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# Application of Natural Dyes for Herbal Textiles

*Anupama Mishra and Sapna Gautam*

## Abstract

Clothing, the second skin of our body, is of immense importance in human life and has been evolved continuously. Textile products having special properties are used for umpteen purposes, and one such product is herbal textiles. Changing trends in clothing, cosmetics, and aesthetics necessitates the development of newer technologies that can benefit end users by enhancing their health and aesthetics and provide a sense of relief and satisfaction. Herbal textiles are prepared by imparting essential oils and herbal extract finishes to textiles. These treatments provide medicinal value and aroma to the garment, which enhance its value. Herbal extracts and oils can be incorporated in textiles by microencapsulation, sensory perception technology, liposomes, dyes, and coated textile technology. The temperatures of the finish, the duration and concentration of plant extract, the blend of herbs, and the equipment used need to be carefully controlled. Herbal textiles are revitalizing and help in keeping the body fresh and healthy. These fabrics also shown to have therapeutic value in ailments like skin allergies, breathing problems, sleeping disorders, and blood pressure. In this chapter, emphasis is given on the significance of herbal clothing and the use of natural herbal extracts to produce them.

**Keywords:** natural dyeing, herbal finishes, herbal extracts, functional finishes, herbal wear

## 1. Introduction

Textiles are susceptible to micro-organisms and their products (e.g. toxins) known to cause infection and intoxication. Myriad textile products such as herbal textiles and clothing are available in the market to support healthy lifestyle and hygiene. Most textile products are meant to come in contact with the skin; hence, herbally treated fabrics are better choice as they do not harbor harmful chemicals and thus are ecofriendly. People of yore used to live in harmony with nature and passionately protected their environment; however, nowadays, excessive exploitation of natural resources has led to a phenomenal increase in environmental pollution. This is taking a serious toll on the lives of all living beings on the planet earth. Right kind of fabric is of paramount importance to a healthy lifestyle, and synthetic fabrics' teeming with chemicals and dyes poses severe health threat. One would not like to eat a bowl of pesticide-drenched food. Then, why wear clothing doused in chemicals? Textile dyes obtained from natural sources are usually friendly to human skin and are biodegradable and ecofriendly. Some natural dyes have medicinal properties and impart healing qualities to the fabric. They are ecofriendly, save energy, provide rural employment, and preserve traditional craftsmanship [1].

Clothing is our second skin and plays an important role in human life. Textiles finished or dyed from extracts of various medicinal herbs are called herbal textiles. Textiles and clothing infused with medicinal herbs are becoming popular, especially in urban India. The use of such products helps in providing protection against myriad biological toxins and pathogens. Customers demand for new ranges of technology, owing to upward trend in enhancing beauty, that provide better esthetics along with improved health and a sense of relief and satisfaction during use. This trend has produced Cosmetotextiles.

Among technical textiles, medical textiles are a promising product, which plays an important role in maintaining the human health. Medical textiles consist of textiles used in operative and postoperative tasks on and around the patient and medical practitioners. They are broadly classified as nonimplantable materials, implantable materials, extracorporeal devices, hygiene products, protective, and healthcare textiles. Healthcare, disposable, and nondisposable hygiene products mainly used in hospitals to reduce the chances of contamination by biological toxins and infectious organisms.

India has good potential to produce natural dyes commercially as it is considered as 1 of the 17 mega diversity countries globally [2]. Traditional knowledge facilitates the use of plants and their products for healing the wounds and burn injuries and treating the skin infections. Herbal extracts are being used successfully for imparting antimicrobial finish to textiles [3].

Herbal products derived from plants are gaining popularity worldwide for use in textiles on account of their easy availability, green approach, low toxicity, biocompatibility, and ecofriendly nature [2, 3]. Owing to market demand for textile products having added comfort and functional properties, herbal products may be explored for their potential benefits to produce such products. This mandates scientists to devise methods and techniques to use plants containing bioactive agent in producing value added and more attractive functional textile substrates. Insect repellent, deodorizing/aroma, UV protection, antimicrobial, and flame retardant are some of the new properties, which have been imparted recently to textiles. In recent years, the growing demand for herbal products has led to the idea of developing healthcare textile products using herbal extracts.

Currently, herbal colorants are the most attractive option because of high biodegradability, low toxicity, green chemistry, and potential application in the textile dyeing and finishing industry. Natural colorants from plant sources are considered as novel agents in imparting multifunctional properties such as antimicrobial, insect repellent, deodorizing, and UV protection to textiles. Many natural colorants possess some inherent functions in addition to their coloring attribute. These inherent properties are transferred to the textile substrate dyed with an herbal colorant. Alternatively, dyeing textiles with these herbal colorants can combine dyeing with functionality finishes, an ecofriendly process using less water and energy than currently used separate wet treatments. Recently, increased interest in the use of natural dyes in textile dyeing has been observed due to enforcement of the stringent environmental regulations by many countries because of toxic effects of synthetic dyes. This review gives an overview of the herbal methods available at present for dyeing textile materials with aim to provide other useful finishes [4].

## **2. The herbal textile concept**

Textiles dyed exclusively with herbal extracts without using any chemicals are called herbal textiles. The herbs utilized in dyeing are different from vegetable dyes as they also have medicinal values. These herbs are applied to the fabric using natural ingredients in order to preserve medicinal properties. Further, bleaching

of cloth is done by exposing it to sunlight without the use of any chemical bleach. The concept of herbal textiles has been derived from Ayurveda, the ancient Indian method of vedic healthcare. Ayurveda is a branch of Ayurveda. In Sanskrit, *ayur* means health, and *veda* means wisdom, while *vastra* means clothing when it combines the meaning life cloth [5].

It is made by embedding essential oils and herbs into textiles. A wide range of herbs such as turmeric, tulsi, neem, rose, Indigo, lemon grass, castor, and ber can be used for this process providing medicinal value and aroma to the fabric. Ayurveda (marketed as cosmetotextiles) has been used for curing several diseases such as diabetes, arthritis, skin infections, hypertension, and hay fever [5].

