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# Recycling of Cotton Waste Composites in Agrotech Applications

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**Abstract**
Sustainability and textiles are major upcoming areas in the world today. Textiles being the second largest economy generating as well as one of the polluting industries in India. Sustainable strategies are to be adopted for effective utilization of textile waste. Many attempts are being undertaken to find sustainable ways such as recycling fibres, yarns and fabrics. Textile fibres contribute nearly 4.6 % of the total pre-consumer waste materials being recycled in India.
Agrotech is one of the fields of technical textiles which has gained importance in recent years. Hence, a study was undertaken in which needle punched non-woven fabric of 100%, 50:50 and 70:30 combinations was prepared using cotton waste fibers with wool waste, hemp waste, viscose rayon waste and natural nettle fiber waste fibers A comparative study of herbal finish treated and untreated composites was done. The results revealed that when herbal finish was applied on the developed composites and were tested on physical parameters as well as for specialised finishes; Hemp: Cotton 50:50 (herbal finish treated) combination showed 97% UV blocking and the moisture content increased to 11.7 % with good antimicrobial property. It was found that composites with herbal finish treatment showed better results and can be used for agrotech applications like shade nets, mulches, fruit covers and natural fruit ripeners.

**Keywords:** sustainability, composites, herbal finish, needle punched, nonwoven, recycling.

## Introduction:

Recycling is one of the methods to reduce pollution and utilize waste. In textiles pre- and post-consumer wastes is created on a larger scale. This may be because textile is second largest economy generating industries in India. Textiles is used in each and every field today. Textile application is evident in many fields like geotech, okeotech, Mobitech, agrotech, etc. Agriculture is the primary occupation of India. Agrotech has made possible for farmers and cultivators to grow fruits and vegetables. Agrotech is one of the new fields in India today.
India being a tropical country many fruits like bananas, grapes, pomegranates, mangoes apples, oranges are exported at global market. India is seen as a rising economy at global level today. Efforts are taken to find sustainable solutions to the growing pollution caused by the textile industry[2].
Technical textiles contribute to about 15 % in total textile and apparel market. There is a huge potential for the technical market to fulfil the large demand gap as the consumption of technical textiles is only 10-

15 % against other countries[5]. Every state of India has a speciality fruit which contributes in the GDP of our country.

Maharashtra is known for grapes, pomegranates, bananas, guavas, sapotas and custard apples, to name a few which has a huge demand globally. These are exported and are major contributors in global fruit market[4]. Nashik is known for grape and is one of the major contributors in the export market too. Many farmers use shade nets and mulches of synthetic fibers. Synthetic fibers like nylon, polypropylene, polyesters have a dominance in the agrotextile production. But owing to its improper waste management and non-biodegradability factors, researches are carried out to find out sustainable solutions to the problems caused[12].

Therefore, a study was undertaken in which fiber waste of cotton, wool, viscose rayon, hemp and natural nettle fiber waste was collected and fabrics of 100%, 50:50 and 70:30 combinations were prepared using needle punching method of fabric construction. These fabrics were given a finish treatment of Amaranthus extract through padding mangle and dip method of application. These fabrics were used as shade covers in the fields.

**Objectives**:

1. To document the agrotextiles used by grape cultivators of Nashik city.
2. To develop and non-woven fabrics using cotton waste, wool waste, viscose rayon waste, hemp waste and natural nettle fiber waste of 100%, 50:50 and 70:30 combinations and to apply amaranthus extract on to the developed non-woven fabrics.
3. To evaluate the properties of developed fabrics for UV, anti-microbial and moisture content.

**Methodology**:

The present study is action-based research. Primary data collected from the field visits and interviewing grape farm cultivators and experts to understand the difficulties in utilizing the existing agrotextiles. To obtain relevant literature, the investigator gathered secondary data from several websites, journals, and peer-reviewed related articles. Purposive convenience sampling technique was used to select the grape cultivators. Field visits to grape farms were conducted by the investigator in the Nashik city. 9 non-woven fabrics were developed by using industry fibre waste of cotton, wool, and viscose rayon waste in combinations of 50:50. The developed nonwoven fabrics were tested and analysed and results were recorded.

