

The Apparel Industry:

Issues and Solutions



Please note: *This report focuses on environmental impacts and solutions associated with apparel, a second report will present the equally complex social responsibility (SR) issues associated with this industry's life cycle including fair trade, fair labor and animal well-being issues.*

Published by Labeling Ecologically Approved Fabrics (LEAF)

Special thanks to:

Coral Rose, Founder Eco-Innovations Sustainable Textile Strategies

Dr. Gwendolyn Hustvedt-Professor of Textiles, Texas State University

Eric Brody, Principle, Shift Advantage Consulting

¹ Photo Courtesy Mary Kent Hearon, MK@theweeklybeet.com

The fashion industry is a global, trend-setting pioneer. Such influence provides an opportunity to inspire shifts on the international scale as this industry leads a pervasive transition towards even more sustainable and socially responsible ways of conducting business. Thank you for reviewing this report that explores both the systemic *issues*, as well as the exciting *solutions* happening throughout the life cycle of this pioneering industry.

Impacts and Concerns

The environmental footprint of creating apparel varies based on the methods used to produce and extract the resources; the process to create, dye and finish the materials; the steps to cut, sew and assemble the products, and the packaging and distribution systems to move and deliver the product. Examples of the environmental impacts of these steps are discussed below:

Conventional Cotton Farming

Cotton uses approximately 25% of the world's insecticides and more than 10% of the pesticides (including herbicides, insecticides, and defoliants). Fifty-five million pounds of pesticides were sprayed on the 12.8 million acres of conventional cotton grown in the U.S. in 2003 (4.3 pounds/ acre), ranking cotton third behind corn and soybeans in total amount of pesticides sprayed. (USDA)



The Environmental Protection Agency considers seven of the top 15 pesticides used on cotton in 2000 in the United States as "possible," "likely," "probable," or "known" human carcinogens (acephate, dichloropropene, diuron, fluometuron, pendimethalin, tribufos, and trifluralin). (EPA) ²

Cotton is a very water intensive crop. **Over fifty percent of cotton fields in the world require irrigation, and the majority of these crops are in regions where water is scarce.** These irrigated cotton fields produce over seventy percent of the total cotton grown in the world³. It takes an average of 3,644 cubic meters of water to grow one

² Organic Trade Association. (2009) *Cotton and the Environment*. http://www.ota.com/organic/environment/cotton_environment.html

³ Soth, J., Grasser, C., and Salerno, R. (1999) *The impact of cotton on fresh water resources and ecosystems: A preliminary analysis*, WWF, Gland, Switzerland.

ton of cotton in the top fifteen cotton producing countries⁴. That equates to about **347 gallons of water to grow one pound of cotton.**

The impacts on the Aral Sea are a notorious example of the effects of water abstractions for irrigation. In the period 1960-2000, the Aral Sea in Central Asia lost approximately 70% of its volume as a result of diverting water from the rivers that ran to the sea in order to grow cotton in the desert⁵.

Synthetic Fibers (Polyester, Nylons and Acrylics)

The **consumption of non-renewable resources (petrochemicals)** is required to produce two very common synthetics used in the apparel industry, **polyester and nylon.**

Relatively large amounts of energy are consumed in the production of synthetics, which has far-reaching environmental implications, including the release of green house gasses.

Emissions to air and water that have a medium to high potential of causing environmental damage if discharged untreated including: heavy metal cobalt; manganese salts; sodium bromide and titanium dioxide.

Rayon and Acetate represent an estimated 4 % of the market.

Rayon a cellulosic raw material is manufactured from sources such as bamboo or wood pulp, via a chemical-intensive process, and also contributes to deforestation and pollution in developing countries like Indonesia.⁶



The solvent used in the viscose rayon process called carbon disulfide is a toxic chemical that is a known human reproductive hazard posing dangers to factory workers, surrounding communities and the environment via air emissions and wastewater. Approximately half of the carbon disulfide solvent is recovered and half ends up in the environment. Sodium hydroxide and sulfuric acid are other potentially hazardous chemicals used in the viscose process.⁷

Conventional Wool

- More than **14,000 pounds of insecticides were applied to sheep in the United States in**

⁴ A.K. Chapagain, A.Y. Hoekstra, H.H.G. Savenije, and Gautam, R. (2009, May 5) (Sept. 2005) *The Water Footprint of Cotton Production*

⁵ Loh, J. and Wackernagel, M. (2004) *Living planet report 2005*, WWF, Gland, Switzerland.

