Development of Eco-labels for Sustainable Textiles

A.K. Roy Choudhury

Abstract The main purpose of the eco-label is to stimulate consumers to buy environmentally-sound products and, in turn, to stimulate producers to produce in an environmentally friendly manner. Labels allow consumers to make comparisons among products. Consumers are also provided with the ability to reduce the environmental impacts of their daily activities by purchasing environmentally preferable and healthy products and by minimizing adverse consequences during use and disposal. Eco-labeling has emerged globally as a differentiating factor in retail markets for textile and apparel purchases. It is a primary tool for marketing to well-informed and 'green' customer; thus, eco-labeling has become very important to the development of a sustainable and credible textile industry. The Ecolabel Index currently contains brief details about 449 eco-labels in 197 countries and 25 industry sectors.

Keywords Ecology · Eco-label · Restricted substances lists (RSLs) · Organic cotton

1 Introduction

Ecology is the scientific study of interactions among organisms and their environment, such as the interactions organisms have with each other and with their abiotic (nonliving) environment. Ecosystems are composed of dynamically interacting parts, including organisms, the communities they make up, and the nonliving components of their environment. Ecosystem processes, such as primary production, pedogenesis (soil formation), nutrient cycling (the movement and exchange of organic and inorganic matter back into the production of living matter), and various

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S.S. Muthu (ed.), *Roadmap to Sustainable Textiles and Clothing*,
Textile Science and Clothing Technology, DOI 10.1007/978-981-287-164-0_6

niche construction activities, regulate the flux of energy and matter through an environment. These processes are sustained by organisms with specific life history traits, and the variety of organisms is called biodiversity. Biodiversity—which refers to the varieties of species, genes, and ecosystems—enhances certain ecosystem services.

Ecology is an interdisciplinary field that includes biology and earth science. The word *ecology* ("Ökologie") was coined in 1866 by the German scientist Ernst Haeckel (1834–1919). Ancient Greek philosophers, such as Hippocrates and Aristotle, laid the foundations of ecology in their studies on natural history. Modern ecology transformed into a more rigorous science in the late 19th century. Evolutionary concepts on adaptation and natural selection became cornerstones of modern ecological theory. Ecology is not synonymous with the environment, environmentalism, natural history, or environmental science. An understanding of how biodiversity affects ecological function is an important focus area in ecological studies. Ecologists seek to explain:

- Life processes, interactions, and adaptations
- The movement of materials and energy through living communities
- The successional development of ecosystems
- The abundance and distribution of organisms and biodiversity in the context of the environment.

Ecology is a human science as well. There are many practical applications of ecology in conservation biology, wetland management, natural resource management, city planning (urban ecology), community health, economics, basic and applied science, and human social interaction (human ecology). Organisms and resources compose ecosystems, which, in turn, maintain biophysical feedback mechanisms that moderate processes acting on living (biotic) and nonliving (abiotic) components of the planet. Ecosystems sustain life-supporting functions and produce natural capital, such as biomass production (food, fuel, fiber, and medicine), the regulation of climate, global biogeochemical cycles, water filtration, soil formation, erosion control, flood protection, and many other natural features of scientific, historical, economic, or intrinsic value (Odum and Barrett 2005).

This chapter discusses the use of various nonsustainable materials in the textile industry, the development of a large number of eco-labels to assure the nonuse of such substances, and confirmation of the sustainability of textile processes and products.

2 Textile and Ecology

Since prehistoric times, textiles have been produced by human beings. Textile manufacturing developed empirically based on previous experiences and randomly acquired knowledge; many professionals kept their manufacturing experiences secret. Technology stagnated, while the rate of developments and improvements in manufacture was extremely slow. For a long time, there was no scientific approach to textile manufacture. Significant developments in the textile industry started by the end of the 18th century. Increased demand for textiles initiated investigations into ways to improve production. A series of inventions followed in the field of textile machinery and textile chemistry, as well as the introduction of new machines for manufacturing. These machines marked the beginnings of the Industrial Revolution. By the middle of the 19th century, artificial dyestuffs and the mercerization process were invented, which paved the way for a more scientific approach to textile finishing and dyeing. At the end of the 19th and beginning of the 20th centuries, these fields were marked by full industrial development. Environment pollution by this type of manufacturing presented no serious threat because textile manufacture at the time was much smaller, as was the population that used its products. Additionally, the chemicals used were mostly of natural origin (e.g. soaps, starches, vegetable oils), which were all easily biodegradable. Chemicals in wastewater and the air were mostly degraded and neutralized by natural processes. However, increased population and higher consumption of textiles per capita led to increased production and care, which resulted in a serious hazard to the environment.

During the last century, numerous new dyestuffs and auxiliaries were synthesized and gradually accumulated in the environment. Because of increased environment consciousness and enhanced knowledge, people began to realize that numerous chemicals previously considered to be safe and harmless were in fact carcinogenic, potentially carcinogenic, or toxic; consequently, legal regulation to ban these products or to limit their use resulted (Sivaramakrishnan 2009a, b).

According to these regulations, designers and manufacturers of textile products are supposed to pay special attention to meeting contemporary ecological requirements. For a product to be “green”, it should be environmentally friendly throughout its production cycle, during use and care, as well as after its useful life has been terminated. Product design must not consider only the requirements of the economy but also those of ecology (Thiry 2009). In constructing a product, the designer should analyze the production process, together with the product’s end use, everyday use, and care for the product designed.

Special certificates are awarded by independent institutions to the products that are environmentally friendly and do not represent health hazards. Ecological acceptability can be influenced by the raw material selection. Textiles that can be recycled should not be mixed with those that are not acceptable for recycling. Individual garment parts, such as some coatings, fibers, and zippers, may not be ecologically friendly. Although their substitution may be quite expensive, a producer aiming for ecological production will consider substituting such parts with ecologically acceptable and environmentally friendly products.

Designers should keep in mind that the responsibility for the product does not end with its manufacture; it lasts at least as long as the lifecycle of the product in question. It is extremely important for textile products not to emit volatile organic compounds or some other harmful substances (e.g., heavy metals) during their use and care. Textile care exhibits more profound and more serious impacts on the environment than the manufacture itself. Excessive quantities of water are generally used for the repeated washing of used textile materials. This is the reason why textile products should be designed to have as little need as possible for washing and dry cleaning. For example, a proper and environmentally friendly oil-proof finish, if also soil-resistant, can considerably reduce the number of necessary washing and dry cleaning cycles, which obviously saves water and energy in the lifecycle of the product being treated. Washing at lower temperatures offers a method of savings as well.

Another approach to the problem is to extend the lifecycle of the product as much as possible because costs will be reduced in this manner for raw materials, manufacture, and finishing. The product should be manufactured to soil as little as possible, while the colors should not fade until the end of the product's useful life. Another important factor is the elimination of unpleasant odors that could develop in wear and general use. The useful life of the product can be additionally extended in this way.

The last factor is of special importance for sports articles. Antimicrobial treatment is necessary for these products because microorganisms degrade human sweat, and the products of this degradation often develop unpleasant odors. Antimicrobial treatment is even more important in finishing rugs, carpets, and other decorative textiles. Various bacteria and molds often develop on such products, especially under wet conditions, and they can easily damage the texture, cause color changes, or create stains that are extremely hard to remove (Bešensky and Soljacic 1983).

Some experts think that textile designers and manufacturers should be obligated to care for the final disposal of textiles, after their lifecycle is complete. The worst solution is to consider putting such products in landfills. At minimum, a product could be burned, producing some energy in the process. The best solution is to recycle textiles and reuse them as fillers for other textile articles or remanufacture them into new products. Obviously, the advantage is to have textiles designed from a single type of fiber, or fibers of similar properties, so as to make recycling easier (Thiry 2009).

The growing population and increased per capita consumption of textiles result in higher loads on the environment, both by effluent water and exhaust air. The literature confirms that water consumption has double the growth rate of population. Population has tripled in the past 100 years, whereas water consumption increased sevenfold. A serious shortage of potable water is expected in the near future (Strohle and Böttger 2008). There is also a real danger of permanently damaging and polluting the environment. Considerable and harmful consequences could be expected, which will be detrimental to human health and nature, particularly aquatic animal life.

Textile industry is considered to be the most hazardous environmental issue globally (Oecotextiles 2012). Primary sources of ecological problems in the textile industry are the finishing processes, from initial scouring and bleaching, through mercerization and dyeing, to final finishing processes and coatings applied to textiles. Therefore, it is of crucial importance to monitor and control wastewater pollution and exhaust air pollution in order to reduce the harmful effects of the above-mentioned processes. Additionally, textiles produced in conventional processes sometimes contain dyestuffs and residual chemicals, which can evaporate or penetrate through the skin. Some of them are carcinogenic or can cause allergic reactions (Sivaramakrishnan 2009a, b).

