Synthetic Fabric vs. Natural Fabric

Many people have been advertizing the benefits of natural fibers and how much less destructive they are for the environment. From wool to cotton to bamboo and even hemp, natural fibers have been touted as being the new environmentally friendly fabrics. Synthetic fabrics (those made from petrochemicals) have recently gotten a bad reputation as being extremely harmful to the environment for the following reasons.

- They are made from non-renewable resources
- They take massive amounts of energy to produce

In reality, all fabrics that are made for the clothing industry are harmful to the environment in their own way. The details are astounding and worth noting for the future of clothing. Steps can be taken to lessen the destructive procedures to manufacture clothing and most of them start and end with the consumer.

Definitions:

Life cycle inventory (LCI) = to quantify material and energy flows into and out of the environment (16)

Life cycle assessment (LCA) = a cradle to grave approach to finding consistency of production energy and consumption as well as chemical consumption and emissions to air and water (16)

For polyester, cotton, wool or bamboo, this includes growing or acquiring, harvesting, transportation, manufacturing (materials, product fabrication, packaging), distribution, use, reuse and maintenance (washing and drying), waste management or recycling (if possible).

Natural Fabric

COTTON

Energy Usage

Cotton, especially, has been the natural fabric of choice for many generations. Many American's prefer cotton garments because the majority of cotton is grown (37%) in the USA (25). Even though the cotton is grown in the USA almost none of it is kept here for the manufacturing phase of the process. China is the leader in manufacturing the clothing (25). Once the cotton fiber is harvested, it is transported to China where 20-30% of the cotton is unusable due to seeds, soil, lint, stems and fiber inconsistencies (1 and 26). So right from the first step there is a much greater need for more cotton because of the large amount lost. Cotton ginning requires 50kWh per bale of electicity (32). After the ginning process depletes the amount of cotton, the fibers are then spun to make the fabric that then has to be cut, sewn, dyed, washed, finished and then transported back to the USA. This process actually takes very little energy compared to the rest of the life cycle of the cotton garment.

The use phase of the cotton garment is where most of the energy usage occurs. One of the major drawbacks to cotton is the necessity for cleaning, drying and ironing all of which require massive amounts of energy in order to heat the water and air and iron (12). Cotton requires 72% more energy than synthetic fabrics for this phase (1). Once the garment is purchased it takes on average 25 washes during its lifetime (25). All of this accounts for 60% of the total energy during the lifetime of the cotton garment (25). If synthetic fabrics were used over cotton there would b ea 10% reduction in energy during the use phase and a 20% reduction in the use of detergents (16). Many people assume that organic cotton is better for the environment than conventionally grown cotton. This is true in other aspects that will be included later, but for the use phase as well as the manufacturing phase organic cotton and conventionally grown cotton energy consumption is the same.

The following chart shows the energy profile for a 250 gram t-shirt in each phase of its life cycle.

Material	16 MJ (Mega Joule) per piece
Production	24 MJ
Transportation	7 MJ
Use	65 MJ
Disposal	-3 MJ
Total	**109 MJ per piece**

The disposal phase includes incineration on this chart and therefore requires no energy (25).

Water Use, Pollution and Toxicity

Water use for a cotton garment is extremely high. Water requirements for cotton garment compared to a synthetic are 99.9% more (1). Throughout the life cycle of the cotton garment the most water is used in the growing phase. Cotton irrigation is required in almost all areas (73% of total areas) (3) where cotton is grown, especially the US. Cotton irrigation has been blamed for depleting the Aral Sea (3). This much irrigation causes pollution to local water sources, salinization, wildlife contamination, rising water tables and habitat destruction and is less than 40% efficient (2). The effluent from conventionally grown cotton causes eutrophication and nitrate contamination of nearby drinking water as well as a permanent increase in soil salinity (1).

In a study to compare 100% cotton sheets vs. 50% cotton and 50% polyester, the 100% cotton sheets used 300% more water and 72% more energy (1).

Conventionally grown cotton is extremely toxic due to the high levels of pesticides and fertilizers used. Cotton accounts for 24% of the world insecticide market and 11% of world pesticide sales (3 and 26). Not only is this toxic to the local area where the cotton is grown, it is extremely toxic during the manufacturing phase. There are 5 major chemical groups used in cotton production – insecticides, herbicides, fungicides, growth regulators and defoliants. All of these chemicals are washed out of the cotton during the manufacturing stage (25 and 26). After the mostly natural spinning process, the cotton needs to be sized with polyvinyl alcohol to make weaving easier (26). The fabric is then bleached with either less toxic hydrogen peroxide or highly toxic chlorine bleach (26). It is then washed with sodium hydroxide and then dyed with a formaldehyde agent to fix it to the fabric (26). The percentage of impact in terms of toxicity is 93% during the material preparation phase (25). The rest of the phases' impact can be seen in the following chart regarding the toxicity percentages (25).