1. Cotton waste non-woven fabric- 100%
2. Cotton waste: wool waste – 50:50
3. Cotton waste: wool waste – 70:30
4. Cotton waste: viscose rayon waste – 50:50
5. Cotton waste: viscose rayon waste – 70:30
6. Cotton waste: Hemp waste – 50:50
7. Cotton waste: Hemp waste – 70:30
8. Cotton waste: Natural nettle fiber waste – 50:50
9. Cotton waste: Natural nettle fiber waste – 70:30

**Results and Discussion:**

**Documentation of agrotextiles used by farmers of grape cultivation:**

Different farmers and cultivators from Nashik (including seven plant nurseries and two farms of grapes and pomegranate) were contacted through snowball and convenience sampling. Interviews were conducted using open ended questions relating to cultivation of crops, the use of fertilizers and the usage of agrotextiles during the cultivation. Problems faced by them were noted and scope for research was ascertained. It was found that sustainable composites were required as alternative substrates to their currently used polypropylene materials in order to relieve the cultivators from recurring cost and to prevent environment degradation.

**Preparation of Fabric Samples:**

Following fabrics were developed using cotton fiber wastes-

| Sr. No. | Name of the fabric | Composites Developed (100 %) |
|---|---|---|
| 1. | Cotton Waste fiber | 100 |
| 2. | Cotton waste: wool waste | 50:50 |
| 3. | Cotton waste: viscose rayon waste | 50:50 |
| 4. | Cotton waste: hemp waste | 50:50 |
| 5. | Cotton waste: Natural nettle fiber waste | 50:50 |
| 6. | Cotton waste: wool waste | 70:30 |
| 7. | Cotton waste: viscose rayon waste | 70:30 |
| 8. | Cotton waste: hemp waste | 70:30 |
| 9. | Cotton waste: Natural nettle fiber waste | 70:30 |

From the results it was seen that 100 % cotton waste non-woven composite could not be used for field trial as the fabric composite could not withstand the needle punch pressure during composite formation. Whereas, other all combination fabric composites were developed and used for field trial.

The developed samples were laid on the grape farms and trials were run on field for 2 months (January to March 2024) as it is the specific time of ripening of the grapes.

**Preparation and application of amaranthus extract on developed no-woven fabrics**

Amaranthus viridis and amaranthus spinosus are the two varieties of amaranthus. Amaranthus viridis is an annual herb with an upright, light green stem that grows to about 60–80 cm in height. The leaves are ovate, 3–6 cm long, 2–4 cm wide, with long petioles of about 5 cm[13]. Also, it is found in abundance in and around Nashik district. Studies have revealed that amaranthus viridis has inherent antimicrobial and Ultraviolet resistance property.

There were two extraction methods and application methods conducted on the developed non-woven fabrics. The two extraction processes are-

**Exhaution method**- It is a traditional method of extraction of dye. Alum was used as a mordant. The details are as follows-

**Fig 1. Exhaution method**

| Process Parameters | Mordanting | Dyeing |
|---|---|---|
| MLR | 1:30 (g/ml) | 1:30 |
| Concentration of Solution | 10% (o.w.f.) | 10% |
| Temperature | 80ºC | 80-90ºC |
| Time | 45 mins | 60 mins |

**Fig 2 Details of the exhaustion process of Dyeing**

**Using Soxhlet Apparatus-** In this method amaranthus was converted into powered form and extraction was done using Soxhlet apparatus.

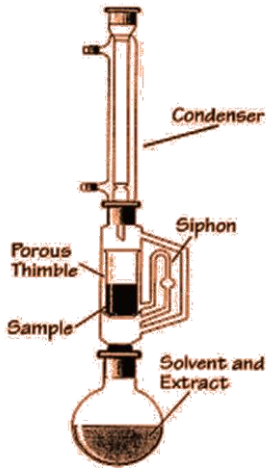


**Fig. 3. Soxhlet Apparatus**

After the dye extraction, the application of the extract on to the developed composites was done by dip method and by using padding mangle. Then the composites were laid on grape fields for field trials for 3 months.

