233.552 **
3	Absorbency (seconds)	5	15	8	11602.29 **
4	Water retention capacity (grams)	5.10	5.01	5.5	108.503 **

** Significant at 1 per cent level.

From the Table – XLII, it is clear that the wickability of the needle punched fabric samples showed the highest rise in sample AAN of 1.8 centimetres of all needle punched samples. Sinking test also showed the maximum absorbency in sample AAN which took minimum time of 4 seconds among all needle punched structures. Absorbency showed the least time of 5 seconds for the absorption to penetrate into the sample AAN among other samples. The water retention capacity showed that sample AAN had the maximum water retaining capacity of 5.10 grams over other samples.

Hence it could be concluded that the needle punched sample with cent per cent *Agave americana* fibres showed the highest absorbency characteristics over the other samples.

The analysis of variance between the nonwoven structures showed a significance at one per cent level in all the properties namely wickability, sinking, water retention and absorbency too.

4.4.7 Air Permeability in Needle Punched Samples

The Table – XLIII shows the findings of air permeability in needle punched samples.

TABLE – XLIII

AIR PERMEABILITY (cc/cm sq/sec) IN NEEDLE PUNCHED SAMPLES

S.No.	Samples	Air Permeability	ANOVA 'F' values
1	AAN	107	1566.328**
2	AJN	158	
3	AHN	130	

** Significant at 1 per cent level.

The Table – XLIII, reveals that the air permeability was the maximum in sample AJN with 158 cc/cm sq/sec followed by samples AHN and AAN with 130 cc/cm sq/sec and 107 cc/cm sq/sec respectively.

Air permeability decrease with increase in fabric weight, stress Debnath and Madhusoothanan (2010). Their finding is proved in this study from the Tables – XL and XLIII as the air permeability of fabric had decreased with increase in weight.

ANOVA 'F' value for samples AAN, AHN and AJN showed a significance at one per cent level.

4.4.8 Moisture Regain in Needle Punched Samples

The moisture regain in needle punched samples are presented in Table – XLIV.

TABLE – XLIV

MOISTURE REGAIN (%) IN NEEDLE PUNCHED SAMPLES

S.No.	Samples	Moisture Regain	ANOVA 'F' values
1	AAN	6.31	7.9421*
2	AJN	6.11	
3	AHN	6.21	

* Significant at 5 per cent level.

From Table – XLIV, it is obvious that the sample AAN had the highest moisture regain of 6.31 per cent followed by samples AHN and AJN of 6.21 per cent and 6.11 per cent respectively. Statistical Analysis proved that the difference between samples AAN, AHN and AJN is significant at five per cent level.

4.4.9 Thermal Conductivity of Needle Punched Samples

Table – XLV shows the thermal conductivity of needle punched samples.

TABLE – XLV

THERMAL CONDUCTIVITY (w/m/k) OF NEEDLE PUNCHED FABRIC SAMPLES

S.No.	Sample	Thermal Conductivity
1	AAN	0.280
2	AJN	0.038
3	AHN	0.032

Thermal conductivity was the lowest in sample AAN with 0.28 w/m/k over other samples.

4.4.10 Soil Burial Test

The weight loss of the samples are presented in the Table – XLVI.

TABLE – XLVI

WEIGHT (GSM) LOSS OF SOIL BURIED NONWOVEN FABRIC SAMPLES

S.No.	Samples	Weight		Weight Loss (%)
		Original	Final	
1	AAN	774.4	595.8	23
2	AJN	1090.2	834	23.5
3	AHN	783.2	634.3	19

As per the Table – XLVI, the nonwoven samples namely AJN, AAN and AHN showed a weight loss of 23.5 per cent, 23 per cent and 19 per cent respectively over the original samples. This reduction in weight may be due to the presence of bacteria and fungi in the soil which might have affected the fabrics by degrading them as said by Kim et al. (2005) that major deterioration of cellulose and lingo cellulosic materials is caused by microorganisms.

4.4.11 Bacterial and Fungal Colonies in Control Soil Sample and Nonwoven Fabric Buried Soil Samples

The number of bacterial and fungal colonies in control soil sample and nonwoven fabric buried soil samples presented in Table – XLVII.

TABLE – XLVII

BACTERIAL AND FUNGAL COLONIES

S.No.	Samples	Bacterial Colonies									Fungal Colonies								
		10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}	10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}	10^{-7}	10^{-8}	10^{-9}
1	Control	30	29	27	23	17	15	12	9	6	21	19	17	16	13	12	11	8	2
2	AAN	33	30	28	26	24	21	18	15	8	24	21	20	19	15	14	13	10	3
3	AJN	34	30	28	24	21	20	17	13	7	23	21	19	17	15	14	13	10	4
4	AHN	32	31	29	28	26	25	18	11	7	22	20	19	18	16	14	12	9	3

From the Table – XLVII, it is obvious that the fabric buried soil samples showed higher bacterial and fungal colonies than control soil sample. This may be due to the degradation of the fabric samples. On serial dilution, a reduction in bacterial and fungal colonies was noted.

4.5 EVALUATION OF RIBBED WOVEN FABRICS AS CLOTH TEX

The ribbed woven samples were evaluated subjectively and objectively.

4.5.1 Visual Evaluation of Original, Scoured and Bleached Ribbed Woven Samples

The results obtained by visual evaluation of the samples are presented in Table – XLVIII.

TABLE – XLVIII

VISUAL EVALUATION OF ORIGINAL, SCOURED AND BLEACHED RIBBED WOVEN SAMPLES

S.No.	Samples	Aspects in Percentage											
		General appearance			Colour			Lustre			Texture		
		Good	Fair	Poor	Bright	Medium	Dull	Good	Fair	Poor	Soft	Coarse	Very coarse
1	CAR	85	15	-	62	38	-	75	25	-	87	13	-
2	CARS	95	5	-	90	10	-	94	6	-	95	5	-
3	CARSB	100	-	-	100	-	-	98	2	-	97	3	-

Table – XLVIII, reveals that cent per cent of the judges rated sample CARSB to have good general appearance followed by samples CARS and CAR of 95 per cent and 85 per cent respectively.

As far as colour is concerned cent per cent of the judges rated sample CARSB to have bright colour followed by samples CARS and CAR of 90 per cent and 62 per cent of the judges respectively. In the case of lustre, the maximum number of 98 per cent of judges rated sample CARSB to have good lustre followed by sample CARS of 94 per cent. Of all the samples, sample CARSB was rated to have soft texture by maximum of 97 per cent of judges.

Hence it could be concluded that sample CARSB had acquired good appearance, bright colour, good lustre and soft texture after the bleaching treatment.

4.5.2 Subjective Evaluation of Dyed, Fragrant Finished And Wear Studied Samples

The Table – XLIX shows the results obtained from the subjective analysis of the ribbed woven lac dyed, fragrant finished and wear studied fabric samples to evenness in dye, brilliancy of colour, texture, lustre, general appearance and fragrance.

TABLE – XLIX

SUBJECTIVE EVALUATION OF DYED, FRAGRANT FINISHED AND WEAR STUDIED SAMPLES

S.No.	Sample	Aspects in Percentage															
		Evenness in dye		Brilliancy of colour			Texture			Lustre			General Appearance			Fragrance		
		Even	Uneven	Very bright	Bright	Dull	Smooth	Medium	Rough	High	Medium	Low	Good	Fair	Poor	High	Medium	Low
1.	CARSBBL	100	-	20	80	-	100	-	-	100	-	-	100	-	-	-	-	-
2.	CARSBBLF	100	-	20	80	-	100	-	-	98	2	-	97	3	-	100	-	-
3.	CARSBBLFW	80	20	-	80	20	100	-	-	-	90	10	85	15	-	98	2	-

From the Table – XLIX, it is understood that about cent per cent judges rated the samples CARSBBL and CARSBBLF to have dye evenness. This was slightly reduced in the washed sample CARSBBLFW as 80 per cent. As for the brilliancy of colour all the three samples were rated as bright by 80 per cent of the judges, but only 20 per cent rated samples CARSBBL and CARSBBLF as very bright. After wear and washes, the samples were found to lose their brightness as 20 per cent of the judges rated the sample as dull. Cent per cent of the judges rated all the samples as smooth in texture. Lustre of the fabric sample CARSBBL was rated as high by cent per cent of judges whereas the sample CARSBBLF was rated as high in lustre by 98 per cent of judges. As for wear studied sample CARSBBLFW was rated as medium in lustre by 90 per cent of judges. The general appearance was rated as good by the maximum number of judges namely 100, 97 and 85 judges for samples CARSBBL, CARSBBLF and CARSBBLFW respectively. As far as the fragrance was concerned cent per cent judges rated the sample CARSBBLF to have high fragrance. On wear and subsequent washing, it was found to have slightly reduced in sample CARSBBLFW as only 98 per cent of judges rated it to have high fragrance.

4.5.3 Wear Study Evaluation of the Over Coat

The feedbacks obtained on evaluation of over coat during wear study are given in Table – L.

TABLE – L

WEAR STUDY EVALUATION OF THE OVER COAT

S.No.	Wash details	Feedbacks (%)											
		Comfort			Stiffness			Warmth			Fragrance		
		H	M	L	H	M	L	H	M	L	H	M	L
1	Before wash	97	3	-	1	95	4	98	2	-	100	-	-
2	After 1st Wash	97	3	-	-	85	5	98	2	-	100	-	-
3	After 2nd Wash	98	2	-	-	80	20	98	2	-	100	-	-
4	After 3rd Wash	98	2	-	-	77	23	98	2	-	98	2	-
5	After 4th Wash	99	1	-	-	75	25	97	3	-	98	2	-
6	After 5th Wash	99	1	-	-	70	30	97	3	-	97	3	-
7	After 6th Wash	100	-	-	-	62	38	97	3	-	97	3	-
8	After 7th Wash	100	-	-	-	56	44	90	10	-	97	3	-
9	After 8th Wash	100	-	-	-	40	60	90	10	-	35	65	-
10	After 9th Wash	100	-	-	-	40	60	-	100	-	30	70	-
11	After 10th Wash	100	-	-	-	40	60	-	100	-	25	75	-

H- High, M – Moderate, L- Low

Garment Comfort

About 97 per cent of subjects expressed that garment was highly comfortable to wear during the 1st and 2nd wears. After the 2nd and 3rd wash 98 per cent of subjects reported that the garment had high comfort quality. This gradually increased and after 6th wash cent per cent of subjects expressed the high comfort quality of the garment which persisted till the final wash.

Garment Stiffness

Stiffness was felt to be moderate in the garment by 95 per cent of subjects before wash which gradually decreased to 40 per cent after 1st wash. Stiffness was reduced gradually and after 9th and 10th washes, the garment was judged to have lower stiffness by 60 per cent of the subjects.

Garment Warmth

As for the warmth of the garment it was stated by 98 per cent of the subjects that after three washes that the garment was high in warmth. This was reduced gradually after 9th and 10th washes as cent per cent of subjects expressed moderate warmthness in the garment.

Garment Fragrance

Fragrance was found to be very high in the garments as per the expression of cent per cent of subjects which gradually decreased and after 8th and 9th washes, 35 per cent and 30 per cent of subjects expressed that the garment was high in fragrance. After 10 washes, fragrance was felt to be moderate by 75 per cent of subjects. Fragrant finish is not permanent to washing or chemical cleaning but regeneration by user is possible, express Schindler and Hauser (2004). Thus findings also showed a diminishing fragrance in the over coat samples.

Hence it could be concluded that the over coat was comfortable after sixth wash, due to the reduction in stiffness, high warmthness in the garment persisted till 8th wash and high fragrance was felt till 7th wash.

4.5.4 Colour Fastness of Ribbed Woven Lac Dyed Samples to Perspiration, Washing, Crocking and Light

The results of ribbed woven lac dyed samples subjected to colour fastness tests namely perspiration, washing, crocking and light are given in Table – LI.

TABLE – LI

COLOUR FASTNESS OF RIBBED WOVEN LAC DYED SAMPLES BEFORE AND AFTER WEAR

S.No.	Samples	Perspiration														Washing							Crocking		Light
		Alkali							Acid																
		CC	Staining						CC	Staining						CC	Staining						Dry	Wet	C
			W	AC	P	N	A	C		W	AC	P	N	A	C		W	AC	P	N	A	C			
1	CARSBBL	3/4	4/5	4/5	4/5	4/5	4/5	4	3	4/5	4/5	4/5	4/5	4/5	4	3/4	4	4/5	4/5	4/5	4/5	4	3/4	3/4	4
2	CARSBBLFW	3	4/5	4/5	4/5	4/5	4/5	4	3	4/5	4/5	4/5	4/5	4/5	4	3/4	4	4/5	4/5	4/5	4/5	4	3	3	3

Grey Scale Ratings : For colour change (CC) : 1–Very Poor, 2–Poor, 3-Moderate, 3/4-Fair,4-Good, 4/5-Very Good, 5-Excellent
For Staining : 1-Very Poor, 2-Poor, 2/3-3 –Moderately poor, 3/4-Fair, 4-Good, 4/5-Very good, 5-Excellent
Staining on – W-Wool, AC -Acrylic, P- Polyester, N-Nylon, A- Acetate.

Alkali Perspiration

From Table – LI, it is clear that sample CARSBBL was rated as fair (3/4) as for colour change due to alkali perspiration whereas sample CARSBBLFW was rated as moderate (3).

Both the samples CARSBBL and CARSBBLFW were rated as very good as for staining on wool, acrylic, polyester, nylon and acetate, but staining on cotton was rated as good (4).

Acid Perspiration

Both the samples CARSBBL and CARSBBLFW were rated as moderate as for colour change due to acid perspiration. Both the samples CARSBBL and CARSBBLFW were rated as very good as for staining on wool, acrylic, polyester, nylon and acetate whereas staining on cotton was rated as good (4).

Washing

As per the colour change due to washing both the samples CARSBBL and CARSBBLFW showed a rating of fair (3/4). In the case of staining, both the samples showed same result with rating of good (4) to wool and cotton whereas it was rated as very good (4/5) to acrylic, polyester, nylon and acetate.

Crocking

The sample CARSBBL showed a rating of fair (3/4) to both dry and wet crocking whereas the sample CARSBBLFW showed a lesser value of 3.

Light

The sample CARSBBL showed a rating of good (4) to light and only moderate (3) in samples CARSBBLFW to light.

4.5.5 Physical and Comfort Properties of Ribbed Woven Original, Treated and Wear Studied Samples

This part of the result exhibits the changes of the ribbed woven cotton-*Agave americana* sample on various parameters by scouring, bleaching, biopolishing, dyeing, fragrant finishing and wear and subsequent washing. This is clearly given in Table – LII and Figure – 11.

TABLE – LII

PROPERTIES OF RIBBED WOVEN ORIGINAL, TREATED AND WEAR STUDIED OVERCOAT SAMPLES

S.No.	Test details		Samples												
			CAR	CARS	Loss / gain (%)	CARSB	Loss / gain (%)	CARSBB	Loss / gain (%)	CARSBBL	Loss / gain (%)	CARSBBLF	Loss / gain (%)	CARSBBLFW	Loss / gain (%)
1	Fabric Count (yarns per inch)	Warp	22	24	9.09	25	13.6	25	13.6	25	13.6	25	13.6	26	18.1
		Weft	27	29	7.4	30	11.1	30	11.1	31	14.81	30	11.1	29	7.4
2	Weight (GSM)		361	324	10.2	281	-22.1	280	-22.4	316	-12.4	316	-12.4	316	-12.4
3	Thickness (mm)		1.19	0.97	-18.4	0.95	-20.1	0.93	-21.8	1.15	-3.36	1.15	-3.36	1.14	-4.20
4	Tensile strength (Kg/cm^2)	Warp	67.3	62.6	-6.9	64	-4.90	50.0	-25.7	50.0	-25.7	50.0	-25.7	40.0	-40.5
		Weft	94	91	-3.19	93	-1.06	90	-4.25	68	-27.6	62	-34.0	50	-46.8
5	Elongation (%)	Warp	32	29	-9.37	30	-6.25	28	-12.5	21	-34.3	20	-37.5	21	-34.3
		Weft	14	12	-14.2	13	-7.14	12	-14.2	12	-14.2	14	0	12	-14.2
6	Abrasion resistance (strokes)	Warp	125	120	-4	115	-8	116	-7.2	117	-6.4	115	-8	112	-10.4
		Weft	495	400	-19.1	334	-32.5	336	-32.1	337	-31.9	337	-31.9	336	-32.1
7	Stiffness (cm)	Warp	2.2	2.2	0	2	-9.09	2	-9.09	2	-9.09	2	-9.09	1.7	-22.7
		Weft	6.77	5.3	-21.7	5	-26.1	5	-26.1	5.2	-23.1	5.3	-21.7	5	-26.1
8	Drape co-efficient (%)		76.04	74.74	-1.7	67	-11.88	64	-15.83	68	-10.57	68	-10.57	60	-21.09
9	Wicking (cm)	Warp	6.2	6.9	-11.2	7.5	-20.9	7.8	-25.8	6.2	0	6.2	0	8	-29.0
		Weft	7.4	8	-8.1	8.3	-12.16	8.6	-16.2	7.4	0	7.4	0	8.7	-17.5
10	Sinking (second)		20	17	-15	7	-65	8	-60	9	-55	10	-50	7	-65
11	Moisture regain (%)		9.5	9.15	-3.68	9	-5.26	8.9	-6.31	8.9	-6.31	8.9	-6.31	8	-15.78
12	Absorbency (second)		19	13	-31.5	10	-47.36	9	-52.6	10	-47.36	9	-52.6	2	-89.47
13	Air permeability (cc/cm sq/sec)		44	41	-6.81	40	-9.09	42	-4.5	38	-13.63	38	-13.63	40	-9.09
14.	Thermal conductivity (w/m/k)		0.060	0.063	5.00	0.065	8.3	0.067	11.66	0.036	-40.00	0.037	-38.30	0.052	-13.30

