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RESEARCH ARTICLE

Challenges and opportunities in product development using natural dyes

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Abstract

Dyeing is a crucial textile technology procedure and one of the most enjoyable Textile Arts. Dyeing is an ancient art form that predates our civilization. All over the world the coloring of textile material is done with bleached fabric using natural and synthetic dyes. Coloring with natural materials is now commonly used as a supplement to hand spinning, knitting, and weaving. This study aims to compare the effluent properties of synthetic and natural dyes. Additionally, a product was created utilizing natural dyes because they are safe for the environment.

This research article compares effluent parameters for natural and artificial dyes used for dyeing cotton fabrics, with a focus on fastness attributes, because while colouring the textile materials not all dyes are transfer, around 10-15% of dyes will remains in dye bath itself. When this effluent discharge, it is intensely colorful and aesthetically unpleasant and it will produce environmental problems.

Keywords: Dyeing, Natural material, Effluent parameters, Eco-friendly, Sustainable.

Introduction

Dyeing is a crucial textile technology procedure and one of the most enjoyable Textile Arts. Dyeing is an ancient art form that predates our civilization and still practiced in North countries (Denton and Daniels, 2002). This article looked at the effluent characteristics of both artificial and natural dyes, and a product was created using artificial and turmeric colors that are both environmentally safe and functional (Samanta and Agarwal, 2009).

This research article compares effluent parameters for natural and artificial dyes used in cotton fabrics, with a focus on fastness attributes. During the coloring process, a large amount of the dye does not bond to the material and is lost to the waste product steam. During the coloring method, around 10 to 15% of dyes are discharged into the environment, making the effluent intensely colorful and aesthetically unpleasant (Prabhu and Bhute, 2012).

Literature Review

Since prehistoric times, natural colors were used for food substrates, animal skin, and textile materials. Due to high fastness and attractive colors, synthetic dyes were used rather than natural dyes (Vankar, 2000). Natural dyes do not give excellent fastness properties since these organic dyes are not suitable for dyeing natural materials. Furthermore, global textile consumption is estimated to be around 30 millstones and is expected to grow at a rate of three times per year. Natural dyes can be used to dye a wide range of natural fibers. As per a recent study, they'll even be capable of dyeing some synthetic materials

Extraction Methods

The information gap is one of the most essential areas to use Natural-Dyes. Only a few significant efforts have been made to acquire fresh information on the use of natural dyes. The characteristics and solubility of coloring components should be observed before the extraction process. There are several methods to extract natural dyes which are mentioned below:

- Simple Aqueous Extraction Methods
- Complicated Solvent Extraction
- Super-Critical Fluid Extraction
- Ultra-Sonic and Micro-Wave Assisted Extraction
- Alkali or Acid Extraction

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• Fermentation
• Enzyme Extraction

Simple Aqueous Extraction Method

The extraction process was used to extract colors from plants and other natural elements. To compare the extraction process, the raw materials are broken into small pieces and soaked in water for 2 to 3 days to loosen the cell structure and promote dye resolution. Where it is then filtered and used for dyeing the textile materials (Singh et al., 2005).

Classification of Dyes by Dye Class

Azonic Dyes

Bright colors, particularly those in the Orange-Scarlet-red spectrum as well as some blue and black hues, are produced with azo dyes. This dyestuff's hue is determined by the precise diazole and coupling components that are utilized.

Reactive Dyes

Reactive dyes are applied from a high-pH solution or a neutral solution that is alkalized in a separate procedure. Different colors are sometimes brought out by applying heat to the dyed textile (Singh et al., 2005).

