

Need for eco-friendly finished textiles

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INTRODUCTION

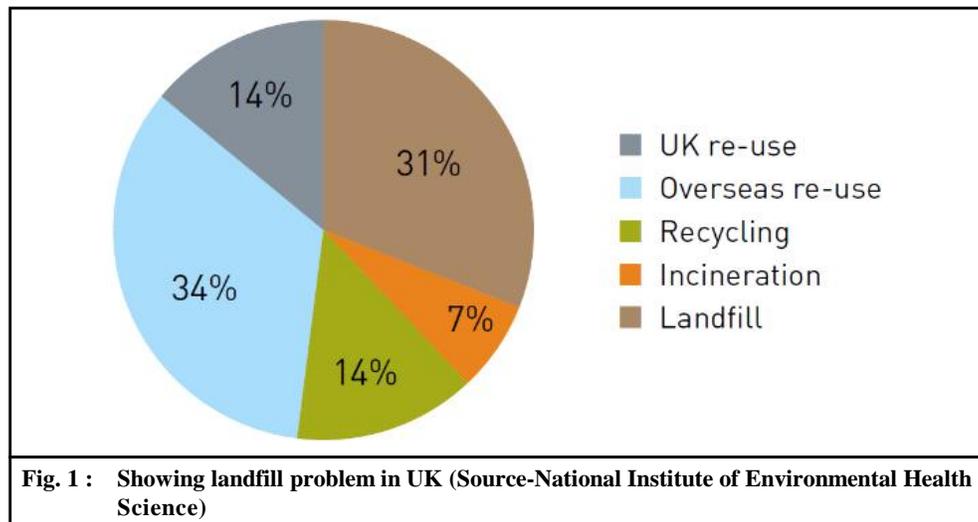
Mankind in the twenty first century has begun to feel a grave need to use resources in a sustainable manner; environment depletion and deterioration has increased manifold due to extreme materialism. Fast production, consumption and discarding of products are leading to an outbreak of problem of heaping toxic landfills. People are seen shifting towards eco-friendly products because of the harm that they have continued to do to their environment for fulfilment of their needs.

Textile industry is a major contributor in polluting the environment. Besides generating harmful toxins during the manufacturing of fabrics the industry also emits poisonous gases like methane into the air. Tons of textiles are produced for global population which continues to grow and compete for improvement in living standards. Consequently tons of textile waste is generated every year which pollutes water and also effects air in general not to mention the sites where the waste is dumped in landfills.

Clothes are made according to fashion and fashion keeps on changing due to which there has been an increase in productivity. This in turn has led to increase in waste generation (Fletcher, 2008). Fabric is either man-made or natural. Man-made fabric requires synthetic chemicals like petrochemicals, perflourinated chemicals (Teflon) and formaldehyde. It is interesting to note that Olefin a synthetic fibre used in sportswear, swimwear and thermal underwear is produced by “cracking” petroleum molecules into propylene and ethylene gases.

According to data from the EPA, in 2010, American salons alone discarded 13.1 million tons of textile waste out of which only 15 per cent was used for recycling and more than 11 million tons of textiles was dumped as landfill across the country. Approximately 11 million tons of textiles cover 126 million cubic yards of landfill space. This is approximately the amount which is discarded in a year. It is difficult to calculate the exact number of clothing, linen and other textiles that are being dumped into the environment but their harmful effects are a major concern for mankind. The dumped fabrics not only produce greenhouse gases but also increase global warming. It is a fact that on an average, a single person in UK is

capable of producing 70 kg of waste fabric in a year due to clothing being available to the people in general at a low and affordable price. This means people are spending less yet buying more and consequently discarding more too (Fig. 1). It is interesting to note that a developed country like UK has banned dumping of textile waste in landfills.