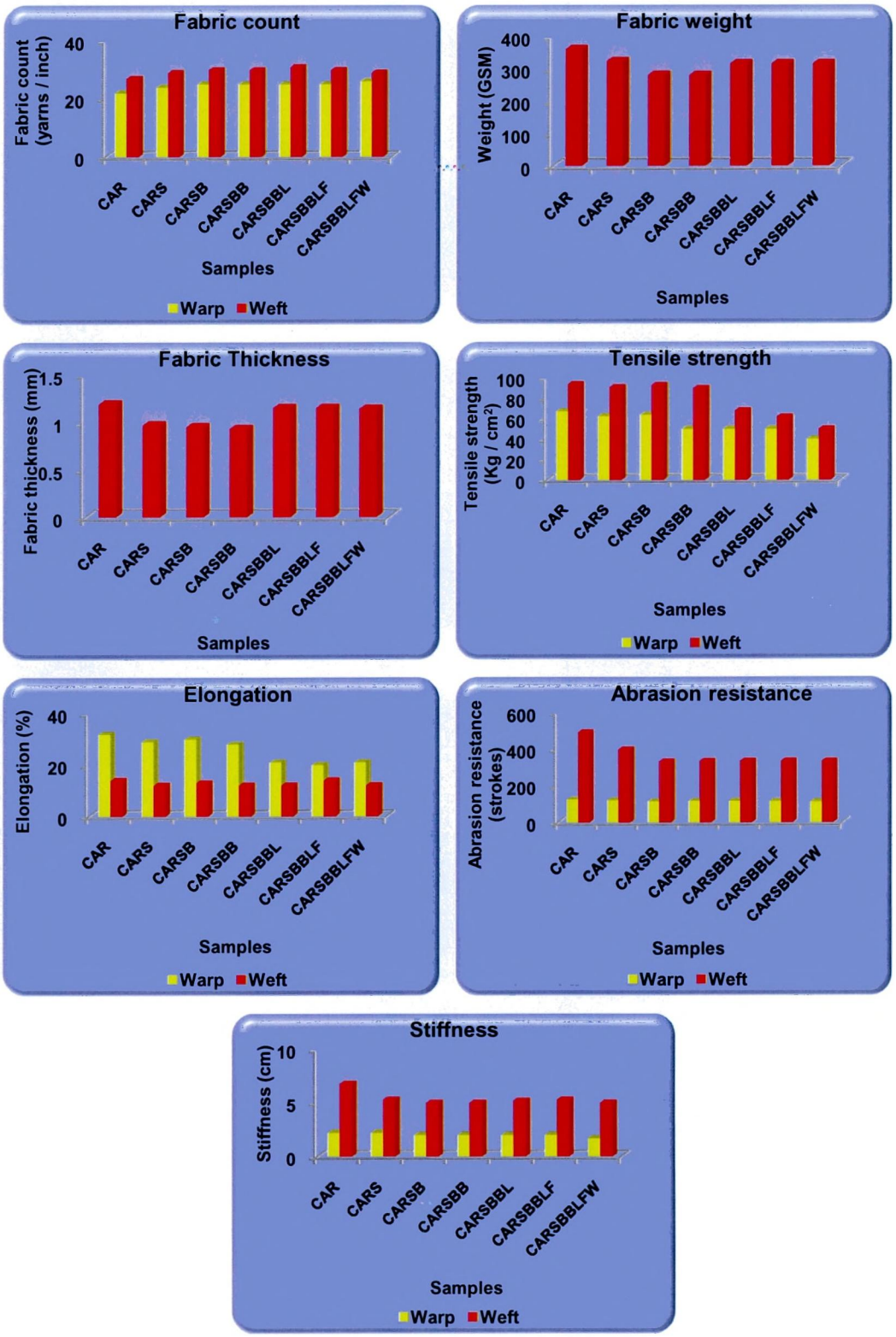


FIGURE – 11

PROPERTIES OF RIBBED WOVEN ORIGINAL, TREATED AND WEAR STUDIED OVER COAT SAMPLES

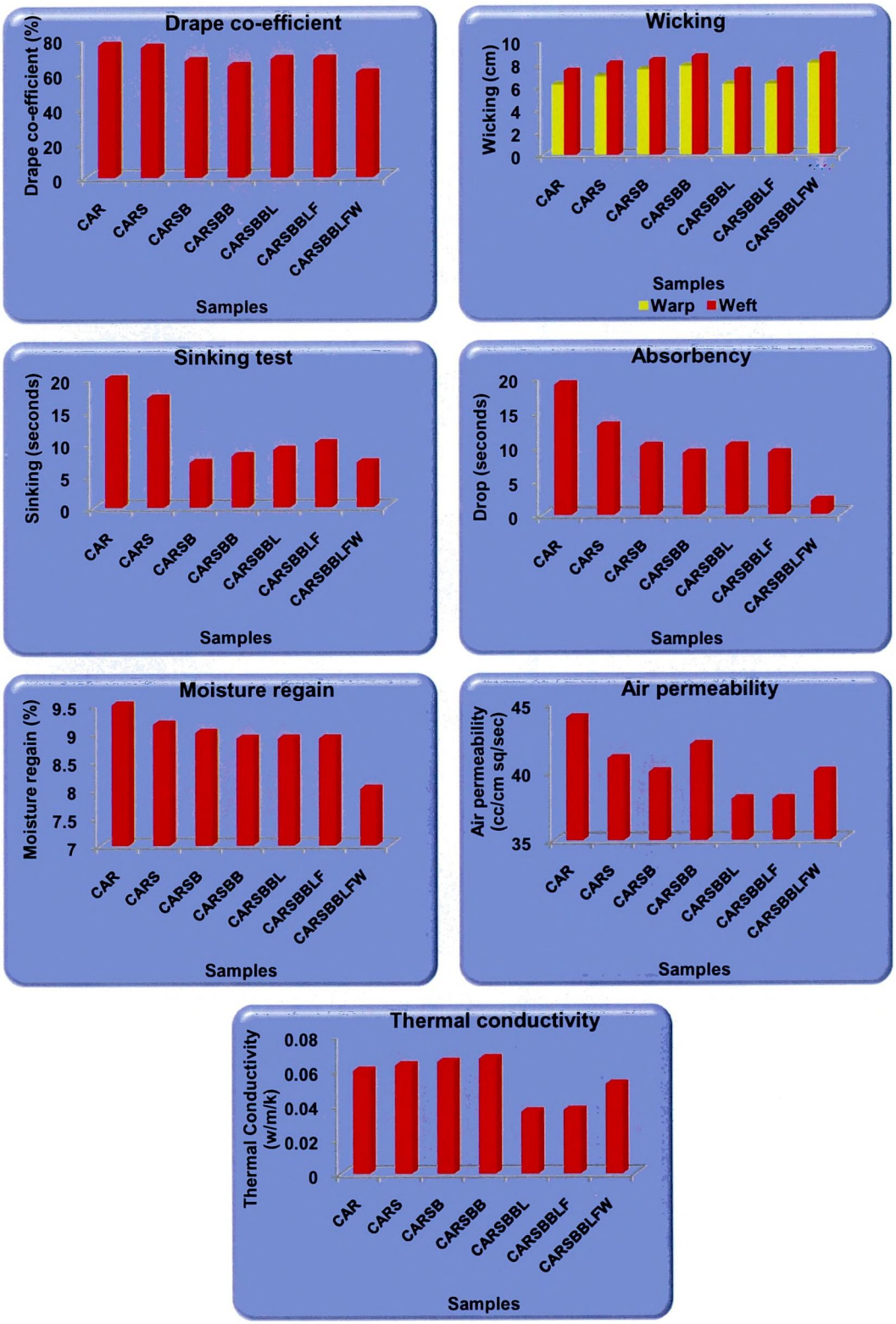


FIGURE – 11 (Contd.)

PROPERTIES OF RIBBED WOVEN ORIGINAL, TREATED AND WEAR STUDIED OVER COAT SAMPLES

Fabric Count

In warp direction, the fabric count was increased in samples CARS and CARSB samples by 9.09 per cent and 13.6 per cent over the original sample. The same count was retained in samples CARSBB, CARSBBL and CARSBBLF. The wear studied sample CARSBBLFW showed an increase of 18.1 per cent in fabric count.

Samples CARS and CARSB showed an increase in count to 7.4 per cent and 11.1 per cent respectively over original sample along the weft direction. Fabric count was increased to about 14.81 per cent in sample CARSBBL. Again a reduction in the count was observed in sample CARSBBLFW by 7.4 per cent over the original sample.

Weight

A loss in weight of 10.2 per cent was observed in sample CARS whereas in sample CARSB it was 22.1 per cent. In the case of sample CARSBB the loss in weight was the maximum of 22.4 per cent, whereas sample CARSBBL showed a loss of 12.4 per cent weight over the original sample. No weight loss was observed in sample CARSBBLFW.

Thickness

In sample CARSB there was a reduction in thickness of 20.1 per cent. A further loss in fabric thickness was observed in sample CARSBB of about 21.8 per cent. The fabric sample CARSBBL gained thickness with a minimum loss of 3.36 per cent over original sample which persisted in sample CARSBBLF also. Again a slight reduction was noted in sample CARSBBLFW of 4.20 per cent over original sample.

Tensile Strength

The tensile strength had decreased in sample CARSB of 4.9 per cent. A loss of tensile strength in samples CARSBB, CARSBBL and CARSBBLF to the extent of 25.7 per cent whereas in sample CARSBBLFW it had further reduced to 40.5 per cent over the original sample along warp direction.

In the weft direction also a loss of 1.06 per cent of tensile strength in sample CARSB over the original sample was observed. About 4.25 per cent loss was noted in sample CARSBB whereas the loss was increased to 27.6 per cent in the sample CARSBBL. Further loss of 34 per cent over original was noted in the sample

CARSBBLF. In the case of sample CARSBBLFW, loss in strength was accounted for 46.8 per cent.

Elongation

As far as the elongation, in warp direction a loss of 6.25 per cent was noted in sample CARSB. On biopolishing a reduction of 12.5 per cent was observed. Among the samples CARSBBL, CARSBBLF and CARSBBLFW a reduction of 34.3 per cent, 37.5 per cent and 34.3 per cent respectively was found.

In weft direction also a reduction of 7.14 per cent was noted in sample CARSB. A decrease of 14.2 per cent in both samples CARSBB and CARSBBL was observed whereas the sample CARSBBLF regained its original elongation and again a loss was observed in sample CARSBBLFW.

Abrasion Resistance

In warp direction, a decrease in flex abrasion resistance was noted to be 8 per cent in sample CARSB. Abrasion resistance was increased in the samples CARSBB and CARSBBL of 7.2 per cent and 6.4 per cent respectively which decreased in the sample CARSBBLF of 8 per cent. The sample CARSBBLFW showed greater reduction in abrasion resistance of 10.4 per cent.

In weft direction of sample CARSB showed a loss in abrasion resistance capacity to 32.5 per cent was observed. The same trend as in warp direction was observed with increase in abrasion resistance capacity in sample of CARSBBL. The sample CARSBBLFW showed a reduction in abrasion resistance value of 32.1 per cent.

According to ASTM Committee (2000), fabrics with highest thickness and weight possess the greatest abrasion resistance. This statement is proved in the untreated sample exhibiting highest weight, thickness and abrasion resistance.

Stiffness

A reduction in stiffness was observed in the sample CARSB of 9.09 per cent in warp direction. It was further reduced to a great extent after washing to 22.7 per cent in warp direction in sample CARSBBLFW.

In weft direction also, greater reduction in stiffness was noted in the samples CARS and CARSB samples : the samples CARSBB and CARSBBLFW showed reduction in stiffness to an extent of 26.1 per cent.

Drape Coefficient

The drape coefficient of the fabric was noted to have a good decrease after each treatment. The sample CARSB showed a decrease in drape coefficient of 11.88 per cent. About 15.83 per cent, 10.57 per cent reduction in drape coefficient values were noted in samples CARSBB and CARSBBL. If the drape coefficient is less then better is the drapability of the fabric samples. The wear studied sample exhibited the maximum drapability over the other fabric samples, as CARSBBLFW exhibited a reduction in drape coefficient of 21.09 per cent.

Wicking

In warp direction the wicking height had an increase gradually on each treatment of CARS, CARSB and CARSBB with about 11.2 per cent, 20.9 per cent and 25.8 per cent respectively. On dyeing, a decrease in wicking capacity was noted as there was no loss observed over the original sample which persisted in the fragrant finished sample also. A drastic increase in wicking was noted in sample CARSBBLFW with an increase of 29 per cent over original sample.

In weft direction also the same trend as in the warp direction was noted with an increase in wicking height of 8.1 per cent, 12.16 per cent and 16.2 per cent in samples CARS, CARSB and CARSBB, over original sample whereas the sample CARSBBLFW showed the best wicking of 17.5 per cent increase over original sample.

Sinking

Sinking time was noted to be decreased in the scoured, bleached and biopolished samples gradually whereas the dyed samples showed a slight increase in sinking time which had increased further in sample CARSBBLF. After ten washes, the fabric sample showed the best absorbency with increase in sinking time to 65 per cent in sample CARSBBLFW.

Cavaco-Paulo and Gubitz (2003), feel that the scouring removes impurities of natural fibres, yarns, fabrics and garments and improves the hydrophilicity, which is proved in the above results also.

Moisture Regain

Moisture regain had reduced in samples CARS, CARSB and CARSBB with 3.68 per cent, 5.26 per cent and 6.31 per cent respectively. This persisted in

CARSBBL and CARSBBLF samples also. It was noted to decrease further in the sample CARSBBLFW.

Absorbency

In the case of absorbency, there was a reduction in time observed in sample CARSB by 47.36 per cent. Absorbency was slightly reduced in sample CARSBB to 52.6 per cent which was regained in sample CARSBBLF. The sample CARSBBLFW showed a drastic decrease in time of absorbency due to several washes carried out in the fabric sample.

Air Permeability

The air permeability decreased in CARS and CARSB samples gradually with 6.81 per cent and 9.09 per cent respectively over original sample. An increase was observed in sample CARSBB of about 4.5 per cent which again reduced in the sample CARSBBL of 13.63 per cent over original. This persisted in the sample CARSBBLF also. In the sample CARSBBLFW again an increase was observed, though it was lesser than the original sample.

Ogulata (2006) is of the opinion that air permeability is influenced by several factors such as the type of fabric structure, the design, fabric density, the amount of twist in yarns, the size of the yarns, the type of yarn structure, and the size of the interstices in the fabric. Thus the air permeability differed after each treatment in the fabric structure due to the changes those occurred in the sample.

Thermal Conductivity

Thermal conductivity of the samples CARS, CARSB and CARSBB was increased to about 5 per cent, 8.3 per cent and 11.66 per cent respectively. The samples CARSBBL and CARSBBLF showed drastic decrease in thermal conductivity of 40 per cent and 38.3 per cent respectively. In the sample CARSBBLFW, slight increase was noted.

Hence it could be concluded that the samples CARSBBL and CARSBBLF showed highest thermal resistance.

Hence it could be concluded that washes given to the fabric have improved the fabric comfort quality though there was a loss in strength and elongation. Biopolishing also had improved the draping efficiency of the fabric thereby reducing the stiffness in the fabric. Lac dyeing of the fabric had created a hydrophobic nature in the fabric structure which was reduced on wears and subsequent washes.

4.6. EVALUATION OF WOVEN FABRICS AS HOME TEX

The results of subjective and objective analyses of ribbed woven samples are presented and discussed under.

4.6.1. Subjective Evaluation

The findings of the subjective evaluation of ribbed woven madder dyed and plain woven catechu dyed samples are given in Table – LIII.

TABLE – LIII

VISUAL ASSESSMENT RATINGS OF RIBBED WOVEN AND PLAIN WOVEN FABRIC SAMPLES BEFORE AND AFTER WEAR STUDY

S.No.	Sample	Aspects in Percentage												
		General Appearance			Brilliancy of colours			Lustre			Texture			Evenness in dye	
		Good	Fair	Poor	Very bright	Bright	Dull	High	Medium	Low	Smooth	Medium	Rough	Even	Uneven
1.	CARSBBM	100	-	-	95	5	-	90	10	-	100	-	-	100	-
2.	CARSBBMW	90	10	-	90	10	-	90	10	-	100	-	-	85	15
3.	CASBBC	100	-	-	100	-	-	100	-	-	100	-	-	100	-
4.	CASBBCW	98	2	-	100	-	-	100	-	-	100	-	-	90	10

4.6.1.1 Subjective Evaluation of Ribbed Woven Madder Dyed Original and Wear Studied Fabric Samples

From the Table – LIII, it is clear that the general appearance of sample CARSBBM was rated as good by cent per cent of judges whereas the sample CARSBBMW was rated as good only by 90 per cent of judges. As for the brilliancy of colour the maximum of 95 per cent of judges rated sample CARSBBM as very bright in colour whereas the wear studied sample CARSBBMW was rated by 90 per cent of judges as very bright in colour.

Lustre of both the samples was found to be high as rated by 90 per cent of judges. Samples of CARSBBM and CARSBBMW were rated as soft in texture by cent per cent of judges. Cent per cent judges rated sample CARSBBM to have evenness in dye whereas the wear studied sample CARSBBMW was rated to have its evenness in dyeing only by 85 per cent of judges.

4.6.1.2 Subjective Evaluation Plain Woven Catechu Dyed Original And Wear Studied Fabric Samples

General appearance was rated as good by cent per cent of judges in sample CASBBC whereas the sample CASBBCW was rated as good by 98 per cent of judges. Cent per cent of judges rated both the fabric samples CASBBC and CASBBCW as very bright in colour, smooth in texture and high in lustre. The sample CASSBC was rated as even in dye adherence by cent per cent of judges whereas the wear studied sample namely CASBBCW was rated as even in dye by 90 per cent of judges.

4.6.2 Objective Evaluation

4.6.2.1 Colour Fastness of Cotton-*Agave americana* Ribbed Woven Madder Dyed and Plain Woven Catechu Dyed Fabrics

Colour fastness of the ribbed woven madder dyed and plain woven catechu dyed samples to washing, rubbing and light are expressed in Table – LIV.

TABLE – LIV

COLOUR FASTNESS OF RIBBED AND PLAIN WOVEN DYED SAMPLES BEFORE AND AFTER WEAR

S.No.	Sample	Change in colour			
		Washing	Crocking		Light
			Dry	Wet	
1	CARSBBM	4	4	4	4
2	CARSBBMW	4	3	3	3
3	CASBBC	5	5	5	5
4	CASBBCW	4	4	4	5

Grey Scale Ratings : For colour change : 1–Very Poor, 2–Poor, 3-Moderate, 3/4-Fair, 4-Good, 4/5-Very Good, 5-Excellent.

From Table – LIV, it is clear that the samples CARSBBM showed good colour fastness rating of 4 to washing, crocking (in dry and wet conditions) and light. The washed sample CARSBBMW had good fastness rating of 4 to washing whereas it had fair rating of 3 against crocking and light. Sample CASBBC had excellent fastness rating of 5 to washing, crocking and light. After wear the sample CASBBCW showed good colour fastness rating of 5 to light. It exhibited good fastness rating of 4 to washing and crocking. Hence it could be concluded that there is a notable reduction in colour fastness of the samples CARSBBMW and CASBBCW to crocking over their respective original samples. The reduction in colour fastness to washing and light was noted in samples CASBBCW and CARSBBMW respectively.

4.6.2.2 Properties of Cotton-*Agave americana* Ribbed Woven Original, Processed and Wear Studied Runner Samples

The result of properties of cotton-*Agave americana* original, processed and wear studied runner sample is presented in Table – LV and Figure – 12.

TABLE – LV

PROPERTIES OF COTTON-*Agave americana* RIBBED WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUNNER SAMPLES

S.No.	Test details		CAR	CARS	Loss/Gain (%)	CARSB	Loss/Gain (%)	CARSBB	Loss/Gain (%)	CARSBBM	Loss/Gain (%)	CARSBBMW	Loss/Gain (%)
1	Fabric count (yarns per inch)	Warp	22	24	9.09	25	13.63	25	13.63	25	13.63	25	13.63
		Weft	27	29	7.4	30	11.1	30	11.1	30	11.1	30	11.11
2	Weight (GSM)		361	324	10.2	281	22.1	280	22.4	278	22.9	276	23.54
3	Thickness (mm)		1.19	0.97	18.4	0.95	20.1	0.93	21.8	0.98	17.6	0.95	20.16
4	Tensile strength (Kg/cm^2)	Warp	67.3	62.6	6.98	64	4.90	50.0	25.7	52	22.13	50	25.70
		Weft	94	91	3.19	93	1.06	90	4.25	92	2.12	90	4.23
5	Elongation (%)	Warp	32	29	9.37	30	6.25	28	12.5	29	9.37	30	6.25
		Weft	14	12	14.2	13	7.14	12	14.2	13	7.14	13	7.14
6	Stiffness (cm)	Warp	2.2	2.1	4.54	2	9.09	2	9.09	1.8	18.1	1.5	31.81
		Weft	6.77	5.3	21.7	5	26.1	5	26.1	4	40.9	3.5	48.30
7	Wicking(cm)	Warp	6.2	6.9	11.2	7.5	20.9	7.8	25.8	7	12.9	8.5	37.09
		Weft	7.4	8	8.1	8.3	12.16	8.6	16.2	8	8.10	8.6	16.21
8	Sinking (seconds)		20	17	15	7	65	6.5	67.5	7.5	62.5	6	70.00
9	Absorbency (seconds)		19	13	31.5	10	47.36	9	52.63	9.5	50.00	8	57.89

Fabric Count

The fabric count was increased in the sample CARS and CARSB by 9.09 per cent, 13.63 per cent which was retained in rest of the treatments also along the warp direction. The fabric count was increased in the samples CARS and CARSB by 7.4 per cent and 11.1 per cent respectively which was retained in the rest of the treatments also along the weft direction.

Weight

The weight of the fabric was reduced in samples CARS and CARSB by 10.2 per cent and 22.1 per cent respectively. Dyeing of the fabric had further reduced the weight of the sample CARSBBM by 22.9 per cent. The sample CARSBBMW showed greatest weight loss of 23.54 per cent over the original sample.

