

Chemistry

Hazardous chemicals

RecyCOOL Lessons

Disclaimer

These lessons have been created for and tested with young people in Slovakia, the Czech republic, Germany, Hungary and Croatia. They are open-source and available for adaptation for different groups globally.

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Hazardous chemicals

Description of the lesson

We will look at the general problem, and then break it down into several questions, like what hazardous chemicals can be found in the fashion industry, how they get out from the materials and what issues they can cause. Then we will look at some details about the most hazardous chemicals and the harms they inflict on people and the environment. We will also do a task to better understand the issue. At the end, we will look at what we can do as consumers if we are not happy with how things are.

Objective

The objective of this lesson is to highlight the risks that the production of clothes inflicts upon people and the environment with the use of hazardous chemicals, as well as to discuss the responsibility of the actors in it, and the actions that we may take to improve the situation. Despite existing legislation on the use of hazardous chemicals, we can still find toxic chemicals in the clothes we wear everyday due to poor enforcement.

After this lesson you will be able to

- list some chemical substances used in the fashion industry during production that are hazardous for health and the environment
- explain how the chemicals get out of the clothes
- identify some environmental issues and illnesses that are caused by hazardous chemicals
- understand how brands, factories and customers are connected to the chemical problem
- list what possibilities there are to make the situation better

Tools and materials:

3 spoons of sodium bicarbonate (a.k.a. baking soda), some vinegar, a porcelain plate, paper and pen

HAZARDOUS CHEMICALS:

Any element, compound, or mixture of elements that is a physical hazard or a health hazard.

Health hazards include, among others: chemicals that are carcinogens, reproductive toxins, irritants, corrosive, neurotoxins, hepatotoxins, and chemicals that damage the lungs, skin, eyes, or mucous membranes.

Physical hazards include, among others: chemicals that are combustible, explosive, flammable, oxidizers, reactive, unstable, water-reactive, as well as compressed gases.

HAZARDOUS:

Dangerous, hiding certain risks.

CHEMICAL REACTION:

A process in which the structure of atoms or molecules that make up a substance are changed.

BIOACCUMULATION:

The build-up of a substance in living organisms.

Chemistry is all about consequences. When you put certain things together, they will react with each other. You take a substance that has certain characteristics and pair it with something else, which has different ones, and those two will generate a chemical reaction.

Do we know what substances are used in the fashion industry and what the mixing of them causes?

We all wear clothes and fashion impacts 100% of the population. Our skin is our largest organ and yet, very few know the chemicals used to make our clothes and how these chemicals might harm us, the people who make our clothes, or the environment.

Our environment and the people who are working in the production line are even more exposed to these harmful chemicals.

The fashion industry has huge problems. Whilst there are no blanket international regulations that clarify which chemical substances are safe and unsafe to use in the production of garments, there are some at regional level.

For example, the European Union's REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) regulation applies to all chemical substances used in both industrial and consumer applications.

The law requires companies to demonstrate how they are managing potential risks as well as how chemical substances can be safely used. In October 2020, the EU also published a chemicals strategy for sustainability that aims to “boost innovation for safe and sustainable chemicals” and would “ban the most harmful chemicals in consumer products – allowing their use only where essential.”

So, overall, major brands and retailers might not be obligated to disclose the data on what the various substances they apply to their products are if there is not a regulation that applies to them. Without mandatory disclosure requirements, they may not openly share information.

Citizens, who are consumers too, should have the right to know the composition of the clothes they buy and yet they often have to make a choice based on little information and without the knowledge of the dangers behind what's in their clothes.

In addition, while REACH provides a list of chemicals that are banned or how they should be used, studies have shown that even EU brands do not respect the REACH legislation, especially when their manufacturing takes place in China and South East Asia.

Whether you yearn for the latest fashion item or you are in need of some humble pieces, risky substances are lurking in a big part of the apparel available on the market. The industry sometimes does not publish these facts, but the consumer has the right to know.





For example, Fashion Revolution's [Global Fashion Transparency Index](#) reviews and ranks 250 of the world's largest brands and retailers according to the level of public disclosure across their human rights and environmental policies, practices, outcomes and impacts.