Material	93%
Production	3.5%
Transportation	1.0%
Use	2.5%
Disposal	0.0%

Organic cotton is much better for the environment in terms of less toxicity during the growing and material phases. The impact percentages are seen in the following table (25).

Material	7.5%
Production	48%
Transportation	10%
Use	34.5%
Disposal	0.0%

As you can see, the percentages for the stages changed, but the toxicity is still high in other phases of organic cotton's life cycle due to dyeing and finishing the fabric. There is only about a 10% decrease in toxicity from conventionally grown cotton (25). Organic cotton uses natural manufacturing processed as much as possible the entire way through the process. Instead of the harsh chemicals, natural spinning oils are used to facilitate spinning the yarn and other natural substances are used instead of chlorine bleach, formaldehyde and others to reduce the toxic effects even further (26).

Unfortunately, organic cotton uses equal amounts of water throughout the life cycle. For cotton growers, there is not enough incentive to grow organically because in general yields are 20-50% lower (3). Organic cotton growing accounts for only 0.03% of the total amount of cotton grown (3). This number is rising thanks to consumer demand and competitive pricing.

Neither conventional nor organically grown cotton fabrics are ideal for the environment. Solutions to help curb the effect are to buy less clothing, especially cheap, fast fashion clothing, buy more second hand clothing, repair clothing and recycle used clothing (donating to charities or thrift stores).

WOOL

Energy Use

Wool energy use is less than cotton but is not significant enough to make a difference. According to a life cycle assessment of wool in New Zealand the energy uses for wool and other fibers are as follows: (6)

Nylon	250 MJ/kg of fiber
Acrylic	175
Polyester	125
Polypropylene	115
Viscose	100
Cotton	55
Wool	63

Scouring (or cleaning) wool accounts for 90% of the energy use during the production phase (6). Scouring requires 1552 kWh/tonne of greasy wool and 2607 kWh/tonne top of electricity (6). The CO_2 emissions from the production of wool are 1326 kg/tonne greasy wool and 2230 kg/tonne top (6). This incorporates the CO_2 released on the farm, producing and using agrichemicals, transportation and everything else involved with wool fiber production.

Wool energy processing totals are 49% from the farm, 47% from processing and 3% from transport (6). Wool requires 2.7 times less energy than polyester and between 3.8 and 5 times less energy than other man-made, non-natural fibers such as nylon or acrylic (6).

Pollution and Toxicity

Sheep on the farm have a relatively high rate of pollution. Farm animal flatulence and belching can produce up to 600 liters/day of methane gas (27). Methane gas contributes to 4-9% of global greenhouse gases and is growing at a rate of 4 times carbon dioxide, which accounts for 9-26% of greenhouse gases (27). Sheep also require pesticides and antibiotics to stay healthy and produce more wool. Three of the main pesticides used for sheep are not necessarily dangerous for humans, but are extremely harmful to fish and amphibians (28). These pesticides are often highly water-soluble and can be removed from the sheep's wool easily with rain or irrigation water (28). The antibiotics that go through the sheep's digestive system can often be found in groundwater and surface water as well as drinking water (28).

Wool scouring produces pollution equivalent to that produced by 30,000 people (31). Manufacturing wool uses harsh scouring agents to clean and purify the wool as well as chlorine bleach (28). Formaldehyde (and other similar agents for finishing cotton) is used to treat the final garments (28). Dyes can often contain copper, chromium and zinc and those heavy metals are often found in the effluent of the manufacturing plant (28). Each ton of greasy wool has 150 kg lanolin, 40 kg suint, 150 kg dirt, 20 kg of vegetable matter, and 640 kg of wool fiber (31).

During the scouring process all of the agrichemicals that are used on the sheep are washed out and are often found downstream. These chemicals can also not be recycled, which increases the energy used and CO_2 produced to make the chemicals used for every application.

In the end, wool is not the answer for a sustainable and environmentally friendly fabric just the same as cotton.

Bamboo

Energy Use

Bamboo is another natural fiber that is claimed to be both sustainable and environmentally friendly. While bamboo is much more sustainable than cotton because of its extremely quick growing phase, the manufacturing process is highly toxic.