With growing environment consciousness, people are desirous of shifting towards eco-friendly products. They are realizing what harm is being done to the environment in the process of fulfilling their own human needs. Scientists and Researchers are finding novel ways to find solutions to this problem by proposing the use of natural fibre sources and natural herbal extracts for finishing and dyeing of fabrics. Use of harmful chemicals needs to be replaced by these natural products in a big way for health and environment benefits. For example essential use of organic cotton and natural dyes is not uncommon. Besides oils are being used for their anti-bacterial, anti-odour and mosquito repellent properties; as also for their aroma.

Keeping in view this emerging problem the present review work has been undertaken in order to generate and share more awareness about the issue and to further explore the area of research that would help find a solution to the growing problem. An effort has been made to explore various traditional materials and methods as well as modern technologies being used by the industry today to learn the extent to which it is feasible to replace the new with the old.

Objective :

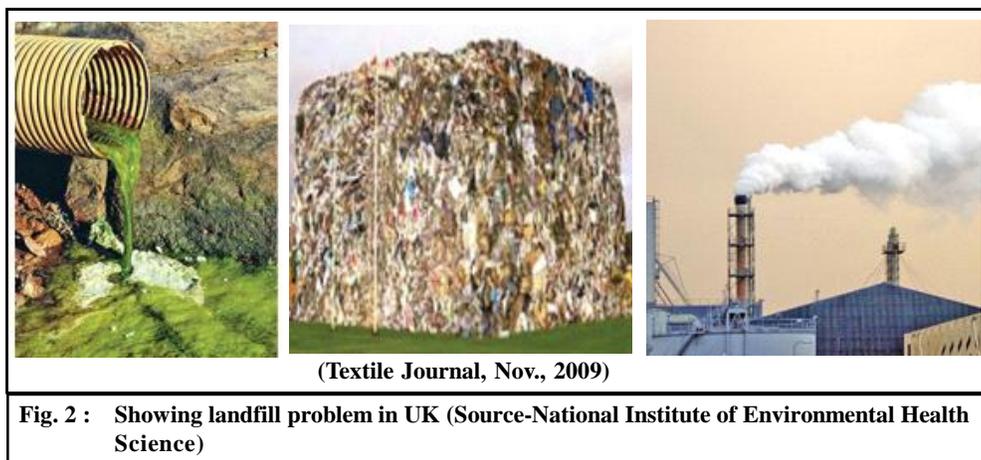
- To review various secondary sources to get information about various harmful synthetic substances used for finishing and processing of textiles.
- To find out about various eco-friendly and sustainable alternatives to synthetic substances being used to finish and process textiles.
- To explore the possibility of developing anti-bacterial, anti-odour and mosquito

repellent, cost effective textiles that are free from toxins and thus environment friendly.

Textile finishes and processes that are harmful to environment :

Color is an integral part of any design and fabric. Since antiquity color has played an important role in textiles either natural or synthetic. Earlier natural dyes were used to add color to textiles but with advancement in new technologies synthetic dyes came into existence. Synthetic dyes are cheap, easily available, and easy to apply. They do not bleed easily, give a wide range of colors but are harmful to the environment and consequently to all forms of life.

Right from processing stage of fabric to turning it into a final garment involves usage of large amounts of water, dyes and chemicals. Parvathi *et al.* (2009) studied the various environmental problems related to textile industry. The researchers found that tons of toxic effluent, which includes dye effluent as well, is discarded into rivers as textile waste by textile industries thus polluting the water. Emission of Volatile Organic Compounds (VOC)'s, into the air and excessive noise and odour are also a cause of growing pollution and a health hazard (Fig. 2 and Table 1).



Caulfield (2009) studied the problems associated with dumping textile in landfill in Australia. It was found that use of synthetic fibres in clothes prolonged the decomposition process of textiles as compared to natural fibres. Moreover, the gas liberated and leaching of chemicals into soil surface from decomposition further led to pollution of the environment. This finding should be certainly kept in mind by the manufacturers of the textile industry.

Wallander (2012) studied the harmful effects of dumping textile wastes as landfills. It was found that decomposed clothes release methane which is a harmful greenhouse gas that leads to global warming. Clothes contain dyes and chemicals that can leach into the surface thereby contaminating groundwater. Wallander was of the opinion that in order to avoid environmental harm, dumping textile waste into landfills should be banned.