To prevent these harmful effects, but also thanks to new knowledge and higher levels of ecological awareness, more and more restrictions and bans have been imposed or proposed, concerning on the use of particular chemicals and dyestuffs. In some instances, their use is limited by the regulations dealing with maximum allowed concentration for a particular chemical compound that can be used in treating a textile or that is allowed to remain on a particular textile substrate (Soljacic and Pušic 2005). This problem has been recognized since the 1960s, although some protective measures were taken even earlier. The measures aimed at protecting the environment and workers' health are becoming stricter. Currently, the following measures and procedures are most often implemented:

- Complete elimination of all the carcinogenic or potentially carcinogenic chemicals and dyes
- Substitution of aggressive chemicals with biodegradable materials
- Elimination of active chlorine and other active halogen compounds or, at minimum, a reduction in their use
- Recycling, purifying, and reusing chemicals (e.g., caustic soda from mercerization)
- Substitution of formaldehyde compounds with those that contain no formaldehyde or, when necessary, with compounds that contain reduced amounts of formaldehyde
- Elimination of dyestuffs containing heavy metal ions
- Use of dyestuffs with maximum exhaustion (if possible, above 90 %) so that wastewater pollution is reduced
- Reduction of the dye-to-liquor ratio, as well as the reduction of water, energy, chemical, and dyestuff consumption
- Reuse of heat and water (using them repeatedly in treatment processes) by which considerable savings in energy and water can be realized while reducing the level of environment pollution

Textile care consumes more water, chemicals, and energy than textile production (dyeing, finishing). Additionally, textiles are not washed only in large laundries, but primarily in numerous households, which multiplies the effect. Generally, the same principles of environment protection are implemented in textile care and production as well. Maximum energy, water, and chemical savings are the aim, while toxic and hazardous chemicals are supplemented by ecologically more favorable products that have less harmful impacts on both the environment and human health.

Special attention in laundering is given to compounds that are not fully biodegradable, primarily surfactants, which should be eliminated; biodegradable compounds should be used instead. Textile products that come to a shop should be marked with hanging tags or in-sewn labels—or often, both. Care instructions should contain the information on how and under which conditions a particular textile product should be washed or dry cleaned to remain functional and keep its appearance for as long as possible.

Ecology has been, for some time, one of the key factors in selecting and managing textile finishing and care processes. Proper selection of dyestuffs, detergents, and chemicals, together with optimal process control, can result in serious savings of natural resources, water, and especially energy, as well as in considerable reduction of environment pollution.

2.1 Textile Ecology

The term *textile ecology* is easier to comprehend if it is explained in three parts: production ecology, human ecology, and disposal ecology (Moore and Wentz 2009).

Production ecology refers to the process of production and manufacture of fibers, textiles, and garments. Sustainable textiles should be environmentally friendly and should satisfy the rational conditions to respect social and environmental quality by pollution prevention or by installing pollution control technologies. Third-party certification bodies and governments have issued Restricted Substances Lists (RSLs) that link production ecology to human ecology. Such lists provide stimuli to promote the use of safer chemical inputs and provide targets for the verification of cleaner production of textile products.

Human ecology focuses on the effects of textiles on the users and their near environment or surroundings. According to the present methodology, concentrations of substances that could induce dangerous effects on humans during normal use must be understood, modeled, and managed. Consumers are concerned with this aspect of textile human ecology. Risks have been addressed through the development of RSLs by governments, retail organizations, producers, and non-governmental organizations. RSLs must be analyzable for the final textile products used by people, and they must be reviewed regularly as living documents.

Product analyses to detect and quantify RSL substances should be performed by accredited independent laboratories. Consensus-based test methods must be used to verify the absence or concentrations of harmful chemicals. The diverse and complex nature of global textile production requires analytical verification of the absence or concentration of restricted substances by accredited international laboratories. The modular concept of the Oeko-Tex Standard 100 certification at every stage of production has the advantage that intermediate textile components can be certified for eco-labeling. It prevents costly supply rejections at every step of the textile chain and supplements conventional quality assurance testing. The development of updated RSLs and the corresponding development of international third-party laboratory networks to verify RSL compliance is becoming an important tool for human ecology product assurance. This concept of disposal ecology is based on what happens at the end of the ‘first use’ of textile products. Disposal ecology addresses the recycling, reuse, energy, disposal, and/or decomposition of textile products without release of harmful substances or thermal elimination without endangering air purity.

Ecology for textiles, and by inference eco-labels for textiles, may address production, human, and disposal ecologies. Because the textile industry is truly global in scope, products are made and sold throughout the world. Therefore, compliance with various companies' individual requirements can be a challenge. Some trade regulations have produced unified information label requirements that describe the country of origin and fiber content. Eco-labels are now attempting to inform consumers additionally of the 'textile ecology' of the products they are buying.

For modern production technologies, analytical laboratories (after rapid information dissemination) can produce eco-certifications and labeling schemes that are transparent, accurate, and cost-effective. Until recently, textile labels that addressed composition, care, and origin were considered adequate. Human ecology, production ecology, and lifecycle information are now demanded by major international retailers. The eco-labels of the future will provide a myriad of information that encompasses the social and environmental aspects of a product.

3 Sustainability

Sustain means "to maintain" or "to uphold." With regards to industrial processes, *sustainability* means establishing principles and practices that help to maintain the equilibrium of nature—or, in other words, to avoid damage to the earth's natural sources. A greater degree of sustainability in industrial processes and systems requires a better balance between the social, economic, and environmental aspects of textile production. A sustainable product is one that is manufactured in the following ways:

(1) It respects the social elements of fair trade and the human rights of the people involved in the whole of the manufacturing chain.
(2) It has the lowest possible adverse effect on the environment with the most efficient use of water and energy, recycling of raw materials and water, and recovery of heat from wastewater.
(3) It should not be an uneconomic choice versus less sustainable products and the economic returns should be fairly distributed along the supply chain.

Various fashion brands and retailers are considering the options available to make their products "green." To achieving more ethical or sustainable clothing, one should start at the design stage, such as the use of more sustainable textile fibers and low-impact dyes and chemicals. Eco-friendly fibers may be natural or synthetic, but they must have reduced environmental impact in their production and processing compared to conventional fibers. Exclusion or reduction in the use of pesticides and synthetic fertilizers during their production results in less hazards for human beings, especially for farmers. Some of these fibers have been used in the textile and apparel industries for a long time but became more important in recent years due to

Table 1 Classification of eco-friendly textile fibers

Class	Eco-friendly fibers
Organic	Organic cotton, organic wool, organic silk
Man-made	Corn/soya bean, lyocell, pineapple, milk weed
Recycled	Recycled cotton, recycled polyester
Natural	Naturally colored cotton

their environmental benefits, such as organic fibers (cotton, wool, silk), recycled cotton, naturally colored cotton, lyocell, corn, soya bean, recycled polyester, and some others, as listed in Table 1 (Jain and Easter 2010).

With the increase in consumer interest and the establishment of third-party certification systems, the textile industry has emphasized the production of sustainable fibers and the search for newer alternatives. Some successful examples are Tencel, recycled polyester, recycled and organic cotton, and bamboo. However, the sustainability and eco-friendliness depend critically on how the fiber is subsequently processed.

The careful selection of dyes and chemicals through accurate and reliable information provided by reputed suppliers enables processors to match a customer's RSL criteria. Because of a lack of clear information and the absence of an internationally agreed-upon standard for a definition of eco-friendly dyes, various myths and misinformation have emerged around dyestuffs.

In summary, a sustainable approach covers the following points:

- Minimum use of resources (water and energy)
- Minimum chemical consumption
- Minimum pollution load
- Elimination of toxic chemicals from the supply chain.

Therefore, sustainable textiles or apparels are,

- Safe for humans and the physical environment
- Made from renewable materials
- Produced while making the most efficient use of resources, such as water and energy
- Manufactured by people employed in decent working environments
- Capable of being washed at low temperatures using environmentally friendly laundering agents
- Capable of being returned safely to the environment at the end of their useful life (Performance Apparel Markets 2009).

In terms of life cycle assessment, sustainable textiles are manufactured and used in sustainable ways without using restricted substances and can be disposed of sustainably after use.

To minimize the usage, it is important to measure the inputs. To eliminate the most harmful chemicals, it is important to know and understand what is being used.