The research finds that only 32% of brands publish their Manufacturing Restricted Substance Lists, which inform suppliers what substances are prohibited in their raw material and product manufacturing processes.

More brands (47%) disclose their Restricted Substances Lists (RSLs), which only covers the chemicals that are not permitted to end up in the finished product. Whilst RSLs and MRSLs are important, publicly disclosing an MRSL signals brands' commitment to restricting the usage of toxic chemicals in the production of our clothes is not enough to know exactly if these guidelines are respected.

It is hard to state an exact figure but the textile industry uses approximately 43 million tons of chemicals in different phases of the manufacturing process and for various purposes.

What are the substances used in the fashion industry?

It is impossible to know all of them, because there are more than 8000 different chemicals used in the fashion value chain, although not all of them are hazardous. However, here are some that are the most well-known to be harmful.

Formaldehyde

Phthalates

Heavy metals (lead, cadmium)

PFCs

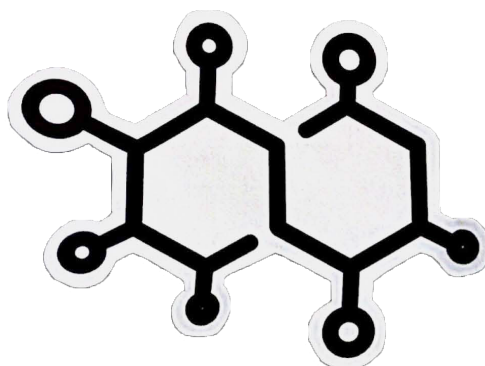
Nonylphenols

Antimony

Organotins

Chromium, etc.

You will not be able to find them on the labels or in the description of the product, as the fashion industry is not required to disclose this. What's more, brands often don't know this themselves.





Fashion brands might choose the materials and dyes on the basis of aesthetics and don't think so far as the harm that can be done in the creation and life cycle of a product.

The choices made are not considering the long-term impacts that the clothing manufacture actually has on the environment and on people's health. Some hazardous chemicals are also used for specific properties, such as Wrinkle-free label textiles, which may contain per-fluorinated chemicals (PFCs) and are known to cause many health problems.

Harmful chemicals can be found in material components, dyes and finishes.

- **Materials:** polyester (PES) and all synthetic materials (acrylic, nylon, spandex/ elastane, poly-everything), also (non-organic) cotton because of the pesticides
- **Dyes:** synthetic (azo dyes)
- **Finishes:** fire retardants, leather finishes, wrinkle free, iron free, moisture wicking, stain resistant, mould retardant, anti-static, untangling coatings, prints, surfactants, softeners, solvents

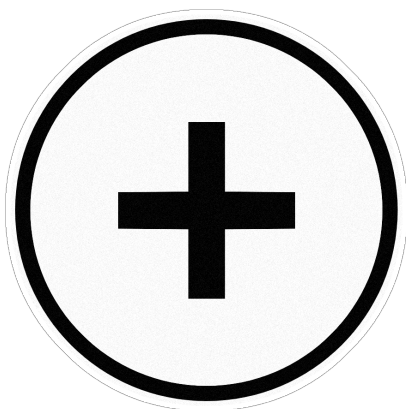
How do the substances or chemicals get out from the materials themselves?

From growing natural fibres like cotton using pesticides, making synthetic fibres, dyeing and processing these fibres to the finished product, chemicals are present at every step of the supply chain.

Many countries do not implement stringent environmental regulation to manage these toxic chemicals and the impacts of hazardous materials are felt at all stages of production and manufacturing – from the people who make our clothes to the people who wear them.

In addition, even after these clothes have been made, they keep releasing toxic chemicals. This happens mostly by washing these clothes and exposing them to the sun's rays. This means they end up in the air or the wastewater, and then (since they are not filtered properly), in the freshwaters and the oceans.