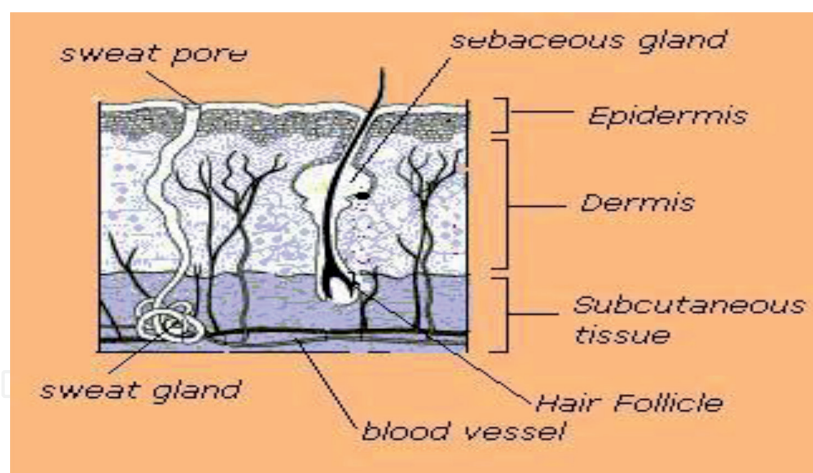
Herbal clothing is an ancient technique of dyeing textiles in medicinal herbs. This alternative method of treatment originated more than 5000 years ago in India. Its core principles are rooted in the Vedas, which are an ancient book of Hindus. The Vedas date back to around 3000 BC. The science of life or Ayurveda dates back to around 1000 BC. The origins of Ayurveda are also found in the Atharvaveda. It contains incantations and hymns that cure various diseases through mantra. Mythology says that Ayurveda was given to Dhanvantri by Lord Brahma. Charaka Samhita and Sushruta Samhita are the oldest known Ayurvedic texts [6]. About 100 years ago, people from different parts of India were using various forms of natural dyeing in which they repeatedly dipped clothes in herb-based preparations following each wash [7]. These herbs are used traditionally in Ayurvedic treatment and many medical applications. When this fabric is worn, the medicinal property of the fabric is then transferred to the skin. The process of herbal dyeing was developed through extensive research during the age-old dyeing methods practiced since the days of the Indus civilization. Herbs were used to create different colors and to provide various health benefits. The natural/herbal fabrics are 100% organic, completely free of synthetic chemicals, and toxic irritants and are biodegradable [8].

Herbal clothing is prepared from organic cotton fabric impregnated with special herbs and oils for health benefits. Since ancient times, herbal clothing (Ayurveda) is believed to cure diabetes, skin infections, psoriasis, hypertension, asthma, arthritis, rheumatism, high blood pressure, eczema, and cancer. Antimicrobial property or natural dyes such as indigo, pomegranate, myrobalan, and Indian madder of against bacteria such as *Escherichia coli* and *Klebsiella pneumoniae* have been reported [9]. Herbs such as harad, rakta chandana, shweta chandana, and kumkuma are used in Ayurveda for protecting the skin from harmful rays of sun. The herbal preparations act on melanocytes present in the skin, modulate their function, and block the effect of UV rays on the skin. References in different texts of Ayurveda are replete with examples of wearing pure cotton clothes impregnated with herbs such as chandana, haridra usheera, manjista, and nimbi aragwadha to safeguard human body from inclement weather and to keep it healthy. They used herbal products such as soap nut and lime for washing cloths before soaps and detergents were discovered. Herbal textiles and dyes have great vista of applications in diverse walks of human life. These herbal dyes have been used for centuries to produce colors for fabrics, yarns, leather, food, and so on. Natural dyes exhibit better biodegradation and have a better compatibility with the environment. The application of natural dyes has the potential to earn carbon credit by consumption of fossil fuel-based synthetic dye [10].

### 3. Mode of action of herbal textiles on the body/herbal couture technology

Skin is the largest sense organ in the human body (**Figure 1**). It can act as a barrier as well as a medium for entry of certain substances in the body. Several





**Figure 1.**  
*Structure of the human skin [6].*

toxins and chemicals present in the environment get accumulated in the conventional clothing and may enter into the body through the skin. Hence, enhancing skin's ability to resist entry of harmful chemicals and toxins into the body will improve the health. The radiated heat activates herbal molecules of the cloth and is reflected back to the body along with the herbal molecules. Through the blood, the herbal molecules enter deep into the body, show its effects at different levels of the body, and help in curing various diseases [5]. The skin can act not only as a protective barrier but also as a medium for outside substances to enter into the body. In the same way, the skin has the ability to absorb herbs found in our natural dyes. These herbs release their medicinal qualities in the body and strengthen the skin's ability to block and resist the harmful substances. The close contact of herbal clothing next to the skin enhances the body metabolism, which leads to effective elimination of body toxins. The herb-infused and herb-dyed organic fabrics act as healing agents after the herbs being absorbed through the skin [6].

### 3.1 Penetration of herbal molecules across skin

- Skin temperature helps the herbal molecules to be absorbed into the body through sweat pores to manifest the desired medicinal effect.
- The cloth should be in direct contact with the skin to manifest its curative effects.

### 3.2 Herbs and healing effects of herbal textile

Herbs are garden plants that are grown and harvested for culinary, aromatic, medicinal, and fibrous uses. Plant herbs are placed in the garden for their unmistakable fragrances, attractive textures, appealing colors, and variety of home uses. Due to current ecoconsciousness, there has been a revival of inherent in ecofriendly natural dyes throughout the world. The application of herbal products has given a new direction toward the treatments of various diseases through textile products. The herbs also do not pollute the environment through contamination of water resources in areas close to processing units. All kinds of shades of red, yellow, brown, orange, and green can be obtained with the help of the herbs.

Functional finishes using natural dyes have been in the vogue that promotes an ecofriendly lifestyle. Natural dyes are environmental friendly, nontoxic, noncarcinogenic, nonallergic, and renewable resources. Biosphere is being gifted with more than 500 plant species that yield the natural dyes [11]. The roots, flowers, leaves, seeds, and barks of more than 200 medicinal herbs, plants, flowers, roots, and barks are used to make the dyes. In herbal textiles, the color is gained from the medicinal preparation only, and no other colorants are used. As a result, its properties will last as long as the color is there. Since the herbs make beautiful shades, herbal wears are also becoming very popular for its primordial elegance.

Only herbal preparations devoid of any chemical are used in dyeing herbal textiles, whereas chemicals such as copper sulfate and ferrous sulfate are used as catalysts when dyeing is done with vegetable dyes. Thus, herbal dyes are different from vegetable dyes as they also impart some medicinal value. Herbal clothing is believed to help restore the balance within the body's systems and strengthen the immune system. Some of the medi-herbs used in herbal textiles give the magical healing quality to the dyed fabric or yarn (**Table 1**) [12–15]. **Table 1** shows the diseases cured by different herbs.

