International Journal on Science and Technology (IJSAT)
E-ISSN: 2229-7677 ● Website: www.ijsat.org ● Email: editor@ijsat.org

# Sustainable Innovation in Sports Textiles

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## ABSTRACT

The global textile industry is under increasing pressure to reduce its environmental footprint while maintaining high performance in its products. This study investigates the potential of sustainable textile materials, specifically organic cotton and recycled polyester, in the creation of high-performance sports textiles using trilayer knitting technology. The research aims to compare the performance of these sustainable fabrics in various aspects, including moisture management, tensile strength, abrasion resistance, air permeability, drape behavior, and bursting strength. The two primary fabric samples tested in this study were designed using different yarns: Sample 1 consisting of cotton and polyester, and Sample 2 incorporating organic cotton and recycled polyester. The impact of reactive dyeing on the performance of the fabrics was evaluated. The results suggest that the incorporation of organic cotton and recycled polyester in trilayer knitted fabrics significantly enhances moisture management and other performance characteristics while also supporting sustainability goals. The study offers insights into the application of sustainable fibers and innovative textile technologies to meet the growing demand for eco-friendly yet high-performance sportswear.

## 1. INTRODUCTION

The textile industry is one of the most significant contributors to environmental pollution, particularly in terms of water consumption, chemical waste, and fiber disposal. As consumers and manufacturers become more aware of the environmental impacts of textile production, there is a growing demand for more sustainable alternatives. The shift towards sustainable fibers, such as organic cotton and recycled polyester, plays a critical role in addressing this issue.

Sports textiles, which require high-performance characteristics such as moisture management, durability, and comfort, are a prime focus of sustainable textile innovations. Trilayer knitting technology is one such innovation that holds significant potential. This knitting technique enables the integration of three layers of fabric into a single structure, allowing for improved moisture management, breathability, and comfort. This study investigates the performance of two different fabric configurations, both using trilayer knitting: one with traditional cotton and polyester and the other using more sustainable organic cotton and recycled polyester. The impact of reactive dyeing on the final fabric's performance is also explored, focusing on how dyeing affects the fabric’s properties and environmental impact.

## 2. METHODOLOGY

### 2.1 Yarn Selection

The yarn selection is a critical step in determining the sustainability and performance of the final fabric. For this study, organic cotton and recycled polyester yarns were chosen for their eco-friendly properties. Organic cotton is grown without harmful pesticides and fertilizers, which significantly reduces its environmental footprint. Recycled polyester (rPET), on the other hand, is made from post-consumer plastic bottles, thus contributing to the reduction of plastic waste and the need for virgin polyester.

### 2.2 Fabric Formation: Trilayer Knitting

The fabrics were produced using trilayer knitting technology, which integrates three distinct layers within a single knitted structure. The top and bottom layers were made of either organic cotton or cotton to ensure comfort and breathability. The middle layer, made of recycled polyester or polyester, provides enhanced moisture-wicking properties, allowing the fabric to manage sweat and regulate body temperature effectively during physical activities. This This innovative fabric construction helps balance comfort, durability, and moisture management—all key factors for sportswear.

### 2.3 Dyeing Process

The fabrics were dyed using reactive dyes, a sustainable dyeing method that chemically bonds with the fabric fibers, improving colorfastness and water usage efficiency. Unlike conventional dyeing methods, reactive dyeing uses water-based dyes, which are more eco-friendly and minimize the environmental impact by reducing the use of toxic chemicals. The dyeing process was carried out both before and after performance testing to evaluate the effect of dyeing on the fabric's performance.

### 2.4 Performance Testing

To evaluate the performance of the fabrics, the following tests were conducted:

- **Moisture Management Test (MMT):** This test measures the fabric's ability to wick moisture away from the skin and allow it to evaporate. The wicking ability of fabrics is crucial for activewear, as it helps keep the wearer dry and comfortable.
- **Tensile Strength Test:** The tensile strength of the fabric was measured by applying force to the fabric until it broke. This test assesses the fabric's durability and its ability to withstand stretching during physical activities.
- **Abrasion Resistance Test:** This test simulates the wear and tear the fabric will experience under friction. Sports textiles must be durable enough to resist damage from regular use and repeated washing.
- **Air Permeability Test:** This test evaluates the fabric's breathability, which is essential for maintaining comfort during physical activities. Fabrics with high air permeability allow better ventilation, keeping the wearer cool during exercise.
- **Drape Test:** This test evaluates the ability of the fabric to drape or hang naturally when placed over a flat surface. In sportswear, good drape behavior ensures that the fabric conforms to the body and maintains a comfortable fit without stiffening or creating discomfort.