The samples were tested on three grape vineyard farms located at different places in the city including Two farms at Panchavati, Nashik. (Mr. Sharad Gunjal and Mr. Dilip Gunjal) and One farm at Makhmalabad Naka, Nashik (Mr. Pingle)

The developed fabrics were placed in different parts of the vineyard in every farm. Some were placed on top and some of the fabrics were placed on the soil. The field trials were conducted at the time of ripening of grapes (January to March)

**Testing of developed needle punched non-woven fabrics:**

The developed composites were tested for Ultraviolet radiation of sun, moisture content and for anti-microbial property. Out of 9 composite combination, 50:50 Cotton waste : Hemp waste composite combination was found adequate for the grape vine cultivation as compared to other composite fabrics. Whereas, the remaining combinations did not show adequate results as required for the grape cultivation. Therefore, the results mentioned are of 100% hemp waste and 50:50 cotton waste and hemp waste composite fabric.

**Ultraviolet radiation test**- From the results it was seen that 100% hemp (untreated) composite showed UV A blocking 97.69% and UV A transmittance 2.31 % whereas the amaranthus treated composite showed 99.95% UV A blocking UV A transmittance 0.05%, For 50:50 cotton waste: hemp waste combination showed maximum UV A blocking 99.21% and UVA transmittance 0.79% and UV B Blocking 99.77 % and UV-B transmittance 0.23% and after the application of amaranthus the UV-A blocking increased to 99.94 %and UV A transmittance was 0.06%, whereas UV B blocking was 99.95 % and UV-B transmittance was 0.05%.

**Moisture Content** – The moisture content of 100% hemp waste composite is 8.6 % whereas the moisture content increased after amaranthus application by 10.9 % and 50:50 cotton waste: hemp waste of untreated composite was 8.0% whereas after amaranthus application moisture content was increased to 11.7%.

**Anti-microbial test**- From the AATCC 6538 and AATCC 4352 test results it was seen that both the treated and untreated 100 % hemp waste and 50:50 cotton waste: hemp waste combination showed no microbial activity.

| **Sample Name** | **Antimicrobial test result AATCC 147** | **UPFBS EN 13758-1:2002** | **Moisture content ASTM D629-2015 (%)** |
|---|---|---|---|
| 100% Hemp (untreated) | +ve | UV-A Blocking % 97.69% UV-A Transmittance % 2.31% UV-B Blocking % 99.48% UV-B Transmittance % 0.52% | 8.6% |
| 100% Hemp (amaranthus treated) | +ve | UV-A Blocking % 99.95% UV-A Transmittance % 0.05% | **10.9%** |

| | | | |
|---|---|---|---|
| | | UV-B Blocking % 99.95% UV-B Transmittance % 0.05% | |
| 50:50 Hemp: Cotton (untreated) | +ve | UV-A Blocking % 99.21% UV-A Transmittance % 0.79% UV-B Blocking % 99.77% UV-B Transmittance % 0.23% | 8.0% |
| 50:50 Hemp: Cotton (amaranthus treated) | +ve | UV-A Blocking % 99.94% UV-A Transmittance % 0.06% UV-B Blocking % 99.95% UV-B Transmittance % 0.05% | **11.7%** |

**Conclusion**

Based on the results obtained, it can be concluded that agrotextiles prepared from natural fibre waste can be utilized at various stages of cultivation of grapes. Out of all the developed composites 100 % hemp waste and 50:50 cotton waste: hemp waste combination showed adequate results which can be used as agrotextiles for grape cultivation.

From the test results, it can be seen that after the application of amaranthus extract on the developed composites the anti-microbial, UV and moisture content properties improved.

Thus, it can be concluded that needle punched non-woven fabrics developed from textile fiber waste can be used for agrotextiles application as eco-friendly alternatives for protective shades and mulch mats instead of the non-biodegradable polypropylene that is currently being used. Hence this can be considered a step towards to recycling and utilization of natural fibre waste for ecofriendly agrotextiles and sustainable choices for fruit farmers.

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