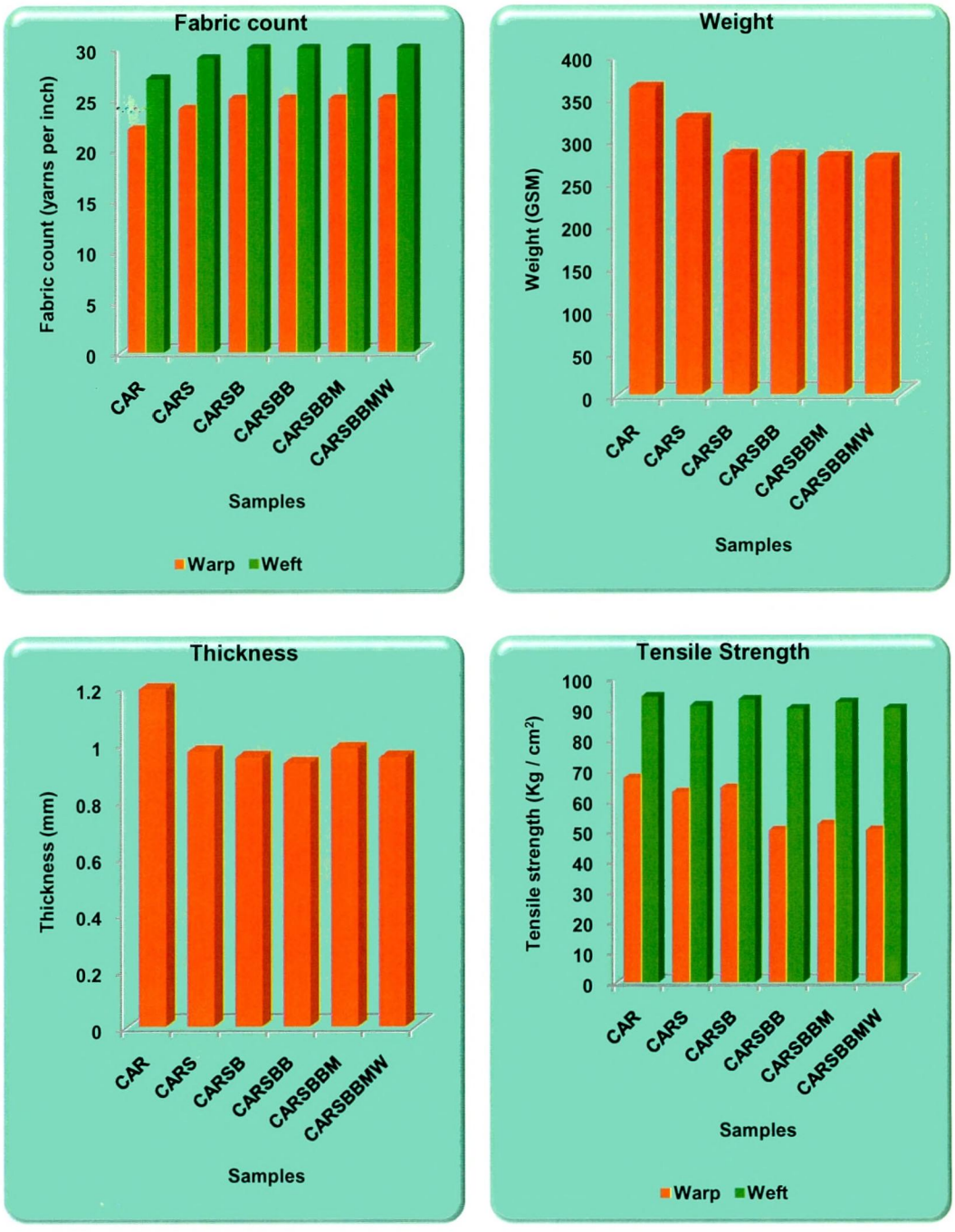


FIGURE – 12

PROPERTIES OF COTTON-*Agave americana* RIBBED WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUNNER SAMPLES

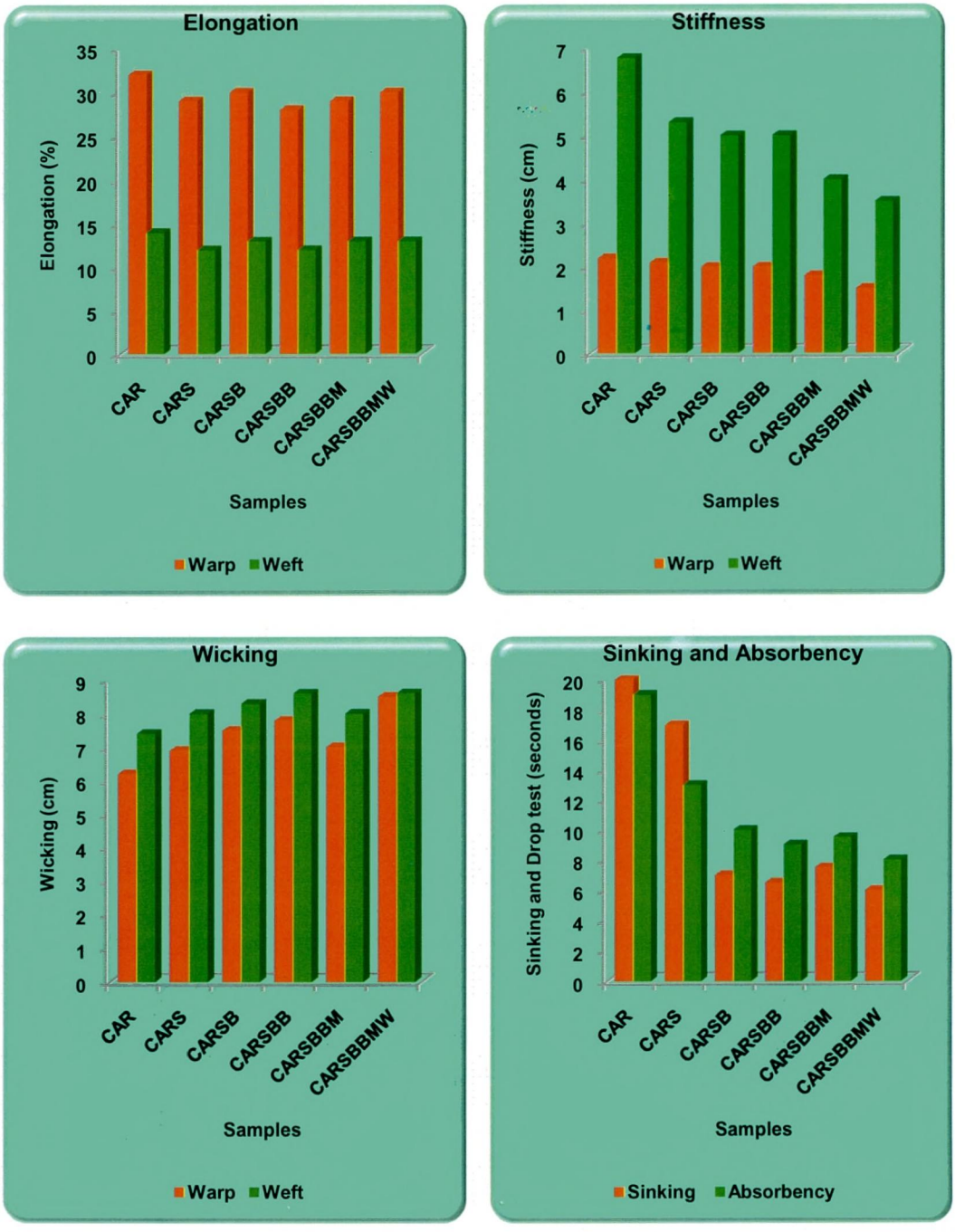


FIGURE – 12 (Contd...)

PROPERTIES OF COTTON-*Agave americana* RIBBED WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUNNER SAMPLES

Thickness

Thickness of the fabric sample was reduced gradually on CARS, CARSB and CARSBB by 18.4 per cent, 20.1 per cent and 21.8 per cent respectively. The thickness was increased slightly on dyeing as the loss was only 17.6 per cent. In sample CARSBBMW, thickness reduction was the highest of 20.16 per cent due to the wear and wash of the sample.

Tensile Strength

The tensile strength of the samples CARS and CARSB was decreased to 6.98 per cent and 4.90 per cent respectively over the original sample in warp direction. In samples CARSBB, CARSBBM and CARSBBMW the reduction in tensile strength was observed to be 25.7 per cent, 22.13 per cent and 25.70 per cent respectively. The dyed sample showed a gain in strength over biopolished sample.

Reduction in strength was 3.19 per cent in sample CARS whereas the sample CARSB showed only 1.06 per cent reduction. The samples namely CARSBB, CARSBBM and CARSBBMW showed loss in strength of 4.25 per cent, 2.12 per cent and 4.23 per cent respectively over original.

Elongation

In warp direction, the sample CARS showed a decrease in elongation of 9.37 per cent over the original whereas the sample CARSB showed a loss of only 6.25 per cent. The sample CARSBB exhibited a loss of 12.5 per cent whereas the samples CARSBBM and CARSBBMW showed loss in elongation of 9.37 per cent and 6.25 per cent respectively.

A loss in elongation was noted in the sample CARS of 14.2 per cent and sample CARSB of 7.14 per cent in weft direction. The loss further increased in the samples CARSBB and CARSBBM by 14.2 per cent and 7.14 per cent respectively which was retained in sample CARSBBMW also.

Stiffness

Sample CARS showed a reduction in stiffness of 4.54 per cent followed by sample CARSB of 9.09 per cent loss which was retained in the sample CARSBB also further loss was observed in the sample CARSBBM of 18.1 per cent which was drastically reduced in sample CARSBBMW by 31.81 per cent over original sample in warp direction.

The stiffness was reduced in sample CARS by 21.7 per cent the sample CARSB exhibited further reduction of 26.1 per cent in the weft direction. The same was retained in the sample CARSBB also. Reduction occurred further in sample CARSBBM by 40.9 per cent. The sample CARSBBMW showed the highest stiffness reduction of 48.30 per cent. This may be due to the wear and washes carried on the fabric.

Wicking

Wicking height was increased after each treatment in samples CARS, CARSB and CARSBB of 11.2 per cent, 20.9 per cent and 25.8 per cent respectively in warp direction. On dyeing a loss of absorbency was noted as the wicking height increased to only 12.9 per cent over the original sample. Sample CARSBBMW showed the highest wicking capacity of 37.09 per cent along warp direction.

In weft direction also the same trend of increase in wicking was noted in samples CARS, CARSB and CARSBB of 8.1 per cent, 12.16 per cent and 16.2 per cent respectively over the original sample. The sample CARSBBM showed a reduction in absorbency as the wicking height increased only to 8.10 per cent over the original. The sample CARSBBMW showed drastic increase in wicking height.

Sinking

Sinking time was decreased in samples CARS, CARSB and CARSBB by 15 per cent, 65 per cent and 7.5 per cent respectively over original sample. In dyed sample it was reduced further by 62.5 per cent, sinking time was drastically reduced in sample CARSBBMW by 70 per cent over original sample.

Absorbency

The time taken for the fabric to absorb water drop reduced after each treatment in sample CARS, CARSB and CARSBB to 31.5 per cent, 47.36 per cent and 52.63 per cent respectively. The sample CARSBBM showed a slight reduction of 50 per cent whereas the samples showed highest absorbency with least time for the penetration of the water droplet into the fabric showing reduction of 57.89 per cent over the original sample.

Hence it could be concluded that though there was a reduction in certain physical properties of cotton-*Agave americana* ribbed woven sample utilized as runner, an increase in the comfort qualities was observed in the fabric sample.

4.6.2.3 Properties of Cotton-*Agave americana* Plain Woven Original, Processed and Wear Studied Rug Sample

The results of processed and wear studied carpet samples for basic physical and comfort properties are presented in Table – LVI and Figure – 13.

TABLE – LVI

PHYSICAL AND COMFORT PROPERTIES OF PLAIN WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUG SAMPLE

S.No.	Test details		CA	CAS	Loss/Gain (%)	CASB	Loss/Gain (%)	CASBB	Loss/Gain (%)	CASBBC	Loss/Gain (%)	CASBBCW	Loss/Gain (%)
1	Fabric count (yarns per inch)	Warp	22	23	4.54	23	4.54	23	4.54	24	9.09	24	9.09
		Weft	16	16	0	16	0	16	0	16	0	16	0
2	Weight (GSM)		649	570	12.17	444	31.58	440	32.20	440	32.20	420	35.28
3	Thickness (mm)		1.79	1.59	11.17	1.43	20.11	1.50	16.20	1.50	16.20	1.48	17.31
4	Tensile strength (Kg/cm^2)	Warp	58.6	51	12.9	52	11.26	52	11.26	53	9.5	50	14.67
		Weft	159	149.6	5.91	154	3.14	155	2.51	155	2.51	150	5.66
5	Elongation (%)	Warp	35	30	14.28	31	11.42	32	8.57	32	8.57	30	14.28
		Weft	16	13	18.75	15	6.25	14	12.5	14	12.5	13	18.75
6	Stiffness (cm)	Warp	2.9	2.6	10.34	2	31.03	1.8	37.93	1.6	44.82	1.2	58.62
		Weft	10.04	9.7	3.38	9	10.35	8.5	15.33	8.2	18.32	7.8	22.31
7	Wicking (cm)	Warp	6	6.7	11.66	7.3	21.66	7.6	26.6	7.9	31.6	8.2	36.66
		Weft	6.8	7.4	8.82	8.2	20.58	8.5	25	8.7	27.94	9	32.35
8	Sinking (seconds)		20	17	15	7	65	6	70	5.5	72.5	5	75
9	Absorbency (seconds)		21	15	28.57	8	61.90	7.5	64.28	7	66.66	6.8	67.6

Fabric Count

The fabric count was noted to be the same in all the processed and in wear studied samples in both the warp and weft directions.

Weight

The weight of the sample gradually reduced on scouring by 12.17 per cent, bleaching by 31.58 per cent and biopolishing by 32.20 per cent over original sample. The weight loss was drastic in the sample CASBBCW by 35.28 per cent over the original sample.

Thickness

The thickness of the sample also showed the same trend as in the case of weight reduction in the fabric samples. The sample CASBBCW showed the highest weight loss of 17.31 per cent over the original sample.

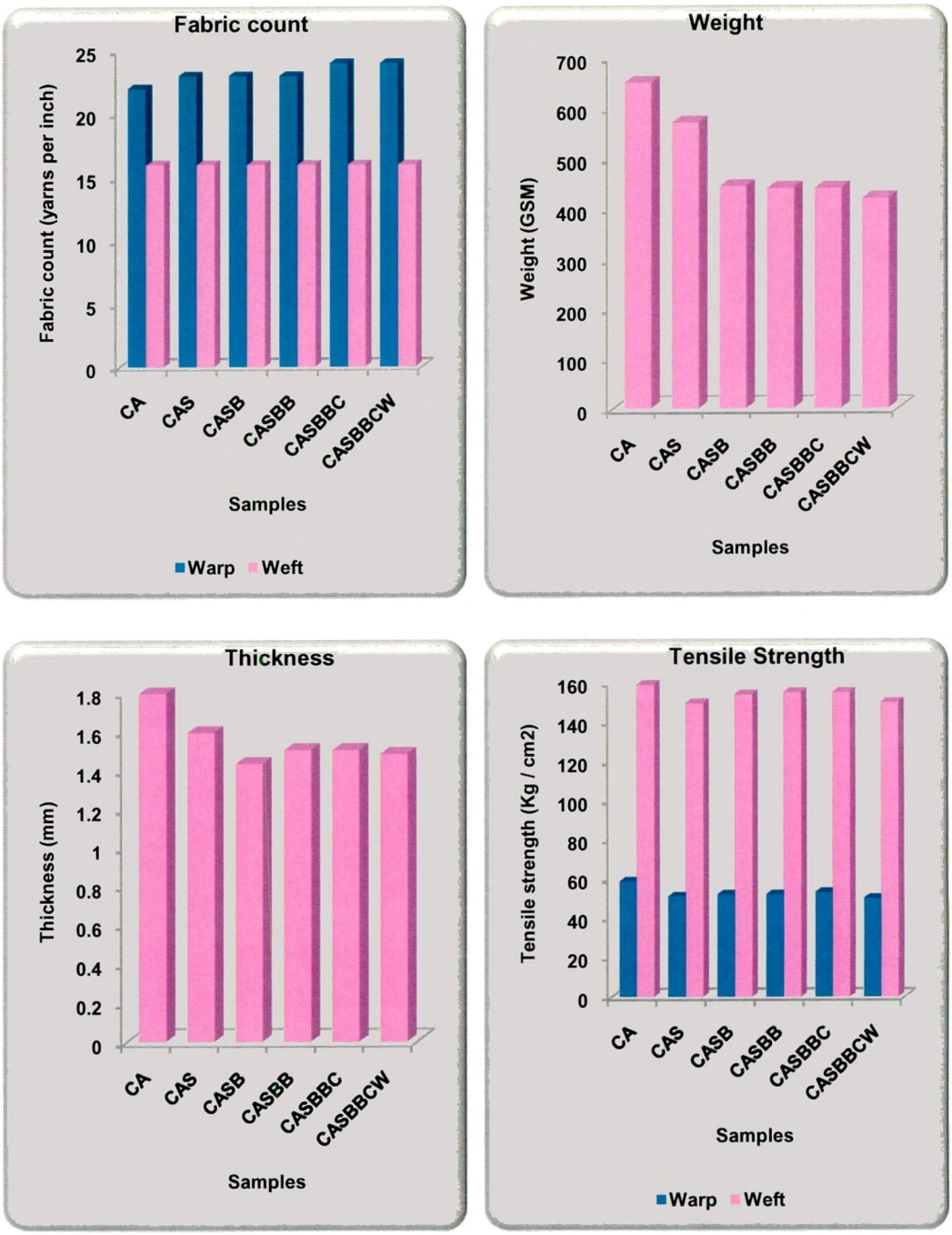


FIGURE – 13

PROPERTIES OF COTTON-*Agave americana* PLAIN WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUG SAMPLE

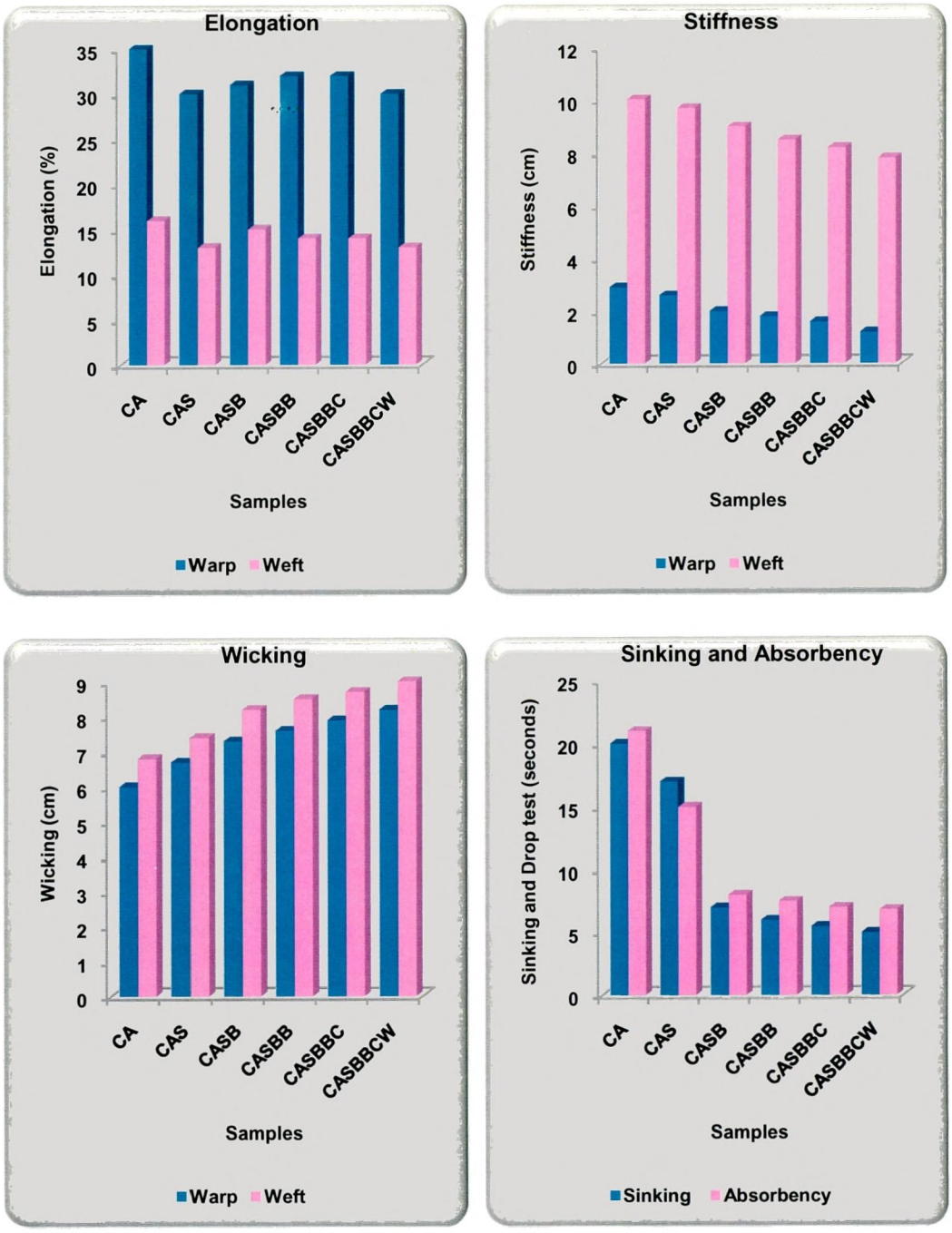


FIGURE – 13 (Contd...)

