Textilní chemie

14. Ekologie a životnost textilií

Jakub Wiener

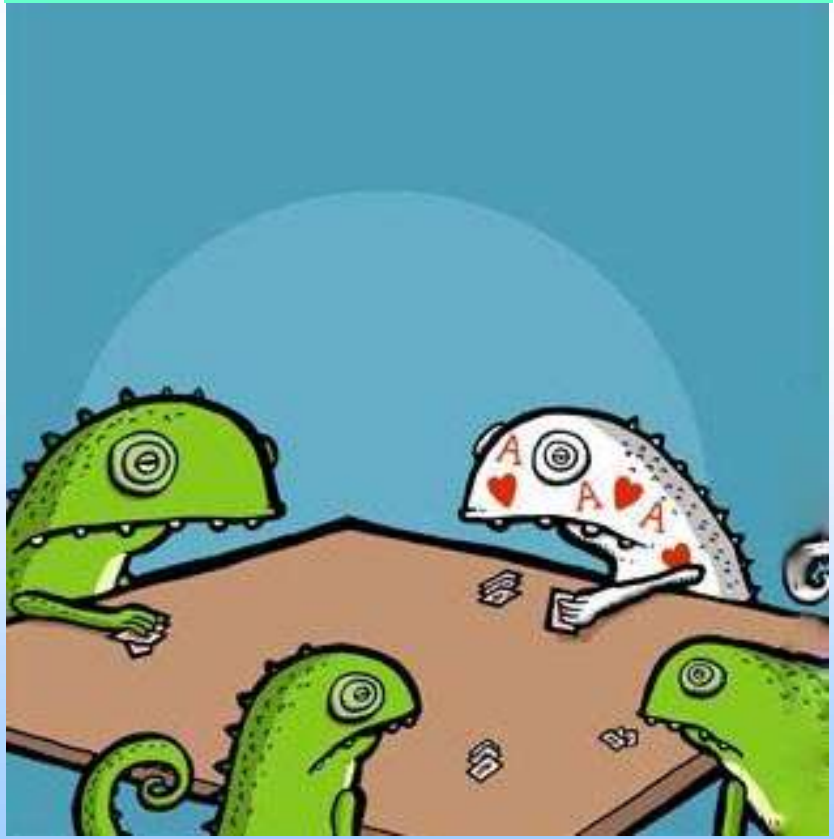
fastness of dyes on textiles

Important for customers – one of basic evaluations for textile sale

It is observed the fastness to many influences

1 fastness test = 1 effect on textile in life time

Poker is not a popular game for chameleons



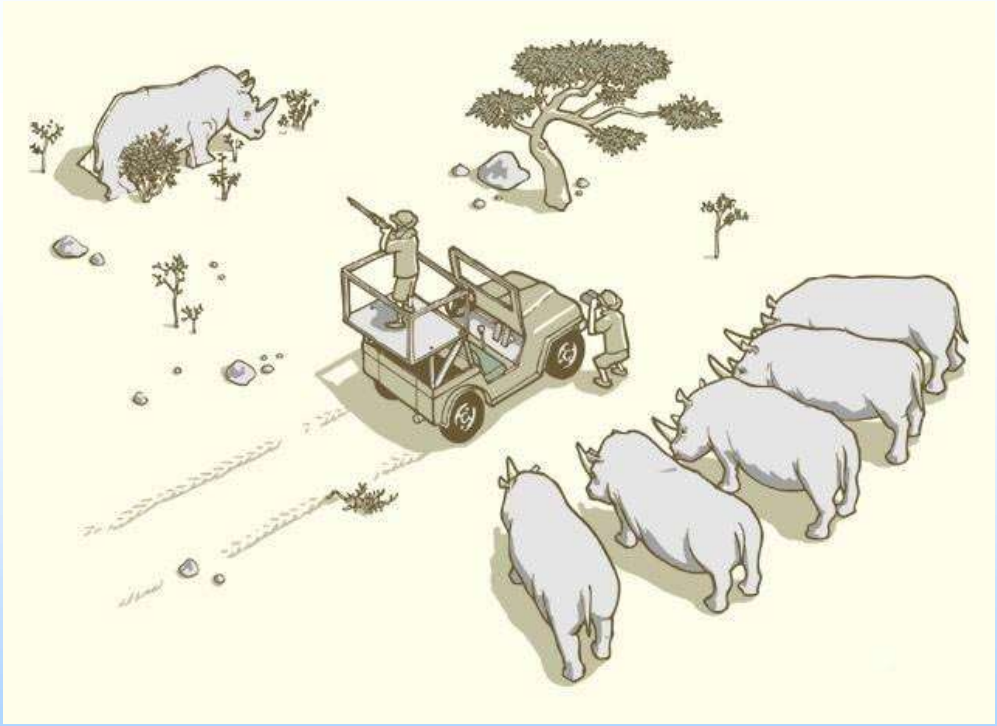
fastness of dyes on textiles

General: one excellent fastness to one cause is not necessary excellent fasten to all other causes

Between fasten tests results are some connection, bat the analyses is not so easy.