S. no.	Name of the herb	Medicinal properties	Diseases claimed to be cured
1.	<b>Neem</b> ( <i>Azadirachta indica</i> )	Antibacterial and antifungal	Common skin diseases, skin allergy, controls blood sugar levels
2.	<b>Curry leaves</b> ( <i>Murraya koenigii</i> )	Medicinal value	Beneficial in curing arthritis suppresses pain and reduces inflammation
3.	<b>Shoe flower</b> ( <i>Hibiscus rosa-sinensis</i> )	Controls blood sugars	Diabetes
4.	<b>Fenugreek/ Methi</b> ( <i>Trigonella foenum-graecum</i> )	Medicinal value	Controls cholesterol, hypertension
5.	<b>Amla</b> ( <i>Emblica officinalis</i> )	Antifungal, antibacterial, antiviral	Boosts immunity
6.	<b>Acacia</b> ( <i>Catechu</i> )	Antifungal, antibacterial	Used for treatment of parasitic infestation and itching
7.	<b>Manjistha</b> ( <i>Rubia cordifolia</i> )	Medicinal value	Blood purifier and diuretic, leprosy
8.	<b>Cuscus/Khus khus grass</b> ( <i>Chrysopogon zizanioides</i> )	Medicinal value	It helps in fighting asthma
9.	<b>Arjuna</b> ( <i>Terminalia arjuna</i> )	Medicinal value	Cardiovascular support, hypertension, asthma
10.	Pomegranate ( <i>Punica granatum</i> )	Antibacterial, antiviral, astringent	Antimicrobial treatment, hypertension
11.	<b>Harad/myrobalan</b> ( <i>Terminalia chebula</i> )	Antiseptic, anti-inflammatory, controls cholesterol	Hypertension, anemia, asthma cures, wounds, ulcers
12.	<b>Aloe vera</b> ( <i>Aloe barbadensis</i> )	Antibacterial, antifungal	Burns, wounds, common skin diseases, psoriasis, anemia
13.	<b>Gurhal</b> ( <i>Hibiscus rosa-sinensis</i> )	Controls blood sugar levels	Diabetes
14.	<b>Jamun</b> ( <i>Syzygium cumini</i> )	Controls blood sugar levels	Diabetes controls blood sugar levels

S. no.	Name of the herb	Medicinal properties	Diseases claimed to be cured
15.	<b>Mahuva</b> ( <i>Madhuca longifolia</i> )	Controls blood sugar levels	Control diabetes
16.	<b>Champa flower</b> ( <i>Magnolia champaca</i> )	Controls blood sugar levels	Diabetes, anemia
17.	<b>Touch-me-not</b> ( <i>Mimosa pudica</i> ),	Medicinal value	Controls blood sugar levels, diabetes
18.	<b>Eucalyptus</b> ( <i>Eucalyptus globules</i> )	Antiseptic	Relieve congestion, prevent infection, ease muscle soreness
19.	<b>Tulsi/basil</b> ( <i>Ocimum tenuiflorum</i> )	Antibacterial, antiseptic, antispasmodic, diaphoretic, febrifuge, nervine, controls cholesterol	Respiratory disorders, viral, bacterial infections. Controls blood sugar levels, boosts immunity, hypertension, HIV/ AIDS
20.	Chitosan	Antimicrobial	Naturally occurring biopolymer having antimicrobial properties
21.	Balloon vine ( <i>Cardiospermum halicacabum</i> )	Antiphlogistic, analgesic, blood refrigerant, anti-infectious	Cold, fever, renal edema, urinary tract infections, furuncle, carbuncle, eczema, sprains, external wounds
22.	<b>Sandalwood</b> ( <i>Santalum album</i> )	Alterative, antibacterial, anti-inflammatory, antiseptic, astringent, carminative, disinfectant, diuretic, expectorant, hemostatic, refrigerant, sedative, stimulant	Headache, acute dermatitis, bronchitis, cystitis, eye diseases, gonorrhea, herpes zoster, infection, palpitations, sunstroke, urethritis cools the skin, curing skin itching, burns, its mild fragrance has a soothing effect that helps in fighting stress
23.	<b>Onion</b> ( <i>Allium cepa</i> )	Antioxidant, antimicrobial	Skin diseases, control diabetes
24.	<b>Indian Madder</b> ( <i>Rubia cordifolia</i> )	Antibacterial, anti-inflammatory, antiseptic, astringent, sedative, stimulant	It removes blood impurities and cures various skin diseases, HIV/AIDS
25.	<b>Indian Mulberry</b> ( <i>Morinda pubescens</i> )	Antibacterial, anti-inflammatory	It is blood purifier and used for wound healing, control diabetes
26.	<b>Saffron</b> ( <i>Crocus sativus</i> )	Medicinal value	Controls heart disease
27.	<b>Indigo</b> ( <i>Indigofera tinctoria</i> )	Antibacterial, antiallergy, antiseptic and aromatic, anti-inflammatory properties	Controls cholesterol, helps reducing the insulin resistance, thus controls diabetes, boosts immunity, anemia, skin diseases
28.	<b>Turmeric</b> ( <i>Curcuma longa</i> )	Antihepatotoxic, antioxidant, antimicrobial antiseptic, antiallergic	Fighting skin diseases and helps fight skin disease, anemia, psoriasis, liver disorders
29.	<b>Henna</b> ( <i>Lawsonia inermis</i> )	Blood purifier, anti-irritant, deodorant, antiseptic	Skin irritations such as heat rashes and skin allergies and to cool the body. Because of this cooling property, henna used as a prophylactic against skin diseases like burns, bruises, and skin inflammations, including sores from leprosy

S. no.	Name of the herb	Medicinal properties	Diseases claimed to be cured
30.	<b>Brazil wood</b> ( <i>Caesalpinia echinata</i> )	Blood purifier, anti-irritant	Skin diseases such as burns, bruises, and skin inflammations
31.	<b>Castor</b> ( <i>Ricinus communis</i> )	Blood purifier	Skin diseases
32.	<b>Baheda</b> ( <i>Terminalia bellirica</i> )	Controls cholesterol	Hypertension, anemia
33.	<b>Guar</b> ( <i>Cyamopsis tetragonoloba</i> )	Controls cholesterol	Hypertension
34.	<b>Safflower</b> ( <i>Carthamus tinctorius</i> )	Controls cholesterol	Hypertension, HIV/AIDS
35.	<b>Reetha</b> ( <i>Sapindus trifoliatus</i> )	Medicinal value	Psoriasis, skin disease
36.	<b>Amaltas</b> ( <i>Cassia fistula</i> )	Therapeutic effect	Psoriasis
37.	<b>Cluster fig</b> ( <i>Ficus racemosa</i> )	Therapeutic effect	Psoriasis
38.	<b>Winter cherry</b> ( <i>Withania somnifera</i> )	Therapeutic effect	Psoriasis, rheumatism

**Table 1.**  
Some of the medi-herbs used for herbal textiles.

Different parts of the plants namely root, bark, leaf, fruit, wood, seed, and flower are used to extract dyes. It is estimated that over 2000 pigments are found in various parts of plants; however, only about 150 have been commercially utilized [16]. Herbal cloth production by a particular method is accomplished by utilizing extracts of selected herbs for dyeing cotton/silk/linen, yarn, and fabric. Synthetic/chemical dyes are not used at any stage, and for washing, specific products are used [17].