PROPERTIES OF COTTON-*Agave americana* PLAIN WOVEN ORIGINAL, PROCESSED AND WEAR STUDIED RUG SAMPLE

Tensile Strength

The sample CAS showed a loss in tensile strength of 12.9 per cent over the original sample in warp direction. The sample CASB showed a slight increase in strength over the scoured but loss over original sample was 11.26 per cent. This persisted in the sample CASBB also. The sample CASBBC showed a loss in strength of 9.5 per cent which was further reduced in the sample CASBBCW by 14.67 per cent over original.

In the weft direction also a decrease in strength in the sample CAS of 5.91 per cent over original and a slight increase in strength in the sample CASB was observed though there was a loss of 3.14 per cent over original sample. The strength was gained in the samples CASBB and CASBBC over the bleached sample though the loss was noted over the original sample as 2.51 per cent in both samples. In the sample CASBBCW 5.66 per cent loss was observed over the original sample.

Processes like scouring, bleaching, biopolishing and dyeing have reduced the strength in both warp and weft directions and the loss was higher in scoured sample than the rest. The sample CASBBCW had further reduced in strength.

Elongation

As for the elongation, there was a loss observed in the sample CAS of 14.28 per cent which slightly increased in the sample CASB which showed a loss of 11.42 per cent over the original sample in warp direction. The sample CASBB showed further reduction in elongation of 8.57 per cent which was retained in the sample CASBBC also. A drastic loss in elongation was observed in the sample CASBBCW of 14.28 per cent.

The elongation per cent decreased by 18.75 per cent which slightly increased in the sample CASB though the loss was 6.25 per cent over the original sample in the weft direction. The elongation per cent was reduced further in sample CASBB by 12.5 per cent which was retained in the sample CASBBC also. The sample CASBBCW showed further loss in elongation by 18.75 per cent over original sample.

Stiffness

Stiffness of fabric was gradually reduced after each process and in the sample CASBBCW, a reduction of 58.62 per cent over the original sample in warp direction was seen. The same trend was observed with the sample CASBBCW

showing 22.31 per cent reduction in stiffness over the original sample in weft directions.

Wicking

Wicking capacity of the fabric in warp direction increased gradually in scoured, bleached, biopolished, dyed and wear studied samples with 11.66 per cent, 21.66 per cent, 26.6 per cent, 31.6 per cent and 36.66 per cent respectively. In the weft direction also the same trend of increase in wicking capacity was noted, with wear studied sample showing 32.35 per cent over the original sample.

Sinking

Sinking time also decreased gradually by 15 per cent in CAS and 65 per cent in the CASB samples. The CASBB, CASBBC and CASBBCW samples showed a reduction of 70 per cent, 72.5 per cent and 75 per cent respectively.

Absorbency

The time required for the water to get into the fabric decreased on subsequent treatments by 28.57 per cent, 61.90 per cent, 64.28 per cent, 66.66 per cent and 67.6 per cent in samples CAS, CASB, CASBB, CASBBC and CASBBCW respectively. This may be due to the increase in absorbency of the fabric on processing.

On processing treatments namely scouring, bleaching, biopolishing and dyeing, the samples showed reduction in strength, elongation, stiffness, weight and thickness over original sample. Fabric count and absorbency characteristics of all the processed samples showed increase over the original sample. The wear studied sample too showed the same condition but to higher level.

Hence it could be concluded that though there was a reduction in certain physical properties of cotton-*Agave americana* plain woven sample utilized as rug, an increase in the comfort qualities were observed in the fabric sample.

4.7 EVALUATION OF WOVEN AND NEEDLE PUNCHED FABRICS AS MULCH SHEETS IN AGRO TEX

4.7.1 Survey Conducted Among Farmers

The results obtained from the survey conducted to elicit the awareness about natural mulch sheet among farmers are as follows.

Out of the 150 farmers surveyed, 33 per cent of them earned Rs.72,000 per annum, 33 per cent of the farmers earned Rs.36,000 per annum

whereas 20 per cent and 14 per cent of the farmers earned Rs.1,00,000 and above Rs.60,000 per annum respectively.

The crops grown in their field were noted to be vegetables, beverage crops and sugarcane. The soil type was reported to be red, black, red clay and sandy clay by 64 per cent, 20 per cent and 8 per cent each of the latter two by the farmers respectively. The irrigation method adopted by the farmers were found to be drip irrigation by 8 per cent and surface irrigation by 92 per cent of the farmers. As for fertilizer application, 56 per cent of the farmers expressed the use of natural fertilizers and 44 per cent of the farmers used chemical fertilizers for the plants.

The weed management technique adopted by 20 per cent of farmers was by weedicides, manual method by 56 per cent and both the methods were used by 24 per cent of the farmers. The common weeds growing were parthenium, grass and others as expressed by the farmers. Frequency of weeding was reported to be carried out once in 10-15 days as expressed by 68 per cent of farmers, once a month by 24 per cent and once in 3 months by 8 per cent of farmers. The problems caused by weeds were expressed as damage to the main plants by 56 per cent of farmers breeding of insects by 28 per cent of farmers and both the problems were expressed by 16 per cent of farmers. The expenditure for controlling weeds was found to be Rs.1500/acre/month and Rs.2500/acre/month by 56 per cent and 44 per cent of farmers respectively.

About 4 per cent of the farmers have heard about the mulching sheet, made of polythene, but they were not ready to use them due to the fear that these would affect the soil in future. About 4 per cent of farmers used natural materials like plantain waste, coconut tree waste and dried leaves as mulches. About 92 per cent of the farmers were not aware of the natural mulching sheets.

Hence from, survey conducted among farmers of Uzhavar Sandhai in Coimbatore, it could be concluded that the farmers were not aware of the natural mulching sheet and if some eco-friendly product was let into the market they would use them as weeds are creating major problems to the main plants.

4.7.2 Effect of Woven and Nonwoven Fabrics as Mulch Sheet on Soil Moisture Content

The effect of woven and nonwoven fabrics as mulch sheet on soil moisture content is given in Table – LVII and Figures – 14a and 14b.

TABLE – LVII

EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL MOISTURE CONTENT (%)

S.No.	Samples	Days										
		22/2	2/3	9/3	17/3	23/3	30/3	5/4	12/4	19/4	26/4	Mean
Unmulched plot												
1	Control	14.2	11.1	10.7	11	10	20	10.1	11.3	12	12	12
Woven sample mulched plot												
2	AA	14.8	13	12	11.8	10.8	22	9.7	11.8	15.5	13	13.4
3	AJ	18.7	16	11.9	11.7	17.6	20	9.4	11.6	15.3	14	14.6
4	JA	15.7	13.9	13.7	12	13.7	20	10.6	13.4	14.7	14	14
5	AH	15.9	18.8	11.9	19.4	19	22.4	15.6	16.3	16.4	15	17
6	HA	19.2	17.4	13.3	19	20.2	20.7	9.9	13.1	16.1	15.5	16
7	AC	18	10.7	17.9	11.8	10.9	20.2	9.21	11.7	14.2	14	13.8
8	CA	17	15.8	17.8	14	13	22.7	14.7	15.4	11.5	13	15.5
Nonwoven sample mulched plot												
9	AAN	17.5	17.6	11.2	11.1	10. 7	22	10.7	12	15	13	14
10	AJN	17.3	12.7	11.5	12.2	13.7	22.4	17.8	23.8	13.8	13.7	15.8
11	AHN	20.7	19	12.6	11.1	14	25	15.2	19.8	17.9	16.5	17
Weather data of the days of tests carried during the cropping period												
12	Relative humidity	31.0	17.0	23.0	22.0	17.0	43.0	25.0	33.0	48.0	42.0	30.1

From the Table – LVII, it is clear that the mean soil moisture content was found to be 12 per cent in the control plot.

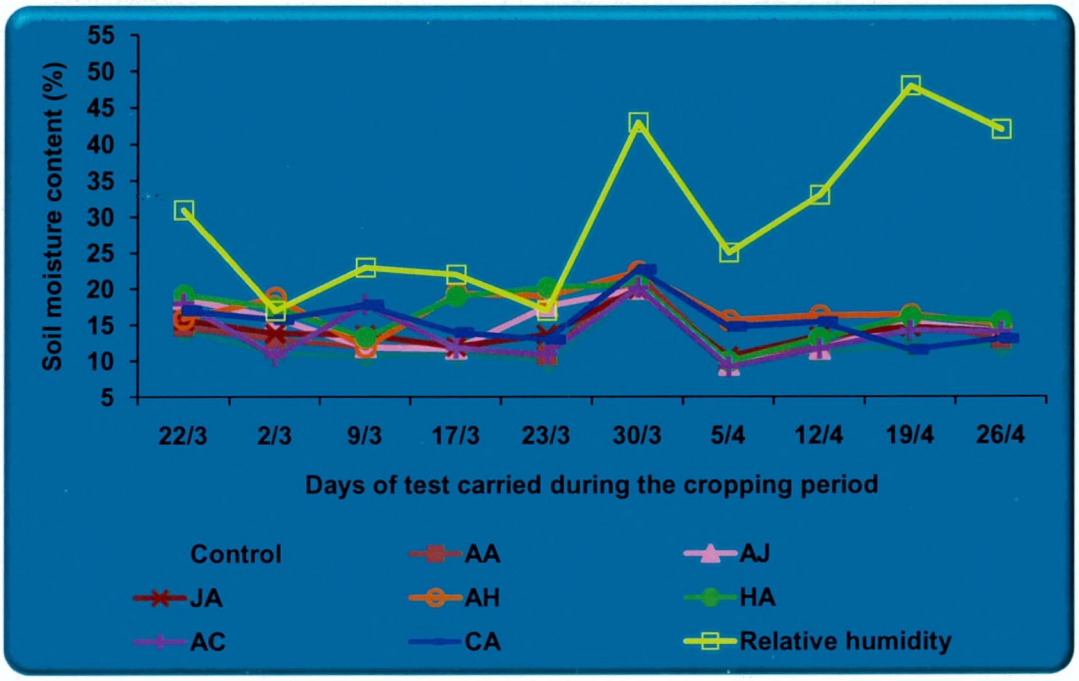
Woven Mulches

The mean soil moisture content was observed to be the maximum in sample AH mulched plot with 17 per cent. This was followed by samples HA, CA, AJ of 16 per cent, 15.5 per cent and 14.6 per cent respectively, and samples JA, AC and AA of 14 per cent, 13.8 per cent and 13.4 per cent respectively.

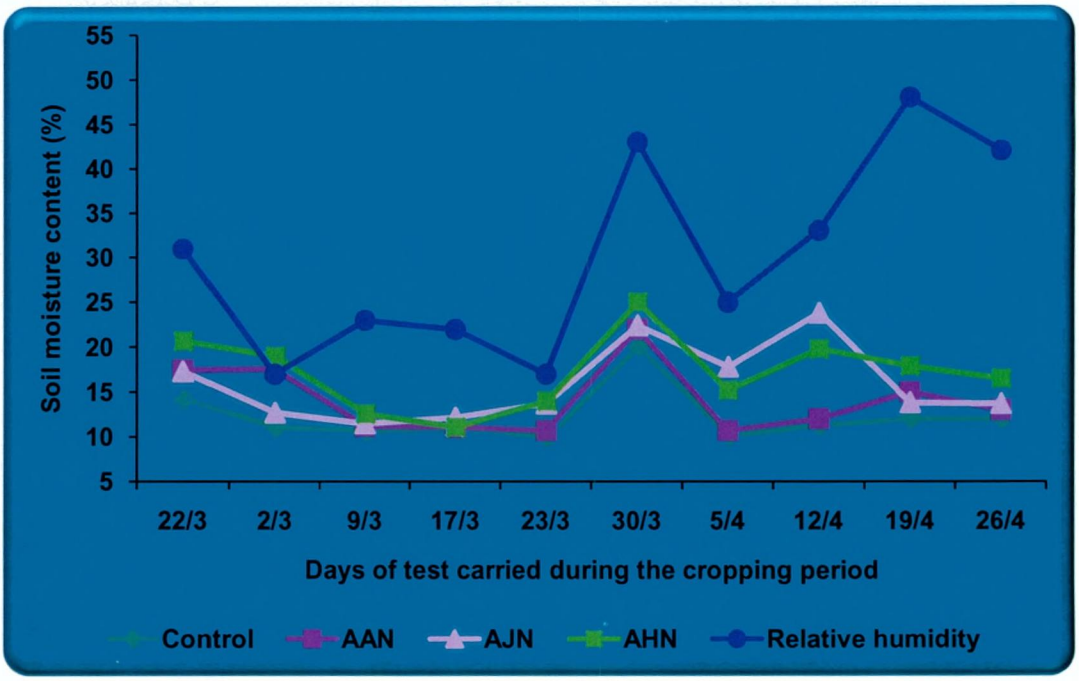
Nonwoven Mulches

The maximum mean soil moisture content was observed in sample AHN mulched plot with 17 per cent followed by samples AJN and AAN with 15.8 per cent and 14 per cent respectively.

From the mean soil moisture observations, it is clear that the soil moisture content was higher in all the mulched plots than the unmulched plot. Hence it is concluded that mulching with agro textiles, either woven or nonwoven fabrics, enhanced the moisture retention capacity of the soil favouring the crop growth.



14a. Woven Mulch Sheet



14b. Nonwoven Mulch Sheet

FIGURE – 14

EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL MOISTURE CONTENT

4.7.3 Effect of Woven and Nonwoven Agro Textiles as Mulch Sheet on Soil Temperature at 15 cm Depth

The effect of woven and nonwoven agro textiles as mulch sheet on soil temperature at 15 cm depth is given in Table – LVIII and Figures – 15a and 15b.

TABLE – LVIII

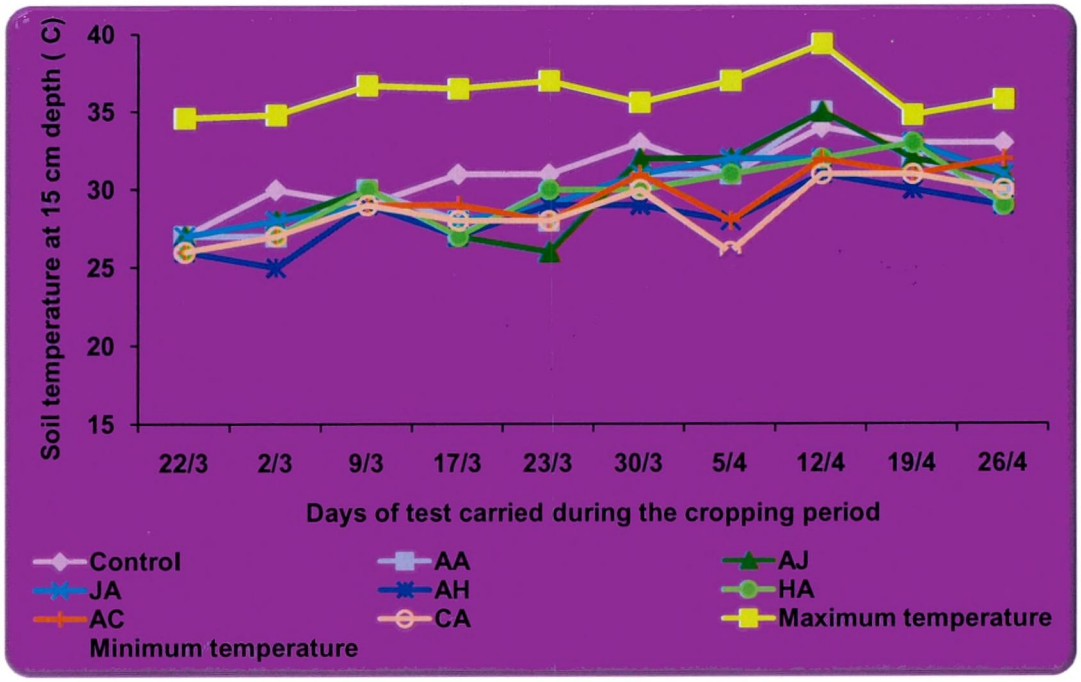
EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL TEMPERATURE AT 15 CM DEPTH (°C)

S.No.	Samples	Days										Mean
		22/2	2/3	9/3	17/3	23/3	30/3	5/4	12/4	19/4	26/4	
Unmulched plot												
1	Control	27	30	29	31	31	33	31	34	33	33	31
Woven sample mulched plot												
2	AA	27	27	30	28	28	31	31	35	32	30	29.9
3	AJ	27	28	30	27	26	32	32	35	32	31	30
4	JA	27	28	29	28	29	31	32	32	33	31	30
5	AH	26	25	29	27	29	29	28	31	30	29	28
6	HA	26	27	30	27	30	30	31	32	33	29	29.5
7	AC	26	27	29	29	28	31	28	32	31	32	29
8	CA	26	27	29	28	28	30	26	31	31	30	28.6
Nonwoven sample mulched plot												
9	AAN	26	25	27	28	27	29	29	30	32	30	28.3
10	AJN	26	25	28	31	28	30	28	29	30	31	28.6
11	AHN	25	24	26	27	27	28	27	29	31	28	27.2
Weather data of the days of tests carried during the cropping period												
12	Maximum temperature	34.6	34.8	36.7	36.5	37.0	35.6	37.0	39.4	34.8	35.8	36.22
13.	Minimum temperature	22.3	20.0	23.5	24.0	19.0	24.0	25.6	26.4	24.5	26.0	23.53

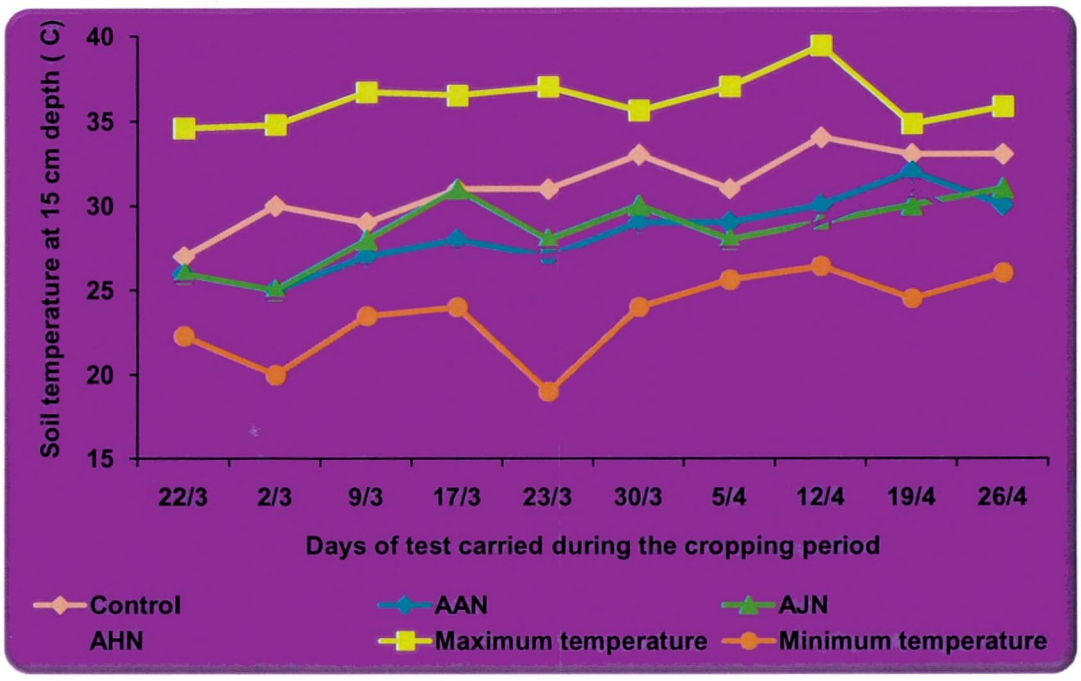
From the Table – LVIII, it is clear that the mean temperature was found to be 31°C in the ulnmulched control plot.