The problem of color fastness is necessary to observe by many tests

the selection of tests should be realized according the probably future using if this textile



You can not shoot all, but you can choose the right aims

fastness of dyes on textiles

Colour Sample	Name of Colour	C.I. No	Light	Water retting	Washing	Perspiration		Rubbing		Iron
						Acid	Alkaline	Dry	Wet	
	Direct Yellow DV-120	D.Y 12	3-4	2	1-2	2	2-3	3	1	3-4
	Direct Yellow DV-121	D.Y 50	6	4-5	3-4	4	3	4	3-4	4-5
	Direct Orange DV-122	D.O 39	4-5	4	4-5	5	5	4-5	3-4	4-5
	Direct Brown DV-126	D.B 2	2-3	4	2-4	4	3-4	3	2	4
	Direct Red DV-124	D.R 23	4-5	4-5	4-5	4-5	4-5	4	3	4-5
	Direct Black DV-128	D.B 38	3	3-4	3	3-4	3-4	3	1-2	3-4
	Direct Blue DV-132	D.B 15	2	2-3	2-3	4	3-4	4	2-3	4
	Direct Blue DV-134	D.B 86	5	2-3	2-3	2-3	4	3	2	3-4
	Direct Blue DV-136	D.G 1	2	3-4	3-4	2	3	3-4	2-3	4-5
	Direct Red DV-140	D.R 28	2	3-4	3-4	2	3	3-4	2-3	4-5
	Direct Red DV-142	D.R 31	2	3	2-3	4	4	4	2	4-5

Typical description of fastness in the paterncard

Theory of color fastness

„Principle: simulation of one case of fastes problems in laboratory scale

Prictical fastness problems: effect of many causes in combination and at unrepeatable conditions

Fastems laboratory testing: selection of only one cause and realization in repeatable condition

2-3 laboratory tests=predictuion of all important influences in live time of textile products

Set the required fastness!!!

Aim: prevention of wrong behavior of textiles an the using of textiles

Theory of color fastness

Principles of laboratory fastness tests:

- maximalyzed of the selected influence (short time of a test, results depends only on the one property of colored textile)

- typical example: by the wet fastness we are testing sample sawed together with two different white samples – the diffusion gradient of dye is maximal

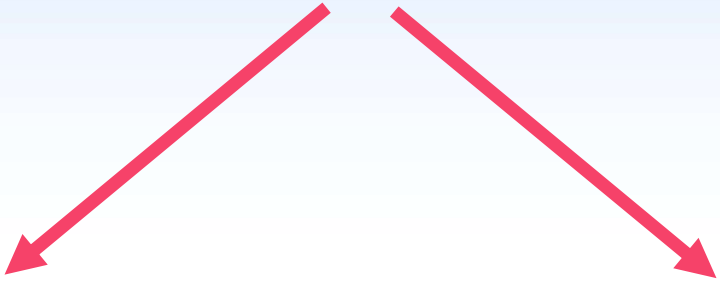
- one dyestuff on different textile fibers = different fastness

- one fiber with different dyes = different fastness

Important is only combination fiber-dyestuff +influence of finishes, fiber diameter...

fastness - dividing

According the used causes of color change



dry

To rubbing (observation of dye traqnsport to white textile)

To light (decomposition of dye by light)

..

wet

To washing (tranport of dye to white sample)

To perspiration (tranport of dye to white sample)

..