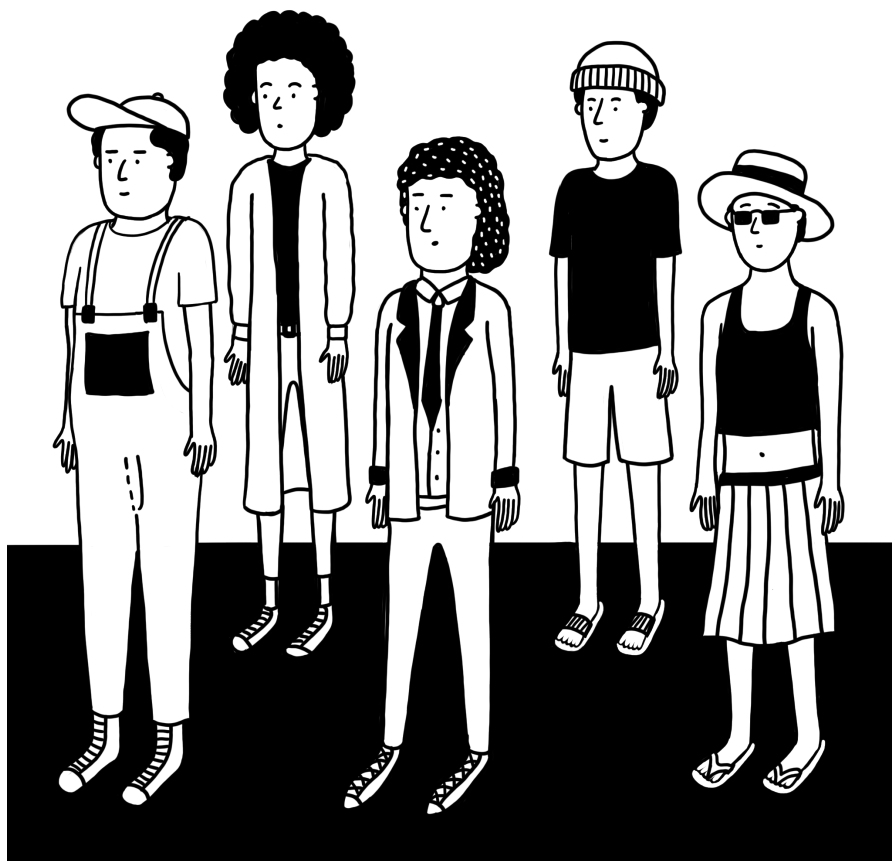
They can also accumulate in humans through inhalation or ingestion. Small children might also put the clothes and accessories into their mouths. At the end of a garment's life, incineration is a common method, which also releases a lot of harmful chemicals into the air.



What do they cause?

They pollute freshwater, the air, and endanger the health of the whole ecosystem. They persist in the environment, bioaccumulate in animals and humans.

This may result in biological dysfunctions and serious illnesses in humans, like headaches, fatigue, blurred vision, rashes, dermatitis, irritation of the respiratory tract, asthma, immune disruption, disruption of the endocrine system, hormone disruption, sterility, and cancer.



More details

PER- and POLY-FLUORINATED CHEMICALS (PFCs): used in textiles and leather for their ability to repel water and oil, their ionic (relating to atoms that have an electrical charge) versions (PFOS and PFOA) can be harmful for children and adults as well, they have hormone disrupting properties, which can impact the reproductive and immune system, and it can potentially cause cancer.

Volatile (easily changing from a liquid or solid state into a gas) PFCs evaporate from outdoor clothes.

NONYLPHENOL ETHOXYLATES / NONYLPHENOLS (NPEs/ Nps): used as surfactants when manufacturing textiles and then they likely get into the wastewater. When NPEs are released to the environment, they degrade to NPS, which are toxic.

They are also persistent and bioaccumulative, so they can pile up in living organisms and disrupt hormones.

PHTHALATES: softeners in plastics, especially PVC, used in plastisol prints. They are not chemically bound to plastics, so they release to the environment.

They are also feared to be toxic to wildlife and humans, particularly because of their hormone-disrupting effects. Some types of phthalates are listed as substances of very high concern. DEHP is one of the most widely used, which is detrimental to reproductive development in mammals, and it might even cause sterility.

ANTIMONY: it is similarly toxic as arsenic. A more toxic form of antimony may cause dermatitis, irritation of the respiratory tract and damage to the immune system.

It is possibly carcinogenic to humans when inhaled (which is common in occupational settings). No regulations exist to prohibit their use in textile manufacture although alternatives are available.