Uncontrolled or unknown inputs lead to the unmanaged use of resources and uncontrolled outputs. The measurement and control of these inputs and outputs can lead to the following:

- Improved resource productivity
- Improved eco-efficiency
- Improved cost efficiency
- Improved customer satisfaction
- Improved brand reputation

4 Restricted Substances

The relocation of production due to globalization has created additional levels of complexity for sustainable textile production because different nations have different environmental laws—or even none at all. To secure a clean production by manufacturers, trade and brands around the world refer to the RSL. The number of demanding and critical consumers requesting transparent value chains and high-quality, harmless, and environmentally safe products is constantly growing. This is a challenge that future-driven businesses have to accept. The textile industry is a major manufacturing industry and will continue to be so in the foreseeable future. It is no longer adequate to have a finished product be safe only to human beings—the product has to be environmentally safe during its entire lifecycle, and even beyond. Environmental technology (or green technology, clean technology) is the application of the environmental science and green chemistry to conserve the natural environment and resources and to curb the negative impacts of human involvement.

RSLs can be very extensive. These lists differ from country to country and from industry to industry. Not surprisingly, governments and industries focus on the dangerous substances that are important to them, in the sense that they cause severe health or environmental problems. Nevertheless, some substances are commonly found in RSLs.

Textile industries are using a large number of chemicals, which include toxic and harmful substances used during various processes; a few are listed here (Roy Choudhury 2011):

(a) Cotton growing—banned pesticides such as DDT, Dieldrin, Aldrin, etc.
(b) Sizing—pentachlorophenol as a preservative
(c) Scouring—chlorinated products
(d) Bleaching—sodium and calcium hypochlorite
(e) Dyeing and printing—azo dyes containing/releasing banned amines, dyes containing traces of heavy metals (e.g. arsenic, lead, cadmium, mercury, nickel, copper, chromium, cobalt and zinc), formaldehyde-based auxiliaries
(f) Finishing—formaldehyde-based finishes, stain removers containing chlorinated products
(g) Packing—wooden boxes treated with insecticides

4.1 Azo Dyes

The use of azo dyes is one of the hottest issues that the textile/garment and apparel industries have had to face. These dyes have outstanding fastness properties and have been widely used in the industry, accounting for about 60–70 % of the dyes used. However, certain azo dyes may, under suitable conditions, undergo in vivo reductive cleavage of the azo bond to form harmful aromatic amines. Some of these aromatic amines are either proven or suspected carcinogens. At present, 22 amines are classified by the European Union or the MAK Commission as human carcinogens. The use of dyes that may cleave to any of those 22 amines has been restricted.

Before 1970, bladder cancer was common among workers engaged in handling benzidine in the production of benzidine dyes. In 1971, the major German colorant manufacturers voluntarily agreed to cease production and marketing of such azo dyes.

At the beginning of the 1990s, the German Senate Commission for testing for harmful substances recommended that azo dyes should be treated in the same way as the amines on which they are based, because the azo dyes can be split under certain physiological conditions to form carcinogenic amines. In a second amendment in 1994 to the Ordinance on Materials and Articles, the use of certain azo dyes is prohibited in the manufacture of materials and articles that are designed for more than temporary contact with the human body. The specific azo dyestuffs include those that are known to be toxic or are suspected to release harmful aromatic amines.

Two German laws have been amended that apply specifically to textile processing activities: the Fourth Federal Emission Protection Ordinance and the ordinance on materials and articles. The German Legislation came in force from 30th June 1996. The German ordinance on materials and articles has received worldwide attention because of its fundamental importance for the textile supply chain. It is probably the most widely discussed law in the textile sectors in the last few years. Twenty aromatic amines are banned, which are listed below (source: Eco-Tex Consortium, Germany).

Amines definitely carcinogenic in nature:

(1) Benzidine
(2) 4-chloro-o-toluidine
(3) 2-naphthylamine
(4) 4-aminodiphenyl
Amines reasonably suspected to be carcinogenic:
(5) o-toluidine (3,3′ dimethyl benzidine)
(6) o-dianisidine (3,3′ dimethoxy benzidine)
(7) p-chloro-aniline
(8) 4-chloro-o-toluidine
(9) 3,3′-dichloro-benzidine
(10) o-amino-azotoluene

(11) 2-amino-4-nitrotoluene
(12) 2,4-toluylendiamine(4-methyl 1-1,3 phenylenediamine)
Other prohibited amines:
(13) 2,4-diaminoanisole (4-methoxy-m-phenylenediamine)
(14) 4,4′-diaminodiphenylmethane
(15) 3,3′-dimethyl-4-4′-diaminodiphenylmethane
(16) p-kresidine (2-methoxy 5-methylaniline)
(17) 4,4′-methylene–bis-(2-chloroaniline)
(18) 4,4′-oxydianiline
(19) 2,4,5-trimethylaniline
(20) 4,4′-thiodianiline
Dyes releasing following amines on decomposition that are to be phased out:
(21) p-amino-azobenzene
(22) 2-methoxyaniline

Approximately 70 % of all dyes (belonging to various dye classes) used in the textile industries are azo dyes. Due to their toxic nature or amine-releasing properties, approximately 25 % of the azo dyes are already prohibited in manufacture and use.

According to DIN 55493, pigments are colorants that are not bioavailable because they are not soluble in the application medium. The Fifth Amendment (November 1996) excludes poorly soluble pigments with a molecular weight of more than 700. The decision on whether a pigment is prohibited is based on the official test method.

The forbidden dyes belonging to various dye classes are listed below (without any guarantee of completeness).

Direct dyes (amine releasing, 82 dyes):

C.I. Direct Yellows 1 (22250), 24 (22010), 48 (23660).

C.I. Direct Oranges 1 (22370), 6 (23375), 7 (23380), 8 (22130), 10 (23370), 108 (29173).

C.I. Direct Reds 1 (22310), 2 (23500), 7 (24100), 10 (22145), 13 (22155), 17 (22150), 21 (23560), 22 (23565), 24 (29185), 26 (29190), 28 (22120), 37 (22240), 39 (23630), 44 (22500), 46 (23050), 62 (29175), 67 (23505), 72 (29200).

C.I. Direct Violets 1 (22570), 12 (22550), 21 (23520), 22 (22480).

C.I. Direct Blues 1 (24410), 2 (22590), 3 (23705), 6 (22610), 8 (24140), 9 (24155), 10 (24340), 14 (23850), 15 (24400), 22 (24280), 25 (23790), 35 (24145), 53 (23860), 64 (22595), 75 (24411), 76 (24411), 151 (24175), 160 (-), 173 (-), 192 (-). 201 (-), 215 (24115), 295 (23820).

C.I. Direct Greens 1 (30280), 6 (30295), 8 (30315), 8:1 (-), 85 (30387).

C.I. Direct Browns 1 (30045), 1:2 (30110), 2 (22311), 6 (30140), 25 (36030), 27 (31725), 31 (35660), 33 (35520), 51 (31710), 59 (22345), 79 (30056), 95 (30145), 101 (31740), 154 (30120), 222 (30368).

C.I. Direct Blacks 4 (30245), 29 (22580), 38 (30235), 86 (24115), 91 (30400), 154 (-).

Direct dyes (without C.I. No.) - (23820), - (30230).

Acid dyes (amine releasing, 24 dyes):

C.I. Acid Orange 45 (22195).
C.I. Acid Reds 4 (14710), 5 (14905), 24 (16140), 73 (27290), 85 (22245), 114 (23635), 115 (27200), 116 (26660), 128 (24125), 148 (26665), 150 (27190), 158 (20530), 167 (-), 264 (18133), 265 (18129), 420 (-).
C.I. Acid Violet 12 (18075), Brown 415 (-).
C.I. Acid Blacks 29 (-), 94 (30336), 131 (-), 132 (-), 209 (-).

Acid dyes (poisonous, 2 dyes):

C.I. Acid Oranges 156 (26501), 165 (28682)

Acid dyes (carcinogenic, 4 dyes):

C.I. Acid Red 26 (16150), Violets 17 (42650), 49 (42640), (without C.I. No.) - (16155).

Basic dyes (carcinogenic, 8 dyes):

C.I. Basic Yellows 2 (41000), 21 (48060).
C.I. Basic Reds 9 (-), 12 (48070).
C.I. Basic Violet 16 (48013).
C.I. Basic Blues 3 (51004), 7 (42595), 81 (-).

Basic dyes (amine releasing, 3 dyes):

C.I. Basic Reds 42 (-), 111 (-).
C.I. Basic Brown 4 (21010).

Azoic colors (poisonous, 3 components):

C.I. Azoic Diazo Components 20 (37175, Blue BB), 24 (37155, Blue RR), 41 (37165, Violet B).