Woven Mulches

The temperature was the maximum in mulched plot of samples AJ and JA with mean temperature of 30°C. This was followed by the samples AA, HA, AC and CA with temperatures of 29.9°C, 29.5°C, 29°C and 28.6°C respectively. The least mean temperature (28°C) was observed in the mulched plot of sample AH favoring the plant growth. This least temperature of all AH mulched plot may be due to higher moisture content in the soil of this plot.



15a. Woven Mulch Sheet



15b. Nonwoven Mulch Sheet

FIGURE – 15

EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL TEMPERATURE AT 15 CM DEPTH

Nonwoven Mulches

The maximum temperature of 28.6°C was observed in sample AJN followed by samples AAN and AHN with 28.3°C and 27.2°C respectively.

The mulched plots show lesser soil temperature than the unmulched plots of both woven and nonwoven sample mulched plots. Hence it could be concluded that the woven and nonwoven samples of *Agave americana*-hemp (AH and AHN) showed the best suppression of temperature at 15 cm depth thereby enhancing the plant growth.

4.7.4 Effect of Woven and Nonwoven Agro Textiles as Mulch Sheet on Soil Temperature at 30 cm Depth

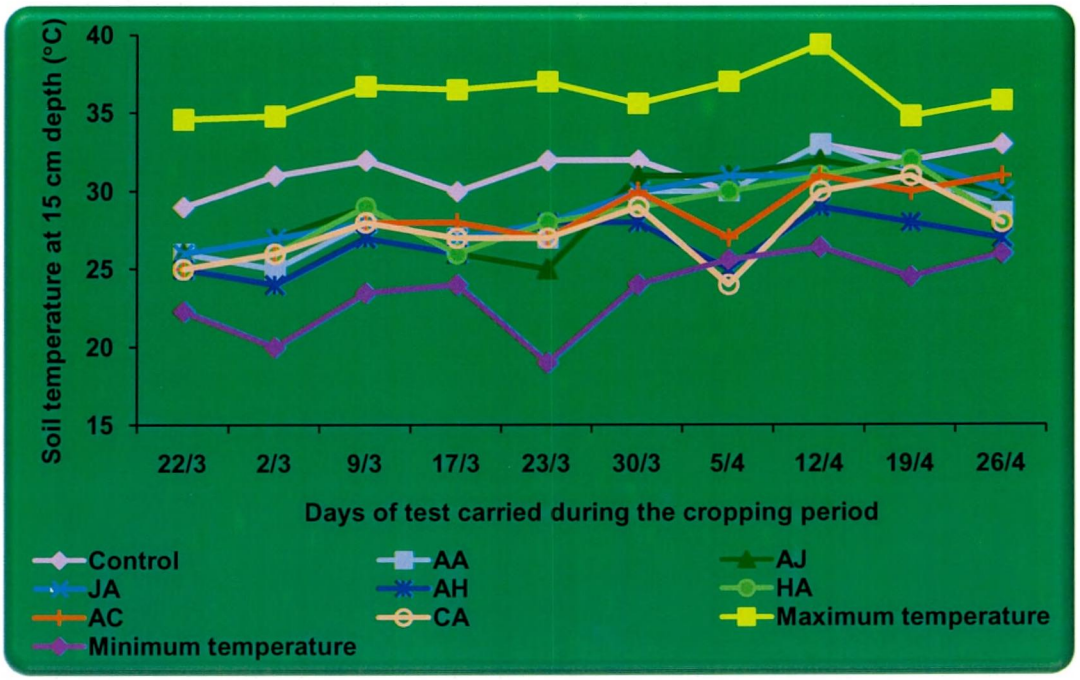
The effect of woven and nonwoven agro textiles as mulch sheet on soil temperature at 30 cm depth is presented in Table – LIX and Figures – 16a and 16b.

TABLE – LIX

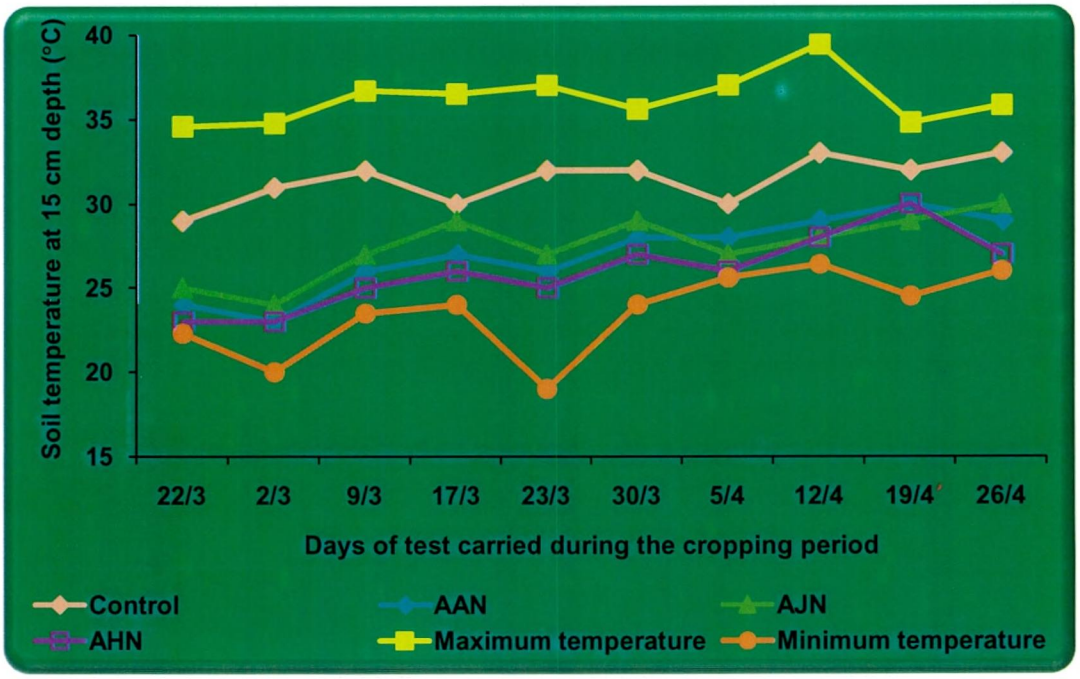
EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL TEMPERATURE AT 30 CM DEPTH (°C)

S.No.	Samples	Days										Mean
		22/2	2/3	9/3	17/3	23/3	30/3	5/4	12/4	19/4	26/4	
Unmulched plot												
1	Control	29	31	32	30	32	32	30	33	32	33	31
Woven sample mulched plot												
2	AA	26	25	28	27	27	30	30	33	31	29	28.6
3	AJ	26	27	29	26	25	31	31	32	31	30	28.8
4	JA	26	27	28	27	28	30	31	31	32	30	29
5	AH	25	24	27	26	28	28	25	29	28	27	26.8
6	HA	25	26	29	26	28	29	30	31	32	28	28
7	AC	25	26	28	28	27	30	27	31	30	31	28
8	CA	25	26	28	27	27	29	24	30	31	28	27.5
Nonwoven sample mulched plot												
9	AAN	24	23	26	27	26	28	28	29	30	29	27
10	AJN	25	24	27	29	27	29	27	28	29	30	27.5
11	AHN	23	23	25	26	25	27	26	28	30	27	26
Weather data of the days of tests carried during the cropping period												
12	Maximum temperature	34.6	34.8	36.7	36.5	37.0	35.6	37.0	39.4	34.8	35.8	36.22
13.	Minimum temperature	22.3	20.0	23.5	24.0	19.0	24.0	25.6	26.4	24.5	26.0	23.53

From the Table – LIX, it is clear that the mean temperature of the unmulched plot was observed to be 31°C.



16a. Woven Mulch Sheet



16b. Nonwoven Mulch Sheet

FIGURE – 16

EFFECT OF WOVEN AND NONWOVEN AGRO TEXTILES AS MULCH SHEET ON SOIL TEMPERATURE AT 30 CM DEPTH

Woven Mulches

From the Table – LIX, it is clear that the maximum temperature at 30 cm depth in the mulched plot was found in sample JA of 29°C followed by samples AJ and AA of 28.8°C and 28.6°C respectively. It was 28°C in both the samples HA and AC. It was minimum in the sample CA of 27.5°C.

Nonwoven Mulches

The maximum mean temperature of 27.5°C was found in sample AJN followed by samples AAN and AHN with 27°C and 26°C respectively.

Hence it could be concluded that samples of mulched plots in both woven and nonwoven structures namely AH and AHN were examined to have the minimum soil temperature of all the sample mulched plots there by reducing the heat in the soil for favorable growth of the plant.

4.7.5 Analysis of Variance of moisture Content and Temperature in Mulched and Unmulched Plots

The analysis of variance of moisture content and temperature in mulched and unmulched plots are given in Table – LX.

TABLE – LX

STATISTICAL ANALYSIS OF SOIL MOISTURE AND TEMPERATURE IN MULCHED AND UNMULCHED PLOTS

S.No.	Factors	DF	AA	MS	F	Significance
Woven sample mulched plots						
1	Soil Moisture content	7	54.001129	7.714447	725.0501	**
2	Soil Temperature (15 cm depth)	7	15.858917	2.265560	328.9947	**
3	Soil Temperature (30 cm depth)	7	44.854733	6.407819	675.057	**
Nonwoven sample mulched plots						
4	Soil Moisture content	3	41.726292	13.908764	1679.6897	**
5	Soil Temperature (15 cm depth)	3	23.062558	7.687519	592.7408	**
6	Soil Temperature (30 cm depth)	3	57.703492	19.234497	1258.7564	**
Woven and Nonwoven fabric mulched plots						
7	Soil Moisture content	3	1.584746	0.528249	45.7146	**
8	Soil Temperature (15 cm depth)	3	2.326879	0.775626	86.5528	**
9	Soil Temperature (30 cm depth)	3	2.403646	0.801215	62.0210	**

** Significant at 1 per cent level.

Woven Sample Mulched Plot

From the statistical table, it is clear that the one way ANOVA between woven sample mulched plots a significance of one per cent was noted in soil moisture content and temperature at 15 cm and 30 cm depths with a difference value of 7.

Nonwoven Sample Mulched Plots

The soil moisture content and temperature data at 15 cm and 30 cm depths of nonwoven sample mulched plots were significant at one per cent level with a difference value of 3.

Comparison Between Woven and Nonwoven Samples Mulched Plots

It is evident that two way interaction between woven and nonwoven sample mulched plots showed a significance at one per cent as for soil moisture content and temperature at 15 and 30 cm depths with a difference value of 3 between them.

4.7.6 Comparison of Weather Data During Cropping Period

Comparison of the obtained weather data with the experimental results of moisture content and temperature are expressed in Figures – 15a, 15b, 16a and 16b.

From the figures, it is evident that a vast fluctuation had occurred each day during the cropping period in relative humidity and temperature. The mean temperature of the day ranges between 23.53°C to 36.22°C which may have impact on the soil temperature. This fluctuation and the negative impacts caused due to this had been reduced due to mulch sheet laid on the soil.

4.7.7 Presence of Macro and Micro Nutrients in Mulched and Unmulched Plots Before and After Experiment

The presence of macro and micro nutrients in woven and nonwoven mulched plots over unmulched plot before and after the experiment are presented in Table – LXI.

TABLE – LXI

PRESENCE OF MACRO AND MICRO NUTRIENTS IN WOVEN AND NONWOVEN MULCHED PLOTS OVER UNMULCHED PLOT AND PRE EXPERIMENT SOIL SAMPLE

S.No.	Samples	pH	EC	Macro Nutrients (Kg/acre)			Micro Nutrients (ppm)			
				N	P	K	Fe	Mn	Zn	Cu
Unmulched										
1	Control	8.1	1.92	48	7.5	195	6.12	1.63	1.02	0.96
2	Pre experiment	8.1	1.92	36	7.0	190	5.68	1.50	1.01	0.91
Woven sample mulched										
3	AA	8.3	1.91	62	8.5	220	8.12	2.06	1.27	1.53
4	AJ	8.4	1.90	49	8.2	200	7.62	2.13	1.21	1.48
5	JA	8.3	1.92	62	8.0	200	6.98	1.76	1.58	1.08
6	AH	8.1	1.90	67	9.5	215	9.41	2.98	1.98	1.98
7	HA	8.3	1.90	70	9.4	225	9.77	2.72	1.97	1.93
8	AC	8.3	1.92	53	8.5	230	6.22	1.69	1.67	1.06
9	CA	8.3	1.91	62	8.0	220	6.24	1.77	1.59	0.96
Nonwoven sample mulched										
10	AAN	8.4	1.92	70	8.8	198	8.17	1.72	1.31	0.98
11	AJN	8.4	1.90	59	8.5	200	6.28	1.78	1.18	1.03
12	AHN	8.3	1.91	67	9.3	215	9.50	2.90	1.96	1.97

pH of Soil

The pH of the soil in both control plot and sample before experiment were 8.1 whereas in the mulched plots, pH ranged between 8.1 to 8.4.

Behera (2006) expresses that the soil pH of 7.5 – 8.4 indicates the existence of free lime and this condition is associated with excellent filtration and percolation of water due to high Ca content of clays. He further adds that both phosphorus and micro nutrients are less available in these soils.

EC of Soil

The EC of soil was noted to be 1.92 in the control plot and soil in pre experiment plot. It was reduced in samples AJ, AH, HA and AJN to 1.90. In all the mulched plots the soil showed a reduction in EC except samples JA and AAN.

Macro Nutrients

The soil sample from control plot showed N, P, K of 48, 7.5 and 195 Kg/acre. The pre experiment soil sample showed lesser amount of N, P, K. The increase in

the control plot and experiment plots may be due to the spraying of fertilizers during the cropping period.

Dreistadt and Clark (2004) are of the opinion that organic mulches have the major advantage of gradually improving soil quality as they decompose releasing minerals and organic matter thereby enriching deficient soils and replace nutrients taken up by roots as plants grow and often enhance earthworm populations.

The increase in N, P, K was noted in all the mulched plots over the unmulched plots. The maximum increase of nitrogen was observed in the plots mulched with samples HA (70 Kg/acre) and AAN (70 Kg/acre). The phosphate increased to the maximum in the mulched plots of samples AH (9.5 Kg/acre) and AHN (9.3 Kg/acre).

The maximum increase of potassium was observed in soil from plots mulched with AC (230 Kg/acre) followed by sample HA (225 Kg/acre). As for the nonwoven samples, the potassium increase was noted to be the maximum in the soil from plots mulched with sample AHN (215 Kg/acre).

Higher increase in the fabric mulched plots than the control soil sample and the pre experiment soil sample even after the absorption of the fertilizers and soil nutrient by the plants indicate the enhancement of soil nutrient by the biodegradation of the fabric samples.

Micro Nutrients

The presence of micro nutrients in the soil of pre experiment soil sample and control plot soil sample were lesser than the plots mulched with various fabric samples. The maximum amount of Fe was observed in HA and AHN mulched plots of 9.77 ppm and 9.50 ppm respectively. The Mn in soil was noted to be the maximum in plots mulched with sample AH (2.98 ppm) and AHN (2.90 ppm). The presence of Zn was the highest in plot mulched with sample AH (1.98 ppm) and AHN (1.96 ppm). The presence of Cu in soil was observed to be the maximum in soil mulched with sample AH (1.98 ppm) and AHN (1.97 ppm).

Hence it could be concluded that there was an increase in micro and macro nutrients in the soil from mulched plots over pre experiment soil and control soil samples.

Soil nutrients are higher in the mulched plots than in the unmulched plots. Crop residue mulches constitute better source of nutrients and therefore act as a fertilizer. Organic matter constitutes a key component of soil fertility, as a reservoir of nutrients, as a main source of cation exchange capacity and as a major promoter of aggregate structural stability, express Technical Centre for Agricultural and Rural Cooperation (2004). The above findings also prove this statement.

4.7.8 Weed Suppression in Woven and Nonwoven Mulched Plots Over Unmulched Plots (%)

Weed suppression in woven and nonwoven mulched plots over unmulched plots are presented in Table – LXII.

TABLE – LXII

WEED SUPPRESSION IN WOVEN AND NONWOVEN MULCHED PLOTS OVER UNMULCHED PLOT (%)

S.No.	Samples	Weed count		Weed Suppression (%)
		Mulched plot (per sq.m)	Unmulched plot (per sq.m)	
Woven				
1	AA	3	357	99.15
2	AJ	-	283	100
3	JA	-	283	100
4	AH	3	362	99.17
5	HA	-	357	100
6	AC	-	178	100
7	CA	-	362	100
Nonwoven				
8	AAN	-	259	100
9	AJN	-	315	100
10	AHN	1	495	99.79

Woven Mulches

From the Table – LXII, it is clear that there was 100 per cent weed suppression in the woven fabric mulched plots namely AJ, JA, HA, AC and CA. There was only 99.17 per cent and 99.15 per cent suppression in the woven mulched plots namely AH and AA respectively as there were average of two weeds namely *Trianthema portula castrum* L. of Aizoaceae family and Common Grass over the mulched plot.

Nonwoven Mulches

Among the nonwoven fabrics namely AJN, AHN and AAN, there was cent per cent suppression of weeds in the mulched plots over the unmulched plots. But in the sample AHN, there was only 99.79 per cent of weed suppression as there was the growth of the weed *Trianthema portula castrum* L. belonging to Aizoaceae family over the mulched plot.

From the above observations on weed growth and weed count it was found that the woven and nonwoven fabrics used as mulches, had impact on the suppression of weed growth as the number of weeds were almost zero. There was 100 per cent weed suppression in the plots with mulches. There was no competition between weeds and crop in the mulched plot creating favorable environment for main crop growth.

4.7.9 Observation of Vegetation

The biometric and yield parameters are presented in Table – LXIII.

TABLE – LXIII

OBSERVATION OF VEGETATION

S.No.	Sample	Biometric parameters (90 days)				Vegetable yield days (Average of 2 harvests)	
		Germination (%)	Root length (cm)	Shoot length (cm)	Vigour Index	Number	Length (cm)
1	Control	75	50.1	104.7	11610	10	14
Woven							
2	AA	91	54.62	104.9	14516.3	12	15.5
3	AJ	83	53.0	108.05	13367.15	12	15
4	JA	87	53.87	110.1	14265.39	10	15
5	AH	100	55.15	111.3	16645.0	13	16.5
6	HA	100	54.56	109.8	16436.00	12	15
7	AC	84	52.10	108.45	13486.20	11	14.3
8	CA	86	51.75	105.5	13523.50	11	14
Nonwoven							
9	AAN	91	52.73	105.45	14394.38	10	15
10	AJN	91	54.86	109.75	14979.51	11	15
11	AHN	100	55.01	110.00	16501.00	12	16

Vigour Index = Germination (%) x (Root length + Shoot Length)

- **Vegetation in Woven Fabric Mulched Plots**

Germination Percentage

The germination percentage of the seeds was found to be cent per cent of the seeds sown in the mulched plots of samples AH and HA of woven structures. The minimum germination percentage was observed in the plots mulched with samples AJ, JA, CA and AC of woven structures. The germination per cent was observed to be higher in all the mulched plots than the control plots.

Root Length, Shoot Length and Vigour Index

The root length was the highest in the plant grown in the plot mulched with the woven sample AH with 55.15 cm length. The shoot length also was observed to be the maximum in the plant grown in the sample AH mulched plot with 111.3 cm. As far as vigour index is concerned, it was the maximum in the same sample mulched plot of AH. All the three parameters were observed to be higher in the mulched plots of various samples than the unmulched plots.

Yield

Yield of the plants was also found to be the maximum in the mulched plots of sample AH. The yield was noted to be higher in all the mulched plots than the unmulched plots.