ORGANOTINS used in shoes, socks and sports clothes as biocides and fungicides to prevent smells from sweat and as stabilisers in plastisol prints. Even a low level of exposure is toxic to mammals, as well as other organisms. It impacts the development, the immune system and the nervous system.

FORMALDEHYDE and other antifungal chemical agents are also applied at the end of manufacturing for wrinkle prevention, and also to keep mildew away from clothes (since moisture is a risk when being transported). Even a low amount may cause rashes or skin discomfort, but more importantly, they are known to be human carcinogens.

CHROMIUM: salts are widely used for leather tanning as they speed up the process. Often not disposed of properly, the residues can leave an impact on food crops and workers might have rashes and respiratory problems. Chromium compounds are also found in soil and groundwater.

CADIUM a highly poisonous heavy metal used for jewellery, and pigments in the fashion industry, and is associated with a number of diseases, concerning the kidney and the cardiovascular system among others, when exposed for a longer time. It damages the environment, too. Cadmium has also been linked to cases of autism.

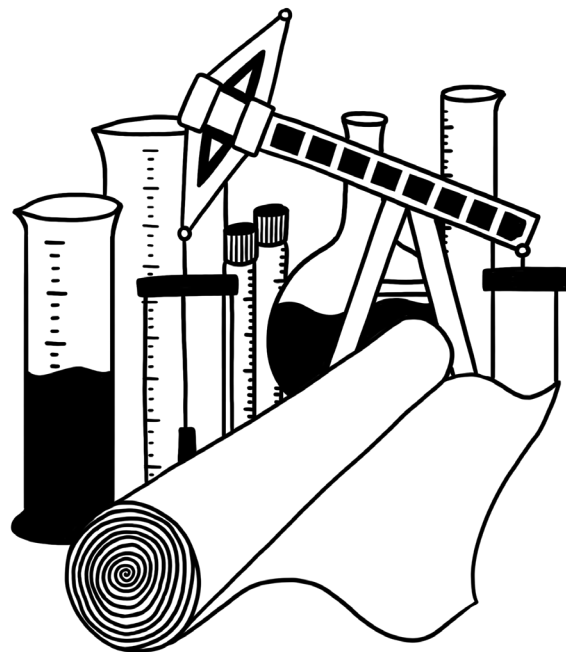
LEAD:extremely toxic heavy metal extensively used as colouring pigments. This element has no role in our biology and even the lowest level of lead exposure is unsafe. It affects every organ and system in the human body, gets into the bloodstream and interferes with the proper functioning of enzymes, can damage the brain and kidneys and causes death.

METALS studies have shown that high levels of toxic metals.

SOLVENTS they dissolve pigments in dyes. They can affect the central nervous system and organ functioning when overexposed to them.

SURFACTANTS used for scouring, dyeing and finishing to make clothes anti static, untangled and softer. They can damage marine wildlife.

PESTICIDES cotton growing uses many of the most hazardous pesticides, which harm people, wildlife and the environment, by poisoning farm workers, and also leaving their impact on the communities that live nearby, polluting the waters and killing beneficial insects and soil microorganisms.



Is the use of chemicals in the clothes regulated?

There are several regulations that help control the use of chemical substances in general, but none of them target that in textiles and apparel specifically.

However, many companies develop a Manufacturing Restricted Substances List (MRSLs), which gives suppliers some guidelines the limit of hazardous chemicals to be used during the production of our clothes as well as Restricted Substances Lists (RSLs) which provide guidelines on what chemicals should not be present in the finished product.

Other than that, in the EU there is a General Product Safety Directive (GPSD), in which we find rules on the matter. A product is said to be safe if it meets all statutory safety requirements under European or national law.

In the USA, there is a government Agency, the Consumer Product Safety Commission (CPSC) that protects citizens from products with potential safety hazards. They investigate consumers' complaints concerning unsafe products, and issue recalls of products that are defective or violate mandatory standards.

A recent case in November 2022 saw the recall of 87,000 products in America because of their lead content. What makes it even more alarming is that these were children's clothing. The CPSC revealed that the amount of lead in the ink, with which Disney themed patterns were painted on the garments, exceeded the accepted lead content.