Azoic colors (amine releasing Components, 8 Nos.):

C.I. Azoic Blue 37.
C.I. Azoic Diazo Components 11 (37085, Red TR), 12 (37105, Scarlet G), 17 (37270, Orange R), 29 (37255, Red GTR), 48 (37235, Blue B), 112 (37225, Corinth B), 113 (37230, Dark Blue R).

Disperse dyes (carcinogenic, 1 dye):

C.I. Disperse Blue 1 (64500).

Disperse dyes (allergenic, 26 dyes):

C.I. Disperse Yellows 1 (10345), 3 (11855), 7 (26090), 9 (10375), 23 (26070), 39 (-), 49 (-), 54 (47020), 56 (-), 64 (47023).
C.I. Disperse Oranges 1 (11080), 3 (11005), 76 (-), 149 (-).
C.I. Disperse Reds 1 (11110), 11 (62015), 15 (60710), 17 (11210), 151 (-).
C.I. Disperse Blues 3 (61505), 7 (62500), 26 (63305), 35 (-), 102 (-), 106 (-), 124 (-).

Others:

C.I. Developer 14 (76035, Developer B)
C.I. Ingrain Blue 2/2(74160, Phthalogen Brill. Blue IF3G, Brill. Blue 3G)

4.2 Chlorinated Phenols

Chlorinated phenols (e.g., pentachlorophenol [PCP] and tetrachlorophenol [TeCP]) have been used as wood preservatives, as an impregnation agent for textiles, as a bactericide in tanning, and in the paper and pulp industries. They are very hazardous to both humans and the environment.

4.3 Formaldehyde

Formaldehyde, with its pungent smell, can be used as a cross-linking. anti-greasing, and anti-shrinking agents; it is also used as a preservative. Formaldehyde is a suspected carcinogen and is irritating to the eyes, nose, and other tissues.

4.4 Brominated Flame Retardants

Brominated flame retardants are also on RSLs. These substances persist once they enter the environment and the food chain and are likely to accumulate in biological tissues, implicating them as being dangerous to wildlife. The European Parliament has banned the application of pentabromodiphenyl ether (pentaPBDE) and octabromodiphenyi ether (octaPBDE), while risk assessments of decabromodiphenyl ether (decaPBDB) are in progress.

4.5 Organotin Compounds

Organotin compounds are commonly used as plastic stabilizers, catalytic agents, industrial biocides, and antifouling paints. They are environmental pollutants and are particularly harmful to the aquatic environment. Organotins are very toxic to marine and freshwater organisms, even at very low levels.

4.6 Other Substances

Some RSLs have been extended to include other substances causing health concerns. Chemicals such as disperse dyes for polyesters and nickel released from metal parts may cause skin sensitization when the articles are in direct contact with skin. Heavy metals with different health hazards may be present as impurities in dyes or catalytic agents. Pesticides and biocides raise serious health concerns because of their particularly toxic nature. Other substances such as some organic solvents, chlorinated organic carriers, nitrosamines, and nonylphenol may also be listed.

5 Organic Fiber Production

Organic vegetable fiber is produced from plants that are not genetically modified and are certified to be grown without the use of any synthetic agricultural chemicals, such as fertilizers, pesticides, or defoliants. They are produced according to the internationally recognized organic farming standards of EU regulation 834/2007, the US National Organic Program, the Indian National Programme for Organic Production, or the Japanese Agricultural Standard. Organic fiber production is more environmentally friendly and better for the health of the community (Global Organic Cotton Community Platform 2012).

Organic cotton production does not simply mean replacing synthetic fertilizers and pesticides with organic types. Rather, it is a systemic approach that aims to establish a diverse and balanced farming ecosystem, ideally including all types of crops and farm activities. Farms typically need to complete a two-year conversion period to change their production system from conventional to organic. An essential element of organic cotton production is the careful selection of varieties adapted to local conditions in terms of climate, soil, and resistance to pests and diseases. Soil fertility management and crop nutrition are based on crop diversification and organic inputs, such as compost, mulch, and manures. Pest management focuses on pest prevention and the stimulation of a balanced agro-ecosystem through crop rotation, mixed cultivation, trap crops, and the use of natural pesticides when pest infestation rises above the economic threshold. The beneficiaries of organic cotton are farmers, traders/retailers, and consumers. The benefits gained include the following (OTA 2013):

(1) A balanced ecosystem and enhanced health
(2) Improved economic situation and food security
(3) Improved access to markets
(4) Training and education

The benefit for the traders and retailers include the following:

(1) Participation in a dynamic market
(2) Traceability, risk management, and quality management
(3) Contribution to ecological and social sustainability
(4) Credibility and a good image

Benefits for consumers include the following:

(1) Buying a healthy product
(2) Traceability, clear standards, and labels
(3) Environmental friendliness
(4) A positive impact on producers' livelihoods

5.1 Organic Cotton

For a given weight of cotton harvested, a farmer uses one-third of that weight in chemical fertilizers. Cotton plants are highly susceptible to pests, especially in humid areas (Grose 2009). Clay (2004) reported that whilst cotton production is restricted to 2.4 % of the cultivatable land globally, an estimated 25 % of insecticide and 11 % of global pesticide production is consumed in cotton cultivation. A report (Bĺecourt 2010) claimed that the global insecticide share used on cotton had declined from 19 % in 2000 to 15.7 % in 2008. Also in 2008, cotton's pesticide consumption was claimed to be 6.8 % of global use. This thirsty crop also requires 7,000–29,000 L of water to produce 1 kg of cotton fiber (ISIS 2007).

Historically, cotton was planted at low densities and rotated with other crops to ensure the optimum health of the soil. Pest cycles were taken into consideration before planting and harvesting. Significant amounts of pesticides began to be applied from the mid-twentieth century. The advent of dichlorodiphenyltrichloroethane and other neurotoxins were considered to be cheaper ways of controlling pests compared with strategic crop management and the efforts of agricultural laborers (Haenow.com 2012). Today, however, there are increasing concerns that the pesticides used in 'conventional' (versus 'organic') cotton farming increasingly threaten people, wildlife, and the environment; as insects gradually become resistant to pesticides, ever-increasing amounts of pesticides need to be applied to be effective, resulting in ecological damage and crop failures (ISAAA 2011).

In 2010, organic cotton represented 0.76 % of global cotton production. Organic cotton was grown in 22 countries worldwide, with the top ten producer countries led by India, followed by (in order of rank) Turkey, Syria, Tanzania, China, the United States, Uganda, Peru, Egypt and Burkina Faso. Approximately 220,000 farmers grew the organic fiber (Ferrigno 2012).

In the United States, it is required by law that any producer wanting to label and sell a product as "organic" must meet the standards established by the Organic Food Production Act of 1990, enforced by the state organic program. This act specifies the procedures and regulations for the production and handling of organic crops (US Department of Agriculture 2013). The Global Organic Textile Standard (GOTS) was developed in 2006 through a collaboration by leading standard setters. The aim of GOTS is to define requirements that are recognized worldwide and that ensure the organic status of textiles, from the harvesting of raw materials through environmentally and socially responsible manufacturing all the way to labeling, in order to provide credible assurance to the consumer (Global Standard 2013). The preparatory processes required before dyeing and printing are similar for organic cotton and conventional cotton processing. However, some chemicals, such as substances with high adsorbable organic halogens (AOX) values, bluing agents, chelating agents, chlorine compounds, and formaldehyde, are prohibited for use on organic textiles. All dyestuffs should conform to ETAD (1997) restrictions regarding residual heavy metals and banned aromatic amines. The first choice for dyeing organic fabrics, where applicable, could be plant-based natural vegetable dyes; however, they have never been subjected to rigorous eco-toxicological testing, and their commercial availability is limited. The best choice may be low-impact dyes, such as fiber-reactive dyestuffs made from petrochemicals.

Permitted synthetic and non-synthetic chemicals are listed in eco-labels, such as the GOTS (www.global-standard.org). The use of synthetic flame-retardants and many functional finishes are prohibited. Mechanical finishing techniques must be explored instead of chemical finishes wherever possible (Wakelyn and Chaudhry 2009). Most of the top apparel brands and retailers in the world—such as Nike, Levi's, Walmart, Patagonia, Timberland, Orvis, Adidas, Marks and Spencer, Roots, Cotton Ginny, and Target—have already introduced organic cotton into their product range and are expecting increases in the demand for organic textiles in coming years, particularly in the health-conscious, high-end markets (Hanu 2010).