The process of herbal dyeing was developed through extensive research during the age-old dyeing methods practiced since the days of Indus civilization. Manufacturing herbal textile begins with 100% hand-loomed organic cotton or silk wool, linen, jute, hemp, and so on and their natural blends that are dyed exclusively in herbal infusions for both color and health purposes. No chemical process is involved while dyeing and processing the fabric. The fabrics have to pass through various stages of treatment before they are turned into finished products. Herbal textiles are extra smooth and good for transpiration that helps in recovering from various diseases. Each fabric is infused with specific herbs, which are known to cure diseases. It may help to treat a broad range of diseases and skin infections such as eczema and psoriasis; the fabric also helps with conditions such as heart ailments, rheumatism, arthritis, blood pressure, diabetes, and respiratory conditions, such as asthma and sleeping disorders. It also helps in boosting immunity. The antibacterial and anti-inflammatory properties of herbal medicated clothing extend its use as dressings and bandages. It can also relieve the general body aches, stimulate the weight loss, and strengthen the immune system. It can also be used as energy booster; mood enhancer, for overall wellbeing, calming, and blood purification; and cooling [18]. The most effective time to wear herbal cured clothing is when the body is at rest, such as during sleep, relaxation, or meditation because this is when the body is naturally healing and re-establishing balance. Hence, most of herbal clothing products are sleepwear, bed sheets, towels, meditation clothes, and cotton mats [19].



## 4. Herbal dyeing process

The herbal textile production begins with pure organic yarn/fabric, and each step is carefully and meticulously controlled without the use of any chemical process in dyeing and processing. The process starts with the gray cloth going through various stages of treatment before it is dyed and becomes ready to wear. Only certified organic cotton, natural cotton, silk wool, linen, jute, hemp, and their natural blends should be used for herbal dyeing. The herbal dyeing process has been developed following the extensive research and is in practice since the Indus civilization. Machines are not used to prepare herbal clothing, and all the processes namely bleaching, dyeing, and other processes are accomplished in big vessels fabricated according to need. Further, no chemicals are added during spinning, weaving, or enhancing the appearance [20].

Most common fabric used is organic cotton, the cotton that is cultivated without chemical pesticides and fertilizers. Silk, wool, coir, linen, hemp banana, nettle, and bamboo are also used to prepare herbal clothing. For handloom, the process starts with the cotton yarn and goes through a process named desizing (to remove loose particles, debris, etc.). The common processes used in manufacturing of herbal clothing are detailed in the following paragraphs.

### 4.1 Desizing

It involves washing of the processed gray cloth with mineral-rich water and sea salt to remove sizing, gums, and oils used in the weaving.

### 4.2 Bleaching

This process is actualized with biodegradable, organic cleaning agents, and surfactants and sun dried. The bleaching of cloth is done naturally by exposing it to sunlight on a natural grass base and by using animal manure. The fabric or yarn is first bleached using cow urine, milk, honey, along with biodegradable, naturally derived, organic cleaning agents, and surfactants such as Saptala (*Acacia sinuata*) and Phenila (*Sapindus mukorossi*) [21]. Many Ayurvedic doctors consider cow's urine highly beneficial in balancing an individual's "doshas" or basic constituents of an individual's physiology and psychology, strengthening the immune systems and as an elixir in giving life [22]. The process ends with exposing the fabric or yarn directly to sunlight.

### 4.3 Mordanting

To make the colors look bright and retain color fastness, natural mordants such as myroballans, rubhabs leaves, oils, alum, fruit extracts of haritaki, bark of lodhra, minerals, and iron are used. Use of heavy metallic mordants such as copper, chrome, zinc, and tin is avoided as they are not ecofriendly. Mordanting is done before dyeing the fabric or yarn to make the colors look bright and retain fastness.

### 4.4 Dyeing/medication

The word medication is used instead of dyeing because the medicinal herbs are used to impart required color to fabric or yarn [20, 23]. The yarn or fabric is then medicated in a carefully controlled mixture of herbal medicinal preparations depending on the disease or ailment being treated. Required herbs are applied directly to the fabric with the help of natural ingredients so as to keep the medicinal value of herbs intact [7, 11]. Steps involved are as follows:

- The organic cotton yarn/fabric is dyed carefully with concoction of herbal dyes indicated for the treatment of desired disease(s).
- The herbal dyes are prepared by careful blending of medicinal herbs derived from plants, flowers, roots, and barks.
- The temperature, duration, number of the soaks, blend of herbs, and equipment are carefully controlled.
- Desired herbs with the help of natural ingredients are applied directly on fabric in order to preserve the medicinal value of herbs.
- Shades of red, yellow, brown, orange, and green can be obtained with careful use of herbs.
- Finally, the medicated cloth is cooled and washed several times to remove the nonabsorbed particles and always dried in shade.

#### 4.5 Finishing

The finishing process used after herbal dyeing is also organic and is given by sprinkling pure water on the cloth and then stretching under pressure, using hand rolls, *Aloe vera*, castor oil, and so on [7, 11].

#### 4.6 Recycling residue

After dyeing, residue can be recycled. Solid and liquid wastes are separated by the filtration and used for farming purposes—as biomanure and for watering the fields and also to generate the biogas [11].

### 5. Technologies used for herbal finishing

Herbal textile is made by embedding essential oils and herbal extract finishes into textiles. Such textiles have their applications in providing medicinal value and aroma to the garment. Microencapsulation, sensory perception technology, liposomes, dyes, and coated textile technology are used for incorporating the herbal drugs and oils in textiles. The temperatures of the finish, the duration and concentration of plant extract, the blend of herbs, and even the equipment used are carefully controlled [24].

Spray drying, air suspension coating, solvent evaporation, sol-gel microencapsulation, and in-situ polymerization are some commonly used techniques used for textile finishing by microencapsulation. For encapsulation of flavor, fragrance, and oils, spray drying is used in which core particles dispersed in a polymer solution and sprayed into a hot chamber leading to solidification of shell particles on core material and polynuclear or matrix-type microcapsules are obtained. Air suspension coating is done by suspending solid particles of core material in a hot or cold upward moving stream of air. Coating material may be derived from cellulose derivatives, dextrans, emulsifiers, lipids, protein derivatives, and starch derivatives, which is atomized through nozzles into the chamber and deposits as a thin layer on the surface of suspended particles. Solvent evaporation is a process in which the drug is dissolved, dispersed, or emulsified in an external aqueous or oil phase; it has been used to impart antifungal finish to textiles. Sol-gel microencapsulation is

used to produce flame retardant, water/oil repellent, UV protecting, antiwrinkle, self-cleaning, flavor and odor containing, and antibacterial textiles. Sol-gel synthesis involves the hydrolysis of silicone monomer and the condensation of silica into a porous structure with a three-dimensional networked structure, which can be tailored for a wide range of useful properties.

Microencapsulation, widely used in textile finishing, is a process in which small capsules having desired properties are prepared using small particles/droplets surrounded by a coating material. The material inside the microcapsule is known as core material, whereas outer coating is called a shell. Microcapsules may have diameter ranging a few micrometers to a few millimeters. Many special and functional properties can be imparted to the fabrics by microencapsulating the core material. This core material can be any substance having a special function to perform for the fabric. Encapsulation has allowed moisturizers, therapeutic oils, and insecticides to be incorporated into fabrics. Microencapsulation of antimicrobial agents is also gaining popularity in sportswear and medical textiles [25].