Photo credit: [CPSC](#)

Lead is toxic, and even more so when ingested by young children, with adverse health issues according to the CDC (Centers for Disease Control and Prevention):

- Damage to the brain and nervous system
- Slowed growth and development
- Learning and behaviour problems
- Hearing and speech problems

All this may lead to developing a lower IQ, decreased ability to pay attention, and underperformance in school. There is also evidence that childhood exposure to lead can cause long-term harm.

We are going to take a closer look at synthetic dyes.

What chemicals are in synthetic dyes?

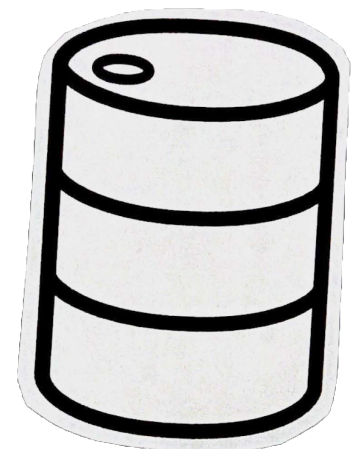
Examples of synthetic dyes are disperse, reactive, acid and azo dyes.

Natural dyes, meaning colour obtained from naturally occurring sources – are another source of colour for textiles, but these are rarely employed on industrial scales. They are made of coal tar and petroleum.

The components of a synthetic dye are derived from hydrocarbon benzene, which absorbs bands (wave-length) of light in the ultraviolet spectrum. The addition of substances known as chromophores (chromophore is the part of a molecule responsible for its colour) can shift this absorption band into the visible spectrum, creating different colours.

In addition to chromophores, most of the dyes also contain auxochromes (colour helpers).

Textile industry uses synthetic dyes, like azo dyes. Azo dyes are the most important synthetic dyes, used in textile, printing and paper manufacturing businesses.

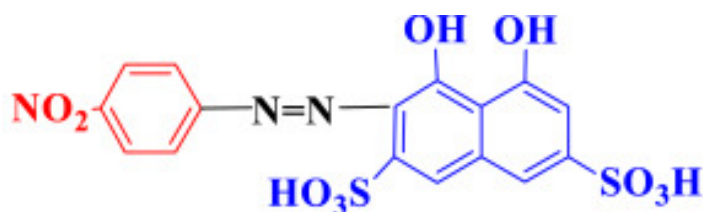


Azo dyes are a commercially popular colourant for textiles.

They are popular because they can be used at lower temperatures than Azo-free alternatives, and achieve more vivid depths of colour.

But some are listed as carcinogens, and under certain conditions, the particles of these dyes can cleave (producing potentially dangerous substances known as aromatic amines). Upon contact with the skin, these can be harmful to humans and pollute water systems.

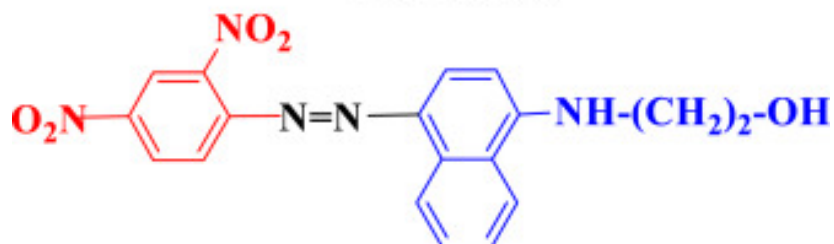
Legislation exists in certain countries, including EU member states and China, that prohibits the sale of products containing dyes that can degrade under specific test conditions to form carcinogenic amines, but low traces of these amines have still been found in garments.



Mordant Red (a)



Blue dye (b)



Blue dye (c)

Azo dyes are a type of direct dye – meaning that they colour the fibres “directly”. These dyes can cause cancer, birth and reproductive organ defects.

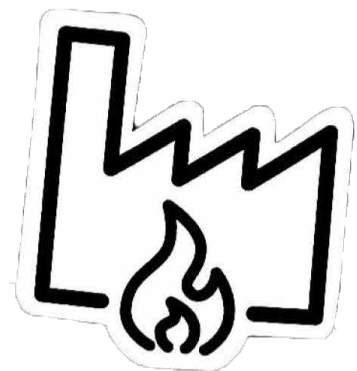
Certain azo dyes can release aromatic amines which are toxic to the environment and the people, so these substances were banned or their use was regulated in certain countries and the European Union. There is still a risk of finding azo dyes in Europe, because their synthesis has fallen into the public domain, and they continue to be used by some Asian countries like China and India and borders are not completely watertight.