Besides helping the environment, there are other benefits from organic cotton products. Working environments are better for those on farms, and small-scale farmers save money by not having to buy large amount of pesticides. Consumers benefit, also. Some suggest that organic cotton products are softer and easier on the skin. Recent awareness of these benefits has increased demand for organic cotton and thus lowered its cost (Baldwin 2008).

Organic agriculture protects the health of people and the planet by reducing the overall exposure to toxic chemicals from synthetic pesticides that can end up in the ground, air, water, and food supply, and that are associated with health consequences from asthma to cancer. Because organic agriculture does not use toxic and persistent pesticides, choosing organic products is an easy way to help protect oneself (OTA 2011a).

5.2 Organic Flax

The flax plant (*Linum usitatissimum*) is one of the oldest fiber crops in the world and has been used in the production of linen for over 5,000 years. Organic linen refers to linen made from flax fibers grown without the use of toxic pesticides or chemical fertilizers. Although there are products on the market claiming to be "organic linen" or "eco-friendly linen," some of these products may be made from flax fibers, but many are made from other fibers.

Like all conventional crop farming, flax cultivation has environmental impacts (Duigou et al. 2013), which can be greatly reduced if a certified organic method of crop production is used. Compared with other crops, flax performs poorly in soils with low fertility and can require significant use of fertilizers. However, by using crop rotation, multi-seeding methods, biological pest control, and green manure and compost, organic flax farming can produce the seeds with reduced environmental impact. Crop rotation is not only essential from an organic certification standpoint but also for maintaining soil quality (www.natural-environment.com 2008).

5.3 Organic Wool and Silk

Organic certification standards vary between countries. In some countries, the standards are set and overseen by the government, whereas in others, the standards are set by a non-profit organization or private company. The requirements for certification of organic wool by the Organic Trade Association (OTA) in North America are as follows (OTA 2011b).

- Livestock feed and fodder used from the last third of gestation must be certified organic.
- The use of synthetic hormones and genetic engineering is prohibited.
- The use of synthetic pesticides (internal, external, and on pastures) is prohibited.
- Producers must encourage livestock health through good cultural and management practices.

To be classified as organic, wool must have been sheared from sheep given organic feed and raised without the use of hormones or pesticides. Organic livestock management is different from nonorganic management in at least two major ways:

(1) Sheep cannot be dipped in parasiticides (insecticides) to control external parasites, such as ticks and lice.
(2) Organic livestock producers are required to ensure that they do not exceed the natural carrying capacity of the land on which their animals graze.

This poses problems in the prevention of blowflies (meat-seeking fly strikes) on sheep when the usual sheep dipping is not allowed. In many countries, sheep are dipped in organophosphate or synthetic pyrethroid types of pesticide. In the United Kingdom, between 1.25 and 30 ml of fully-active sheep dip is used per sheep year. Wool textiles as a whole constitute less than 2 % of total world textile fiber production; hence, the production of organic wool (and silk) is small.

Organic silk must not only be obtained by feeding the silkworms with leaves from mulberry bushes that have been grown organically, but in which no ‘cruelty’ has been employed (i.e. not by the conventional production method of placing the cocoons containing the live silk worms into boiling water) . Thus, in the so-called ‘peace’ or ‘vegetarian’ varieties, the silkworms are allowed to develop and emerge as moths. As a consequence, the silk is obtained in the form of a short staple instead of continuous filament, yielding a fabric with a different appearance and handle, but with a warmer handle.

6 Eco-certification

The objective of certification is to gain access to the market for environmentally sustainable products (Rundgren and Hagenfors 1999). The certification process should help because data collected in the process of certification can be very useful for market planning as well as for extension and research; moreover, it improves the image of product and increases its credibility and visibility. Auriol and Schilizzi's (2003) studies have shown that the costlier the certification process, the fewer the firms that are able to afford certification. That is, cost becomes a major factor in deciding market structure, potentially leading to monopoly and ultimately to no certification at all.

7 Eco-label

Eco-labels identify products, raw materials, or companies that meet a particular organization's or government agency's standards in terms of organic content, sustainability, or minimizing risks to humans, animals, or the environment. Eco-labels will certify the quality of a particular product and also provide information about the whole lifecycle. Eco-labeling is becoming a differentiating factor on a worldwide scale in retail markets for textile and apparel purchases. Consumers are becoming increasingly concerned with the adverse impacts of industrial pollution on the environment and their health, resulting in mounting pressure on the textile and fashion industries to adopt more eco-friendly chemicals and manufacturing processes. Environmental concerns raised by production systems have been recognized since the late 1960s. Attempts to move towards more sustainable and environmentally friendly approaches have been through a range of regulatory measures, from green taxes to strict bans.

One approach gaining increasing importance is that of environmental labeling or eco-labeling. According to Piotrowski and Kratz (2005), environmental labeling is broad, covering a range of labels and declarations of environmental performance, with a focus on consumption rather than the production of a given product (e.g. recyclable material). Eco-labels, on the other hand, are a subgroup of environmental labeling. They convey environmental information about a product to the consumer and communicate that the environmental impacts are reduced over the entire life-cycle of a product, without specifying the production practices. An eco-label provides brief information on environmentally related product qualities. It enables consumers to identify products that are environmentally safe, have been manufactured using eco-friendly materials, and do not contain chemicals that are harmful to the user. Certification, such as eco-labels, plays a major role in giving credible assurance to retailers and end consumers that products comply with standards based on social, ecological, and environmental standards.

The characteristics of an eco-label are as follows:

- It identifies the overall environmental preferences of a product.
- It carries information on environmentally related product qualities.
- It is a tool for consumers to identify environmentally safe products.
- It assures that a manufacturer has used eco-friendly raw materials and ingredients.
- It is an additional product quality that can be used as a marketing tool.
- It can be issued by a private or public body.
- It assures less stress on the environment.
- It increases the selling value of products.

The benefits of eco-labeling (Sivaramakrishnan 2012) include the following:

(1) Global marketing: Manufacturers and retailers of textile goods come under pressure to comply with the international eco-labels.
(2) Improved product quality: Eliminates substances in the fabric that may be harmful to the customer.
(3) Financial savings—Results in saving of water, chemicals, and energy through process optimization and improvements. Frequently, the processing time is reduced by adopting a "Right the First Time" approach. These benefits generally offset the incremental costs of using eco-friendly chemicals or of adopting a modified process.
(4) Improved environmental performance—Achieved through the phase-out of toxic and hazardous substances and conservation of water, energy, and raw material usage. This leads to a reduction in the quantities and pollution potential of various emissions. Elimination of hazardous chemicals from the textile manufacturing process is also beneficial for the environment. For example, a complete phase-out of sodium hypochlorite and the antichlor agent sodium bisulphite results in the elimination of halogenated organic compounds (AOX) and a reduction of total dissolved solids in the effluent. The removal of these hazardous chemicals results in safer and better working conditions in the workplace.

The Organic Exchange Fiber Report (2008/2009) estimated a 54 % increase in cultivation of organic cotton from the previous year, but production of organic cotton only 0.959 % of conventional cotton. That is, the growth in eco-labeled textiles is not reflected in consumer demand, raising questions about the impact of eco-labeled or 'sustainable' textiles. A number of issues may impede the spread of eco-labeled textiles through the supply chain: costs and time required to achieve, use and renewal, the eco-label, the recession, and the potential loss of competitive advantages.

The five factors for measuring the effectiveness of an eco-label (EPA 1994) are as follows:

(1) Consumer awareness of labels
(2) Consumer acceptance of labels (credibility and understanding)
(3) Changes in consumer behavior

(4) Changes in manufacturer behavior
(5) Net environmental gains.

The first four of the above items serve to support the last.

There are many challenges for eco-labeling, the most serious of which are misleading or fraudulent to uninformative claims, unfair competition and protectionism, and lack of stringency or standardization in the process or mechanisms of eco-labeling. Eco-labeling educates the consumer, differentiates the product and the targeted market, provides a sustainable connotation for the producer or seller, and develops a higher or different perception for the product in the eyes of the entire supply chain. However, eco-labels can be used as market-based trade barriers, and some research indicates that although a global, transparent eco-labeling system benefits markets, regional eco-labeling can limit market access and reduce global competition (Hyhyvarinen 2008).

Differences in testing and certification methods create difficulties in the application of an eco-label to a particular product category. A few questions are stated below:

- Should the assessment be the product's environmental burden over its entire lifecycle, or some subset of it?
- What techniques can be used to measure environmental impact?
- What specific environmental impacts are the most important?
- What criteria are appropriate in rating impacts?
- How can the consumer verify the claims made by the eco-label?