- **Vegetation in Nonwoven Fabric Mulched Plots**

In the case of nonwoven fabric mulched plots, also the sample AHN showed the best result of 100 per cent germination. The root length and shoot length were noted to be the maximum in the sample. AHN. In turn the vigour index was also observed to be 16501.

Hence it could be concluded that the sample AHN showed the best result in both woven and nonwoven structures in both biometric and yield parameters.

4.7.10 Visual Assessment of Woven and Nonwoven Fabric Samples After Mulching

The visual evaluation of the woven and nonwoven fabric samples after mulching, exhibited black spots on the fabric samples which showed the development of microorganisms. The fabric showed reduction in lustre and became very soft in texture.

From the visual evaluation of the original fabric samples and wear studied woven and nonwoven samples as mulching sheets in the field of agro textiles, the observations are given in Table – LXIV.

TABLE – LXIV

VISUAL EVALUATION OF WEAR STUDIED WOVEN AND NONWOVEN SAMPLES

S.No.	Samples	Aspects in Percentage														
		General Appearance			Colour			Lustre			Texture			Black Spots		
		G	F	P	B	M	D	H	M	L	CH	S	VS	Ma	L	VL
WEAR STUDIED WOVEN SAMPLES																
1	AA	5	90	5	-	14	86	-	10	90	-	18	82	3	90	7
2	AJ	3	89	8	-	5	95	-	8	92	-	14	86	5	93	2
3	JA	3	94	3	-	3	97	-	7	93	-	17	83	3	94	3
4	AH	7	88	5	-	10	90	-	10	90	-	16	84	2	2	96
5	HA	9	86	5	-	8	92	-	10	90	-	17	83	4	2	94
6	AC	-	77	23	-	2	98	-	4	96	-	6	94	94	6	-
7	CA	-	76	24	-	3	97	-	3	97	-	10	90	97	3	-
WEAR STUDIED NONWOVEN SAMPLES																
8	AAN	20	80	-	-	14	86	-	25	75	-	16	84	5	95	-
9	AJN	20	80	-	-	12	88	-	27	73	-	17	83	4	96	-
10	AHN	13	87	-	-	10	90	-	28	72	-	11	89	6	90	4

G-Good; F-Fair; P-Poor; B-Bright; M-Medium; D-Dull; H-High; M-Moderate; L-Low; CH-Coarse and Hard ; S-Soft ; VS-Very Soft; Ma-Many ; L-Little ; VL-Very Little.

From the Table – LXIV, it is clear that both woven and nonwoven fabric samples had the maximum ratings for fair general appearance over their respective original sample. The woven and nonwoven samples were found to lose their colour and lustre as the maximum number of judges rated those to be dull in colour after wear study as mulching sheet. Texture was judged to be very soft in the wear studied samples over original sample. As for the presence of black spots, in the woven samples, the maximum number of 97 and 94 per cent judges reported that the samples CA and AC respectively had many black spots on their surface, whereas 94, 93 and 90 per cent of judges expressed that the fabric samples namely JA, AJ and AA showed little black spots on the surface of the samples AH and HA showed very little black spots as per 96 and 94 per cent of judges respectively. As for the nonwoven samples, black spots were noticed to be little by maximum number of judges of 96 per cent in sample AJN.

4.7.12. SEM Appearance

The Scanning Electron Microscopic appearance showed the fibre damage that had occurred after the utilization as mulching sheet. The fibres from nonwoven fabric showed more damage than the fibres from woven structures (Plates – 15a – 15e).

4.8 EVALUATION OF WOVEN AND NONWOVEN FABRICS AS SCREENS AND SEPARATORS IN GEO TEX

The evaluation of woven and nonwoven fabrics as screens and separators in the field of geo textiles is given under the following heads.

4.8.1 Physical Parameters of Filtered Water with Various Woven Screens, Media and Proportions

The evaluation of hydraulic efficiency, pH neutralising efficiency, Electrical conductivity reducing efficiency and sediment removal efficiency of filtered water with various woven screens, media and proportions are presented in Table – LXV(a) and Figure – 17.

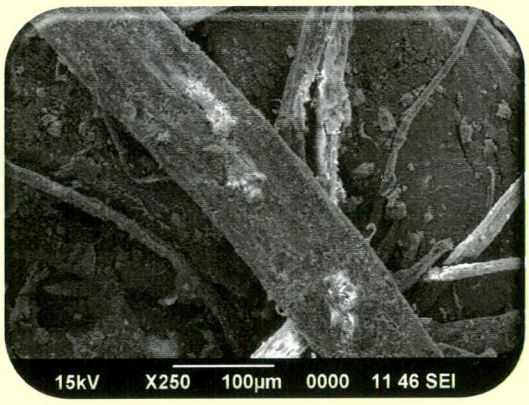
TABLE – LXV (a)

EVALUATION OF PHYSICAL PARAMETERS FOR VARIOUS WOVEN SCREENS, MEDIA AND PROPORTIONS

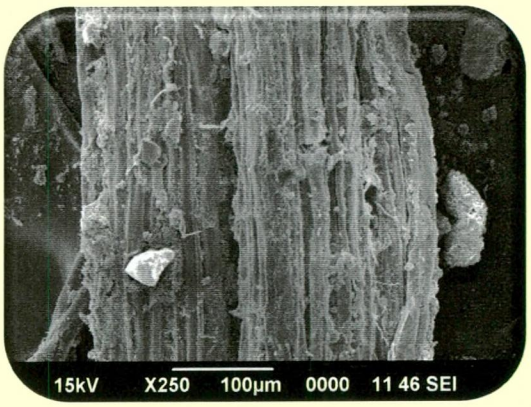
S.No.	Media	S_1 – HA				S_2 – AJ				S_3 – AA				S_4 – No Screen			
		HE	pH	SED	EC	HE	pH	SED	EC	HE	pH	SED	EC	HE	pH	SED	EC
Proportion (P_1)																	
1.	M_1	34.21	93.69	58.95	17.30	20.12	93.44	66.88	12.01	10.32	88.97	100	11.92	90.39	91.60	10.09	13.09
2.	M_2	22.63	96.47	55.34	22.01	39.02	95.33	0	12.20	52.08	90.00	43.44	22.20	10.71	91.94	100	3.71
3.	M_3	26.56	90.59	0.60	22.01	52.28	95.58	0	12.71	11.71	91.38	0	12.30	20.55	90.32	0	12.78
4.	M_4	91.22	94.41	0	20.30	10.96	93.17	66.66	11.92	18.24	92.92	66.66	9.23	23.88	87.22	100	11.43
5.	M_5	14.01	93.53	66.88	10.76	23.12	91.17	100	10.76	39.96	92.07	66.66	12.11	47.15	92.67	0	20.30
Proportion (P_2)																	
6.	M_1	91.71	96.71	0	18.46	8.04	92.60	66.88	8.73	25.36	91.76	33.33	16.92	30.61	95.48	10.33	10.85
7.	M_2	71.04	92.35	52.34	22.20	42.23	91.92	100	16.26	31.35	93.51	0	13.75	10.57	91.65	66.88	12.40
8.	M_3	58.07	94.37	74.00	19.92	58.53	94.91	0	8.54	6.60	91.08	100	12.89	12.62	90.98	66.88	14.13
9.	M_4	91.42	93.54	36.09	14.52	7.38	91.35	66.6	12.30	12.32	92.47	33.33	14.80	24.93	93.54	100	12.59
10.	M_5	7.18	92.29	66.88	12.88	25.98	91.12	100	14.42	27.46	93.15	0	18.46	31.50	58.63	0	10.47

HE – Hydraulic Efficiency, pH – pH Neutralising Efficiency, SED – Sediment Removal Efficiency, EC –Electrical Conductivity Reducting Efficiency

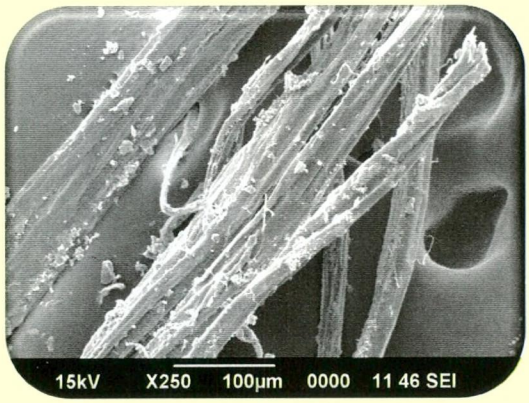
The ANOVA of hydraulic efficiency, pH neutralising efficiency, sediment removal efficiency and electrical conductivity reducing efficiency are presented in Table – LXV (b).



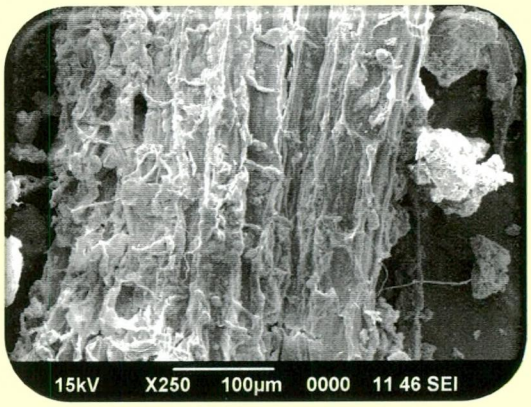
15a. Jute Fibre from AJ



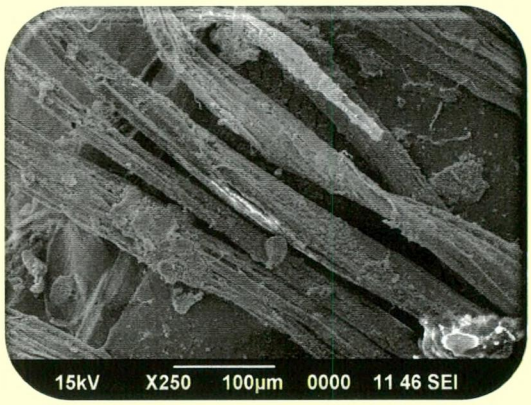
15b. *Agave americana* Fibre from AA



15c. Jute Fibre from AJN



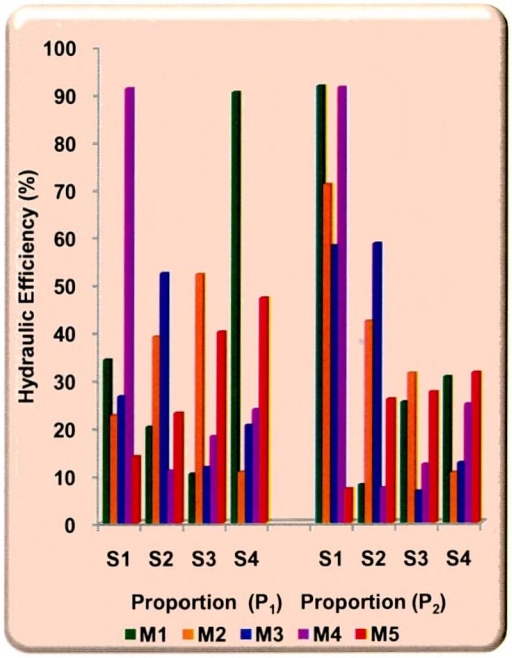
15d. *Agave americana* Fibre from AAN



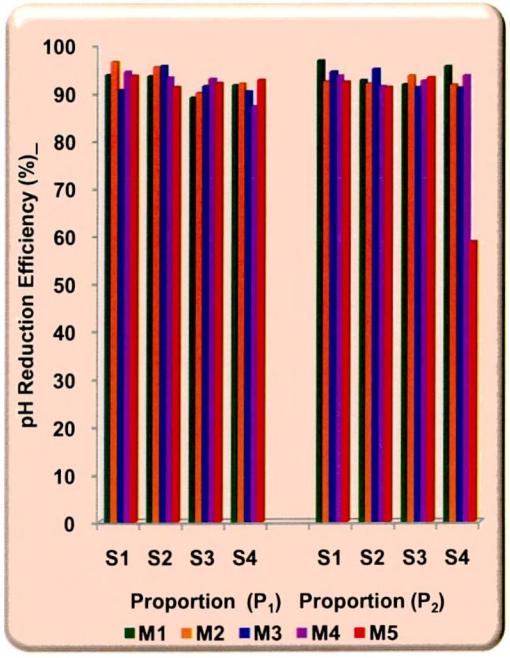
15e. Hemp Fibre from AHN

PLATE – 15

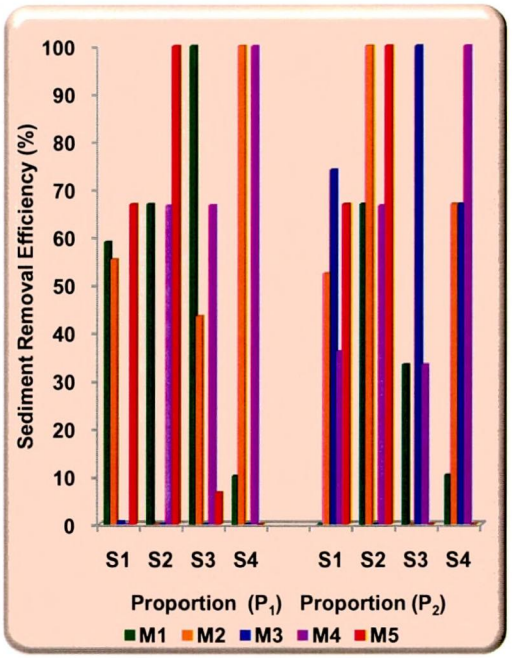
SEM IMAGE OF FIBRES FROM WEAR STUDIED MULCHED FABRIC



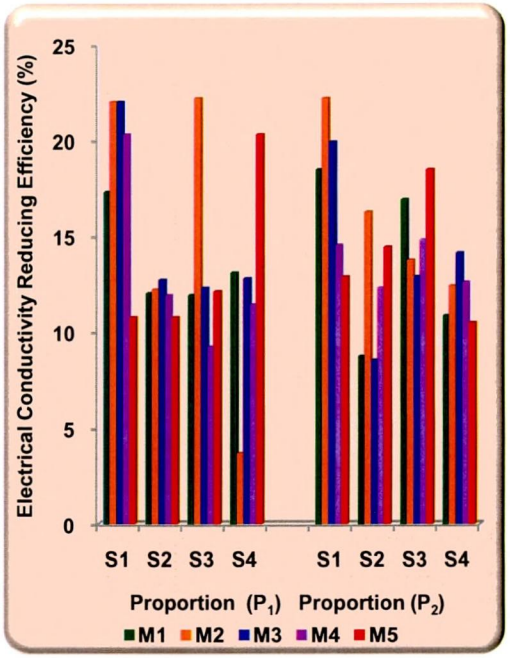
17a. Hydraulic Efficiency



17b. pH



17c. Sediment Removal Efficiency



17d. Electrical Conductivity

FIGURE – 17

EVALUATION OF PHYSICAL PARAMETERS WITH VARIOUS WOVEN SCREENS, MEDIA AND PROPORTIONS

TABLE – LXV (b)

STATISTICAL ANALYSIS FOR PHYSICAL PARAMETERS OF FILTERED WATER WITH WOVEN SCREENS

ANOVA of Physical Tests							
S.No.	Factor	Hydraulic Efficiency		Sediment Removal Efficiency		Electrical Conductivity Reducing Efficiency	
		'F' Value / Significance	Best Rank	'F' Value / Significance	Best Rank	'F' Value / Significance	Best Rank
1.	P	0.2979^{NS}	-	108.2489**	P_2	0.1184^{NS}	-
2.	M	7.8342**	M_1 M_2 M_4	796.6935**	M_4	1.5258^{NS}	-
3.	S	69.0415**	S_1	391.5658**	S_2	19.4439**	S_1
4.	PM	3.9134**	P_1M_1 P_1M_4 P_2M_1 P_2M_2 P_2M_3 P_2M_4	2049.4594**	P_1M_1 P_2M_3 P_2M_4	0.3238^{NS}	-
5.	MS	55.8700**	S_1M_4	1984.2289**	S_2M_5 S_4M_4	4.6229**	S_1M_2 S_1M_3
6.	PS	39.5473**	P_2S_1	686.1265**	P_2S_2	0.7996^{NS}	-
7.	PMS	12.1180**	$P_1S_4M_1$ $P_2S_1M_1$ $P_1S_1M_4$ $P_2S_1M_4$	819.9907**	$P_1S_3M_1$ $P_1S_4M_2$ $P_2S_2M_2$ $P_2S_3M_3$ $P_1S_4M_4$ $P_2S_4M_4$ $P_1S_2M_5$ $P_2S_2M_5$	4.2836**	$P_1S_1M_1$ $P_2S_1M_1$ $P_2S_3M_1$ $P_1S_1M_2$ $P_1S_3M_2$ $P_2S_1M_2$ $P_1S_1M_3$ $P_2S_1M_3$ $P_1S_1M_4$ $P_1S_4M_5$ $P_2S_3M_5$

** - 1% significance * - 5% significance NS – No significance.

4.8.1.1 Hydraulic Efficiency

From the Tables – LXV (a) and LXV (b), it is observed that the hydraulic efficiency was highly significant at one per cent level on change of all factors namely M, S, PM, MS, PS and PMS. The best rank for media were for M_1, M_2 and M_4. Similarly the best screen was S_1 (Hemp-*Agave americana*) with 'F' value of 7.8342 and 69.0415 respectively.

In the two way interaction of proportion and media (PM), P_1M_1, P_1M_4, P_2M_1, P_2M_2, P_2M_3 and P_2M_4 were ranked as the best. As for the combination of medium and screen (MS), S_1M_4 was observed to be the best in hydraulic efficiency with 'F' value of 55.8700.

In the three way interactions proportion, media and screen (PMS), $P_1S_4M_1$, $P_2S_1M_1$, $P_1S_1M_4$ and $P_2S_1M_4$ were on par showing the best efficiency with 'F' value of 12.1180 in transmitting water through them.

4.8.1.2 pH Neutralising Efficiency

As for pH is concerned, the change in proportion, screen, media and their combinations showed no significant difference.

4.8.1.3 Sediment Removal Efficiency

In the case of sediment removal efficiency, the proportion P_2 (1:2:3) showed one per cent significance. As for media and screen a significant difference of one per cent was observed. In the combinations of PM, MS and PS also a significance of one per cent was noted with 'F' value of 2049.4594, 1984.2289 and 686.1265 respectively. In the three way interaction between PMS, also one per cent level significance with 'F' value of 819.9907 was observed.

From the above data, it is clear that the proportion P_2 showed the best result in sediment removal efficiency in ANOVA ranking. As for media is concerned M_4 (coir fibre) was ranked as the best of all. The two way interactions of PM, the combinations P_1M_1, P_2M_3 and P_2M_4 were the best of all the combinations. In the two way interactions between MS the combination S_2M_5 and S_4M_4 were ranked to be the best of all the combinations. The combination P_2S_2 showed the best ranking in sediment removal efficiency. The combinations $P_1S_3M_1$, $P_1S_4M_2$, $P_2S_2M_2$, $P_2S_3M_3$, $P_1S_4M_4$, $P_2S_4M_4$, $P_1S_2M_5$ and $P_2S_2M_5$ showed the best result in PMS combination in removing sediment from water.

4.8.1.4 Electrical Conductivity Reducing Efficiency

The screen S_1 (Hemp-*Agave americana*) was observed to be significant at one per cent level with 'F' value of 19.4439. In the two way interaction of medium and screen (MS) one per cent significance with 'F' value of 4.6229 was noted. In the three way interaction of PMS also significance of one per cent was noted.

The screen S_1 (Hemp-*Agave americana*) showed the best rank as per ANOVA in electrical conductivity reducing efficiency. In screen and medium (SM) combinations, S_1M_2 and S_1M_3 showed the best result. The combinations $P_1S_1M_1$, $P_2S_1M_1$, $P_2S_3M_1$, $P_1S_1M_2$, $P_1S_3M_2$, $P_2S_1M_2$, $P_1S_1M_3$, $P_2S_1M_3$, $P_1S_1M_4$, $P_1S_4M_5$ and $P_2S_3M_5$ were on par showing the best result in the electrical conductivity reducing efficiency of water.

4.8.2 Physical Parameters of Filtered Water with Various Nonwoven Screens, Media and Proportions

The evaluation of hydraulic efficiency, pH neutralising efficiency, sediment removal efficiency and electrical conductivity reducing efficiency for various nonwoven screens in different media are presented in Table – LXVI (a) and Figure – 18.