It is rather alarming to know that besides the direct harm that is caused to environment by apparel industry, use of clothing made from man-made fibre involves the usage of chemicals

Table 1: Type of waste generated during manufacturing of textiles			
Process	Emission	Wastewater	Solid wastes
Fibre preparation	Little or none	Little or none	Fibre waste and packaging waste
Yarn spinning	Little or none	Little or none	Packaging waste, sized yarn, Fibre waste, Cleaning and processing waste.
Slashing/ Sizing	VOCs	BOD; COD; Metals;	Fibre lint; Yarn waste; packaging waste; cleaning waste; starch based sizes.
Weaving	Little or none	Little or none	Packaging waste; yarn and fabric scraps; used oil.
Knitting	Little or none	Little or none	Packaging waste; yarn and fabric scraps.
Tufting	Little or none	Little or none	Packaging waste; yarn and fabric scraps; off-spec fabric
Desizing	VOCs from glycol ethers	BOD from sizing lubricants; biosites; antistatic compounds	Packaging waste; fibre lint; yarn waste; cleaning and maintenance materials
Scouring	VOCs from glycol ethers and scouring solvents	Disinfectants, insecticide residues; NaOH; detergents, oils; knitting lubricants; spin finishes; spent solvents	Little or none
Bleaching	Little or none	H ₂ O ₂ , stabilisers; pH	Little or none, even if little, the impact could be considerable
Singeing	Small amounts exhaust gases from the burners exhaustic which components	Little or none	Little or none
Mercerising	Little or none	High pH; NaOH	Little or none
Heat setting	Volatilisation of spin finish agents synthetic fibre manufacture	Little or none	Little or none
Dyeingss	VOCs	Metals; salt; surfactants; organic processing assistants; cationic materials; colours; BOD; COD	Little or none
Printing	Solvents, acetic acid – drying and curing oven emission combustion, gases	Suspended solids; urea; solvents; colour; metals; heat; BOD	Little or none
Finishing	VOCs; contaminants in purchased chemicals; formaldehyde vapors combustion gases	COD; suspended solids; toxic material Spent solvents	Fabrics scraps and trimming, packaging wastes

Source: Indian Textile Journal (Nov., 2009)

that can cause illnesses like cancer, hormonal dysfunction, behavioural problems as well as immunity deficiency (Bruna Messina, 2012).

Akarslan and Demiralay (2015) studied the harmful effect of textile production on human beings and environment at every stage of textile and garment manufacture. *i.e.* fiber to fabric to garment. Several processes and finishes that are toxic in nature are applied to fiber and fabric before the end product reaches the consumer. The researchers were of the view that people should be made aware of the materials used in textile processing and that have toxic effects.

Polyester is a synthetic fibre and is dangerous for the environment because it can neither be recycled nor bio-degraded. Other synthetic fabrics which pose a threat to the environment are acrylic, acetate, triacetate, nylon, spandex and olefin. Polyester is synthesised by using esters of dihydric alcohol and terephthalic acid which are highly toxic and are not recommended to persons with sensitive skin. Since clothes are in constant touch with human body, toxins in them can enter the blood stream through the skin which is moist and permeable. (Bruna Messina, 2012).

When a fabric dyed with synthetic dyes comes in contact with human skin it can cause certain health problems (Chemical Sensitivity) in adults like skin rashes, headaches, trouble concentrating, nausea, diarrhoea, fatigue, muscle and joint pain, dizziness, difficulty in breathing and irregular heartbeat. In children the symptoms of chemical sensitivity like redness in cheeks and ears, dark circles under the eyes, hyperactivity and behaviour or learning problems have been seen. Shana in the CNN report October 2007 on Green Cotton mentioned that young babies and children have increased levels of chemicals in their skin and bloodstream. The body of a baby is usually warm and so the pores of its skin remain open and this allows perspiration as also absorption of chemicals through the skin. These chemicals generally come from their clothing which is in contact with their skin. [<https://greencotton.wordpress.com/2008/06/18/synthetic-dyes-look-at-the-good-the-bad-and-the-ugly>(<http://www.chemicalsensitivityfoundation.org>)]