An analysis of the ecological labeling process by Lavallee and Plouffe (2004) concluded that a 'cradle-to-grave' analysis for eco-labelled products and services is not always respected. At the present time, eco-label delivery criteria are not sufficiently stringent or standardized, leading to confusion in the marketplace, making it difficult for companies to identify stakeholder preferences, and making it difficult for justified environmental claims to be considered credible (EPA 1998).

Types of labels include the following:

- Eco-labels
- Organic labels
- Fair-trade labels
- Health-related labels

Eco-labels may be voluntary or mandatory. Mandatory labeling is always third-party labeling (i.e. issued by an independent body). Voluntary programs may be established by firms or business associations, as well as third parties. Currently, there are no eco-labels in textiles and clothing enforced by mandatory rules. Eco-labels are normally issued either by government-supported or private enterprises once it has been proven that the product of the applicant has met the criteria (Hyvarinen 1999).

The following eco-labels are issued by the governments of various countries:

- Blue Angel (Germany)
- Eco Mark (Japan)
- Environmental Choice (Canada)
- White Swan (Nordic countries)
- Eco-Mark (India)
- Green Label (Singapore)

Some of the eco-labels issued by private agencies are as follows:

- Eco-tex
- Oeko-Tex (textiles and clothing) (Germany)
- Green Seal (United States)

The eco-label has a role in Integrated Product Policy, aiming for minimum environmental degradation caused by any of the phases of a product's lifecycle (European Commission, 2008). The criteria for granting eco-labels are mostly based on the "cradle-to-grave" approach—that is, the lifecycle analysis of the product and assessment of its impact on the environment from the processing of raw materials, production, distribution, consumption, maintenance, (i,e, washing, ironing, dry-cleaning), and finally disposal of the product. All participants—namely designers, industry, marketers, retailers, and consumers—are to be engaged. A 'cradle-to-cradle' certification program assesses the sustainability of product ingredients for human and environmental health, as well as their recyclability or compostability, making it easier at the design stage to create ecologically intelligent products by choosing materials that meet key sustainability criteria for material health and material reutilization (Braungart and McDonough 2008). Differences between various eco-labeling schemes confuse public understanding of eco-labels: some are based on detailed analysis of the environmental impacts, whereas others analyze only certain stages of the lifecycle. The International Standards Organization (ISO) has classified voluntary labels into three typologies: Type I, II, and III, according to the specification of preferential principles and procedures (Moore and Wentz 2009):

- Type I is voluntary, based on multiple criteria. It is issued by third-party programs that award a license, which authorizes the use of environmental labels on products indicating environmental preference within a category based on lifecycle considerations. Type I programs can also be categorized as 'multi-criteria practitioner programs.'
- The Type II labels are informative self-declarations of environmental claims *(de facto).* These are self-declarations based on common terms, definitions, and symbols.
- Type III labels are voluntary and provide quantifiable environmental data under preset categories, which are produced by a qualified third party and verified by that or another qualified third party. Such programs provide quantified product information report cards of performance in multiple areas of qualification, such as social responsibility, ecological performance, toxic residues, etc.

Many other prominent international trade and environmental organizations deal with issues related to eco-labeling, such as the United Nations, the World Trade Organization through its International Trade Centre and Committee on Trade and Environment, the US Environmental Protection Agency, and the Organisation for Economic Co-operation and Development.

The ISO labeling standards are principle-based. Requirements include the following (Moore and Wentz 2009):

- Accurate labeling that is verifiable, relevant, and nondeceptive
- Relevant information concerning attributes must be available and their derivation transparent to purchasers
- Labels must be based on scientific methods that are reproducible and based on agreed standards of practice,
- Transparency for information and methods should be ensured for all stakeholders and interested parties
- Labeling should include the lifecycle of the product or service
- Administration of the eco-labels should not be burdensome
- Labels should not create unfair trade restrictions
- Labels should not inhibit innovations that improve ecological performance
- Label criteria should be developed by consensus

Greenwashing (or green sheen) is a form of spin (i.e. propaganda) in which green marketing is deceptively used to promote the perception that an organization's products, aims, or policies are environmentally friendly. Evidence that an organization is greenwashing often comes from pointing out the spending differences—that is, when significantly more money or time has been spent advertising being "green" (i.e. operating with consideration for the environment) than is actually spent on environmentally sound practices (Greenpeace USA 2013). Greenwashing efforts can range from changing the name or label of a product that contains harmful chemicals to evoke the natural environment to multimillion dollar advertising campaigns portraying highly polluting energy companies as eco-friendly (Karliner 2007).

While greenwashing is not new, its use has increased over recent years to meet consumer demand for environmentally friendly goods and services. The problem is compounded by lax enforcement by regulatory agencies, such as the Federal Trade Commission in the United States, the Competition Bureau in Canada, and the Committee of Advertising Practice and the Broadcast Committee of Advertising Practice in the United Kingdom. Critics of the practice suggest that the rise of greenwashing, paired with ineffective regulation, contributes to consumer skepticism of all green claims and diminishes the power of the consumer in driving companies toward greener solutions for manufacturing processes and business operations (Dahl 2010).

8 Various Eco-labels

The Ecolabel Index is the largest global directory of ecolabels, currently tracking 449 eco-labels in 197 countries and 25 industry sectors (http://www.ecolabelindex.com, accessed on 20 April 2014). Within Europe, there are many textile eco-labels, such as Ecotex, Oekotex, GuT, Nordic Swan, Stitching Milieukeu, and Skal Organic. For EU eco-labels, a single set of criteria was agreed upon, which is intended to reduce key impacts, such as energy use, global warming, acid rain, and water pollution. The Nordic Swan label is the world's first multinational environment labeling scheme. The standard Eco-Mark scheme of different organizations in Germany is based on seven major eco-parameters: (a) formaldehyde (b) toxic pesticides (c) pentachlorophenol (d) heavy metal traces (e) azo dyes that release carcinogenic amines, (f) halogen carriers, and (g) chlorine bleaching.

Some of the eco-labels are discussed below:

8.1 Green Mark

Figure 1 is an example of a certification label issued for the production of textile materials. The label is a registered trademark of Green Mark (Taiwan).

Objectives include the following:

- To guide consumers in product purchasing
- To encourage manufacturers to design and supply

Product categories include cloth diapers and unbleached towels.

Criteria for cloth diapers are defined as follows:

The product shall not contain fluorescent whitener, formaldehyde, or other hazardous chemicals. The product shall last for at least 150 times of use to bear a label reading "reusable diaper". The diaper shall contain not less than 50 % cotton. The name and address of the Green Mark user must be clearly printed on the

Fig. 1 Green mark (Taiwan). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 2 Thai green label (Thailand). Retrieved from, http://www.ecolabelindex.com/legal/

product or on the packaging material. For nonmanufacturing logo users, the manufacturer's name and address shall also be shown.

Criteria for nonbleached towels are defined as follows:

There shall be no use of bleach of any kind fluorescent whitener and formaldehyde in the manufacturing process of the product. Any dyestuff used in the manufacturing process must not contain mercury, chromium (+6), cadmium, lead, copper, zinc, arsenic, or other heavy metals or their oxides. The product shall be made of 100 % natural fiber to bear a label reading "nonbleached." The packaging box used for the product is recommended to be made from recycled pulp with at least 80 % recycled paper.

8.2 Thai Green Label

Developed by Thailand Environment Institute in 1994, the Green Label (Fig. 2) uses lifecycle consideration and stresses certain high-priority national goals, such as waste reduction and energy and water conservation.

Product categories (made from cloth) include the following:

- Hats, bags
- Products made for babies
- Garments (i.e. shirts, trousers)
- Clothing accessories
- Home and household textile fabrics

8.3 Eco Mark

The Eco Mark (Fig. 3) Program was established in 1989 by the Japanese Environmental Association. Products must meet the following criteria:

- Impose less environmental load than similar products in their manufacture, use, and disposal
- Reduce the environmental load in other ways

Fig. 3 Eco mark (Japan). Retrieved from, http://www.ecolabelindex.com/legal/

Product categories include the following:

- Cloth diapers for infants (24 products, 9 companies)
- Unbleached clothes, bed linens, and towels (68 products, 55 companies)
- Cloth shopping bags (53 products, 27 companies)
- Textiles made of waste fibers (122 products, 91 companies)
- Clothing made of used polyethylene terephthalate resin.

8.4 Ecomark

The Government of India launched the Ecomark scheme (Fig. 4) in 1991. The label is awarded to consumer goods that meet the specified environmental criteria and the quality requirements of Indian standards. The logo is an earthen pot, which uses a renewable resource, does not produce hazardous waste, and consumes little energy in making.