⁶ Retrived from: www.KateFletcher.com

⁷ Patagonia (2009, April) *On Bamboo and Rayon*. The Footprint Chronicles.

2000, the most recent year for which data is available (in the 22 states which have the highest sheep production). These pesticides are used to control mange, mites, lice, flies, and other pests. Some sheep and lambs receive multiple applications of several different chemicals.

- **Pesticides used in sheep production can pose risks to human health and the environment.** The top three insecticides used on sheep in 20005-fenvalerate, malathion and permethrin-are all slightly acutely toxic to humans, moderately to highly toxic to fish and amphibians, and suspect endocrine disruptors. Malathion is highly water soluble (can be easily transported from the application site by stormwater or irrigation water runoff) and the anaerobic half-life for fenvalerate in soil is more than 155 days, potentially enabling it to cause groundwater contamination.
- **Pesticides used in sheep dips have consistently been linked with damage to the nervous system in workers that have been exposed to them in the United Kingdom.** Even low-dose exposure over the long term has been conclusively linked with reduced nerve fiber function, anxiety, and depression. Long-term exposure to sheep dip has also been linked to reduced bone formation. In addition, residues of diflubenzuron, an insecticide used in sheep dips, persist in the environment for more than a year.
- Two antibiotics, oxytetracycline and chlortetracycline, are approved for growth promotion in sheep. These antibiotic feed additives are used to promote slightly faster growth and to compensate for overcrowded and unhealthy conditions in concentrated animal feeding operations. **Mounting evidence suggests that widespread use of agricultural antibiotics is contaminating surface waters and groundwater, including drinking water,** in many rural areas as a result of their presence in animals waste. This non-human use of antibiotics is compromising medicine's effectiveness in people as bacteria become resistant to antibiotics over time.⁸



Manufacturing Issues

Textile wet processes consume water, energy, dyes, auxiliaries, chemicals, detergents and finishing agents in the conversion of raw materials to finished product. According to an analysis done by **Levi Strauss and Company** it takes **3481 liters of water and 32 kg of CO₂** to produce one pair of jeans.⁹

⁸ Organic Trade Association. (2005) *Organic Wool Fact Sheet*. Retrieved from: http://coralrose.typepad.com/my_weblog/about_organic_wool/index.html

⁹ *LS&CO.'s Life Cycle Assessment on Levi's®501®Jean for U.S. Market, 2006 production year.*

Generally, textile waste water effluents are highly colored, saline and contain non-biodegradable compounds. Approximately 65% of the chemicals used in the textile finishing process for cotton end up in the waste water and 55% of the chemicals used for synthetics end up in the wastewater. Up to 600 liters of waste water results from the creation of one kilogram of textile at a mill¹⁰.

These factors combine to present numerous operational problems in municipal wastewater treatment works, which use biological systems to process sewage and not intended for the breakdown of complex organic molecules. **The presence of metals and other dye compounds in waste water inhibits microbial activity and in some cases may cause failure of biological treatment systems.**

For instance, toxic runoff in China's booming textile industry is one reason why many of the nation's largest rivers resemble open sewers and 300 million people lack access to clean drinking water.¹¹

The textile dyeing and finishing sector has identified environmental issues that need to be addressed as a result of the large volumes of wastewater generated by the industry.

High Impact Dyes

Many dyes present health risks to those working with them as well as damaging the environment in a number of ways. The dyeing process generally involves a range of toxic chemicals such as dioxins, which are carcinogenic and possibly disrupt hormones; toxic heavy metals such as chrome, copper, and zinc, which are known carcinogens; and formaldehyde, a suspected carcinogen.

Other dyes or dye processes include heavy metals like copper, chromium or cobalt. Many dyes, including natural dyes, do not “stick” to the fabric well enough to prevent a large amount of colored water from being washed off the fabric right after it is dyed. For example, only about 80% of synthetic dyes called direct dye is retained by the fabric; the rest is flushed out from the garment.

Each year, the global textile industry discharges 40,000-50,000 tons of dye into rivers and

“Toxic runoff from China’s booming textile industry is one reason why many of the nations largest rivers resemble open sewers and 300 million people lack access to clean drinking water”
-Jane Spencer
Wall Street Journal

¹⁰ Waber, P. (2009, May 5) *Bluesign Presentation*, Seattle, WA.

¹¹ Spencer, J. (2007, August 26) *China's waterways pay price in textile boom*. *The Wall Street Journal*.