TABLE – LXVI (a)

EVALUATION OF PHYSICAL PARAMETERS WITH NONWOVEN SCREENS, MEDIA AND PROPORTIONS

S.No.	Media	NS_1 – AHN				NS_2 – AJN				NS_3 – AAN				NS_4 – No Screen			
		HE	pH	SED	EC	HE	pH	SED	EC	HE	pH	SED	EC	HE	pH	SED	EC
Proportion (P_1)																	
1.	M_1	17.29	95.00	0	22.58	18.28	90.33	19.85	9.70	8.85	97.54	100	11.73	90.39	96.14	0	13.09
2.	M_2	16.96	91.76	19.85	21.44	13.52	95.16	100	12.59	52.08	87.43	43.44	22.20	20.01	94.87	33.44	31.88
3.	M_3	16.40	97.09	30.68	12.14	52.28	95.55	0	12.71	16.34	97.24	100	28.84	12.63	91.78	66.88	12.78
4.	M_4	91.22	94.41	0	20.30	24.69	94.74	66.66	28.84	19.47	90.67	0	11.53	8.67	95.26	100	10.08
5.	M_5	29.79	95.16	100	29.57	18.63	92.37	66.66	11.73	78.31	97.37	66.66	10.96	47.15	90.92	0	20.30
Proportion (P_2)																	
6.	M_1	79.23	95.47	100	24.67	10.53	96.53	33.44	10.85	10.13	97.62	33.33	10.57	40.27	97.24	10.33	10.85
7.	M_2	18.48	91.76	32.48	25.62	23.08	92.70	66.88	9.50	43.44	91.72	0	13.75	11.32	93.95	66.88	9.12
8.	M_3	24.95	93.70	55.34	25.43	58.53	90.06	0	8.54	22.35	91.19	100	8.84	11.82	95.70	0	10.27
9.	M_4	91.42	97.09	0	14.52	12.94	93.87	66.6	10.0	9.18	92.66	33.33	11.92	7.97	95.65	0	11.43
10.	M_5	17.88	92.12	33.44	9.31	10.64	89.75	66.66	10.0	8.44	94.87	66.66	7.30	47.78	87.43	0	10.47

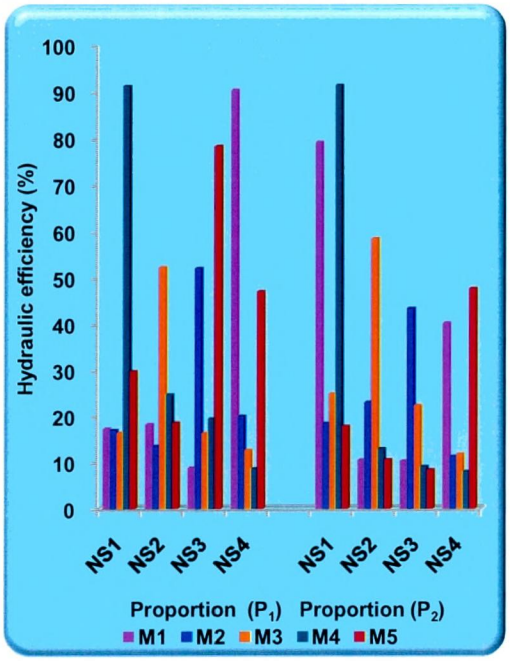
HE – Hydraulic Efficiency, pH – pH Neutralising Efficiency, SED – Sediment Removal Efficiency, EC – Electrical Conductivity Reducing Efficiency,

The ANOVA of hydraulic efficiency, pH neutralising efficiency, sediment removal efficiency and electrical conductivity reducing efficiency are presented in Table – LXVI (b).

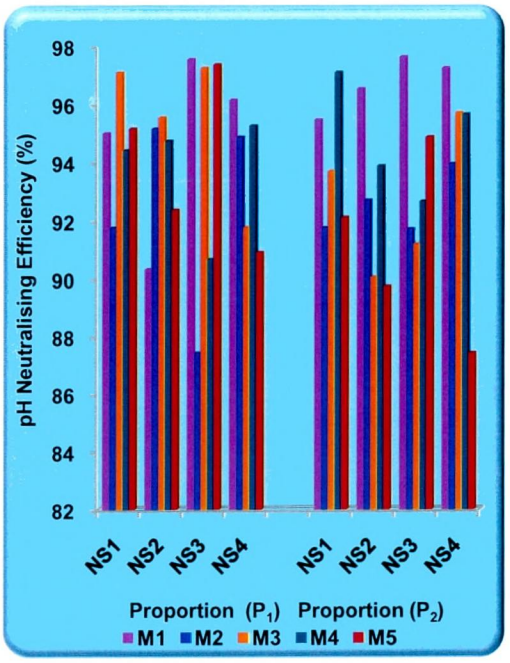
TABLE – LXVI (b)

STATISTICAL ANALYSIS FOR PHYSICAL PARAMETERS OF FILTERED WATER WITH NONWOVEN SCREENS

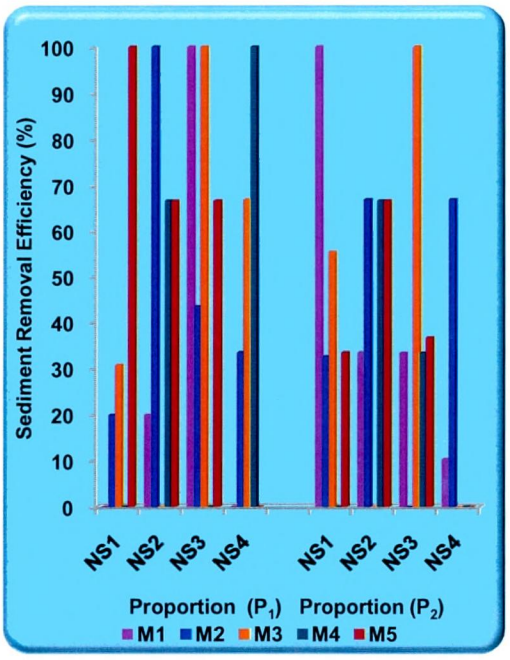
ANOVA of physical Tests									
S.No.	Factor	Hydraulic Efficiency		pH – Neutralising Efficiency		Sediment Removal Efficiency		Electrical Conductivity Reducing Efficiency	
		'F' Value / Significance	Best Rank	'F' Value / Significance	Best Rank	'F' Value / Significance	Best Rank	'F' Value / Significance	Best Rank
1.	P	230.0545**	P_1	0.6650^{NS}	-	646.4353**	P_1	59.0503**	P_1
2.	S	533.7238**	NS_1	4.2990**	M_1 M_3 M_4	1650.516**	NS_3	5.7657**	M_2
3.	M	150.4770**	M_1	0.7513^{NS}	-	418.9046**	M_5	30.0286**	NS_1
4.	PM	241.7890**	P_1 M_5	2.7959*	P_1M_1 P_1M_3 P_2M_1 P_2M_4	381.9035**	P_1 M_5	5.4804**	P_1 M_2
5.	MS	1528.4324**	NS_1M_4	2.9144**	NS_1M_1 NS_1M_3 NS_1M_4 NS_2M_2 NS_2M_4 NS_3M_1 NS_3M_3 NS_3M_5 NS_4M_1 NS_4M_2 NS_4M_4	2681.738**	NS_3 M_3	6.9418**	NS_1M_1 NS_1M_2 NS_4M_2
6.	PS	423.4015**	P_2NS_1	0.1930^{NS}	-	815.5881**	P_1NS_3	3.9846**	P_1NS_1 P_2NS_1
7.	PMS	337.0786**	$P_1NS_4M_1$ $P_1NS_1M_4$ $P_2NS_1M_4$	1.3721^{NS}	-	1546.594**	$P_1NS_3M_1$ $P_2NS_1M_1$ $P_1NS_2M_2$ $P_1NS_3M_3$ $P_2NS_3M_3$ $P_1NS_4M_4$ $P_1NS_1M_5$	12.4725**	$P_1NS_4M_2$ $P_1NS_3M_3$ $P_1NS_2M_4$ $P_1NS_1M_5$



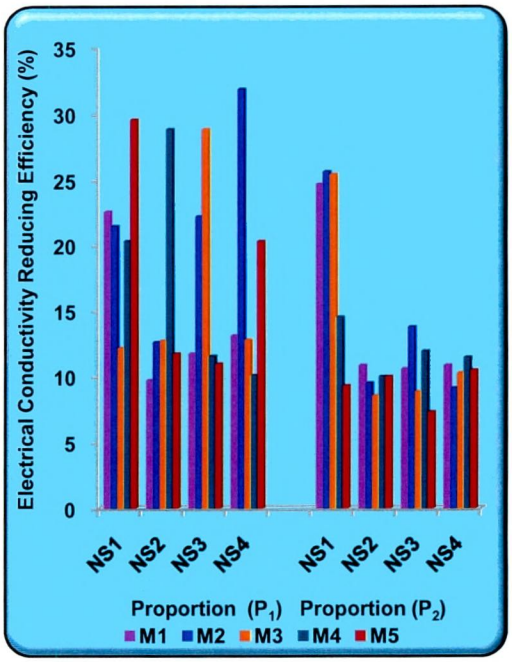
18a. Hydraulic Efficiency



18b. pH



18c. Sediment Removal Efficiency



18d. Electrical Conductivity

FIGURE – 18

EVALUATION OF PHYSICAL PARAMETERS WITH VARIOUS NONWOVEN SCREENS, MEDIA AND PROPORTIONS

4.8.2.1 Hydraulic Efficiency

From the above data, it is clear that the hydraulic efficiency of non-woven structures showed a significance at one per cent level for the variables namely, media, screen and proportions as per ANOVA.

As for the proportion, P_1 showed the best result in hydraulic efficiency. The screen NS_1 and media M_1 showed the best ranks in the analysis. In the two way interactions of PM, MS and PS, the combinations P_1M_5, NS_1M_4 and P_2NS_1 respectively were ranked as the best of all the combinations. In the three way interaction between PMS, the combinations $P_1NS_4M_1$, $P_1NS_1M_4$ and $P_2NS_1M_4$ showed the best result in hydraulic efficiency.

4.8.2.2 pH – Neutralising Efficiency

From the above data it is vivid that the media showed a significance of one per cent level. In the combinations of PM and MS, five per cent and one per cent significance respectively were noted. As for the media, M_1, M_3 and M_4 were ranked to be the best of all.

In the two way interaction of PM, the combinations P_1M_1, P_1M_3, P_2M_1 and P_2M_4 showed the best rank of all. In the interaction between MS, the combinations NS_1M_1, NS_1M_3, NS_1M_4, NS_2M_2, NS_2M_4, NS_3M_1, NS_3M_3, NS_3M_5, NS_4M_1, NS_4M_2 and NS_4M_4 showed the best rank of all the combinations.

4.8.2.3 Sediment Removal Efficiency

The sediment removal efficiency of non-woven structures also showed a significance of one per cent level as per the ANOVA results in different media, screen and proportions.

As for the sediment removal efficiency, the proportion P_1 was ranked to be better than the other one. The screen NS_3 (*Agave americana*-Hemp) was ranked to be the best of all screens. The media M_5 (coir) showed the best result of all the media. In the two way interaction of PM, MS and PS the combinations, P_1M_5, NS_3M_3 and P_1NS_3 showed the best ranks of all the combinations. In the three way interaction between PMS, the combinations $P_1NS_3M_1$, $P_2NS_1M_1$, $P_1NS_2M_2$, $P_1NS_3M_3$, $P_2NS_3M_3$, $P_1NS_4M_4$ and $P_1NS_1M_5$ were observed to be the best of all the combinations.

Though hydraulic efficiency was lesser, sediment trapping efficiency was found to be the best screen in NS_3 (*Agave americana*-Hemp).

4.8.2.4 Electrical Conductivity Reducing Efficiency

As far as the electrical conductivity is concerned the changes in proportion, media and screen were found to be significant at one per cent level.

The proportion P_1 showed the best result in reducing the electrical conductivity. As for the media and screen, M_2 and NS_1 were ranked to be the best of all. In the combinations of MS, NS_1M_1, NS_1M_2 and NS_4M_2 and in PM, P_1M_2 combination was ranked to be the best of all. In the PMS three way interaction, $P_1NS_4M_2$, $P_1NS_3M_3$, $P_1NS_2M_4$ and $P_1NS_1M_5$ combinations were ranked as the best of all the combinations.

4.8.3 Evaluation of Chemical Filtration Efficiency of Selected Combinations using Woven Screens

The evaluation of chemical filtration efficiency of selected combinations using woven screens are presented in Table – LXVII (a) and Figures – 19a, 19b and 19c.

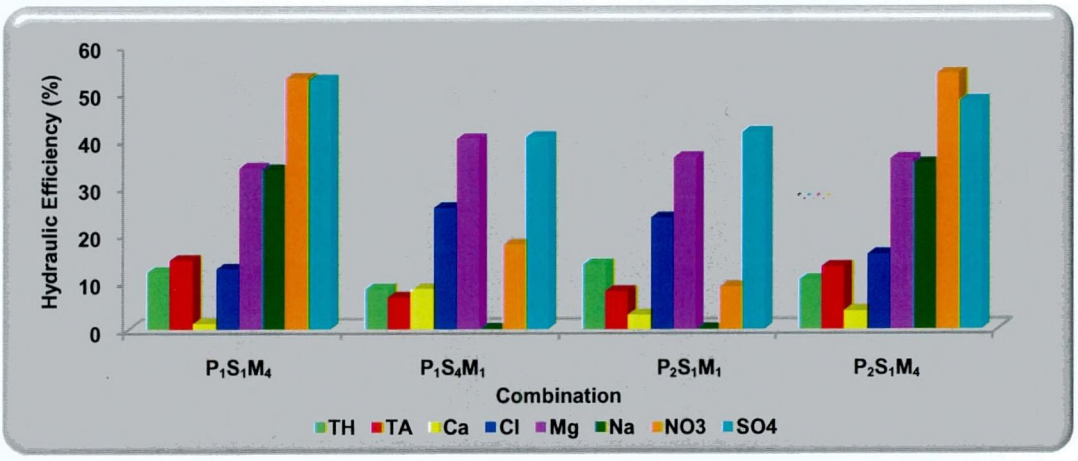
TABLE – LXVII (a)

CHEMICAL FILTRATION EFFICIENCY OF SELECTED COMBINATIONS USING WOVEN SCREENS (%)

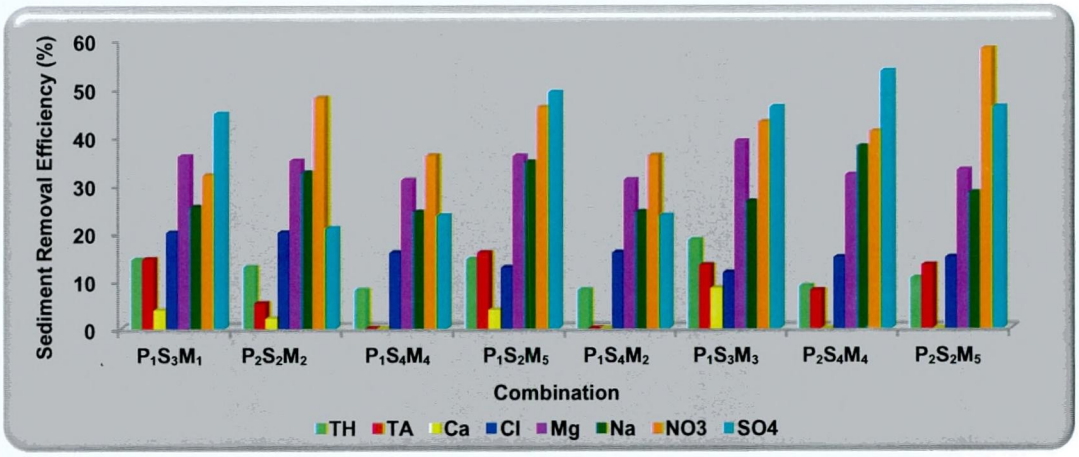
S.No.	Combination	TH	TA	Ca	Cl	Mg	Na	NO_3	SO_4
Hydraulic Efficiency Vs Chemical Filtration Efficiency									
1.	$P_1 S_1 M_4$	12	14.47	1.19	12.63	34	33.57	53	52.60
2.	$P_1 S_4 M_1$	8.4	6.57	8.38	25.51	40.19	0	17.77	40.52
3.	$P_2 S_1 M_1$	13.6	7.89	2.994	23.46	36.27	0	8.88	41.57
4.	$P_2 S_1 M_4$	10.4	13.15	3.89	15.78	36	35	54	48.26
Sediment Removal Efficiency Vs Chemical Filtration Efficiency									
5.	$P_1 S_3 M_1$	14.4	14.47	3.89	20	36	25.35	32	44.78
6.	$P_2 S_2 M_2$	12.8	5.26	2.09	20	35	32.5	48	20.86
7.	$P_1 S_4 M_4$	8	0	0	15.78	31	24.28	36	23.47
8.	$P_1 S_2 M_5$	14.4	15.78	3.89	12.63	36	34.64	46	49.13
9.	$P_1 S_4 M_2$	8	0	0	15.78	31	24.28	36	23.47
10.	$P_1 S_3 M_3$	18.4	13.15	8.38	11.57	39	26.42	43	46.08
11.	$P_2 S_4 M_4$	8.8	7.89	0	14.73	32	37.85	41	53.47
12.	$P_2 S_2 M_5$	10.4	13.15	0	14.73	33	28.21	58	46.08
Electrical Conductivity Reducing Efficiency Vs Chemical Filtration Efficiency									
13.	$P_1 S_1 M_1$	16	10.52	5.68	20	37	33.57	36	44.78
14.	$P_2 S_2 M_1$	13.6	7.89	2.994	23.46	36.27	0	8.88	41.57
15.	$P_2 S_1 M_1$	12.8	5.26	2.09	8.42	35	38.21	61	57.82
16.	$P_1 S_3 M_2$	13.6	0	0	15.30	32.35	0	0.05	25.26
17.	$P_1 S_1 M_2$	19.2	15.78	9.28	11.57	39	35.35	49.0	50.82
18.	$P_1 S_1 M_3$	16	10.52	5.68	20	37	33.57	36	44.78
19.	$P_2 S_1 M_3$	16	10.52	5.68	10.52	37	37.85	44	55.65
20.	$P_1 S_4 M_5$	10.4	10.52	0	17.89	33	37.85	52	42.60
21.	$P_2 S_3 M_5$	14.4	7.89	3.89	21.05	36	28.21	42	41.73

TH – Total Hardness, TA – Total Alkalinity, Ca – Calcium, Cl – Chlorine, Mg – Magnesium, Na – Sodium, NO_3 –Nitrate, SO_4 – Sulphate

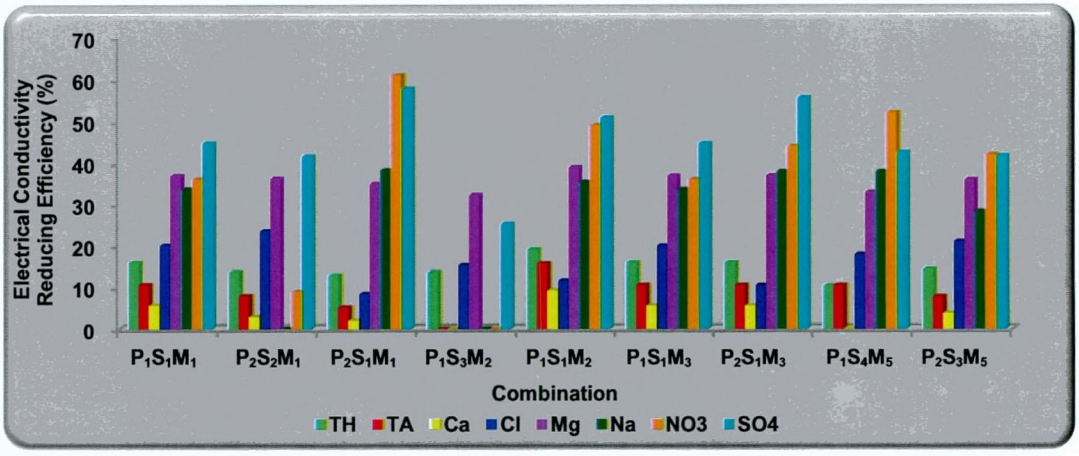
ANOVA of chemical filtration efficiency is given in Table – LXVII (b).