Deep of shade

Fastens tests results dend on the shades of tested textiles

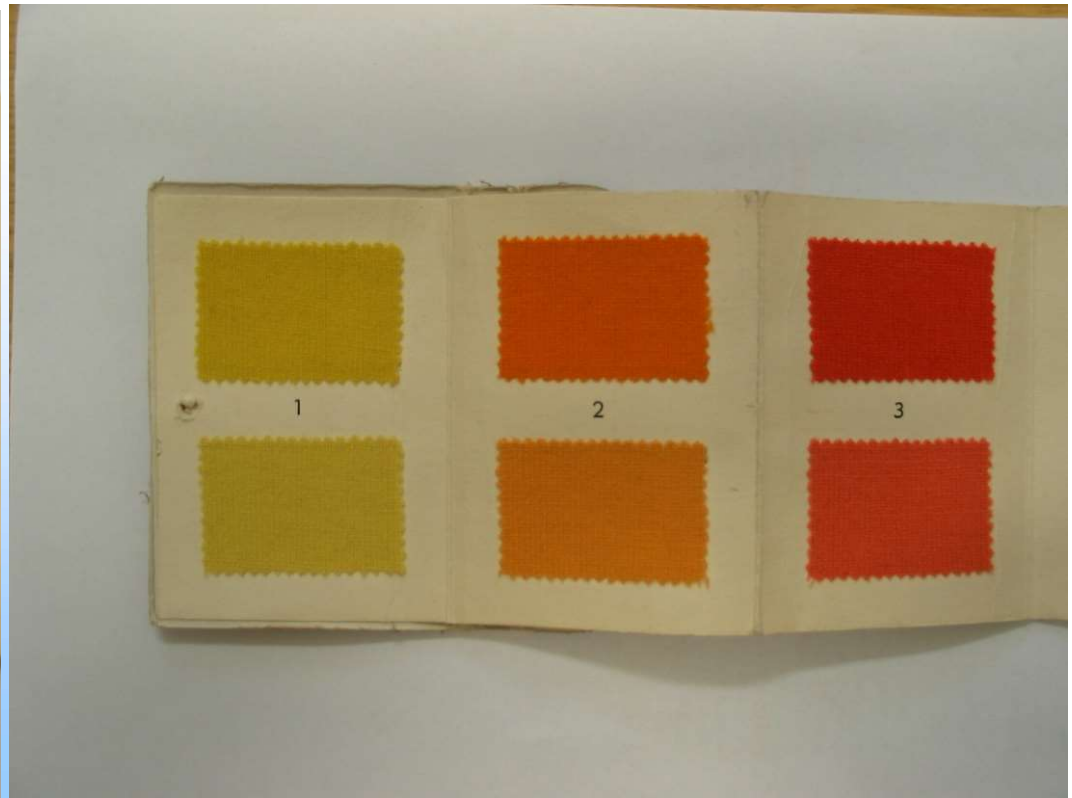
Light shades – low concentration of dyestuf in textile = low disposition for dyestuff desortpion = better fastness to washing or rubbing or sublimation

Deeper shades – higher concentration of dyestuff in textile = low effect of dystuff destroing by light = beter light fastness

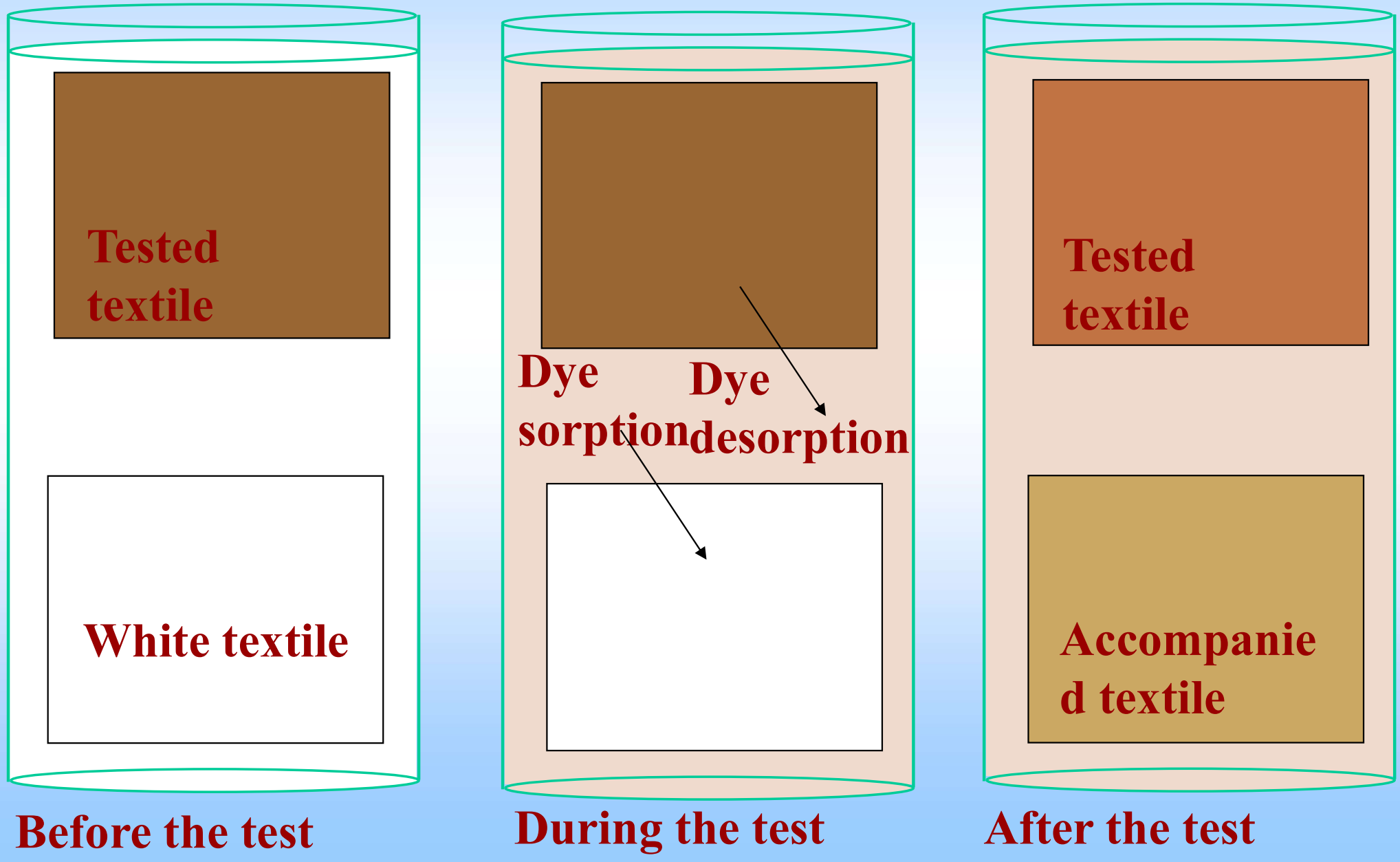
To right evaluate the fastness is necesary to compare the tested samples color with color standards to find the „type of color“ ... Comparabile results !!!