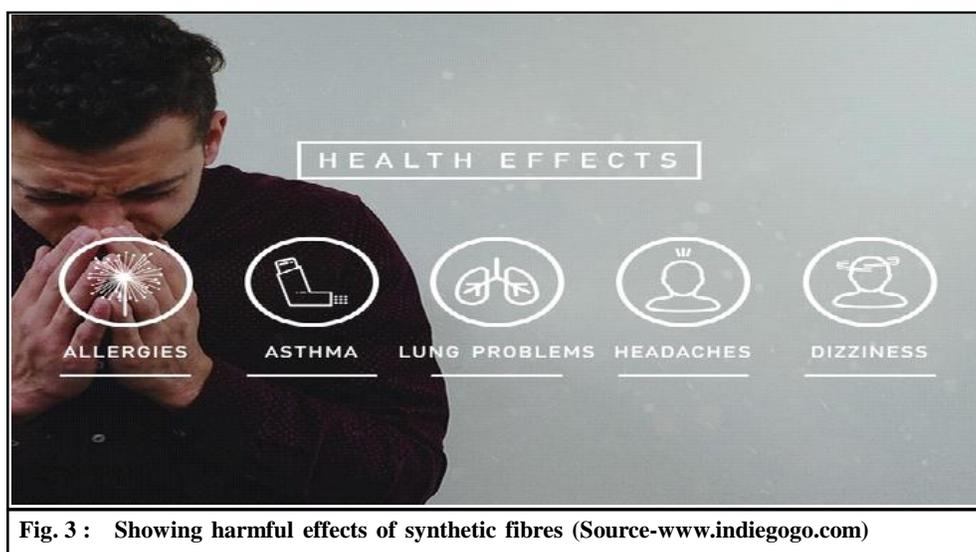


Fig. 3 : Showing harmful effects of synthetic fibres (Source-www.indiegogo.com)

Brit (2008) studied various problems faced by dye workers involved in usage of chemicals in manufacturing of dyes in dye industry. The workers handle synthetic chemical compounds that constitute dioxin, toxic heavy metals and formaldehyde. Similarly, garment finishes like wrinkle-free, stain resistant, flame retardant, anti-static, anti-fungal, anti-bacterial, odour-resistant, permanent press and non-shrink fabric finishes also consist of chemicals harmful to human being. It can be concluded from this study that owners of Dye units and workers employed in them handling harmful chemicals, should take due precautions and be engaged in best practices.

According to U.S. Environmental Protection Agency guidelines, chemically treated fabrics are a source of toxins that affect our environment and health. They are made up of chemicals which are carcinogenic and are hormone disruptors like dioxin, formaldehyde and toxic heavy metals such as chrome, copper, zinc. Some finishes are also made of harmful chemicals such as easy care finish; wrinkle free, shrinkage free containing formaldehyde, water repellent finishes containing fluoro polymers as in Teflon which are used to repel oil and water, bacterial and fungicidal chemicals containing triclosan and nano-particles. Formaldehyde is a major constituent of anti-cling, anti-static, anti-shrink, waterproof, perspiration-proof, chlorine resistant, moth-proof and mildew resistant. It is found to be associated with lung cancer, skin and contact dermatitis. (www.cancerdefeated.com/newsletters/the-clothes-that-kill-you-slowly-but-surely.html 2016)

Dr. Richard Dixon, Head of the World Wild Life (WWF) Federation Scotland, opined that the use of man-made chemicals in textiles is posing a threat to human beings as well as wild life. So better alternatives have to be adopted that are safe to environment by replacing the hazardous usage of chemicals in textiles and other consumer products. (<http://www.ifdcouncil.org/the-dangers-of-synthetic-fabric>. 2016)

Various alternatives to synthetic finishes that are eco-friendly and sustainable :

To reduce the toxicity of fabric and make it more eco-friendly, scientists through their researches and technological advances are finding innovative methods of developing fabric and finishes so that they are non-toxic to human beings and environment. Due to recent outbreak of diseases and global warming, the usage of essential oils which are obtained from plants is increasing to make fabric anti-odour, anti-bacterial and mosquito repellent.