19a. Hydraulic Efficiency Vs Chemical Filtration Efficiency



19b. Sediment Removal Efficiency Vs Chemical Filtration Efficiency



19c. Electrical Conductivity Reducing Efficiency Vs Chemical Filtration Efficiency

FIGURE – 19

CHEMICAL FILTRATION EFFICIENCY OF SELECTED COMBINATIONS USING WOVEN SCREENS (%)

TABLE – LXVII (b)

ANOVA FOR PHYSICAL VERSUS CHEMICAL FILTRATION EFFICIENCY OF SELECTED COMBINATIONS USING WOVEN SCREENS

S.No.	Details	TH		TA		Ca		Cl		Mg		Na		NO_3		SO_4	
		'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank
1.	HE	3034.8378**	$P_2S_1M_1$	4676.754**	$P_1S_4M_1$	13279.4037**	$P_1S_1M_4$	4682.878**	$P_1S_1M_4$	164.3560**	$P_1S_1M_4$	22590.404**	$P_1S_4M_1$	24051.674**	$P_2S_1M_4$	755.7240**	$P_1S_4M_1$
2.	SED	4206.2074**	$P_1S_3M_3$	27447.6852**	$P_1S_2M_5$	26296.1013**	$P_1S_3M_3$	1435.1737**	$P_1S_3M_1$ $P_2S_2M_2$	354.5845**	$P_1S_3M_3$	1677.7793**	$P_2S_4M_4$	1559.0351**	$P_2S_2M_5$	5294.5330**	$P_2S_4M_4$
3.	EC	1735.7767**	$P_1S_1M_2$	11664.3295**	$P_1S_1M_2$	36425.2070**	$P_1S_1M_2$	4412.6015**	$P_2S_2M_1$	227.1531**	$P_1S_1M_2$	14644.7131**	$P_2S_1M_1$ $P_2S_1M_3$ $P_1S_4M_5$	12553.3754**	$P_2S_1M_1$	3373.8294**	$P_2S_1M_1$

HE – Hydraulic Efficiency, EC – Electrical Conductivity Reducing Efficiency, SED – Sediment Removal Efficiency

TH – Total Hardness, TA – Total Alkalinity, Ca – Calcium, Cl – Chlorine, Mg – Magnesium, Na – Sodium, NO_3 –Nitrate, SO_4 –Sulphate

4.8.3.1 Hydraulic Efficiency Vs. Chemical Filtration

From the Tables – LXVII (a) and LXVII (b), it is clear that the screen S_1 (Hemp-*Agave americana*) showed the best result in efficient reduction of total hardness, Ca, Cl, Mg, Na and NO_3 with maximum significance of one per cent level among the combinations which gave the best results of hydraulic efficiency. As for media and proportion, M_4 (coir fibres) and P_1 (1:1:1) gave the best result.

4.8.3.2 Sediment Removal Efficiency Vs. Chemical Filtration

Among the combinations that for the sediment efficiency, the screen S_3 gave the best result in reducing TH, Ca, Cl and Mg. These combinations also were found to be significant at one per cent level. As for media and proportion, M_3 (Jute fibres) and P_1 (1:1:1) gave the best result.

4.8.3.3 Electrical Conductivity Reducing Efficiency Vs. Chemical Filtration

Among the combinations which reduced electrical conductivity of the water, the screen S_1 was observed to be the best in reducing TH, TA, Ca, Mg and Na, NO_3 and SO_4. The ANOVA shows a significant difference between the combinations at one per cent level. As for media and proportion, M_2 (*Agave americana* fibres) and M_1 (charcoal) and P_1 (1:1:1) gave the best result respectively.

Among overall performance, the screen S_1 (Hemp-*Agave americana*) was found to be the best.

4.8.4 Evaluation of Filtration Efficiency of Chemicals with Selected Combinations using Nonwoven Screens

The evaluation of filtration efficiency of chemicals with selected combinations using nonwovens screens is clearly presented in Table – LXVIII (a) and Figure – 20.

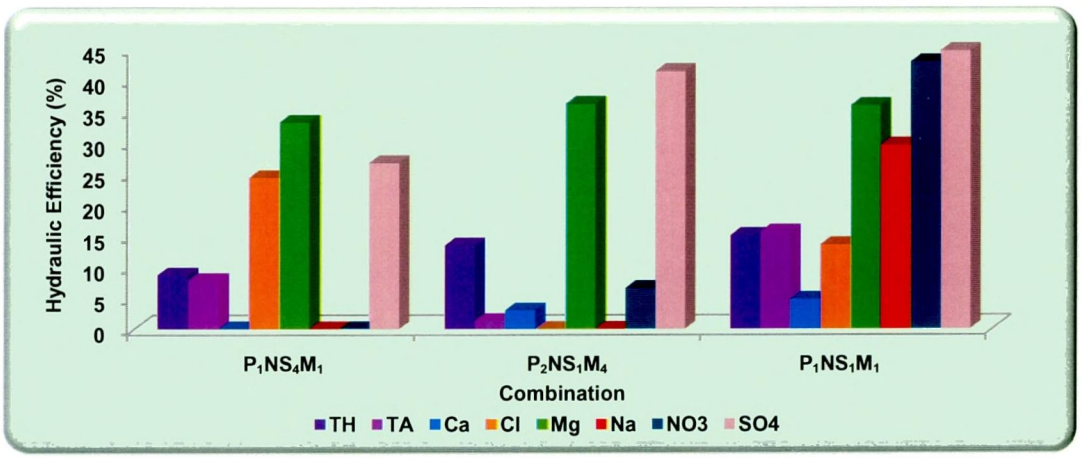
TABLE – LXVIII (a)

EVALUATION OF FILTRATION EFFICIENCY OF CHEMICALS WITH SELECTED COMBINATIONS USING NONWOVEN SCREENS (%)

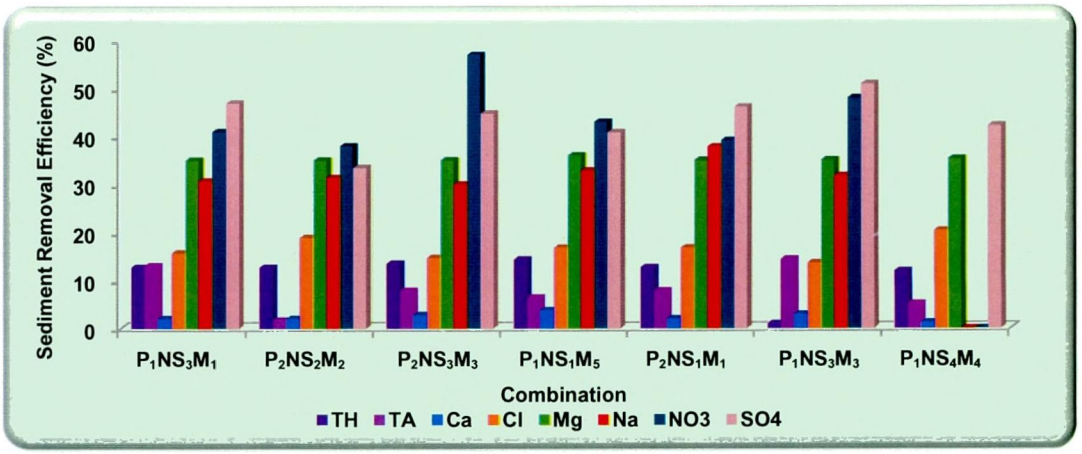
S.No.	Combination	TH	TA	Ca	Cl	Mg	Na	NO_3	SO_4
Hydraulic Efficiency Vs. Chemical Filtration Efficiency									
1.	$P_1 NS_4 M_1$	8.8	7.89	0	24.48	33.33	0	0	26.84
2.	$P_2 NS_1 M_4$	13.6	1.31	2.99	0	36.27	0	6.6	41.57
3.	$P_1 NS_1 M_1$	15.2	15.78	4.79	13.68	36	29.64	43	44.78
Sediment Removal Efficiency Vs. Chemical Filtration Efficiency									
4.	$P_1 NS_3 M_1$	12.8	13.15	2.09	15.78	35	30.71	41	46.95
5.	$P_2 NS_2 M_2$	12.8	1.78	2.09	18.94	35	31.42	38	33.47
6.	$P_2 NS_3 M_3$	13.6	7.89	2.89	14.73	35	30	57	44.78
7.	$P_1 NS_1 M_5$	14.4	6.56	3.89	16.84	36	32.85	43	40.86
8.	$P_2 NS_1 M_1$	12.8	7.89	2.09	16.84	35	37.85	39.14	46.08
9.	$P_1 NS_3 M_3$	1	14.47	2.99	13.68	35	31.78	48	50.86
10.	$P_1 NS_4 M_4$	12	5.26	1.19	20.40	35.29	0	0	42.10
Electrical Conductivity Reducing Efficiency Vs. Chemical Filtration Efficiency									
11.	$P_1 NS_1 M_5$	13.6	6.57	0	12.63	33	33.21	52	53.47
12.	$P_1 NS_2 M_4$	10.4	13.15	3.89	15.78	36	35	54	48.26
13.	$P_1 NS_3 M_3$	12.8	5.26	2.09	13.68	35	35	39	51.30
14.	$P_1 NS_4 M_2$	12	10.52	1.19	15.78	34	37.85	51	47.39

TH – Total Hardness, TA – Total Alkalinity, Ca – Calcium, Cl – Chlorine, Mg – Magnesium, Na – Sodium, NO_3 –Nitrate, SO_4 - Sulphate

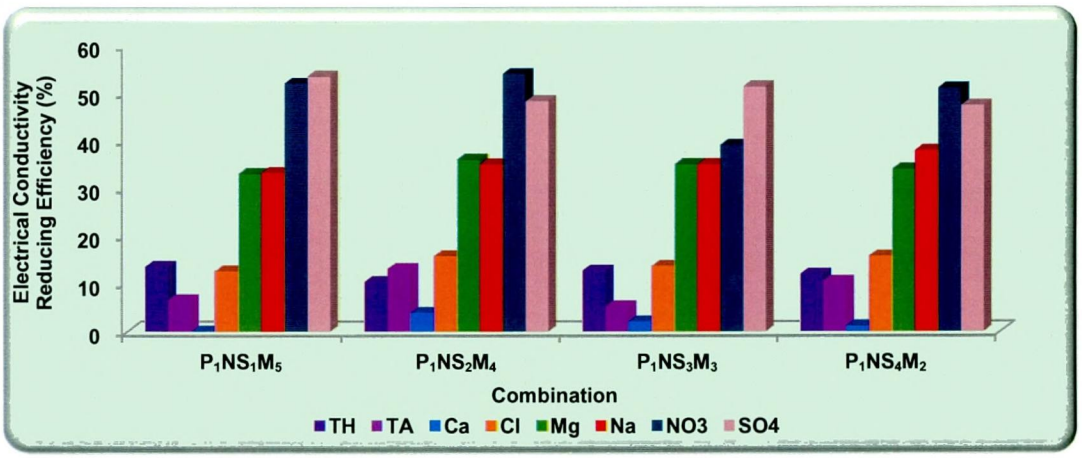
ANOVA of chemical filtration capacity of various selected combinations using nonwoven screens are presented in Table – LXVIII (b).



20a. Hydraulic Efficiency Vs Chemical Filtration Efficiency



20b. Sediment Removal Efficiency Vs Chemical Filtration Efficiency



20c. Electrical Conductivity Reducing Efficiency Vs Chemical Filtration Efficiency

FIGURE – 20

CHEMICAL FILTRATION EFFICIENCY OF SELECTED COMBINATIONS USING NONWOVEN SCREENS (%)

TABLE – LXVIII (b)

ANOVA FOR PHYSICAL VERSUS CHEMICAL FILTRATION EFFICIENCY OF SELECTED COMBINATIONS USING NONWOVEN SCREENS

S.No.	Details	TH		TA		Ca		Cl		Mg		Na		NO_3		SO_4	
		'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank	'F' value significance	Best Rank
1.	HE	10528.014**	$P_1NS_1M_4$	36662.3283**	$P_1NS_1M_4$	22400.6378**	$P_1NS_1M_4$	58441.4893**	$P_1NS_4M_1$	136.4434**	$P_2NS_1M_4$ $P_1NS_1M_4$	574077.2816**	$P_1NS_1M_4$	44016.4144**	$P_1NS_1M_4$	9359.4784**	$P_1NS_1M_4$
2.	SED	9066.2105**	$P_1NS_1M_5$	13225.355**	$P_1NS_3M_3$	4345.4834**	$P_1NS_1M_5$ $P_1NS_4M_4$	715.5757**	$P_1NS_2M_2$	9.3567**	$P_1NS_1M_5$ $P_1NS_4M_4$	432.666**	$P_2NS_1M_1$	1400.5454**	$P_2NS_3M_3$	1077.4235**	$P_1NS_3M_3$
3.	EC	644.5672**	$P_1NS_1M_5$	5296.1865**	$P_1NS_1M_5$	15501.4060**	$P_1NS_3M_3$	2132.0581**	$P_1NS_2M_4$	52.2224**	$P_1NS_2M_4$ $P_1NS_3M_3$	18029.1222**	$P_1NS_1M_5$	14940.3107**	$P_1NS_4M_2$	602.7673**	$P_1NS_4M_2$

HE – Hydraulic Efficiency, EC – Electrical Conductivity Reducing Efficiency, SED – Sediment Removal Efficiency

TH – Total Hardness, TA – Total Alkalinity, Ca – Calcium, Cl – Chlorine, Mg – Magnesium, Na – Sodium, NO_3 – Nitrate, SO_4 –Sulphate

4.8.4.1 Hydraulic Efficiency Vs. Chemical Filtering Capacity of the Selected Combinations

ANOVA between the combinations showed a significance of one per cent. The screen NS_1 showed the best result in reducing Total hardness (TH), Total alkalinity (TA), Ca, Mg, Na, NO_3 and SO_4.

As for the proportion P_1 and media is concerned, P_1 and M_4 gave the best result.

4.8.4.2 Sediment Removal Efficiency Vs. Chemical Filtering Capacity of the Selected Combinations

ANOVA between the combinations showed a significance of one per cent. In this also, NS_1 was observed to be the best in reducing TH, Ca, Mg and Na whereas the screen NS_3 was best in reducing TA, NO_3 and SO_4, Media – M_3 and proportion P_1 were observed to be the best of all.

4.8.4.3 Electrical Conductivity Reducing Efficiency Vs. Chemical Filtering Capacity of the Selected Combinations

ANOVA between the combinations showed significance at one per cent level. Effective reduction in TH, TA and Na was observed to be the best with the screen NS_1, M_5 and P_1 were observed to be best media and proportion respectively of all.

All the screens act as the best separators in preventing the mixing of sand, gravel or charcoal / fibres with each other.

4.8.5 Evaluation of Filtration Efficiency on Physico-Chemical Parameters Using Hemp-*Agave americana* Screen and Coir Fibres

The filtration efficiency and physico-chemical parameters of filtered and unfiltered dosed water using hemp-*Agave americana* screen, gravel, coir fibres, sand in 1:1:1 proportion are presented in Table – LXIX.

TABLE – LXIX

FILTRATION EFFICIENCY OF PHYSICO-CHEMICAL PARAMETERS WITH HEMP-*Agave americana* SCREEN

S.No.	Sample	Physical Examination						Chemical Examination											
		Colour	Appearance	Odour	Turbidity (NT units)	TDS MG/LIT	EC (micromho/cm)	pH	Total alkalinity $CaCO_3$	Total hardness $CaCO_3$	Ca	Mg	Na	K	NO_3	Cl	F	SO_4	PO_4
1	A_1	C	C	N	7	3269	4670	7.69	390	866	231	69	610	60	120	1000	0.4	382	0.03
2	B_1	CL	CL	N	5	2786	3980	7.86	180	830	222	66	480	49	110	910	0.6	380	0
	L%				**28.57**	**-14.77**	**-14.77**	**2.21**	**-53.84**	**-4.15**	**-3.89**	**-4.34**	**-21.32**	**-18.33**	**-8.33**	**-9.0**	**-50**	**-0.52**	**100**
3	A_2	C	C	N	5	3745	5350	7.63	470	1250	334	100	570	60	200	1020	1.0	460	0
4	B_2	CL	CL	N	6	2961	4230	7.59	400	1200	320	96	430	43	140	850	1.0	420	0
	L%				**20**	**-20.93**	**-20.93**	**-0.52**	**-14.89**	**-4**	**-4.19**	**-4**	**-24.56**	**-28.33**	**-30**	**-16.66**	**0**	**-8.69**	**0**
5	A_3	C	C	N	8	4410	6300	7.75	630	1500	400	120	600	180	170	1250	0.8	560	0
6	B_3	CL	CL	N	7	3087	4410	7.57	700	1280	342	102	520	52	130	880	0.8	450	0.05
	L%				**-12.5**	**-30**	**-30**	**-2.32**	**11.11**	**-14.66**	**-14.5**	**-15**	**-13.33**	**-71.11**	**-23.5**	**-29.6**	**0**	**-19.64**	**100**

A_1, A_2 and A_3 – Unfiltered dosed water ; B_1, B_2 and B_3 – Filtered dosed water.

From Table – LXIX, it is clear that in almost all the samples, a reduction was noted in both physical and chemical parameters in filtered water samples (B_1, B_2 and B_3) over the unfiltered water samples (A_1, A_2 and A_3) expressing the reduction in hardness of water on filtration.

Sara and Everett (2002) state that, geo textiles could significantly influence the flow and the transfer of pollutants such as heavy metals. Geo textiles are not presumed to interact directly with these pollutants, due to the low chemical reactivity of their fibres. But they may interact with the soil to produce a new soil geo textile system with new characteristics. When geo textiles are put into the soil, they constitute a particular layer with a particular structure. This structural heterogeneity could modify the soil around geo textiles due to soil particle movement and other physical and chemical processes.

Thus the Hemp-*Agave americana* woven fabric along with other media namely gravel, coir fibres and sand had reduced the physical parameters namely, turbidity, TDS and EC. The chemical parameters namely total alkalinity $CaCO_3$, total hardness $CaCO_3$, Ca, Mg, Na, K, NO_3, Cl, F, SO_4 and PO_4 were also reduced through filtration.

4.9 EVALUATION OF SELECTED FABRIC STRUCTURE FOR GEO TEX

The geo textile properties evaluated for hemp-*Agave americana* woven fabric samples are presented in Table – LXX. The original test results obtained from the laboratory are presented in Appendix – 19.

TABLE – LXX

GEO TEXTILE PROPERTIES OF HEMP-*Agave americana*

WOVEN FABRIC SAMPLE

S.No.	Test	Result values
1.	Mass (g / m^2)	587.6
2.	Thickness (mm)	2.67
3.	Trapezoid tear strength (N)	
	Warp direction	225.8
	Weft direction	484.4
4.	Wide tensile strength (KN/m)	
	Warp direction	11.4
	Weft direction	35.2
5.	Elongation (%)	
	Warp direction	22.9
	Weft direction	10.5
6.	CBR puncture strength (N)	2557

From the Table – LXX, it is clear that the mass of the sample hemp-*Agave americana* was observed to be 587.6 g / m^2, thickness under pressure 2 Kpa was noted to be 2.67 mm. The trapezoid tear was observed to be 225.8 N in warp and 484.4 N in weft directions. As for the wide strip tensile strength, in warp and weft directions, it was noted to be 11.4 and 35.2 KN/m respectively. The CBR puncture strength was evaluated as 2557 N.

According to Shukla and Yin (2006), trapezoid tear strength found as per ASTMD 4533 requirement for regular geo textiles is 450 N. The findings presented in the above table showed that the tear strength of sample HA was 484.4 N in weft direction which is greater than the required value.

The minimum requirement for geo textile filters for high way works as per specification for high way works (SHW) is tear resistance of 200 N and CBR puncture resistance of 1200 N, state Corbet and King (1993). The above findings show better values than the required values as it had tear strength of 225.8 and 484.4 in warp and weft directions respectively, and CBR puncture strength of 2557 N.

4.10 ECONOMICS OF WOVEN AND NONWOVEN FABRICS

The estimated cost of woven and nonwoven fabrics is enclosed in Appendix – 20.