Deep of shade

Color standrsd: intermationaly defined in all colors (basic: 1/1 – standard deep of shade)
To quntification of lighter shades: 1/3, 1/6, 1/12, 1/25
or deeper shades: 2/1
+ special standard for black colors



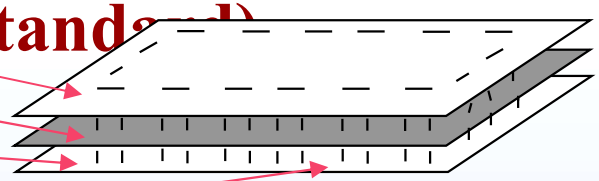
Principle of wet fastness



Combined sample for washing test

„Sandwich“ – typical size 10x4 cm.

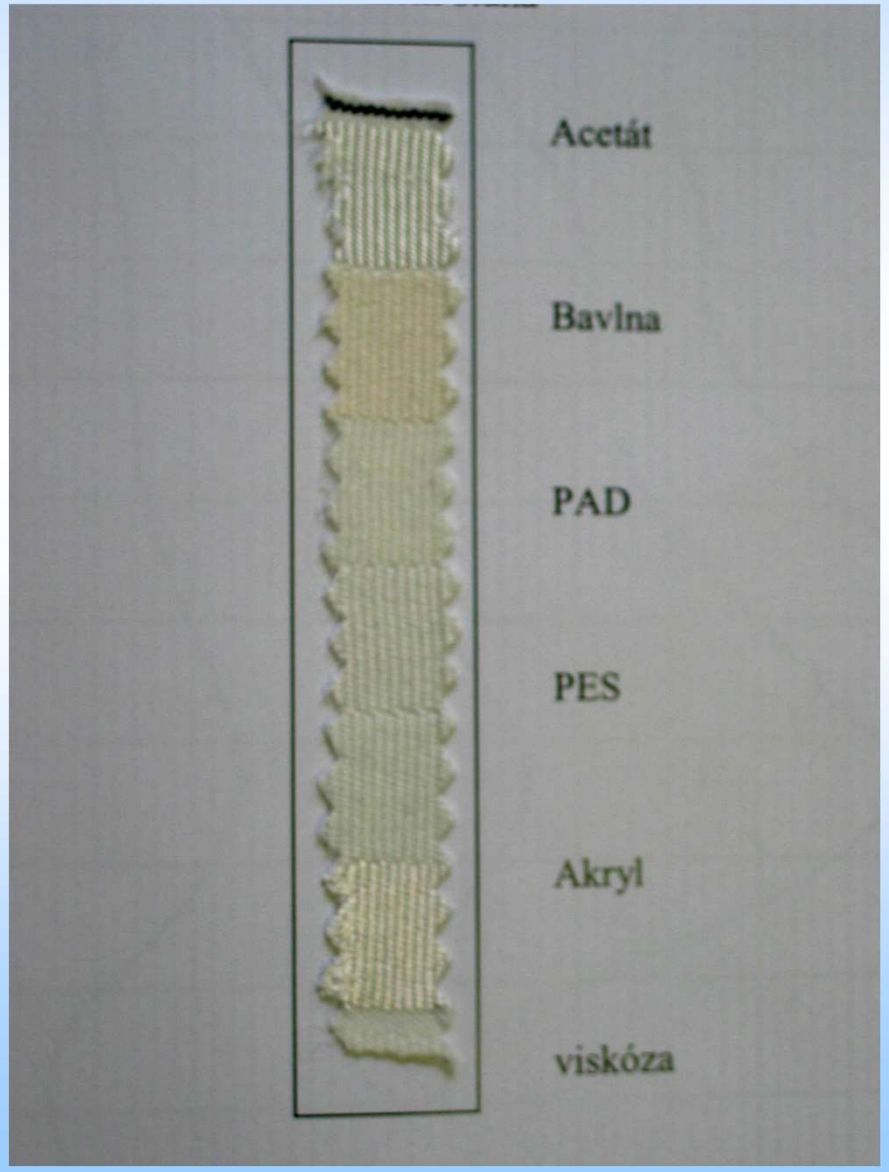
First supporting textile (from the same fibers as the tested sample)
Tested textile
Second supporting textile (fibers are defined in standard)



Saw together at the sides of combined sample.