- **Bursting Strength Test:** This test measures the ability of the fabric to withstand pressure before it bursts. It simulates the stress the fabric might endure in intense physical movements. A higher bursting strength is critical for durability in activewear

## 3. RESULTS AND DISCUSSION

### 3.1 Moisture Management Test (MMT)

Before dyeing, Sample 1 (cotton, polyester, cotton) exhibited a moisture management rating of 3, while Sample 2 (organic cotton, recycled polyester, organic cotton) scored 3.5, indicating a superior moisture-wicking ability for the organic cotton-recycled polyester combination. After dyeing, Sample 1 saw a slight decrease in performance, dropping to 2.5, while Sample 2 maintained its moisture management rating of 3.5. This shows that the combination of organic cotton and recycled polyester performs better in moisture management even after the dyeing process.

**Table 3.1 Moisture Management Test (MMT)**

| Sample | MMT Rating (After Dyeing) | Difference (Before vs. After) |
|---|---|---|
| **Sample 1 (Cotton-Polyester-Cotton)** | 3.1 | 0.1 |
| **Sample 2 (Organic Cotton-Recycled Polyester-Organic Cotton)** | 3.5 | 0.0 |

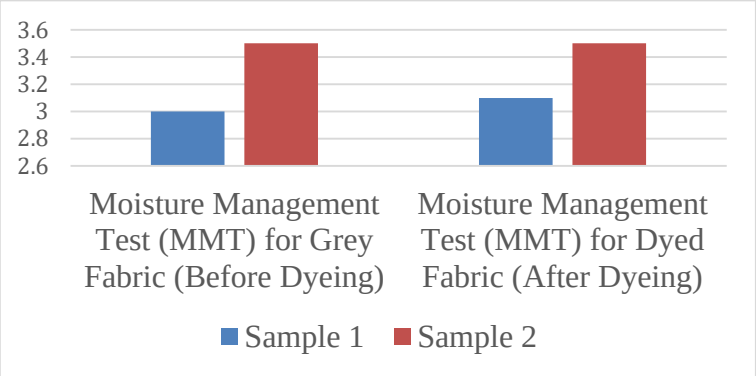


**Figure 3.1 Moisture Management Test (MMT)**

### 3.2 Tensile Strength

In terms of tensile strength, Sample 2 outperformed Sample 1, indicating that the recycled polyester in Sample 2 contributes to improved fabric strength. This is a key factor for sportswear, which undergoes significant stretching and pulling during physical activities.

**Table 3.2 Tensile Strength**

| Test Condition | Sample 1 | Sample 2 |
|---|---|---|
| **Tensile Strength (N)** | 92 | 100 |

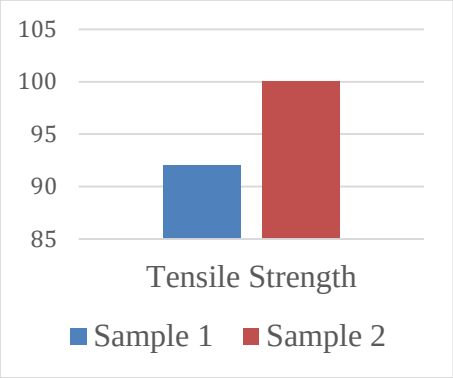


**Figure 3.2 Tensile Strength**

### 3.3 Abrasion Resistance

Sample 2 exhibited higher abrasion resistance compared to Sample 1, showing that the use of recycled polyester in the middle layer of the fabric increases its durability. This is important for sports textiles, which need to withstand frequent washing and wear from contact with various surfaces during exercise

**Table 3.3 Abrasion Resistance**

| Test Condition | Sample 1 | Sample 2 |
|---|---|---|
| **Abrasion Resistance (cycles)** | 30/45 | 40/45 |

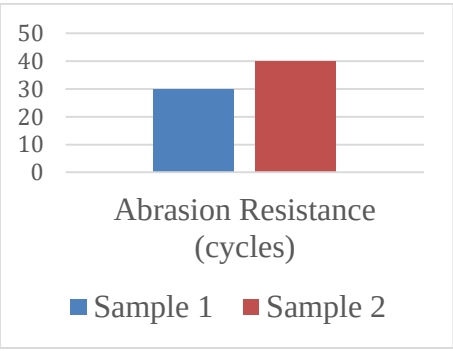


**Figure 3.3 Abrasion Resistance**

### 3.4 Air Permeability

The air permeability test demonstrated that Sample 2 allowed for better ventilation than Sample 1, making it more breathable. The combination of organic cotton and recycled polyester promotes airflow, which is essential for comfort during intense physical activity.