For preparation of herbal textile by microencapsulation, the “core material” along with the wall material should give a durable finish. This wall material can be certain substances like gum acacia, and the core material is the desired herbal extract. The microencapsulated herbal extracts have shown antimicrobial activity and wash durability up to 20 washes [26]. Microencapsulation is a very popular technique for incorporating fragrance into fabrics. These capsules applied are unbreakable under the normal conditions, and the application of pressure on fabric releases fragrance, which causes healing in aromatherapy [27]. Microencapsulated herbal extracts such as *Aloe barbadensis* Mill, Bitter Gourd, Ginger, and *Cuminum cyminum* Linn have successful application in which the herbal extracts are used as core material and gum acacia as wall material [28]. According to the study, microencapsulated extracts of *Andrographis paniculata*, when applied on the fabric to impart mosquito repellency finish, gave good mosquito repellent activity up to 30 washes [29].

### 5.1 Microencapsulation in cosmetic textiles

New textile technologies have enabled the application of cosmetic ingredients on fabric to provide its functional benefit to the end-use product, and therefore, cosmetic textiles are moving from laboratory to showrooms. Fragrance finish is one such finish that falls under this category. A fragrance is made from a pleasant smelling aroma compound. Aromachology is a science that studies the effects of fragrances on the human body and mind. It researches how scents can be used to induce relaxation and make life more pleasant. Fragrances can be used in various forms such as essential oils, perfumes, colognes, household products, and pot-pourri. Some areas in textiles where fragrance finish can find application include Cosmetotextiles.

The major use of microencapsulation in cosmetic textiles is in the application of vitamins, essential oils, skin moisturizing agents, skin cooling, and antiaging agents [30]. Yamato et al. studied microcapsules having active substances that can improve the physiological conditions of human skin. The microcapsule gradually released its content when the textile structure was subjected to light pressure created due to the movement of human body [31].

Aroma finish is a process by which textile material is treated with the pleasant odor producing essential oils and aromatic compounds so that the wearer gets beneficial effects. Various essential oils such as lavender, rosemary, and jasmine are used.

The fragrance compounds and the essential oils are volatile substances, and prolonging life span of their odor is most difficult task in preparation of the textiles for aromatherapy. Microencapsulation is an effective technique to achieve this task. Microcapsules are tiny spherical enclosures containing a liquid or gas and assume the shape of the enclosed particle if containing a solid [32]. With microencapsulation method, fragrance lasts for more number of washes since microencapsulation makes the finished particles more securely attached to the internal structure of the fiber and thus releasing them slowly [33].

## 5.2 Microencapsules for antimicrobial finishes

Bacteria often cause decay of fabrics leading to loss of various useful properties of fabrics. This problem can be prevented by the use of antimicrobial finishes that can be applied with the help of microencapsulation. This finish is especially beneficial for textiles for medical and technical uses [34].

Herbal extracts prepared from Chamomile, sage, and green tea were applied to cotton fabric using pad-dry-cure method. Treated fabrics exhibited antimicrobial activity against Gram-negative, Gram-positive bacteria and yeasts. This antimicrobial activity was retained even after 10 cyclic washes [35].

Textile materials having antimicrobial activity are used in hygienic, health, personal care, and surgical products. Some products include baby and adult diapers and sanitary pads. Most of the diapers are made by synthetic materials, which are nonbiodegradable and poor antimicrobial properties, and may cause rashes and dermatitis. Natural antimicrobial coatings on diapers obtained by using curcumin, *Aloe vera*, tulsi, and neem have same antimicrobial effect when compared with synthetic antimicrobial coatings [36]. Curcumin or diferuloylmethane (1,7-bis(4-hydroxy-3-methoxyphenyl)-1,6-heptadiene-3,5-dione) is the main phytochemical present in turmeric. This polyphenolic compound has several biological activities including antimicrobial activity. Curcumin is suspected to affect the bacterial cytoskeleton, thus producing the antimicrobial effect [37]. The *Aloe vera* leaves secrete a colorless gel-like substance, which contains about 98–99% water and 1–2% active compounds such as aloesin, aloin, aloe emodin, aloe mannan, flavonoids, saponin, sterols, amino acids, and vitamins. Anthraquinones and their derivatives such as barbaloin-10-aloe emodin-9-anthrone, isobarbaloin, and chromones, which inhibit the bacterial protein synthesis, are potent antimicrobial agents [38]. Antimicrobial property of tulsi (holy basil) may be attributed to essential oils found in leaves. These essential oils contain germacrene-A, clemene, caryophyllene, eugenol, and caryophyllene oxide. Additionally, tulsi leaves also have other biologically active phytochemicals such as rosmarinic acid, oleanolic acid, and ursolic acid. These essential oils and phytochemicals have antibacterial properties owing to their damaging effect of bacterial cell membrane and thus causing leakage of cellular potassium [39]. Neem leaf, bark, and seeds have antimicrobial properties, and it is high, moderate, and low, respectively. Neem contains several bioactive constituents like azadirachtin and other compounds such as nimbolinin, nimbin, nimbidin, nimbidol, sodium nimbinat, gedunin, salannin, quercetin, nimbanene, 6-desacetylnimbinene, nimbandiol, nimbolide, ascorbic acid, n-hexacosanol and amino acid, 7-desacetyl-7-benzoylazadiradione, 7-desacetyl-7-benzoylgedunin, 17-hydroxyazadiradione gedunin, and nimbiol. Quercetin and  $\beta$ -sitosterol, polyphenolic flavonoids purified from leaves of neem have antifungal and antibacterial activities. Neem (*Azadirachta indica*) in plant parts shows antimicrobial property through bacterial cell wall breakdown [40].



## 6. Herbal finishes by natural dyeing

Wet processing of textile substrates from its preparatory stage to dyeing and then finishing is important for enhancing its esthetic value, removal of impurities, color shade, color pattern, and requisite functionality. Some of the traditional processes used in herbal finishing involve an excessive use of water, energy, and chemicals. Recently, due to global concerns on environmental pollution, sustainability mandates the development of sustainable dyeing and finishing processes using plant waste and nonfood plant extracts [41]. Based on environmental friendly, plant-based products having biocompatibility, biodegradability, and nontoxicity along with insect repellent, deodorizing, flame retardant, UV protection, and antimicrobial activity are in great demand all around the world for producing more appealing and highly functional value-added textiles [42–45]. A wide variety of finishing chemicals from plants are now available in the market that matches the expectations of consumers [46]. Various plants reported as source of natural dyes are teak, mahogany, ketapang, tamarind, mangosteen, mango, suji, pandan, indigofera, guava, banana, and onion [47]. Plant parts including roots, leaves, twigs, stems, heartwood, bark, wood shavings, flowers, fruits, rinds, hulls, husks, and the like used to produce herbal dye. Additionally, most of the herbal dyes have inherent medicinal properties [48].