“ Conventional dyes present health risks to those working with them and to those who wear them, as well as damaging the environment in a number of ways.”

www.betterthinking.co.

streams, and, in Europe alone, 1,000,000, tons of salt (used in the process to even out color) are discharged every year. Although this waste water can be treated to remove the dye, salt and other toxic chemicals such as heavy metals to make the water safe to return to water systems, this treatment process is expensive and does not always happen.

Finally, even when the water may seem clean, the temperature of the water can be an issue. The water used in the dye process is heated resulting in hot waste water discharged into river systems that can impact and

harm the fish and ecosystem.¹²

Manufacturing of conventional dyes limitations

Environmental concerns: The production of synthetic dyes requires strong acids, alkalis, solvents, high temperatures, and heavy metal catalysts.

Increase in cost of energy: Petroleum is the starting material for all synthetic dyes and thus the price of dyes is sensitive to the price of petroleum. Producing synthesis is also very energy intensive (using super-heated steam, boiling acids, etc.), making the process very sensitive to energy prices, and creating greenhouse gases.

Hazardous waste generation: The synthetic production of dyes generally requires very toxic and hazardous chemicals, generating hazardous waste, the disposal of which is a major environmental and economic challenge.

Increasing Transportation Costs: Since dyes are a hazardous material and are produced in central facilities, transportation of dyes from manufacturing plants to textile dyeing and printing facilities is a major cost factor and a logistic challenge.¹³



Packaging

A great deal of packaging is used through the apparel industry. This includes the packaging to transport and distribute the products from the factories to distribution centers to retail stores as well as the retail packaging that goes to the consumer.

¹² *Dyeing for a change: Current Conventions and New Futures in the Textile Color Industry* (2006, July) www.betterthinking.co.uk

¹³ Massachusetts Toxics Use Reduction Institute (2003) *“Green” Dyes for the Textile Industry*. University of Massachusetts Lowell Natural Industry

Packaging is often the part of the product with the shortest span of use, typically ending up in a landfill, gutter, or ecosystem shortly after purchase. Furthermore, excess packaging materials are frequently used to enhance a product's visibility, unnecessarily drawing on resources that do not affect the product's serviceability.¹⁴

Solutions

*Each part of this life cycle tells a technical and complicated story when it comes to devising solutions for industry practices whose underpinnings are industrial. It will take tremendous **marketplace support** for this (or any) industry to make pervasive changes to a sustainable existence. Yet the answers are largely here, and together we have the chance to work directly with the leadership of this industry to bring these new patterns into existence on the mainstream levels.*

“The process of transforming our industry into something more sustainable-and more sensitive to our needs--takes time. It is a long-term commitment to a new way of producing and consuming that requires widespread personal and institutional change”--Kate Fletcher

Organic and More Sustainable Farming Practices

The textile industry is largely based upon the agricultural system. The term "Sustainable Agriculture" ([U.S. Code Title 7, Section 3101](#)) is defined as an integrated system of plant and animal production practices having a site-specific application that will over the long-term:

- *Enhance environmental quality and the natural resource base upon which the agriculture economy depends.*
- *Make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate,*



¹⁴ University of Delaware Sustainable Apparel Initiative. (2009, May). Newark, DE: UDSAI. <http://sai.udel.edu/index.php/policies/policy-3-eliminate-waste-in-all-points-of-the-supply-chain>

natural biological cycles and controls.

- *Sustain the economic viability of the farm operations.*
- *Enhance the quality of life for farmers and society as a whole.*

Organic and More Sustainable Fibers

Understanding fibers and Sustainable fiber options

Fibers are classified into the following three groups; *Natural, Man-made and Synthetic*

Natural fibers are subdivided into two classifications; **Animal (Protein) fibers and Plant (Cellulose) fibers.** *Man-made fibers* are sometimes known as **Regenerated fibers.**

Synthetic fibers are those in which man has produced the entire operation of the fiber production without allowing nature to manufacture the fiber forming substance (called polymers.). **Usually synthetics are made from chemicals derived from non-renewable resources such as coal or oil.** ¹⁵

Hemp

Prior to 1880 the US economy was based on hemp. **Industrial hemp** was a primary source of food, fuel and fiber. It is illegal to grow hemp in the US. Hemp grows well without the use of chemical herbicides and pesticides. Manufactures of hemp fiber claim that the fiber is biodegradable. All hemp fiber in the US is currently imported. China and Eastern Europe are the primary producers of hemp.