Bamboo is one of the fastest growing plants on earth and has great erosion preventing roots (29). Bamboo is great at cleaning the air because its forests grow densely enough to return 30% more oxygen back to earth than most tree forests (29). Bamboo can sequester up to 12 tons of carbon dioxide per hectare (29). It also takes very little maintenance to grow bamboo. No pesticides or fertilizers are needed, and very little water is required (29). Bamboo is also easy to harvest and will regenerate an entire forest very quickly (29). For these reasons alone, bamboo is a much more sustainable natural fiber than either cotton or wool. Unfortunately, the story does not end here.

Pollution and Toxicity

Heavy amounts of chemicals are used during the manufacturing process for bamboo. This in effect negates the sustainability and environmental benefits created during the growth phase. Bamboo can be manufactured without the use of chemicals, but it is extremely labor intensive and therefore, not cost effective (9). Bamboo has to be broken down using sodium hydroxide and carbon disulfide (similar ingredients to Drano) (9). This is called hydrolysis alkalization and is known to be highly toxic to humans (9). There have been cases of bamboo manufacturing workers to become very ill after using these treatments to break down the bamboo fibers into something that is useable and can be spun into fibers for clothing. There are also problems with the effluent from the manufacturing plants getting in to local water sources including drinking water. All of these factors add up to making bamboo not sustainable or environmentally friendly.

The only other beneficial function of bamboo clothing is that it is 100% biodegradable (9 and 29).

Polyester

Energy Use

The phase of manufacturing polyester that requires the most energy and has negative connotations throughout the clothing industry is the material phase (25). Polyester has a 63% higher energy consumption per kilogram of fiber than cotton during this phase (1). Polyester consumes 10 times more energy than cotton during production and produces 4 times more carbon dioxide (2). Polyester raw material releases high amounts of carbon dioxide. This rapidly increases global warming, which is why polyester and other synthetic fabrics are widely discouraged. The other reason is that some synthetic fabrics come from non-renewable resources such as oil. There are some synthetics produced from wood, which is renewable and the preferred method for the ecologically friendly manufacturers (25).

Because most of the energy usage comes from the materials phase, the rest of the life of the garment is considerably less harmful than natural fibers. Refer to the following table to compare energy uses during the life cycle phases (25).

Material	33 MJ per piece
Production	11MJ
Transportation	3MJ
Use	7MJ
Disposal	-3MJ
Total	**51MJ**

As you can see the overall energy usage throughout the lifetime of the garment is considerably less than cotton. Because the majority of the energy required for polyester comes from the manufacturing process, there is much more that can be done to reduce the energy usage even further without having to rely on consumers. It is up to scientists to develop new methods that are healthier for the environment. Cotton has to rely on the end consumer/user to decrease its energy demands. Consumers are not motivated to reduce cleaning costs either by reducing the temperature or by washing less because they do not see the effects and it is not cost effective (25). The costs for upkeep of the garments are less than 2% of the cost for the garment (25). Polyester has a 10% reduction in energy use from cotton because of the lack of upkeep

needed (16). It also shows a 20% reduction in energy use and can cut consumers' energy costs by 20% and detergent costs by 20% (16). Polyester is a very strong and durable material. Polyester is resistant to chemicals, stretching, shrinking (18). It is wrinkle resistant as well as mildew and abrasion resistant (18). For these reasons, it needs to be washed less, dried little and not ironed at all (18).

One other beneficial asset to synthetic fabrics is the recycling option. All synthetic garments can be recycled and some clothing companies are starting recycling programs. Japan has a commonly used recycling program for synthetic fabrics, but it has been slow to move to other countries. People all around the world are becoming more aware of the need to recycle. Most people are already really proficient at recycling plastics and glass. It should be the job of manufacturers to let their customers know that it takes 10 times more energy to produce textiles than it does the same amount of glass (25). If people were more aware of this, there would be greater demand for recycling centers through retailers or other avenues to make it more favorable for all to recycle their synthetic fabrics.

Conclusion

In the end sustainability and environmental friendliness of the clothing industry depends on the entire life cycle of the garment. The entire process needs to be taken into account before wide assumptions are made about which fabric is better for the environment. Natural fabrics are more harmful to the immediate environment (meaning the water and soil) while synthetics take a larger toll on the air and non-renewable resources. In reality, no single fabric is the best for the environment. It is up to consumers to demand that manufactures take a closer look at the processes to produce clothing and find the best way to make it healthier for everyone involved.