Production categories include baby clothing and fabrics made by various textile fibers.

8.5 EcoMark (Africa)

The EcoMark Africa eco-label (EMA, Fig. 5) is currently in development. It will consist of threshold criteria and indicators suitable for the African continent. The standard will be designed in such a way that existing standard systems may be

Fig. 4 Eco mark (India). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 5 Eco mark (Afrika). Retrieved from, http://www.ecolabelindex.com/legal/

benchmarked against it and accredited certifiers may use it to certify companies against it. In both cases, operations that fulfil the requirements of the EMA standard may use the EMA eco-label.

With its certifiable standard, EMA will provide one continent-wide and cross-sectorial label to mark sustainably produced African products. EMA will encourage African producers to access the markets with sustainably produced goods and services. EMA will particularly support small- and medium-sized enterprises to get certified and gain access to niche markets.

8.6 Ecocert

Ecocert (France) (Fig. 6) is a certification body for sustainable development. It is an inspection and certification body established in France by agronomists aware of the need to develop environmentally friendly agriculture and of the importance of offering some form of recognition to those committed to this method of production. From its creation, Ecocert has specialized in the certification of organic agricultural products. Ecocert has contributed to the expansion of organic farming. Conformity with Ecocert's standard is verified by an independent organization (third party) following ISO 14001 and 9001.

Fig. 6 Ecocert (France) (Japan). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 7 Energy star (US). Retrieved from, http://www.ecolabelindex.com/legal/

8.7 Energy Star

ENERGY STAR (United States, Fig. 7) is a voluntary government-backed program dedicated to helping individuals protect the environment through energy efficiency. The ENERGY STAR mark is the national symbol for energy efficiency, making it easy for consumers and businesses to identify high-quality, energy-efficient products, homes, and commercial and industrial buildings. ENERGY STAR distinguishes what is efficient/better for the environment without sacrificing features or performance. Products that earn the ENERGY STAR mark prevent greenhouse gas emissions by meeting strict energy-efficiency guidelines set by the U.S. Environmental Protection Agency.

8.8 Environmental Choice

Environmental Choice (New Zealand) (Fig. 8) is a voluntary, multi-criteria environmental labeling program operating to international standards and principles. It originates from a New Zealand Government initiative and International Accreditation New Zealand manages it on behalf of the Minister for the Environment. The Australian scheme, Environmental Choice Australia, was trialed in Australia from 1991 to 1994 but it did not gain wide industry support.

Product categories include the following:

- Wool pile carpets
- Wool-rich pile carpets

Fig. 8 Environmental choice (New Zealand) (Japan). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 9 EU ecolabel (EU) (Japan). Retrieved from, http://www.ecolabelindex.com/legal/

8.9 EU Ecolabel

EU Ecolabel (EU) (Fig. 9) is a voluntary scheme designed to encourage businesses to market products and services that are kinder to the environment and to allow European consumers (including public and private purchasers) to easily identify them. Conformity with EU Ecolabel's standard is verified by an independent organization (third party) following ISO 17011.

8.10 Nordic Ecolabel

Nordic Ecolabel (Fig. 10) demonstrates that a product is a good environmental choice. The "Swan" symbol, as it is known in Nordic countries, is available for 65 product groups. The Swan checks that products fulfill certain criteria using methods such as samples from independent laboratories, certificates, and control visits.

Each Nordic country has local offices with the responsibility for criteria development, control visits, licensing, and marketing. In Denmark, the Nordic Ecolabel is administered by Ecolabeling Denmark at Danish Standards Foundation; in Sweden, by Ecolabeling Sweden AB; in Finland, by Finnish Standards; in Norway, by The Foundation for Ecolabeling; and in Iceland by the Environment Agency, which operates under the direction of the Ministry for the Environment. Conformity with Nordic Ecolabel or "Swan" standard is verified by an independent organization (third party) following ISO 17011 Accreditation, ISO 17021 Management system certification, and ISO 17025 Testing and Calibration Laboratories.

Fig. 10 Swan ecolabel (Nordic) (Japan). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 11 Austrian ecolabel (Austria). Retrieved from, http://www.ecolabelindex.com/legal/

8.11 Austrian Ecolabel

Österreichisches Umweltzeichen, the Austrian Ecolabel (Fig. 11), is primarily for consumers but also for manufacturers and public procurement. The eco-label provides consumers with guidance in order to choose products or services that are the least hazardous to the environment or health. The eco-label draws the consumer's attention to aspects of the environment, health, and quality (fitness for use).

8.12 Singapore Green Label Scheme (SGLS)

The Singapore Green Label Scheme (SGLS; Fig. 12) aims to help the public identify environmentally friendly products that meet certain eco-standards specified by the scheme. It seeks to encourage eco-consumerism in Singapore as well as to identify the growing demand for greener products in the market. The scheme hopes to encourage manufacturers to design and manufacture with the environment in mind. It was launched in May 1992 by the Ministry of the Environment. It was handed over to the Singapore Environment Council (SEC) on 5 June 1999 and is currently under the authority of the SEC.

Fig. 12 SGLS (Singapore). Retrieved from, http://www.ecolabelindex.com/legal/

Fig. 13 Milieukeur ecolabel (Dutch). Retrieved from, http://www.ecolabelindex.com/legal/

8.13 Milieukeur Label

Milieukeur is the Dutch environmental quality label (Fig. 13) for products and services. There are Milieukeur criteria for a wide variety of food products, consumer products and services, ranging from vegetables, potatoes, fruit, beer, pork, trees and plants to concrete products, fire extinguishers, florists, butchers, green electricity, and car washes.

The Milieukeur criteria relate to the entire lifecycle of the product or service and represent an integrated approach to sustainability. The Milieukeur certification schemes cover a diverse range of sustainability issues, including raw materials, energy and water consumption, noxious substances, packaging and waste, plant protection, fertilizers, animal welfare, nature management, food safety, and employee care. Milieukeur is supported by the Dutch government.

8.14 Oeko-Tex Standard 100

The Oeko-Tex Standard 100 (Fig. 14) is a globally uniform testing and certification system for textile raw materials, intermediate, and end products at all stages of production. The certification covers multiple human-ecological attributes, including harmful substances that are prohibited or regulated by law, chemicals that are known to be harmful to health but are not officially forbidden, and parameters that are included as a precautionary measure to safeguard health.

Textile products may be certified according to Oeko-Tex Standard 100 only if all components meet the required criteria without exception. A tested textile product is allocated to one of the four Oeko-Tex product classes based on its intended use. The more intensively a product comes into contact with the skin, the stricter the human

Fig. 14 Oeko-tex standard 100 (Austrian Textile Research Institute). Retrieved from, http://www.ecolabelindex.com/legal/

ecological requirements it must fulfill. Oeko-Tex Standard 100 is found on millions of products around the world in (almost) all retail segments (based on more than 65,000 certificates issued to date).

Probably the most widely used textile eco-label is the *Oeko-Tex Standard 100*, the label of the International Association for Research and Testing in the field of Textile Ecology founded by Austrian Textile Research Institute. The label or mark states that the textile product or accessory has been tested for harmful substances according to the conditions specified in this standard. The standard is applicable to textile and leather products. The objective is to market products that do not contain substances detrimental to health. The products have been classified into four groups according to their contact with human skin:

Class I: Products for babies up to the age of 2 years.

Class II: Products having direct contact with skin, such as blouses, shirts, and underwear.

Class III: Products not having direct skin contact, such as skirts, trousers, and jackets.

Class IV: Furnishing and decorating materials.

One of the main features of the scheme is the test procedure for chemicals associated with dyeing processes and for dyes themselves. Thus, for each product group, there are limiting values of extractable heavy metals (EHM). Limiting values and fastness properties in the Oeko-Tex Standard 100 are shown in Table 2.

8.15 Oeko-Tex Standard 1000

To achieve better environmental performance for a company, as well as verifying and communicating it to the public, the environmental auditing and certification scheme, Öko-Tex Standard 1000 (Fig. 15), has been developed. The aim of Standard 1000 is an evaluation of the environmental performance of textile sites and products. It also independently documents that certain environmental measures were undertaken and a certain level was achieved.

To complement the product-related Oeko-Tex Standard 100, the Oeko-Tex Standard 1000 is a testing, auditing, and certification system for environmentally friendly production sites throughout the textile processing chain. To qualify for certification according to the Oeko-Tex Standard 1000, companies must meet stipulated criteria in terms of their environmentally friendly manufacturing processes and provide evidence that at least 30 % of total production is already certified under Oeko-Tex Standard 100. In addition, companies must prove that the social standards demanded by Oeko-Tex 1000 are fulfilled.