Hemp is a renewable resource which grows more quickly and easily than trees. Hemp fiber is longer, stronger, more absorbent and insulative than cotton fiber. Although seed for food consumption is readily available certified organic, certified organic hemp fiber is not widely available. To date, IMO certifies only one organic hemp farm in Inner Mongolia. (www.imo.ch/)

Organic Cotton

To be sold in the US as certified organic cotton, all textile fiber must be certified organic in accordance with the USDA National Organic Program(NOP) or for Europe the EU Organic

¹⁵ Rose, Coral (2008, March 12). *Sustainable Fibers Unraveled*. Retrieved from: <http://coralrose.typepad.com/>

Certifications EU 2092/91. Currently that is the legal requirement for certified organic cotton. Organic cotton is grown using methods and materials that have minimal impact on the environment.

Organic cotton production practices also prohibit the use of Genetically Modified Organisms (GMO) seeds; Organic agriculture builds strong soil through crop rotation, retains water more effectively due to organic matter in the soil, and controls weeds without using chemical, toxic fertilizers. This system uses biological practices to control pests including beneficial insects.

Third-party certification organizations verify that organic producers use only methods and materials allowed in organic production.¹⁶



Organic and Humane Wool

In order for wool to be certified as "organic," it must be produced in accordance with NOP federal standards for organic livestock production. Federal requirements for organic livestock production include:

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

Organic livestock management is different from non-organic management in at least two major ways: 1) sheep cannot be dipped in parasiticides (insecticides) to control external parasites such as ticks and lice, and 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. Organic wool can be certified by any accredited third party certification organization that is a member of IFOAM (www.IFOAM)¹⁷

Ranching operation can be independently certified for their humane practices. The "Certified Humane" standards, the American Humane Association's "Free Farmed" certification, and the Animal Welfare Institute's "Animal Welfare Approved" standards are options for ranchers. Each organization offers detailed standards by species, see <http://>

¹⁶ Retrieved from: Organic Trade Association (www.OTA.com)

¹⁷Rose, Coral (2008, March) Retrieved from: http://coralrose.typepad.com/my_weblog/about_organic_wool/index.html

www.awionline.org/, www.americanhumane.org, and <http://www.certifiedhumane.org/>

Flax-Linen

Flax is the plant that produces flax fiber, after the fiber is spun it is known as *linen yarn*. Certified organic flax seed for oil is grown in about half of the USA, however, textile-grade flax fiber is imported to the US. Certified organic flax fiber is grown in Europe and China. Organic Flax can be certified by any accredited third party certification organization that is a member of IFOAM.¹⁸

What can you tell me about this relatively new fiber bamboo?

Bamboo is not, in and of itself, recognized as a fiber in the US or EU. The majority of what is referred to as bamboo fiber in the market is actually viscose/ rayon.



All viscose or rayon fiber from *Bamboo* (as a source) that is imported into the US must carry a legal fiber content label declaration of viscose or rayon. All bamboo imported into the EU must use the legal content declaration viscose; the EU does not permit the use of the word rayon.

As one of the fastest growing plants in the world, bamboo grows to its maximum height in about 3 months and reaches maturity in 3-4 years. It spreads rapidly across large areas. Because of relatively quick growing time and the ability to be grown without fertilizers or pesticides, the fiber is currently being marketed as an 'eco-green-sustainable fiber.' There are also claims that viscose or rayon from bamboo is biodegradable and anti-microbial although these claims are not substantiated. There are potential risks associated with using bamboo as polymer source for rayon since there is currently a lack of transparency in the supply chain. It is not always clear which type of bamboo is used for fiber, where it is grown, how it is cultivated, harvested etc. To date there are no known organic certification of bamboo.

The process to make viscose or rayon fiber from bamboo is the same process used to produce viscose/ rayon from any other plant source. The cellulose is extracted from the bamboo, and then the cellulose is mixed with chemicals to convert the plant pulp into textile quality fiber. This process can be very polluting unless it is carefully controlled, which can be influenced by the age and condition of the equipment as well as whether there is any by-

¹⁸ Burden/Rose (2007) Retrieved from: http://coralrose.typepad.com/my_weblog/about_linenflax/

product recycling or effluent treatment.¹⁹

The U.S. FTC recently fined companies for making unsubstantiated environmental and performance claims regarding of bamboo rayon. For details of these FTC fines see <http://www.ftc.gov/opa/2009/08/bamboo.shtm>

