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Weaving Sustainability: Analyzing the Viability of Hemp and Recycled Cotton in Modern Textile

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ABSTRACT
Hemp and recycled cotton as sustainable textile alternatives, focusing on their environmental benefits and exploring their use in creating durable and eco-friendly fabrics.In view of increasing demands on the textile sector to switch to environmentally friendly methods, sustainable materials are highly sought for. The sustainability of combining hemp fibers with recycled cotton for textile uses is examined in this study. In analyse, the mechanical, thermal, and colorimetric characteristics of hemp-recycled cotton blends to determine their suitability for a range of textile goods. These blends perform better than regular cotton textiles in terms of UV protection, breathability, and tensile strength. The blends are also a desirable choice for eco-friendly textile production due to their reduced environmental impact. The production of cotton helps significantly to trash generation, making the textile industry one of the biggest pollutants in the world. Waste from the production of textiles, pneumafil waste, is a major environmental problem. To produce sustainable textiles, this study explores the possibility of combining hemp fibers with recycled cotton made from pneumafil waste.

Keywords: Sustainable textile, Hemp fibers, Recycled cotton, textile blends, eco-friendly, Pneumafil waste

1. INTRODUCTION

The two essential materials hemp and recycled cotton for the manufacture of clothing, industrial fabrics, and home furnishings are natural and synthetic fibers which are woven, knitted, or bonded together. The history of textiles dates back thousands of years, with the invention of textiles, early civilizations are known to use plant-based cotton and linen fibers, as well as animal-derived materials like silk and wool .Development of smart textiles, and more eco-friendly methods of production. From fashion to medical textiles, these versatile materials shape comfort, style, and functionality, making them an integral part of modern life.

Hemp is an incredibly versatile and sustainable natural fiber that's been used for centuries. It's strong, durable, and eco-friendly, making it a game-changer for textiles, paper production, and even construction materials. Hemp cultivation improves soil health, prevents erosion, and absorbs large amounts of carbon dioxide, making it a valuable tool in the fight against climate change. As people become more aware of the importance of sustainability, hemp is experiencing a resurgence in popularity. With advancements in processing techniques, hemp fabrics can now be blended with other fibers to create softer, more durable textiles. Whether it's textiles, bio plastics, or construction materials, hemp is proving to be a sustainable and eco-friendly solution that's here to stay. Hemp fibers are among the strongest and most durable natural

fibers, widely used in textiles, ropes, paper. Derived from the stalks of the *Cannabis sativa* plant, hemp fibers are known for their tensile strength, resistance to pests, and eco-friendly properties. Unlike cotton, hemp requires minimal water, pesticides, and fertilizers, making it a sustainable alternative in the textile industry. Historically, hemp was used for making sails, ropes, and clothing, dating back thousands of years. Today, advancements in processing techniques have made hemp fabrics softer and more versatile, allowing their use in high-quality clothing, upholstery, and even composite materials for construction. Additionally, hemp fibers are biodegradable and highly absorbent, making them ideal for eco-conscious industries. Due to their durability, hemp textiles outlast many synthetic and natural fabrics, reducing waste over time. Beyond textiles, hemp fibers are also used in making biodegradable plastics, eco-friendly packaging, and insulation materials.

2. METHODS AND MATERIALS

2.1 Selection of Natural fiber

Hemp (*Cannabis sativa*) is one of the world's oldest cultivated annual crops (C3 annual), traditionally grown for its long and strong bast fibers and seeds. Natural fibers like hemp contain a high specific strength and modulus, are inexpensive, recyclable, and readily available. The yarn production process provides Pneumafil Cotton Waste, which is made up of homogeneous fibers that range in thickness from 24 to 28 mm.

2.2 Fiber Extraction

Fiber extraction is a crucial and frequent procedure in fiber-related applications. The main objective is to remove the woody core and extract individual fibers, which is usually accomplished mechanically. For fiber individualization to be successful, the retting process must be interrupted at the right moment to allow the stems to dry and to make it easier for the fiber bundles to compress for release. Fiber extraction technique that makes it possible to acquire fibers more directly and does not require the retting process or stem alignment in order to feed the machine.

2.3 Production of fabric forming

In the textile manufacturing process, the step where textile fibers or yarns are turned into fabric using a variety of techniques is known as fabric forming production. This is a crucial step in the production of textiles and involves a variety of techniques based on the final fabric's qualities that are desired. Warp and weft threads are interlaced to create plain weave fabrics, with each weft thread passing over one warp yarn and under the next to form a straightforward crisscross design Weft and Warp.

2.3 Pretreatment

For a smoother finish, singeing eliminates fluff and coarse, extending fibers. Desizing Prepares the fabric for dyeing and other processes by removing sizing ingredients (such as starch) that were applied to warp threads during weaving. By removing both naturally occurring contaminants (such as oils, pectin’s, and waxes) and any additional contaminants from the production process, scouring purifies the cloth.

3. RESULTS AND DISCUSSION

3.1 Test for tensile strength

Table-1: Tensile Strength tester

SAMPLE	WARP	WEFT
75%HEMP+25%COTTON	41.1	28.6

65%HEMP+35%COTTON	40.7	23.9
55%HEMP+45%COTTON	40.2	30.3

Based on the table-1, the results were obtained for the tensile strength tester warp strength decreases gradually with increasing cotton content. This suggests that hemp fibers contribute more to warp strength—likely due to their higher tensile strength compared to cotton. Since the warp threads experience more tension during weaving, the sturdier hemp fibers provide greater support.

3.2 Test for Water Absorbency – AATCC T9: 2018

Table-2: Test for Water Absorbency

SAMPLE	TIME IN (SEC)
75%HEMP+25%COTTON	More than 60 seconds
65%HEMP+35%COTTON	More than 60 seconds
55%HEMP+45%COTTON	More than 60 seconds

The above table-2 showed the fabrics have low absorbency, regardless of the blend ratio. This could be due to the hydrophobic nature of hemp fibers, which tend to repel water more than cotton. Even though cotton is more absorbent, the presence of hemp in all blends (even at 55%) seems to dominate the fabric's moisture behavior.

4. CONCLUSION

A promising approach to sustainable textiles that effectively balances environmental responsibility, breathability, and durability is the use of hemp and recycled woven cotton fabric. Hemp contributes strength, natural antibacterial properties, and biodegradability, while recycled cotton helps minimize resource consumption and reduce textile waste. When woven together, these fibers create environmentally responsible fabrics that cater to the increasing demand for eco-friendly home and fashion applications. As the textile industry embraces circular economy principles, advancements in weaving techniques, dyeing processes, and end-of-life recyclability will further enhance the practicality and market potential of these blends. The adoption of hemp–recycled woven cotton fabric represents a meaningful step toward reducing the environmental footprint of textiles without compromising on functionality, comfort, or performance.

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