In the last two decades, the prevention of microbial attack on textile materials has become increasingly important to consumers and textile producers. Initially herbal extracts were applied directly on skin but with new developments technologists have been able to make herbal cloth *i.e.* 'Ayurvastra'. It is a clothing made from organic cotton fabric that has been embedded with special herbs and oils to cure disease resulting in good health. Finishes are being applied to textiles which are durable, eco-friendly and non-toxic to humans. (www.textilevaluechain.com)

Sarkar *et al.* (2003) studied the application of clove, neem, tulsi and karanja oil on cotton fabric for their anti-bacterial property and found that clove and neem oil show good anti-bacterial property. Just 1% clove oil with KVISI (DMDHEU- Dimethylol dihydroxyethylene urea based inbuilt catalyst) exhibit excellent results.

Joshi *et al.* (2009) studied the application of various natural herbal extracts, chitosan

and natural dyes on textiles with emphasis on their anti-microbial behaviour. They critically analyzed their future prospects keeping in mind their durability, shelf life and anti-microbial efficiency and found that these agents can be used for imparting finish to the fabrics.

Sathianarayanan *et al.* (2010) studied the application of *Ocimum sanctum* (tulsi leaf) and rind of *Punica granatum* (pomegranate) on cotton fabric. The finish application was done by using direct application method, micro-encapsulation, resin cross-linking and their combinations.

Specos *et al.* (2010) studied the mosquito repellent effect of cotton fabrics treated with citronella oil through usage by humans. The subjects wore gloves made from mosquito repellent finished fabric and observed the effect by keeping their hands inside the box with mosquito *aedes aegypti*. The fabric treated with microencapsulated citronella showed better results as compared to ethanol solution of essential oils. It was concluded that microencapsulation of finish by pad-dry-cure method gives good results.

Chandrasekaran *et al.* (2012) studied the application of 16 medicinal herb such as neem, turmeric, basil, sandal wood etc. on cotton for treatment of 7 different diseases such as dermatitis, psoriasis, asthma, liver disorders, headache, joint pain, sinus / cold and found that there was a correlation between the antibacterial activity and the curative property of fabric.

Sumithra and Raaja (2012) studied the application of herbal extracts of *Ricinus communis*, *Senna auriculata* and *Euphorbia hirta* on 100% cotton denim fabric. It was found that the best combination of herbal extracts *.i.e.* *Ricinus communis*, *Senna auriculata* and *Euphorbia hirta* was (1:2:3) when applied through exhaustion method on fabric. The finish lasted for 30 industrial washes and showed good anti-microbial resistance against microbes.

Sundarajan and Rukmani (2012) studied the antibacterial properties of limonene after applying it to cotton through microencapsulation by using gum acacia as wall material. It was found that limonene microcapsules were fixed to the fabric by using cross linker citric acid which formed covalent bonds with the fabric due to which the fabric retained the antibacterial property even after 5 washing cycles. The durability of the finish can be increased by using fixing agent so that its wash durability can be increased.

Aparna and Krishnaveni (2014) studied the application of Aloe vera gel on 100% cotton knit single jersey through microencapsulation technique. Microcapsules were formed using herbal extracts as core and gum acacia as wall material. These were applied on fabric by simple pad-dry-cure method which was further used in the treatment of skin diseases. It can be concluded that herbal cloth can be made by microencapsulation of essential oils through padding.