Second supporting textile is choose to absorb higher quantity of dye from the bath.

Combined sample for washing test



Standard combined sample: 1 tested textile and the accompanied samples

Othe idea using if one textile created from meny different fibers

After test will be the samples separed, dryed and evaluated

Drying before the unsaw is prohibited – the dye can be

fastness evaluation – grey scal

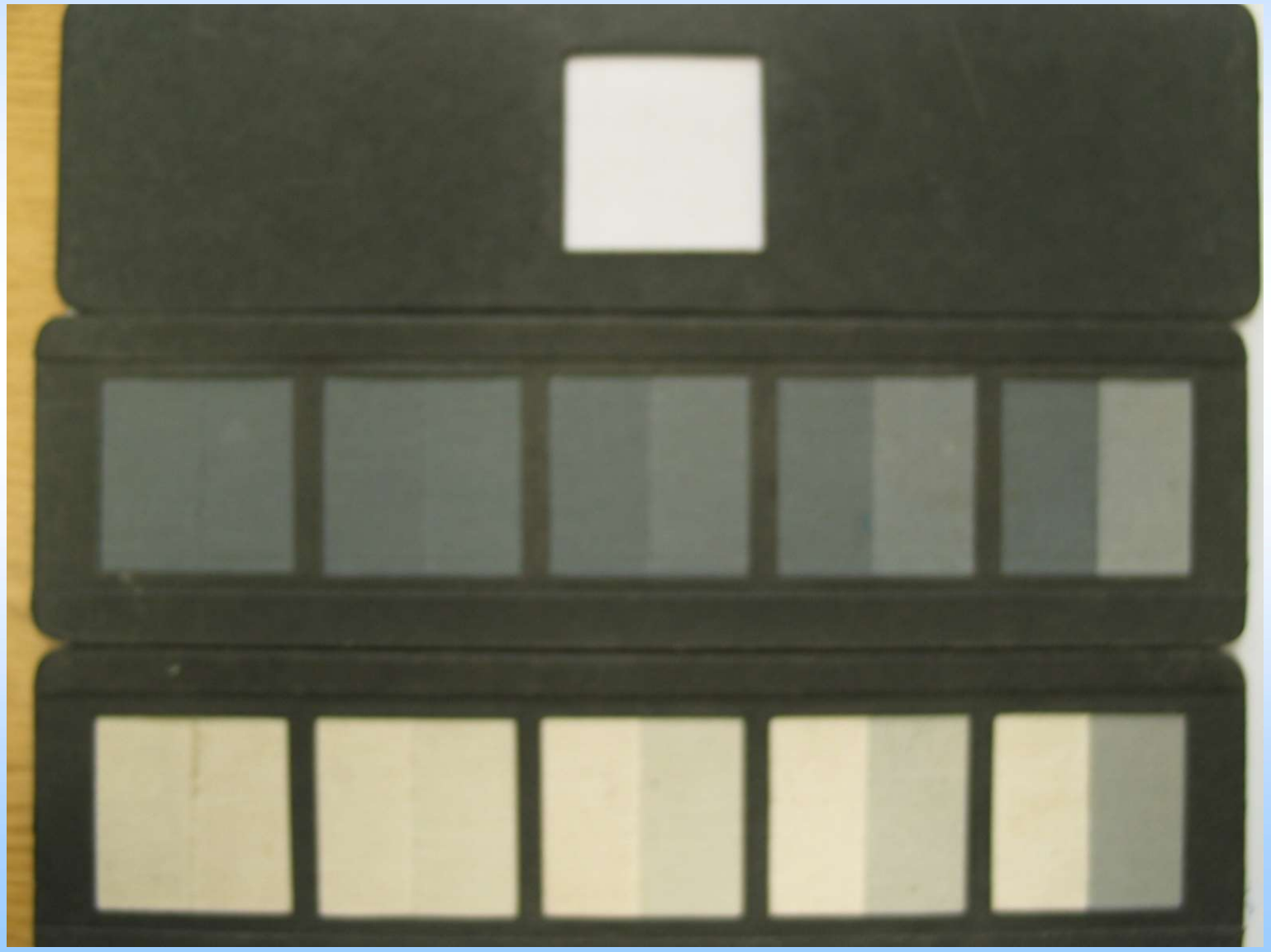
Evaluation: change of color of the original color sample (color change) and the color of originally white sample (color transfer - staining)