### 6.1 Herbal textiles having antimicrobial finish

Natural fibers such as cotton and wool are susceptible to microbial growth and even dust mites because they retain oxygen, water, and nutrients. Hence, antimicrobial finishes should be applied to textiles to destroy or suppress the growth of microorganisms and also to protect the textiles from strength and color loss, unpleasant odor, and quality deterioration [49]. Micro-organisms may deteriorate the clothes in a closet, curtains, carpets, bed, bath and kitchen linens, pillows, and mattresses. Several microorganisms also thrive on the skin, while dust mites live on skin cells shed on sheets, towels, and clothing. A hospital houses an immense amount of textiles with high volumes of traffic. Because of the constant flow of people, especially those with infectious diseases, specific finish hospital uses are required. Patients, caretakers, and hospital staff are at risk of acquiring infection as inherent properties of the textile fibers susceptible to the growth of micro-organisms.

In past, natural dyes were applied to textiles for simultaneous coloration and antimicrobial finishing successfully. Finish imparted by catechu on wool was found to be effective against *Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*, and *Candida tropicalis*. Observed antimicrobial characteristics and negligible cytotoxicity of catechu indicated the dye as a promising antimicrobial agent for developing bioactive textile materials and herbal clothing [50, 51]. Several natural, nonmetallic, and antimicrobial finishes exist, and one of such antimicrobial finish is chitosan, a deacetylated form of chitin, which is a main component in crustacean shells and reported to be effective against both Gram-positive and Gram-negative bacteria [52]. Many antimicrobial textiles are produced with the combinations of bioactive substances to enhance the antimicrobial efficacy of the finishes and counteract the negative aspects of the treatments. By combining finishes, the occurrence of drug-resistant strains arising from the finish is reduced.

Pure cotton woven/knitted fabrics treated with the selected medicinal 16 medicinal herb extracts such as neem, turmeric, holy basil, and sandal wood have been evaluated for curing seven different diseases such as allergic dermatitis, psoriasis, asthma, liver disorders, headache, joint pain, and sinus trouble/cold. Seven different types of curative garments have been developed. The antibacterial assessments of the medicinal

herb extracts treated fabrics and clinical trials have confirmed the correlation between the curative performance and its antibacterial activity. The curative property of the garments in all the cases was found to be significant and lasted for 10–15 washes [53].

Although known since long for dyeing and medicinal value, the protective properties of herbal dyes have been noticed only recently. Several plants used for dye production are classified as medicinal, and some have recently been shown to possess significant antimicrobial activity. Several natural dyes have demonstrated to possess antimicrobial activity like curcumin from turmeric; naphthoquinones such as lawsone from *Lawsonia inermis*, juglone from walnut, lapachol from taigu, and catechin from *Acacia catechu*; and several anthraquinones from *Rubia tinctorum*, *Rubia cordifolia*, *Rheum emodi*, *Punica granatum*, and *Quercus infectoria* [54, 55]. These natural antimicrobial agents may significantly reduce the risk of infections especially when they are used in close contact. Natural bioactive compounds present in natural dyes/pigments have also been reported as significant antimicrobial agents for finishing in green dyeing procedures.

## 6.2 Herbal textiles with UV protection

Ultraviolet (UV) rays, electromagnetic spectrum between visible light and X-rays, influence the physiology of living organisms. Exposure may cause tanning to skin cancers. Sunscreen lotions and clothing provide protection from dangers of UV rays. Change in construction parameters of fabrics with appropriate UV absorbers and adequate finishing methods may be used to prepare the UV protective fabrics.

Textiles, as a protective shield against solar radiation, have been since ancient times. Textile structures provide the desired characteristics such as pliability, good mechanical strength, softness, esthetics, and other engineered properties, which are required for preparing good suncreening apparels. Textiles themselves are not able to provide effective protection against UV rays; hence, UV blocking agents should be applied over the fabric to make them UV protective. Quantum of protection required for different skin types is determined by UV radiation intensity and distribution subject to geographical location, time of day, and season. Several UV protection agents have been developed to enhance the UV protection offered by different textiles. Both organic and inorganic UV blocking agents are available. The organic blockers are also termed as UV absorbers because they absorb UV rays, whereas inorganic blockers scatter them [47].

Three yellow dyes obtained from *Rheum emodi*, *Gardenia yellow*, and *curcumin* have been successfully used for simultaneous dyeing and functionalization of silk to render its UV protective [56]. Wool fabric dyed with dye obtained from the eucalyptus leaves using pad-batch and pad-dry techniques showed ultraviolet protection factor (UPF) values ranging between very good and excellent [57]. UV protection properties of chlorogenic acid, the main ingredient of water extract from honeysuckle, on wool have been studied. The wool treated with honeysuckle extract showed good UV absorbance; thus, extract of honeysuckle may be developed as a natural UV-absorbing agent [58]. Natural plant colorants such as madder (*Rubia tinctorum*) and indigo (*Indigofera tinctoria*) and of insect origin cochineal (*Dactylopius coccus*) were applied on cotton fabrics, and indigo was found to have higher UPF values [59]. UV rays induce DNA damage, oxidative stress, and inflammatory processes in skin. *Rheum emodi* contains anthraquinones (rhein, emodin, aloe-emodin, chrysophanol, physcion, and rhein), stilbenoids (resveratrol and piceatannol), and flavonoids. UV protective effect of *Rheum emodi* is supposed to be due to flavonoids, which absorb the UV radiation [60]. Main coloring ingredient of

the dye extracted from *Gardenia yellow* is crocin, which is a water soluble carotene, which absorbs the UV rays [61]. Curcumin alleviates the effect of UV rays by reducing the transmittance of UV light across fabric [62]. Madder roots contain anthraquinone derivatives mainly purpurin and munjistin and also small amounts of rubiadin, nordamncanthal, pseudopurpurin, and xanthopurpurin. Anthraquinones are considered to be strong UV absorbers [22].

### 6.3 Deodorizing herbal textiles

Bacterial growth and/or waste released from human body are the main causes for odor in garments. Recent advances in textile manufacturing have improved the performance of textiles with respect to odor with antimicrobial and UV protection properties. To meet the consumer's growing demand for hygienic clothing, extensive research has been done to deodorizing property to textiles with the application of natural colorants. The deodorizing performance of fabrics dyed with herbal colorants has been compared, and pomegranate was found to be best among gardenia, *Cassia tora* L., coffee sludge, and pomegranate rind [23]. Fabric dyed with gallnut recorded a better deodorizing function against ammonia, trimethyl amine, and acetaldehyde than control fabrics. Dyed fabrics also found to possess an excellent antimicrobial activity against *Staphylococcus aureus* and *Klebsiella pneumoniae* [20]. Young-Hee Lee and co-workers dyed cotton, silk, and wool fabrics with pomegranate (*Punica granatum*) and showed excellent deodorizing property in the dyed fabrics [21]. Cotton fabrics dyed with C.I. Direct Blue 200, a copper complex direct dye, and pre- and post-mordanted with Cu(II) sulfate for deodorization of ethyl mercaptan showed that deodorization effects increased quadratically with the copper ion uptake [63]. These studies indicate that natural and synthetic dyes can be utilized for deodorizing functionalization of textiles.