Why are synthetic dyes dangerous?

One reason is that they accumulate in the waters, and it results in darkness for the underwater sphere. If light can no longer go through the surface, then the plants are not able to carry on photosynthesis.

This definitely lowers the oxygen content in the water, thus leading to the slow death of aquatic life and plants. Another reason is that some of the synthetic dyes can cause skin and eye irritation, and might even be toxic and carcinogenic.

Synthetic dyeing has both ecological consequences and medical ones, endangering the health of those who are working with these chemicals, the local communities and biodiversity.



Look at this picture of a river coloured by dyes in China in 2011



Photo credit: [STR / AFP](#)

All this is very sad and worrying, because we have gotten very far from a natural and beautiful environment and a healthy society. Unfortunately, the fashion industry has a huge part in this. According to a 2018 article that looks at fashion's ecological footprint, it is predicted that the use of chemicals will even increase by 3.5% by 2030 to keep up with consumer demand.

With this, companies are putting the blame on the citizens and claiming that they are pushing for an increase in production. Both sides have a role to play in this, as companies are profit-oriented and consumers are hungry for new pieces. In order to find solutions, we all need to be more aware. That's exactly why the following exercise was prepared for you.

Task

Put a spoonful of sodium bicarbonate (or baking soda) on a porcelain plate and start pouring some vinegar on it.

Don't worry, these are all safe substances, which can be used in and around the kitchen, food and children with no health risks.

What do you experience?

What kind of a chemical reaction is taking place?

Write down all that you see, hear, smell or sense in any way.

Repeat the experiment two more times on a clean plate.

What do you think will happen?

What did you notice the second and the third time?



Answer:

Technically speaking the equation for the reaction is:

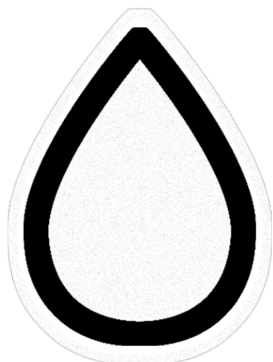


Baking soda and vinegar react with each other because they exchange atoms.

When these two are mixed together, then bubbles of carbon dioxide gas are formed. So, when the mixing happens, then a chemical change takes place between sodium hydrogen carbonate and acetic acid to form three new substances: sodium acetate, carbon dioxide and water.

Effervescence (bubbling, fizzing) is happening because carbon dioxide gas is produced. This effervescence is the evidence that a chemical reaction is taking place.

Whilst this task is not reflective of the chemical reactions that are used to make our clothes, it serves of an example of a chemical reaction more generally. The point is that we must consider and be aware of chemicals and how they reaction in our everyday lives and including what's in our clothes.



Reflection

If we take this experiment as a model, we can see that different substances may react to each other when put in contact. Although in this case none of these substances are harmful, the contrary is often true in the fashion industry where hazardous chemicals will be used at all levels of the supply chain and lead to harmful chemical reactions.

What does this teach us about the fashion industry? We are realising (through the help of science and a developing understanding of the consequences of our deeds) that certain substances are harmful, especially when coming into contact with humans or other life forms, and nature itself.

We are now gaining a greater understanding of the negative impacts of hazardous chemicals on people and the planet through multiple scientific studies, medical findings and even governmental institutions that can prove them.

Examples for such institutions are: the National Institute for Occupational Safety and Health (NIOSH) and the National Toxicology Programme (NTP). Therefore, those responsible for these kinds of damages should be held responsible.

While people may react differently when in contact with certain chemicals due to varying sensitivities, the impacts of some chemicals take a long time to unfold and have long-lasting impacts on the health of the people who make our clothes and their local communities, the surrounding biodiversity and the people who wear these clothes.

Many industries pose health and safety risks for the health of its workers, the environment and consumers. and the fashion industry is no exception. It is time that humanity starts taking responsibility for its actions.