**Table 3.4 Air Permeability**

| Test Condition | Sample 1 | Sample 2 |
|---|---|---|
| **Air Permeability ($cm^3/s$)** | 300 | 350 |

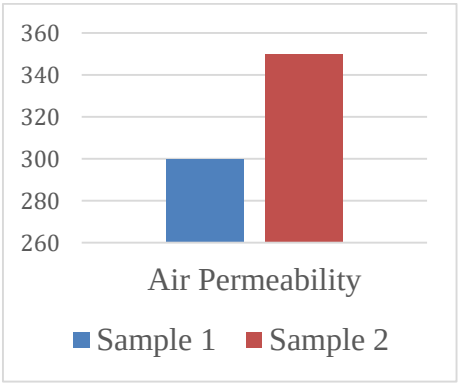


**Figure 3.4 Air Permeability**

### 3.5 Drape Behavior

The drape test results indicated that Sample 2 displayed superior drape characteristics compared to Sample 1. The organic cotton-based fabric provided a smoother, more natural drape, ensuring a better fit on the body and enhancing comfort. This behavior is crucial for sportswear, where fabric fit and comfort are essential for performance.

**Table 3.5 Drape Behavior**

| Test Condition | Sample 1 | Sample 2 |
|---|---|---|
| **Drapery Rating** | 3.0 | 4.0 |

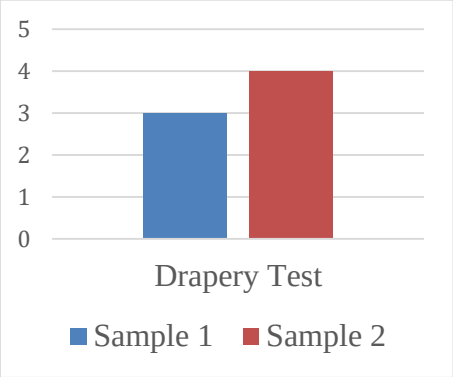


**Figure 3.5 Drape Behavior**

### 3.6 Bursting Strength

Sample 2 exhibited a higher bursting strength than Sample 1, suggesting that the incorporation of recycled polyester adds strength and resistance to pressure. This is particularly important in activewear, which is subjected to high-stress levels during physical activities.

**Table 3.6 Bursting Strength**

| **Test Condition** | **Sample 1** | **Sample 2** |
|---|---|---|
| **Bursting Strength (kPa)** | 210 | 230 |

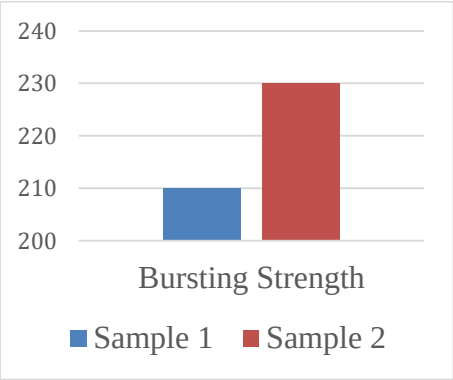


**Figure 3.6 Bursting Strength**

## 4. CONCLUSION

This study demonstrates that the combination of organic cotton and recycled polyester using trilayer knitting technology provides superior performance in key areas such as moisture management, abrasion resistance, tensile strength, air permeability, drape behavior, and bursting strength when compared to traditional cotton and polyester fabrics. The reactive dyeing process further supports the sustainability of

the fabric without compromising its functionality. The results suggest that this innovative fabric combination can be an ideal solution for sustainable sports textiles that meet the performance needs of athletes while also addressing environmental concerns. The findings of this study offer valuable insights for the development of sustainable, high-performance sportswear that contributes to a more eco-friendly textile industry.

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