Classification of Natural Dyes

Based on Structure

• Indigoid Dyes
• Anthraquinone Dyes
• Alphanaphthoquinoness
• Flavonoids
• Di-hydropyrans
• Antthocyanidins
• Carotenoids

Potential Sources of Natural Dyes

• Roots
• Leaves
• Twigs
• Stems
• Heart-Wood
• Bark
• Wood
• Shavings
• Flowers
• Fruits
• Rinds
• Hulls

Plants Used

Flower of the Peacock (CaesalpiniaPulcherima) Bougainvillea
• Bougainvillea - Bougainvillea - Bou (Bougainvillea glabra)
• Root of beet (Beta Vulgaris)
• Cabbage (Red) (Brassica oleracea)
• Skin of anonionsAllium cepa)

Fresh veggies and flowers, particularly those with vibrant hues, were chosen. For better extraction, the skin was peeled and grated with a vegetable grater. In 5 to 10 grams of grated veggies were added to 100 mL of distilled water and thoroughly cooked until the dye was released into the water. This should take at least 15-20 minutes for the entire extraction to be discharged into the water. This should take at least 15- 20 minutes to complete the extraction (Vankar and Shukla, 2019). [7].

Animal Origin

The source of red color is obtained from insects derived from animals and it was documented as animal product. As a result of its strong affinity for animal fibers, it was previously used to color them. However, due to its widespread availability as a by-product, research shows it is effective in painting plastic fibres (Kamboj, Jose and Singh, 2021).

Natural Dyes on Textiles

Characterization & Chemical/Bio-Chemical Analysis of Natural Dyes

• Macro & Micro Chemical Analysis
• UV Visible Spectroscopic Study
• Chromatographic analysis
• Test of Toxicity

Methods of Natural Dyeing

• Conventional dyeing
• Non-Conventional dyeing

Colour Fastness Properties of Natural Dyed Textiles

• Lightfastness
• Wash Fastness
• Rub fastness

METHODOLOGY

The study aims to learn about the differences between natural and synthetic dyes, as well as how well natural dyes are environmentally benign and sustainable. The following are the dyeing materials:

Turmeric is a ubiquitous spice that comes from the monocot genus turmeric. It contains compounds curcumin and cumin, which helps to reduce edema. Turmeric includes bioactive chemicals with medicinal effects, and it can boost brain-derived tropism factors and reduce the risk of heart disease (Shahidi et al., 2021).

A fast-growing tree in the Mahogany family (Meliaceae) used as a medicine is neem, also known as the nim tree an organic pesticide source, and for its wood. *Melia azedarach* is said to be indigenous to the Indian subcontinent and arid portions of South Asia. Immunomodulatory, anti-inflammatory, anti-hyperglycaemic, and anti-carcinogenic properties of neem leaf and its components have been proven. The materials were natural resources, such as neem

tree and turmeric, which were used to color cotton fabric. The neem plant, also known as *Azadirachta Indica*, is a member of the Meliaceae family of trees.

The turmeric plant is also known as *Curcuma longa* from rhizome and Zingiberaceae. The dried leaves of neem and turmeric were ground using a victimization grinder type for effective extraction after being removed from the plants and rinsed completely with water five times. The simple binary compounded extraction technique is used in this case.

Poplin is a fine but thick fabric. It is a basic weave fabric that is easy to care for and resists wrinkles. Poplin can be bleached, dyed, or printed, making it suitable for a wide range of ensembles. The fabric utilised in this research was 100% cotton poplin plain woven cloth.

Neem Leaf Extraction

The leaves of neem plants (*Azadiracta indicia*) were dried and washed repeatedly under running water to remove dust particles and soluble contaminants, then dried at room temperature (24–25°C) before being crushed into a fine powder in an electrical grinder (Fröse, et al., 2019).

Turmeric Extraction

The turmeric was dried and rinsed repeatedly under running water to remove dust particles and soluble contaminants and then left to dry at room temperature (24–25°C) before being crushed into a fine powder in an electrical grinder (Güzel and Karadag, 2021).

Dyeing

Scouring

The initial step in the dyeing process is scouring. If the fibers are not thoroughly scoured, the dye may stick to the residual coating rather than the fiber itself. The colors will not fully permeate the fabric, leading it to dye unevenly. Scouring is a submerged chemical process. Depending on the type of fabric, different water temperatures and scouring chemicals are used.