Geethadevi and Maheshwari (2014) studied the application of essential oils like thyme oil, cypress oil and grapefruit oils in combination with natural gums like sodium alginate, acacia arabica and moringa oleifera by using microencapsulation technique as essential oils in core material. These oils were mixed in different ratio and final ratio selected was 2:1:1. The three natural gum materials were used as shell materials for good durability. It was found that Moringa Oleifera finished fabric showed good results for UV protection, mosquito repellence and no allergic reaction was found on skin.

West and Hitchcock (2014) studied the application of essential oils on textiles with the

Table 2: Natural gum from plant sources					
Natural gum	Common name	Genus	Part used	Uses	Picture
<i>Acacia arabica</i>	Thorn tree, Shittah tree or Babool tree	Acacia	Bark	Anti-Bacterial, Anti-Fungal, Sore throat, Cough, Diarrhoea	
<i>Moringa oleifera</i>	Drumstick tree	Moringaceae	Flower, leaves, seeds, roots	Cholera, Scurvy, Respiratory ailments, Anti-bacterial and Anti-malarial	

Table 3 : Natural gum from animal sources					
Natural gum	Common name	Source	Chemical formula	Uses	Picture
Sodium Alginate	Alginic Acid or Algin or Alginate	Cell wall of Brown Algae	$\text{NaC}_6\text{H}_7\text{O}_6$	It is an anionic polysaccharide which forms viscous gum with water	



usage of different methods like Pad-Dry-Cure, Microencapsulation and Mixed methods. These aroma oils have medicinal and anti-microbial properties benefiting mankind. They are eco-friendly and can be used as medicinal textiles. It was found that microencapsulation of finish yielded good results with pad-dry-cure method because the finish got interlaced between the spaces in the fibre and was not present superficially.

Table 4 : List of essential oils						
Name of essential oil	Botanical Name	Common method of extraction	Part used	Uses	Picture	
Berry oil	<i>Juniperus communis</i>	Steam distilled	Berries	Colds, flu, acne, cellulitis, hemorrhoids, obesity, rheumatism		
Citronella oil	<i>Cymbopogon nardus</i>	Steam distilled	Grass	Excessive perspiration, fatigue, headache, insect repellent		
Clove oil	<i>Eugenia caryophyllata</i>	Steam distilled	Buds	Arthritis, asthma, bronchitis, rheumatism, sprains, strains, toothache		
Grape fruit oil	<i>Citrus paradise</i>	Cold pressed/ Ex-pressed	Citrus Rind	Cellulitis, dull skin, toxin build-up, water retention		
Lemon oil	<i>Citrus lemon</i>	Cold pressed/ Expressed	Citrus Rind	Athlete's foot, chilblains, corns, flu, oily skin, spots		
Lemon grass oil	<i>Cymbopogon citratus</i>	Steam distilled	Grass	Acne, athlete's foot, excessive perspiration, flatulence, insect repellent		
Thyme oil	<i>Thymus vulgaris / Thymus zygis</i>	Steam distilled	Leaves and Flowers/ Buds	Arthritis, colds, cuts, dermatitis, flu, insect bites		

Bano (2014) studied the application of mosquito repellent finish on cotton knitted fabric by using commercial binder and replacing it with natural binder chitosan. It was found that chitosan was more durable as compared to commercial binder in terms of repellence and wash durability.

Javid *et al.* (2014) studied the micro-encapsulation of essential oils with chitosan in presence of cross linking agent dihydroxy ethylene urea and a bio surfactant with respect to their size, morphology and stability and found that anti-bacterial activity increases with increase in concentration of chitosan and essential oils.

Conclusion :

From the above reviews it can be concluded that herbal cloth can be made by applying essential oils on cotton which is safe for environment and human beings. The essential oils are extracted from plants due to which they are non-toxic and safe for usage in comparison to synthetic finishes and fibres which involve the use of chemicals in their manufacturing process.

Herbal finish can be either applied through direct application by traditional pad-dry-cure method or other methods of finish application like microencapsulation of oil followed by padding. So application of finish should be done by using natural herbal extracts leading a path to greener environment.

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