Tencel ® Lyocell

Lenzing is the only manufacture making a regenerated cellulose fiber using a **closed loop system** where the **chemicals are completely recycled with a recovery rate of 99.5%**. The fiber made using this closed looped process is Lenzings **TENCEL ® Lyocell**. More accurately described Lyocell is a solvent spun fiber in which the cellulose is directly dissolved keeping the cellulose much closer to that found in nature. TENCEL® Lyocell, also carries the Oeko Tex 100 certification and Forest Stewardship Council (FSC) certification (<http://www.fsc.org/en/>) to ensure the fibers come from sustainably managed forests. Organic standards do not exist for certifying regenerated fibers using trees as a source e.g. Eucalyptus, or Beechwood. They also have been awarded the European-Eco flower label. (www.Lenzing.com). The quantity of water and energy used in the process does need to be considered.²⁰



Recycled Fibers

Recycled fibers are an option for current conventional synthetic fibers. The following statistics were generated by the EPA regarding recycled textiles:

An estimated 11.8 million tons of textiles were generated in 2006, or 5 percent of total municipal solid waste (MSW) generation. **The textile recycling industry annually prevents 2.5 billion pounds of post-consumer textile product waste from entering the solid waste stream**, according to the Council for Textile Recycling. These 2.5 billion pounds of postconsumer textile waste represents 10 pounds for every person in the United States. Approximately 500 million pounds of textiles collected are used by the collecting agency, with the balance sold to textile recyclers, including used clothing dealers and exporters, wiping rag graders, and fiber recyclers.

¹⁹ Rose, Coral (2008, February) *Have You Been Bamboozled by Bamboo?* Retrieved from: http://coralrose.typepad.com/my_weblog/2008/02/index.html

²⁰ Rose, Coral (2009, October). Retrieved from: http://coralrose.typepad.com/my_weblog/lenzings_r_tencel_and_modal/index.html

Textile waste can be classified as either pre-consumer or post-consumer. Pre-consumer textile waste consists of by-product materials from the textile, fiber and cotton industries. Each year 750,000 tons of this waste is recycled into new raw materials for the automotive, furniture, mattress, coarse yarn, home furnishings, paper and other industries. Through the efforts of this industry approximately 75 percent of the pre-consumer textile waste that is generated is diverted from our landfills and recycled.

Recycle Polyester (PET)

Another innovation for textiles is **polyester materials made from 100% recycled plastic bottles**. Today, consumers only recycle about 23 percent of plastic bottles. Recycled PET can be extruded into a filament yarn which is used to make textiles. Recycled PET is now available in many product categories: carpets, clothing, automotive parts-car seats and even new bottles. With so much demand for the empties, and so many bottles in the marketplace, the question pressing on recyclers and beverage companies alike is how to get more of them recycled?

To process PET first the bottles are cleaned and then chopped into chips, each smaller than a cornflake. Then, they're heated and turned into tiny white pellets of recycled PET, those PET pellets are then extruded into polyester filaments to be made into textiles.²¹

Teijin Fibers produces chemically recycled polyester equal in performance and quality to virgin polyester textiles. Their recycled polyester is made from PET bottles, post-industrial scrap and post consumer materials.

PLA (Polylactide)

PLA is classified as a synthetic. The **monomer in PLA is based on a renewable resource**. PLA is produced in a manufacturing process that converts the corn to sugar (dextrose) and then changes the molecular composition into a high performance polymer called polylactide (PLA) which is branded NatureWorks™ PLA. Ingeo™ fibers are extruded from NatureWorks PLA polymers. Ingeo is produced by NatureWorks, a subsidiary of Cargill.²² NatureWorks claims that each pound of Ingeo resin releases about 60% less greenhouse gas emissions and consumes about 50% less non-renewable energy.

The feedstock for PLA is currently corn. According to the USDA 45 percent of field corn planted in the U.S. in 2004 was genetically modified (GM). The growing use of GM crops has resulted in a documented increase in the use of herbicides and the spread of herbicide-resistant plants. The potential environmental, biodiversity, and health concerns related to GM crops has not been fully researched and many unknowns still remain.

²¹ Cohen, Nancy (2007, June 11th) *For Empty Water Bottles, There's An Afterlife*. Retrieved from: www.npr.org/templates/story/story.php?storyId=10874230

²² Burden, Grose, Rose (2006) *Eco-Textiles*

Corn is also a very energy, pesticide and fertilizer intensive crop. It takes approximately fifty gallons of oil to produce one acre of corn according to Michael Pollan's book, *The Omnivore's Dilemma*. The large volumes of synthetic fertilizers applied to the corn fields has resulted in toxic runoff that makes nearby rivers undrinkable.