Mordanting

This process is called simultaneous mordanting when the dye and mordant are combined and applied simultaneously. Prior to applying the mordant, the dye is applied.. Dyeing comes initially, followed by mordanting in post-mordanting. Cotton is not a good match for natural dyes. Tannins are widely utilized to create ready cotton in order for it to preserve its coloring matter for a long period of time. Tannin or tannic acid is thus the most frequent mordant for cotton. On standing, the aqueous solution of tannic acid decomposes gradually due to fermentation. The addition of boric acid stops the breakdown process. During dyeing, metal tenants from insoluble lakes leave a gift on the textile, which is then dyed with natural dyes (Tutak and Korkmaz, (2012).

Table 1: Process Condition

Sl.No	*Process Condition*	*Neem*	*Turmeric*
1	Dyes (%)	90	10
2	MLR	1:40	1:40
3	Temperature (°C)	100	100
4	Duration (hour)	1	1
5	Mordant	Alum	Alum

Dyeing Parameters

The Table 1 represents the process condition for dyeing the cotton fabric using neem and turmeric.

Process Parameters

M:L:R - 1: 20
Temperature –90 °C
Time –30 minutes

Testing

1. Wash fastness - 15, 30, 45, 60 minutes (ASTM D2096 -11)
2**.** Rubbing - dry and wet rubbing

Dyeing Process

Processing of poplin cotton fabric at 100°C for 60 minutes using a mordant (alum) and natural coloring material derived from turmeric and neem in a liquor ratio of 1:40. The dyeing solution was applied to the fabric sample while submerged in a water bath set at 40°C (Habib, et al., 2021).

RESULT AND DISCUSSION

The following result were analysed for cotton fabric dyed with neem and turmeric as mentioned below:

Color Fastness to Washing

Consumers are always interested in how quickly the color changes is a feature of fabrics. This is due to the fact that a fabric's beauty is useless unless the dye is resistant to the environment in which the fabric will be utilised.

The result analysed the wash fastness for Neem and Turmeric dyed fabric with different temperatures, as shown in Table 1 such as 60, 70, 80, 90 and 100°C with different timings such as 15, 30, 45 and 60 minutes. At 60 to 70°C grade with a duration of 15 to 60 minutes the Wash fastness was very good and it was equal to hand wash, then at 80 to 90°C. The wash fastness was moderate with a duration of 15 to 60 minutes and it was equal to machine wash. At 100°C, the wash fastness was poor with a duration of 15 to 60 minutes. But the result overall analyzed that it can withstand up to 15 wash cycles.

Wash Fastness

Table 2 shows the wash fastness of cotton fabric dyed with neem

Table 3 represents the Wash fastness of cotton fabric which is dyed with natural dye – turmeric

Tables 2 and 3 show the color bleed occurs when the fabric

Table 2: Wash-Fastness of Cotton Fabric Dyed with Neem

Temperature (°C)	*15 Min*	*30 Min*	*45 Min*	*60 Min*
60	4	4	4	4
70	4	4	4	4
80	3	3	3	3
90	3	3	3	3
100	1/2	1/2	1/2	1/2

Table 3: Wash Fastness of Cotton Fabric Dyed with Turmeric

Temperature (°C)	*15 Min*	*30 Min*	*45 Min*	*60 Min*
60	4	4	4	4
70	4	4	4	4
80	3	3	3	3
90	3	3	3	3
100	1/2	1/2	1/2	1/2

gets wet, and dye leaches out of the fibres. This commonly occurs in the washing machine and can result in color transfer between items in the load. color fading is when the fabric has lost much of its dye and therefore lacks vibrancy and depth. In this tabulation, we came to know that in 60 and 70°C**,** The color bleeding is low and also in 80 and 90°C the color bleeding is moderate i.e. The color bleeding increases when compared to 60 and 70°C and finally, in 100°C has lost most of its color and the bleeding is high when compared to other degrees. However, it may be argued that exposure to temperatures of 80°C or more for 15 minutes provided enough resistance to light prevents fading, and temperatures of 100°C from 15 seconds onward improved wash fastness (Sk et al., 2019).

Rubbing Test

A rub test is used in the textile industry to evaluate a fabric's color fastness. This test is crucial. Its fastness to rubbing determines how effectively a fabric resists stains. A test for fastness to rubbing can be conducted on dry or wet fabric.