There are campaigns and organisations that stand up for a better solution. Greenpeace launched a campaign called Detox My Fashion which ended in 2020 to demand that brands make commitments to stop the use of hazardous chemicals to make their clothes. **Meanwhile, Fashion Revolution's hashtag: #whatsinmyclothes aims to hold brands accountable for their chemicals used to make their clothes and fight for a transparent value chain.**

While there may be few clothes without hazardous chemicals in them, here are steps you can take to make the fashion industry more accountable and your clothes safer to wear.

What to do:

- **Avoid buying from brands known to use hazardous chemicals**, but if the brand is being untransparent about the chemicals that they might have used in the production of our clothes, always ask them **#WhatsInMyClothes?** to demand greater transparency.

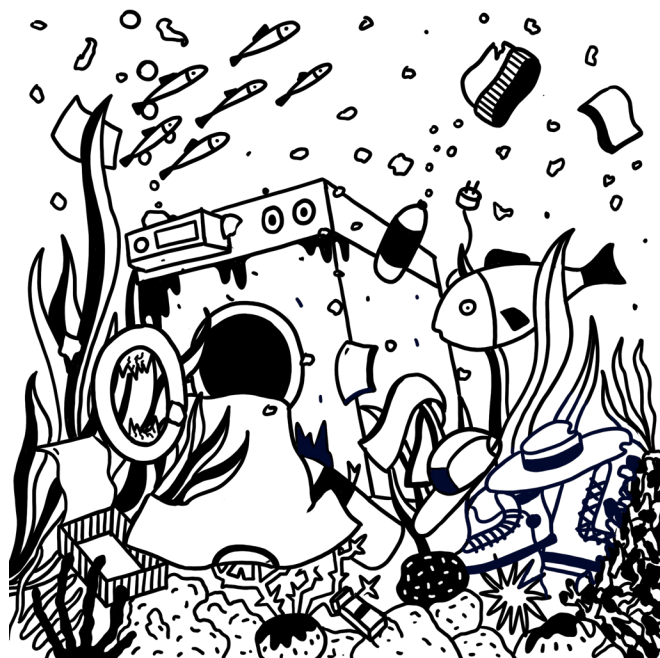
This can help influence brands to act more responsibly. To take action, you could post a photo with your clothes inside out, so the brand name and label is visible, with the hashtag: **#whatsinmyclothes?**

- **Wash clothes after purchase**, before starting to wear them and do laundry in a sustainable way (there is a guide **here**)

- **Buy second hand** (these clothes have already been washed several times supposedly), or garments made in an eco-friendly way (using organic materials dyed using natural dyes or having a certification, like GOTS or STANDARD 100 by OEKO-TEX).

Please note that GOTS means that although the cotton may have been grown without pesticides, the clothes could still have been dyed using hazardous chemicals. Look for brands that are dedicated to providing chemical-free alternatives and publish their manufacturing processes

- **Demand that brands clean their production**, that they use water filtration in every supplier factory, and that they don't use chemicals above the critical amount (watch for petitions by Greenpeace, Fashion Revolution or other organisations and sites collecting signatures for the good cause)
- **Demand that governments implement more stringent legislation** to end the use of hazardous chemicals in fashion supply chains and ensure better controls of products entering the EU market made in countries with few regulations on hazardous chemicals by signing petitions [like](#).



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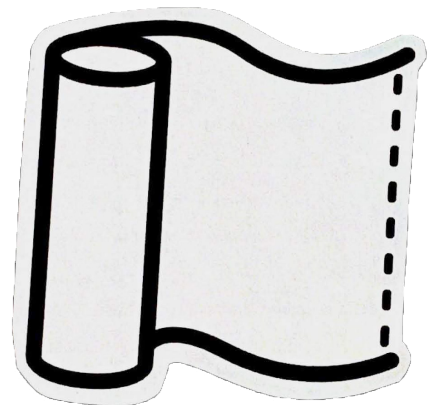
Attachments

<https://www.youtube.com/watch?v=23GhvcpBBEo&list=PLJ1CV1tLuSMJqMph-8q3jbxnBJ4B3QPydQ&index=7>

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