Processing Solutions

Cleaner Production (CP) Manufacturing

Cleaner Production promotes a preventative approach and originated as a response to the overwhelming financial burden brought about by costs of controlling pollution through end-of-pipe means.

In its broadest sense, CP may be defined as: **“Cleaner production is the continuous application of an integrated preventative environmental strategy applied to processes, products and services to increase eco-efficiency and to reduce risks for humans and the environment.”** (United Nations Environmental Program, *Eco-efficiency and Cleaner Production: Charting the Course to Sustainability*)

For manufacturing processes, CP includes:

- Conserving raw materials, water and energy;
- Eliminating toxic raw materials;
- Reducing the quantity and toxicity of all emissions;
- Reducing wastes at source; and
- Reducing all the negative environmental impacts along the life cycle of the product, from raw material extraction through to end use and final disposal.²³

Natural Dyes

If bioengineered natural dyes can be produced at a comparable price to synthetic dyes, the following benefits will be realized:

- Reduce the use of toxics since starting materials are environmentally benign with associated benefits in terms of waste disposal and occupational safety.
- Production can be “decentralized” resulting in savings in transportation costs.
- After extraction of the dye, the biomass can be used for energy generation (e.g., through anaerobic treatment to generate methane, which in turn, can be used as a fuel) and the growth media can be recycled; thus, there are



²³ George W., Dhiraj, M. and Buckley, C. *Cleaner Production in the Textile Industry-Lessons from the Danish Experience*. South African Dyers and Finishers Association, Natal Branch Pollution Research Group, School of Chemical Engineering, University of Natal, Durban, 4041.

virtually no wastes generated.

- Possible beneficial aspects such as higher UV absorption by the fabric (which contains natural dye) can result in reduced incidence of melanoma.²⁴

Low-impact Dyes

Generally, low impact dyes do not contain toxic chemicals or mordants (which fix the dye to the fabric), they require less rinsing and have a high absorption rate in the fabric. High absorption rates and a decreased use of rinse water create less waste water.

Fiber-reactive Dyes

Fiber-reactive dyes are low-impact *synthetic* dyes that directly bond with the garment fibers rather than merely remaining as an independent chemical entity within the fiber.

The benefits:

- Contain no heavy metals or other known toxic substances, and do not need mordants.
- Are easy to apply and are available in a wide range of color and wash-fast bright colors.
- Fixation or absorption rate of low-impact dyes is at least 70%, creating less waste water runoff than conventional dyeing processes.
- Are applied at relatively low temperatures (30°C compared to the 100°C needed for direct dyes), saving energy, and require controlled amounts of salt and alkali.
- Dye from its [effluent](#) rather than discharge it all and start from scratch. The water can also be recycled.
- The entire process normally occurs at a pH of around 7.0, meaning no acids or alkalis need to be added to the water.

The disadvantages:

Like other environmentally damaging dyes, reactive dyes are made from synthetic petrochemicals:

- The process requires very high concentrations of salt (0%-80% of the weight of the goods dyed), alkali and water. Even if the unfixed dye is reclaimed, the effluent from this process.
- Can still contain high concentrations of salts, surfactants and defoamers, and are strongly alkaline.
- The effluent normally contains salt, alkali, detergent and between 0% to 50% of dye used.²⁵

²⁴Massachusetts Toxics Use Reduction Institute (2003) *“Green” Dyes for the Textile Industry*. University of Massachusetts Lowell Natural Industry.

²⁵ Trotter, Cate (2006, July) *Dyeing for a change: Current Conventions and New Futures in the Textile Color Industry*. Retrieved from: www.betterthinking.co.uk

Packaging

The environmental impact of packaging can be reduced by minimizing the volume and weight of packaging, maximizing the recycled content of materials, using FSC (www.fsc.org) certified fibers for forest product based packaging such as paper and paperboard, and avoiding the use of multiple materials, adhesives and coatings to enhance the recyclability of the packaging. The **Sustainable Packaging Coalition (SPC)** has developed comprehensive guidelines for packaging. The SPC makes the claim that sustainable packaging includes the following practices:

- **safe & healthy for individuals and communities throughout life cycle.;**
- **maximizes the use of renewable or recycled source materials;**
- **manufactured using clean production technologies and best practices;**
- **made from materials healthy in all probable end of life scenarios;**
- **physically designed to optimize materials and energy; and**
- **is effectively recovered and utilized in biological and/or industrial cradle-to-cradle cycles.**

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