### 6.4 Moth resistant and insect repellent textiles

Carpets, blankets, and shawls are prepared from wool, and other similar fibers have properties such as warmth, softness, and flame retardancy protein content of the fiber, which are susceptible to attack by moth as its larvae thrive on the protein present in the wool. Cloth moth (*Tineola bisselliella*) and carpet beetle (*Anthrenus verbasci*) are common moths, which attack the wool items. Dichlorodiphenyltrichloroethane (DDT), permethrin, permethrin/hexahydro pyrimidine derivative, and cyhalothrin are some of the insecticides used to provide antimothe finish. Nano titanium oxide particles have also been utilized as an antifeeding compound on wool fabric to kill larvae of the carpet beetle, *Anthrenus verbasci*, which feeds on wool fibers [64]. Chemicals used for antimothe finishing are detrimental to the environment; hence, natural colorants may be good alternatives. Shakyawar et al. used saffron flower waste, onion skin, henna, myrobolan, silver oak leaf, madder, walnut, dholkanali, and yellow root natural dyes for antimothe finishing and recorded the best results for silver oak leaves, walnut husk, and pomegranate rind [65]. Natural dyes from cochineal, madder, walnut (quinines), chestnut, fustic, indigo, and logwood (flavonoids) were also applied on wool, and their antimothe properties against black carpet beetles were tested, all except indigo, which increased the insect resistance of the wool fabric. Metallic mordants were found to have no significant effect on insect resistance with all natural dyes used. The anthraquinone dyes including cochineal, madder, and walnut were found to be quite effective in protecting wool fabric against black carpet beetles [66].



## 7. Production and consumption of herbal textiles

Synthetic/chemical dyes are increasingly being banned for use in the textile industry, which have led to severe blow to the handloom industry. At the same time, textiles dyed with natural herbal dyes having medicinal attributes are commanding a huge market due to their inherent advantages. Nowadays, the use of herbal dyes in the textile industry is preferred owing to the advantage of dyes extracted from the medicinal plants, origin from the renewable resources, limited chemical reactions involved in their preparation, biodegradable properties, disease-curing properties, and ecofriendly in nature [18, 67].

Herbal textiles are of two kinds: one category is for curing diseases and the other is for wellbeing. The first category of cloths, which are used for curing diseases, includes sleep wear, bed sheets, towels, meditation clothes, and coir mats. Herbal textiles are mostly used in making such garments that stay close to human skin, so that all the medicinal components could be absorbed through the skin. Herbal textiles can fetch more competitive than conventional fabrics owing to low production cost. For example, a common chemical dye costs around \$75 per kg, and a herbal dye costs approximately \$5 per kg. Most of the herbs used in dyeing are cultivated in South Asian countries, namely India, Pakistan, and Bangladesh, India being the largest producer. The Handloom Weavers Development Society (HLWDS) of Kerala, India has exported herbal and organic textile worth Rs. 50 Lakh to the United States, Europe, and Japan. The herbal textile is gaining such popularity that the Japanese Government has accorded HLWDS a \$40,218 grant. Large consignments of herbal textiles have been shipped to international markets of the United States, Canada, France, Denmark, Italy, Poland, Maldives, Mauritius, Japan, and Sri Lanka [17, 68–70].

Most effective time to wear the herbal-infused clothing is while resting, sleeping, or meditating, when the body is naturally healing and re-establishing balance, so many of the products are created with these factors in mind. The technique for producing the herbal textiles is also used for floor coverings and coir mats. For coir mats, the fibers are first soaked in herbal dyes and then woven into coir mats. Apart from medicated handloom clothes such as sarees, T-shirts, shirts, trousers, kurtas, dhods, chudidhars, nightwear, fashion wear, sportswear, and inner wears, caps for healing headaches, goosery caps for head balance, cooling caps, hair shining caps, hair strengthening caps, bandages, and mask are also prepared [68, 71].

Plant dyes are increasingly being incorporated by designers into their designs contributing to revival of Ayurveda or herbal clothing. Ayurgenic is a line of loungewear inspired from the concept of Ayurveda. Designer duo Lecoanet and Hemant have revived the tradition of Ayurveda in Ayurgenic, their line of medicinal clothing. The multi-award winning designers who began their journey as couturiers in Paris are now refining the concept of Ayurveda. Anjelika dreams organic produces fair trade, organic handmade clothing that follows this tradition. Gibie towels specialize in Ayurveda towels, Ayurvedam in Ayurveda textiles and yoga mats, and niraamaya in Ayurveda yoga mats. The handloom weavers' development society in India is producing a wide range of herbal fabrics including sarees, bed sheets, and dress materials using medicinal dyes and exporting them to the United States, Germany, the United Kingdom, Singapore, and Taiwan [6, 11].

"Herbalfab" ecofriendly fabric brand has developed a unique technique to dye with flowers, fruits, roots, and so on. Turmeric, myrabolams, onion, kesu and dhavadi flowers, and natural indigo are used for preparing the natural dyes. This prevents the water pollution by replacing the petrochemical dyes with herbal dyes and imparts the medicinal value to cloth. The colors obtained are unique, which can kick start a new fashion trend. Herbalfab also encompasses a range of other



ecofriendly fabrics like khadi, which is handspun and handwoven, nonviolent silk, organic denim, and so on [72].

The Handloom Weavers' Development Society, India produces a variety of home textiles using herbal fabrics in India. They also export herbal clothing such as sarees, bed sheets, and dress materials to other countries. With increasing demand for herbal clothing, companies such as Ayurvastra online have started offering the online products. Many textile industries are getting inclined toward Cosmetotextiles. The brands making herbal clothes are Aura, Cognis, Pantaloons, Quiospheres, and so on. These brands have a range of clothing namely bandee, vest, camisole, men and women's tee, coirs, and so on [73].

