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Eco-Friendly Dye from Waste Leaves of Almond Tree (Terminalia Catappa)

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Abstract: *Today, people are becoming more aware of environmental problems, so the use of safe and natural dyes on textiles is gaining importance. Many synthetic dyes are harmful to human health and can even cause serious diseases. They also create a large amount of pollution during their production and use. Because of these problems, there is a growing interest in bringing back natural dyeing methods as a safer alternative.*

One of the best ways to reduce environmental pollution is to replace harmful chemicals with eco-friendly natural materials. Many natural resources that are usually thrown away as waste actually contain useful coloring substances.

In this study, a natural dye was extracted from the waste leaves of Terminalia catappa (tropical almond tree). The dye was applied to cotton fabric that had been treated with both eco-friendly and chemical mordants. The results showed that the cotton fabrics developed different attractive shades,. This study proves that waste leaves can be turned into a useful and environmentally friendly dye for textile applications.

Keywords: Natural dye, Eco-friendly ,Terminalia catappa, Sustainable dyeing, Cotton fabric , Environmental pollution reduction

1. Introduction

The textile industry plays an important role in daily life, but it is also one of the major sources of environmental pollution. The use of synthetic dyes in textile processing releases harmful chemicals into water bodies, causing damage to ecosystems and posing health risks to humans. These dyes are often non-biodegradable and require large amounts of water and chemicals during processing. Due to growing environmental awareness and stricter regulations, there is an increasing demand for safer and more sustainable dyeing methods.

Natural dyes are safer for the environment compared to synthetic dyes. They are obtained from plants, animals, or minerals and are generally biodegradable and less toxic. Among plant sources, leaves, bark, roots, and fruits have been traditionally used for dyeing textiles. Natural dyes are especially suitable for cotton fabric, which is widely used because of its comfort, breathability, and natural origin. However, the use of natural dyes has declined due to challenges such as lower color fastness and lack of standardized dyeing methods.

Indian almond (*Terminalia catappa*) is a tropical tree commonly found in many parts of India and other coastal regions. Its fallen leaves are often treated as waste, even though they contain natural coloring compounds such as tannins and polyphenols. These compounds have the ability to bind with cellulose fibers in cotton and produce natural shades ranging from yellow to brown. Using fallen leaves as a dye source also supports waste utilization and sustainable resource management.

This study focuses on exploring the potential of *Terminalia catappa* leaves as an eco-friendly natural dye for cotton fabric. The work aims to extract dye from the leaves using simple methods and to evaluate the dyeing performance on cotton. By promoting the use of plant-based dyes, this research supports environmentally responsible textile production and contributes to the development of sustainable alternatives to synthetic dyes.

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2. MATERIAL & METHODOLOGY

MATERIAL:

Plant material: Waste fallen leaves of Terminalia Catappa (fresh or dried)

Fabric: cotton fabric

Chemicals (for mordanting):

Alum (Potassium Aluminum Sulphate)

Ferrous sulphate ($FeSO_4$)

Equipment: Beakers, digital balance, dye bath, thermometer



3. METHODOLOGY

COLLECTION AND PREPARATION:

Fallen and dried leaves of Terminalia catappa were collected from local surroundings. Only naturally shed leaves were selected to ensure sustainability.

The Terminalia catappa leaves were washed with water to remove dust and impurities. They were then shade-dried for several days until completely moisture-free.The dried leaves were crushed and ground into a coarse powder to increase the surface area for extraction.

EXTRACTION:

Approximately 20 g of leaf powder was boiled in 200 mL of distilled water for few minutes. The mixture was allowed to cool and then filtered using muslin cloth or filter paper to obtain the dye extract.

PRE-TREATMENT OF COTTON FABRIC:

SCOURING:

Cotton fabric pieces were scoured by washing with mild detergent to remove any finishing chemicals and dried before dyeing.

MORDANTING:

To improve color fixation, different mordants such as alum, iron sulphates were used. Fabric samples were soaked in mordant solution before dyeing.

DYEING PROCESS & DYE APPLICATION:

The pre-treated cotton fabric was immersed in the dye extract and heated at moderate temperature for few minutes with continuous stirring. After dyeing, the fabric was rinsed and shade-dried.

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Non mordant | Alum as mordant | $FeSO_4$ as mordant

4. RESULT & DISCUSSION

The waste fallen leaves of the almond tree (*Terminalia catappa*) were used to prepare a natural dye. After boiling the dried leaves in water, a dark brown colored liquid was obtained. This shows that the leaves contain natural coloring substances.

When this dye was applied to cotton fabric, different shades of brown were produced.

- Without any mordant, the fabric became light brown.
- With alum mordant, the fabric turned dark brown and looked brighter.
- With iron mordant, the fabric became almost black.

This means mordants help to improve the color and make it darker or brighter.

The cotton fabric absorbed the dye well, especially when mordant was used before dyeing. Higher dye concentration gave deeper color. The study proves that waste almond leaves can be used as a natural and eco-friendly dye source. It produces different brown shades on cotton fabric and gives satisfactory durability.

This method is safe, low-cost, and environmentally friendly compared to synthetic dyes.

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