Dry Rubbing

- Place the specimen on the Crock-mold meters using the fixing clamp. The specimen's long direction is aligned to the rubbing track, ensuring that it lays flat on the baseboard.
- Two experiments are done: one on the direction of the warp/length so the difference in the weft/width, and the other on the direction of the warp/length and so the discrepancy in the weft/width.
- Place a dry rubbing cloth flat over the top of the peg on the crock meter and secure it with the spring clip provided; ensure sure the rubbing cloth is not positioned on the diagonal in the direction the peg is moving.
- Rest the finger on the check specimen, making sure the spring clip isn't caught in the specimen.
- Rub the specimen back and forth for fifty complete cycles (i.e. ten times back and forth) at a speed of one second for every cycle on a straight track 100 + 8 mm in length.

Wet Rubbing

- To get 100% pick-up, wet a rubbing cloth with water and then use it.
- Weigh the dry rubbing cloth, squeeze the wet rubbing cloth between the papers, and re-weigh on the scale. Make adjustments as necessary by blotting out excess water or re-wetting.
- Do the appropriate method in compliance with the Dry-rubbing technique.
- Permit the temperature to dry the tested rubbing cloth.
- Colorfastness to multi-fiber is used in each dry and wet rubbing (i.e, Wool - Acrylic - Polyester - Nylon - Cotton - Acetate)

The result stated in Table 4 shows the BOD, COD and TDS values of 1-kg of cotton fabric. Hence we came to know that Natural dyes are proven to be lower than Synthetic dyes.

Total dissolved solids (TDS) is a measure of the dissolved combined content of all inorganic and organic substances present in an exceeding liquid in molecular, ionized or micro-granular (Colloidal Sol) suspended form principal application of TDS is within the study of water quality for streams, rivers and lakes. According to the EPA Secondary drinking water regulations, 500 ppm is the recommended maximum amount of TDS for your drinking water. Hence Table 4 explains about differences between synthetic and natural dye solutions (Neem/Turmeric). Turmeric and neem dyed garments are shown in Figures 1 and 2.

The BOD value is frequently stated in milligrams of chemical element composed per cubic decimetre of the sample after three (or) five hours of germination at 20 to 27°C and is commonly used as a surrogate for the degree of organic pollution in water. The reduction of BOD is being used to assess the efficacy of waste-water treatment plants.

The chemical oxygen demand (COD) is a measure of the quality of chemical elements that reactions in a sampled solution can consume. It's usually measured in grams per cubic decimetre (mg/L), which is the mass of the chemical element consumed divided by the volume of the solution. The dye solution is incubated at 27°C for 3 days without being broken (RohaniShirvan, Kordjazi, and Bashari, 2021).

Suggestion

Natural dyes are environmentally friendly since they

Table 4: Comparision of synthetic and natural dye solutions

S.No	*Test*	*Synthetic dye solution*	*Neem dye solution*	*Turmeric dye solution*
1	BOD	820	670	102
2	COD	2500	2027	327
3	TDS	4800	1310	338

Figure 1: Turmeric dyed garment

Figure 2: Neem dyed garment

are biodegradable, non-toxic, and do not cause allergic reactions or cancer when they come into contact with human skin. The development of a modern extraction process and a user-friendly approach will entice various industries to employ natural dyes in their supply chains. Similarly, because the effluent footprint generated by natural dye production has a reduced environmental impact, this paper recommends natural dyeing.

Conclusion

Dyeing is one of the traditional way for applying colors to the fabric. Most textile materials were dyed using Synthetic dyes, which create lots of pollution and harm the environment. After analyzing the research, various parameters like BOD, COD and TDS of neem and turmeric dye solution were compared to synthetic dye solution (Reactive Dyes)

The result analyzed the BOD, COD and TDS have been reduced when compare to synthetic dyes such as and wash fastness for neem and turmeric dyed fabric, the wash fastness was good at 60 to 70°C upto 60 minuts and at 80 to 90°C the result analyzed was moderate upto 60 minutes and at 100°C the result analyzed was poor. Compared to dry and wet rubbing, the Wet rubbing was good for both neem and turmeric-dyed samples. The grey scale reading shows 4 to 5. Thus, by using natural dyes, environmental hazards can be reduced and sustainable products can be developed.

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