## 8. Benefits and drawbacks of herbal textiles

### 8.1 Health benefits

- It acts as a revitalizing tonic and helps in keeping the body fresh and healthy. The uses of proper herbs in the textiles have proven to cure diseases such as arthritis and fever. We breathe through our body more than we do through nose. It can improve the skin's natural ability to block and resist the harmful chemicals and toxins from entering the body, which will be beneficial to health.
- Herbal cloths have the ability to protect us from various skin diseases and provide relief from infectious diseases and mental ailments.
- No synthetic/chemical dye is used at any stage of herbal cloth production. For washing and cleaning purpose, the nut or nut powder of *Sapindus laurifolia* is recommended [74].
- Medicinal herbs treated fabrics also have a lot of therapeutic value; thus, the fabric has been found very helpful for people suffering from ailments such as skin allergies, breathing problems, sleeping disorders, and blood pressure.
- The health benefits of herbal clothing and its usage depend on the theory of touch. The body loses toxins when it comes in contact with herbal clothing, and this improves the metabolism. Herbal clothing is also known to help fight against many common diseases such as diabetes, hypertension, skin allergies, asthma, and heart ailments.
- The human body naturally heals itself during sleep or meditation. Thus, when the body is at rest, herbal clothing will work most effectively. The skin is known as the largest organ of the body. Not only it acts as a fence and protects the body, but it can also be the channel for outside germs and toxins to enter into the body. Herbal clothing guards against the harmful toxins trying to enter the body through the skin [75, 76].
- Herbal textiles are mainly used in making sleepwear, undergarments, bed coverings, towels, meditation clothing, and so on, which remain close to the skin absorbing all the benefits it gives out. Herbal textiles are also used in home textile products such as mattresses, coir mats, door mats, bath towels, bed spreads, and carpets.
- Some of herbal constituents are antiallergens and hence are safe for skin contact and are mostly nonhazardous to human beings.

- Natural dyes are usually moth proof and can replace the synthetic dyes in kids' garments.
- We breathe through our skin more than we do through nose, and chemically dyed textiles having carcinogenic amines and chemicals may be allergic and dangerous to human skin. Organic clothing can help reduce the exposure to allergens and other irritants and give a comfortable feeling [77–79].

## 8.2 Environment benefits

- Preparation of herbal cloths is a labor-intensive industry and hence will provide the job opportunities for manpower engaged in cultivation, extraction, and application on textile, food, leather, and so on.
- Use of natural dyes may earn the carbon credit as it reduces the consumption of petroleum-based synthetic dyes.
- It promotes the agriculture and balances the ecological cycle.
- Waste can be used as manure.
- No heavy metals such as chrome and copper are used in natural/herbal Ayurvedic dyeing.
- Manual farming and organic practices have a lower carbon footprint as the entire process consumes less fuel and energy and emits fewer greenhouse gases than chemical textiles.
- Herbal dyes are extracted from the plants cultivated without the use of synthetic pesticides and fertilizers, and also no chemical defoliants are used.
- Processing is in green environment; hence, workers' health is not compromised, and also water and electric use and toxic runoff are reduced.
- Stringent testing ensures that product is free from contaminants such as nickel, lead, formaldehyde, amines, and pesticides.
- It improves the soil fertility and soil structure by increasing the soil activity, thus reducing the risk of erosion.
- It is the massive saving of precious water.
- It promotes the development of earthworms and other arthropods leading to improvement in the growth conditions of the crop. Furthermore, organic crops thrive on root symbioses and are better equipped to exploit the soil; hence, fields can accommodate a more number of plants, animals, and microorganisms [80–82].

Natural fibers and natural dyes used in the preparation of herbal clothing allow its natural breakdown without damaging the environment compared to the synthetic material, which takes hundreds of years to breakdown and leaves the pollutant material in soil [66, 67, 83].

### 8.3 Other benefits

- Herbal textiles are ecofriendly, and also residues they produce can be further used for making the other green products.
- Solid and liquid wastes from herbal dyeing are amenable to recycling producing the organic manure.
- Some of the ecofriendly industries producing the herbal textiles produce organically recycled paper bags by utilizing the residual organic and herbal dyed fabrics that can reduce the pollution due to plastic bags [84].
- It also promotes the cultivation of herbs required for the production of herbal textile products.
- Herbal dyes add value to the cotton fabrics in ecofriendly manner.
- Herbal fabrics are lightweight and so used to construct the perfect breezy clothes. The biggest advantage of cotton herbal cloth is that it is cool in summer and warm in winter [85, 86].
- The color shades produced by herbal dyes are unique, hence commanding high demand in market.

### 8.4 Drawbacks

- Herbal fabrics and dyes are not good substitutes for synthetic dyes offering broader range and variations.
- Retaining color and its herbal benefits demands utmost care in washing; herbal cloths should be washed separately, preferably hand wash or gentle machine wash with bleach-free detergents and should be shed dried. This causes inconvenience to the user.
- The dyeing process is cumbersome and time taking, and each stage should be carefully controlled.
- Medicinal herbs impart colors; hence, color choice for consumer is very limited as only few herbs can be used for dyeing a fabric that meant to be used in a particular disease condition.
- Herbal cloths show the curative effects, but progress is slow.
- Though there are no complaints on allergic reaction by the consumers, some people think that the herbal clothing shows side effects on children [87–89].

## 9. Conclusion

Textile industry has realized its negative contribution to the environmental pollution through the harmful chemicals used in manufacturing processes and is continuously trying to find solution for this problem. Herbal dyeing is one important step toward achieving the organic lifestyle, thus reducing the environmental

pollution. Herbal textile products are devoid of pesticides, fertilizers, antibiotics, growth hormones, genetically modified organisms, additives, irradiation, or sewage sludge, hence avoiding many ailments that are common with conventional clothing.

Modern consumer's demand for novel ecomaterials is expected to increase in future. Recently, efforts have been made toward the development of commercially viable natural colorants by making advances in aspects such as identification of new sources, formulations, extraction, purification, and stability techniques. In spite of enthusiastic studies discussing the socioeconomic viability of natural dye production and applications at commercial scale for sustainable utilization of bioresources, there is a need for investigations related to hygiene and ecosafety, which have great future for the discovery of relatively better and more stable natural pigments that may have wider industrial applications.

Herbal textiles have tremendous scope in world textile market and may become a major textile product in future. The blend of herbs and textiles to achieve the health in an ecofriendly manner is the great way of adopting the healthy life. Herbal clothing is receiving the increased awareness all over the world. Herbally treated textiles are one of the great solutions to revive and increase the share of Indian handloom industry in world textile market. Furthermore, herbal clothing is nontoxic, noncarcinogenic, biodegradable, and ecofriendly; these characteristics make them an obvious choice for modern informed costumer looking for a healthy product. Additionally, the production of biocolorants to meet the rising demand shall force entrepreneurs to take up this venture for greater profits leading to more employment generation.

## Author details

Anupama Mishra<sup>1\*</sup> and Sapna Gautam<sup>2</sup>

<sup>1</sup> Department of Textile and Apparel Designing, College of Community Science, Central Agricultural Universities, Tura, Meghalaya, India

<sup>2</sup> Department of Clothing and Textiles, College of Community Science, PSKHPKV, Palampur, Himachal Pradesh, India

\*Address all correspondence to: [anupamamishra8@gmail.com](mailto:anupamamishra8@gmail.com)

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