Two possible principles: measurement of color difference (not so common) and using of color-difference standards „gray scales“ (standard evaluation)

Grey scale: 2 !! One for „color change „ testing and the second one for the „staining“
In both scales: 5 ... Excellent result, 1 ... Wrong result

comparison of results only at right illumination...

fastness evaluation – grey scal



For color change

For staining

fastness evaluation – grey scal

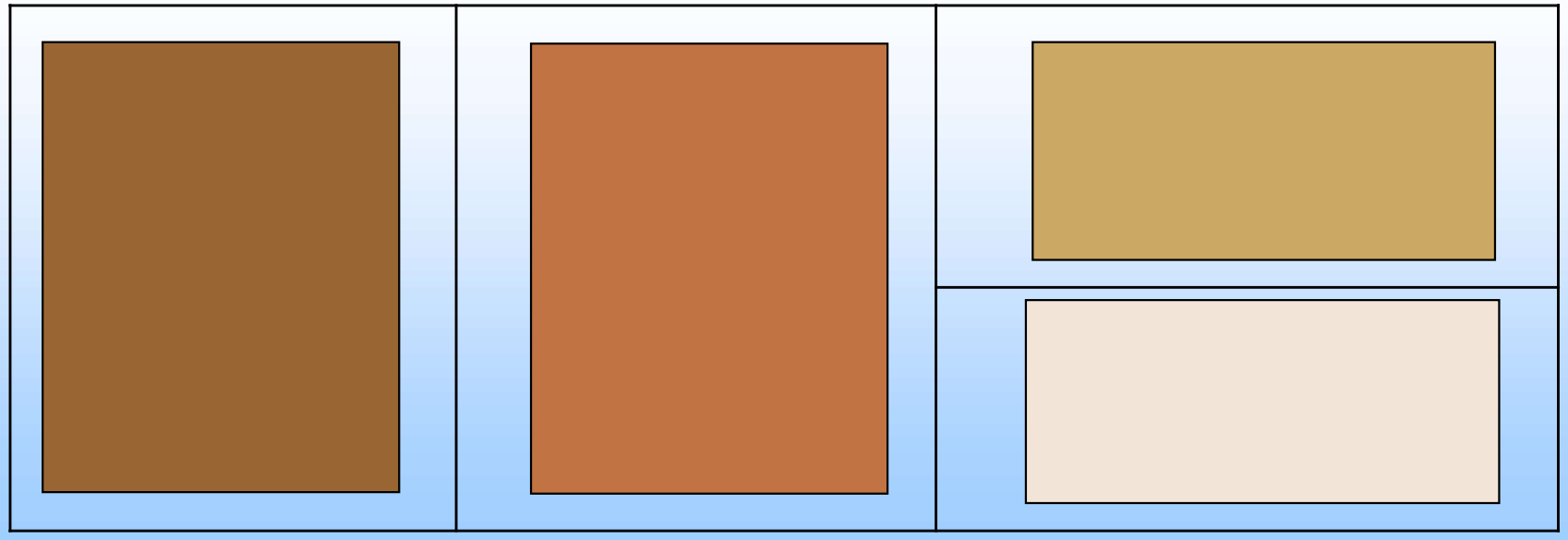
Color difference ΔE and color change accoprding the thy scale:

GSR (grade og grey scale)	ΔE (CIELAB) (color difference)
5	0-0,40
4-5	0,41-1,25
4	1,26-2,10
3-4	2,11-2,95
3	2,96-4,10
2-3	4,11-5,80
2	5,81-8,20
1-2	8,21-11,60
1	> 11,6

Adjusting of samples

Description: 3R / 1-2G / 4-5

Original tested sample (brawn)	After the fastness test (result according the gray scale: 3R (R ... Reddish)	Staining to fabric fromthe same fibers. (1-2 G... greener)
		Staining to fabric from the other fibers . (4-5 ... in the same shade)



Some tests – without accompany samples, or only accompyny

fastness - Changes in the color shade

Changes in the color shade
-in color dye combination – reason of wrong dyestuffs combination (in presented example: red color was from the mixture desorb intensively)
- or in the case of chemical changes in the dyestuff (for example by light fastness)

Description of color shade changes (such as „Reddish“) is not obligatory

fastness - Changes in the color shade

Used code:
Y … yellower,
R … redder,
B … bluer,
G … greener,
D … duller,
Br … brighter,
Str … stronger color.

Description of fastness evaluation and using of grey scales is in the technical standards!!!

List of basic fastness

The most observed fastnesses are:

Light fastness – the sample is illuminated by intensive light, the rate of changes of tested shade is compared with blue scale. The scale has 8 samples of dyed by dyes with different light fastnesses.