Certification criteria include the avoiding the use of environmentally damaging chemicals, auxiliaries, and dyestuffs; compliance with standard values for waste-water and exhaust air; optimization of energy consumption; avoidance of noise and

Table 2 Oeko-tex standard 100 limits

Parameter/compound	Product class			
	I	II	III	IV
pH value	4–7.5	4–7.5	4–9	4–9
Formaldehyde	20	75	300	300
Antimony	5.0	10.0		
Arsenic	0.2	1.0		
Lead	0.2	1.0		
Cadmium	0.1	0.1		
Chromium	1.0	2.0		
Chromium (VI)	Under detection limit[a]			
Cobalt	1.0	4.0		
Copper	25.0	50.0		
Nickel	1.0	4.0		
Mercury	0.02	0.02		
Pesticides[b]	0.5	1.0		
PCP/TeCP	0.05	0.5		
Banned dyes[c]	Not used			
Chlorinated organic carriers	1.0			
Biocidic and flame-retardant finishes	None			
Color fastness (staining)				
Water		3		
Acidic perspiration		3–4		
Alkaline perspiration		3–4		
Rubbing, dry[d]	4	4	4	4
Rubbing, wet[d]	2–3	2–3	2–3	2–3
Emission of volatiles				
Aromatic hydrocarbons	0.3		0.3	
Organic volatiles	0.5		0.5	
Odor	No abnormal odor[e]			

Extractable quantities are in ppm; fastness is in grades

[a] Detection limits, 0.5 ppm for Cr (VI), 20 ppm for arylamines, 0.006 % for allergeneous dyes (using TLC techniques)

[b] Total pesticides incl. pentachlorophenol (PCP)/2,3,5,6 tetrachlorophenol (TeCP)

[c] Cancerogenes, allergenic dyes, and dyes with cleavable arylamines

[d] For pigment, vat, or sulfur dyes, rubbing fastness of 3 (dry) and 2 (wet) are acceptable

[e] No odor of mold, high-boiling fraction of petrol, fish, aromas, or perfumes

Fig. 15 Oeko-tex standard 1000 (Austrian Textile Research Institute). Retrieved from, http://www.ecolabelindex.com/legal/

dust pollution; compliance with defined measures to ensure safety at the workplace; no use of child labor; introduction of the basic elements of an environmental management system; and existence of a quality management system.

8.16 The Global Organic Textile Standard

The Global Organic Textile Standard is the worldwide leading textile processing standard for organic fibers, including ecological and social criteria, backed up by independent certification of the entire textile supply chain. GOTS (Fig. 16) Version 4.0 was published on 1 March 2014, 3 years after Version 3.0 was introduced and 9 years after the launch of the first Version. The high ecological and social requirements as well as worldwide practicability and verifiability were considered in the revision work, in order to achieve a reliable and transparent set of criteria.

The aim of the standard is to define globally recognized requirements that ensure the organic status of textiles, from harvesting of the raw materials, through environmentally and socially responsible manufacturing, up to labeling, in order to provide a credible assurance to the end consumer. Textile processors and manufacturers are enabled to export their organic fabrics and garments with one certification accepted in all major markets.

The standard covers the processing, manufacturing, packaging, labeling, trading, and distribution of all textiles made from at least 70 % certified organic natural fibers. The final products may include, but are not limited to, fiber products, yarns, fabrics, clothes, and home textiles. The standard does not set criteria for leather products.

A textile product carrying the GOTS label grade of 'organic' must contain a minimum of 95 % certified organic fibers, whereas a product with the label grade 'made with organic' must contain a minimum of 70 % certified organic fibers

Environmental criteria include the following:

- At all processing stages, the organic fiber products must be separated from conventional fiber products and must to be clearly identified.
- All chemical inputs (e.g. dyes, auxiliaries, and process chemicals) must be evaluated and meet basic requirements on toxicity and biodegradability/eliminability.

Fig. 16 GOTS label. Retrieved from, http://www.ecolabelindex.com/legal/

- Critical inputs such as toxic heavy metals, formaldehyde, aromatic solvents, functional nanoparticles, genetically modified organisms, and their enzymes are prohibited.
- The use of synthetic sizing agents is restricted; knitting and weaving oils must not contain heavy metals.
- Bleaches must be based on oxygen (no chlorine bleaching).
- Azo dyes that release carcinogenic amine compounds are prohibited.
- Discharge printing methods using aromatic solvents and plastisol printing methods using phthalates and polyvinyl chloride (PVC) are prohibited.
- Restrictions for accessories must be followed (e.g. no PVC, nickel, or chrome permitted).
- All operators must have an environmental policy, including target goals and procedures to minimize waste and discharges.
- Wet processing units must keep full records of the use of chemicals, energy, water consumption, and wastewater treatment, including the disposal of sludge. The wastewater from all wet processing units must be treated in a functional wastewater treatment plant.
- Packaging material must not contain PVC. Paper or cardboard used in packaging material, hang tags, swing tags, etc. must be recycled or certified according to FSC or PEFC.

Technical quality and human toxicity criteria include the following:

- Technical quality parameters must be met (e.g. rubbing, perspiration, light and washing fastness, shrinkage values).
- Raw materials, intermediates, final textile products, and accessories must meet stringent limits regarding unwanted residues.

Minimum social criteria based on the key norms of the International Labour Organisation must be met by all processors and manufacturers. They must have a social compliance management with defined elements in place to ensure that the social criteria can be met (GOTS-IWG 2013).

9 Future Trends

A study by Sinha and Shah (2011) examined the issues within and across the textile supply chain that come to bear upon the growth of eco-labelled sustainable textiles products in particular and in developing a sustainable textile industry in general. All companies interviewed agreed that sustainable textiles products (STPs) are needed. They felt it was very important to note that all naturally grown products are not organic or sustainable. For example, not all naturally grown cotton is organic; it might be genetically modified cotton. Also, there is no assurance that the land does not have any traces of harmful fertilizer or pesticides.

A number of methods are available to enter the sustainability arena. There should be transparency and a clear statement about the extent to which the companies have taken up eco-labeling. Third-party verification of environmental credentials can often bring legitimacy to sustainability. Many of the most successful eco-labels are those that have been backed by issues-led organizations, such as the GOTS certification for textile products made from organic cotton. Third-party verification can range in scope from qualitative assurance of general claims to detailed verification of all stages of a full lifecycle product assessment. Given the generally low levels of consumer trust in big business, some degree of external verification is an essential component of any credible environmental claim.

Educating, enabling, and encouraging people to act towards sustainability is key for the success of any eco-label and STP as consumers' usage and disposal patterns liberate CO_2, so there should be programs to educate them. Methods to do this range from using trustworthy eco-labels with required information, through various media, and through regulations. Once the consumers are educated, then they may be encouraged to prefer buying more sustainable products.

Enlisting employees to promote sustainability is another method because employees are the key players of any manufacturing facility. Investing in the skills of employees is part of a sustainable and responsible human resource management (Brito and Blanquart 2008).

To become sustainable, everyone from manufacturer to consumer should remember to "reduce, reuse, and recycle." Textile waste in landfills contributes to the formation of leachate as it decomposes (which has the potential to contaminate groundwater), methane gas (a major cause of greenhouse gases contributing to global warming), and ammonia (which is highly toxic for land, water and air) (Productivity Commission 2006).

Eco-labels are not simple to understand, so they may not be as appropriate marketing tools as suggested by the government policies. For example, GOTS and OE labeling guides are both standards that are applicable for products made from organic cotton, on which retailers and manufacturers can use their respective logos on the tags. Under both the standards, it is mandatory to mention the percentage of organic cotton on the label. If the product is made from 100 % organically cotton, the manufacturer or retailer can use the statements "Organic" and "Made with 100 % organically grown cotton," respectively.

10 Conclusions

Eco-labeling will continue to grow as a method of providing ecological and social information to consumers. A number of emerging information and labeling from other industries may influence textile eco-labeling. Eco-labels based on a third-party certification, a de jure standard, represent the most reliable and verifiable type of labeling scheme. However, transparency in the standards development process, auditing, and the verification of performance and conformity are extremely important.

Nonstandard testing methods and questionable certification processes may damage the credibility of eco-labeling. They diminish rather than increase the value of ‘eco’ products. Eco-labeling must promote sustainability and responsible decisions by retailers and consumers. The best techniques and practices must be used to produce eco-certification and eco-labels to allow for continuous improvement. Eco-labels are very important to the development of a sustainable textile industry and a credible textile industry.

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