Rubbing fastness – the sample is rubbed by white textile (dry or wet) and transition of dye on white textile is observed.

fastness to perspiration – the sample is wetted by synthetic perspiration. The transition of dye on accompanying sample in condition of human body perspiration (37°C) for 4 hours is observed.

Washing fastness – home washing is simulated. The transition of dye on accompanying sample is observed.

Ironing fastness – home ironing is simulated. The transition and sublimation of dye on accompanying sample is observed.

fastness to perspiration

Principle: Simulation of contact of tested color textile with the white sample.

In live praxes: Sweated textiles on the body are wet and in close contact at the body temperature for long time

Method: The procedure is set by technical test standard. The fastnesses in alkali and acid perspiration are tested together obviously.

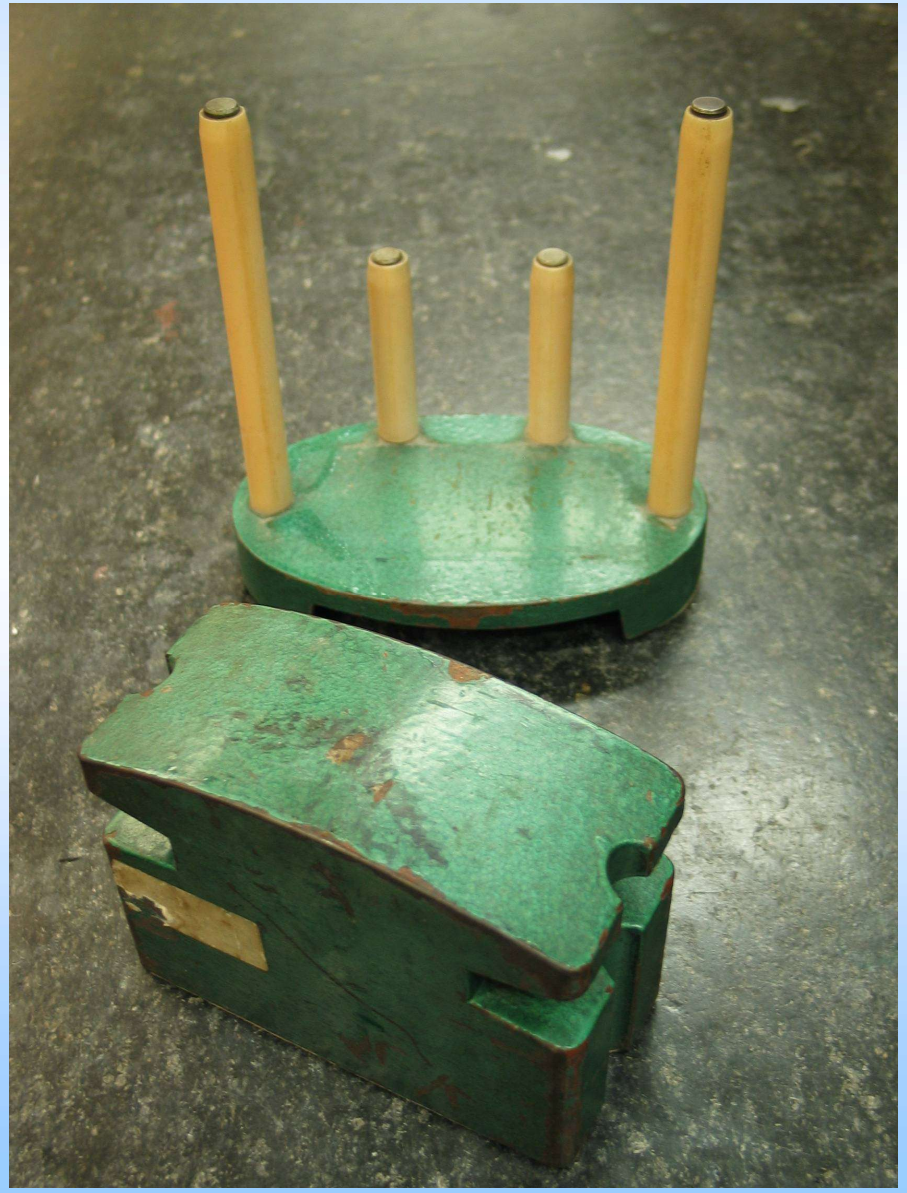
Steps:

Wet the combined samples by synthetic perspiration (Synthetic perspiration: according the standard (NaCl, histidine...) - Alkali: pH=8, acid pH=5.5)

Put it inside to perspirometre and curry it in heat insulation package for 4 hours at 40°C

Dry samples and evaluate its by grey scales

fastness to perspiration



fastness to perspiration

fastness to rubbing

Pull the sample on board of rubbing testing machine.
Fix accompanying textile (wetted in distilled water) on rubbing element (thumb)
Move thumb 10 times on testing surface
Observe the transition of dye to accompanying textile and evaluate it by grey scale
The testing can be made in dry or wet conditions. You tested wet rubbing fastness.
Principle: rubbing between tested sample and white testing sample accrue the transfer of dye to originally colorless textile
Low rubbing fastness = dyestuff is in the surface of textile
… typical for wrong washed textiles and for wrong colloid phase during the dyeing

fastness to rubbing

Tested sample: minimal size is 50x140mm
Rubbing is realized by white cotton fabric with size 50x50mm (more information in the standard).

rubbing element is mowing on the tested surface 10x 10cm

Pressure and the size of rubbing element is set in the standard

fastness to rubbing

Many dyes on the textiles … more tests

Dry *rubbing dry testing fabric*

Wet rubbing … with wet testing fabric (1g of fabric + 1 g of water)
… typically „wrong“ results (water swelling of fibers, solubility of dyes in water…)
… before the evaluation (Grey scale) is necessary to dry the sample (the color of textiles depends highly on the water contained in the textile)

fastness to washing

fastness to washing

Described in technical standards: used accompanied textiles, used temperatures, used pH, used chemicals…

accompanied textiles according table:

1st accompanied fabric	2nd accompanied fabric	
	For tests A a B	**For tests C,D a E**
Cotton	Wool	viskose
Wool	Cotton	-
viscose	Wool	Cotton
polyamide	Wool or Cotton	Cotton
polyester	Wool or Cotton	Cotton

Fiber blends: 1st AF … main component of blend, 2nd AF… second component of blend (other components are not important for testing)

fastness to washing

Test no.	Temperature ^{0}C	Bath volume ml	Active chlorine %	Sodium perboritane g/l	Time min	Number of metal balls	pH
A1S	40	150	0	0	30	10[1)]	
A1M	40	150	0	0	45	10	
A2S	40	150	0	1	30	10[1)]	
B1S	50	150	0	0	30	25[1)]	
B1M	50	150	0	0	45	50	
B2S	50	150	0	1	30	25[1)]	
C1S	60	50	0	0	30	25	10,5 ± 0,1
C1M	60	50	0	0	45	50	10,5 ± 0,1
C2S	60	50	0	1	30	25	10,5 ± 0,1
D1S	70	50	0	0	30	25	10,5 ± 0,1
D1M	70	50	0	0	45	100	10,5 ± 0,1
D2S	70	50	0	1	30	25	10,5 ± 0,1
D3S	70	50	0,015	0	30	25	10,5 ± 0,1
D3M	70	50	0,015	0	45	100	10,5 ± 0,1
E1S	95	50	0	0	30	25	10,5 ± 0,1
E2S	95	50	0	1	30	25	10,5 ± 0,1

[1)] Don’t use balls for wool, silk or blends of these materials.

fastness to washing

Washing agent: anionic, with sodium perboritan, without flourescent agents (concentration: 4g/litre)

Used aparatus: ratation pronciple, stainles steel, termosated bath, closed metal boxes, mechanicl forces are simulated by metal bals inside of metal boxes

Dryeing saparatly,

Evaluation of tested samples and accompanied fabrics according the grey scales

In the report should be the description of realized test

fastness to ironing

Evaluation:
Color change of textile by ironing - immediatly efter heating and fter 4 hours
Staining to accompany white sample (cotton)

-Test modification:
- dry tested textile, without AF
- dry tested textile, wet AF
- wet tested textile, wet AF

Wet: 1g of textile + 1g of water

Temperature: 190-210°C … cellulose fibers, 140-160°C … wool, 110-130°C … PA

fastness to ironing

Temperature range for test: 120°C up to 240°C
Temperature settings: fixed temp. of 150°C,180°C & 210°C;
Size of each pad: 40 mm x 100 mm.
Timer range: 10-60 sec.
Machine dimensions: 38 cm(w) x 34 cm (d) x 28 (h)

Lighfastness

Principle: we are observing the color chages by irradiation during the time

The behavior of tested sample we compare with standsard textiles – 8 degrees of blue scale

Low fastness = short degradation time of color by light

Highest influence: UV light (chemical more effective then VIS or IR light)

Lighfastness

By UV irradiation are in fibers created the radicals, which atacted the chemical structures of dyes and polymers.

Of this decomposition are colorless or other colored then the original dyes

The light damaged textile is not white, but lighter and low brilliant in comparison with the original sample

Blue scale

8 grades = 8 wool samples with different color fastness

Blue scale will be irradiated together with tested samples

Color changes are observed in defined times according the standard

Blue scale


STANDARDY
MODRÉ
STUPNICE
1–8
Pomůcka k ČSN 80 0132
ČSN 80 0150
ČSN 80 0167
ČSN 80 0171
Vydání 1983
PŘECHOVÁVAT V TEMNU!

Blue scale

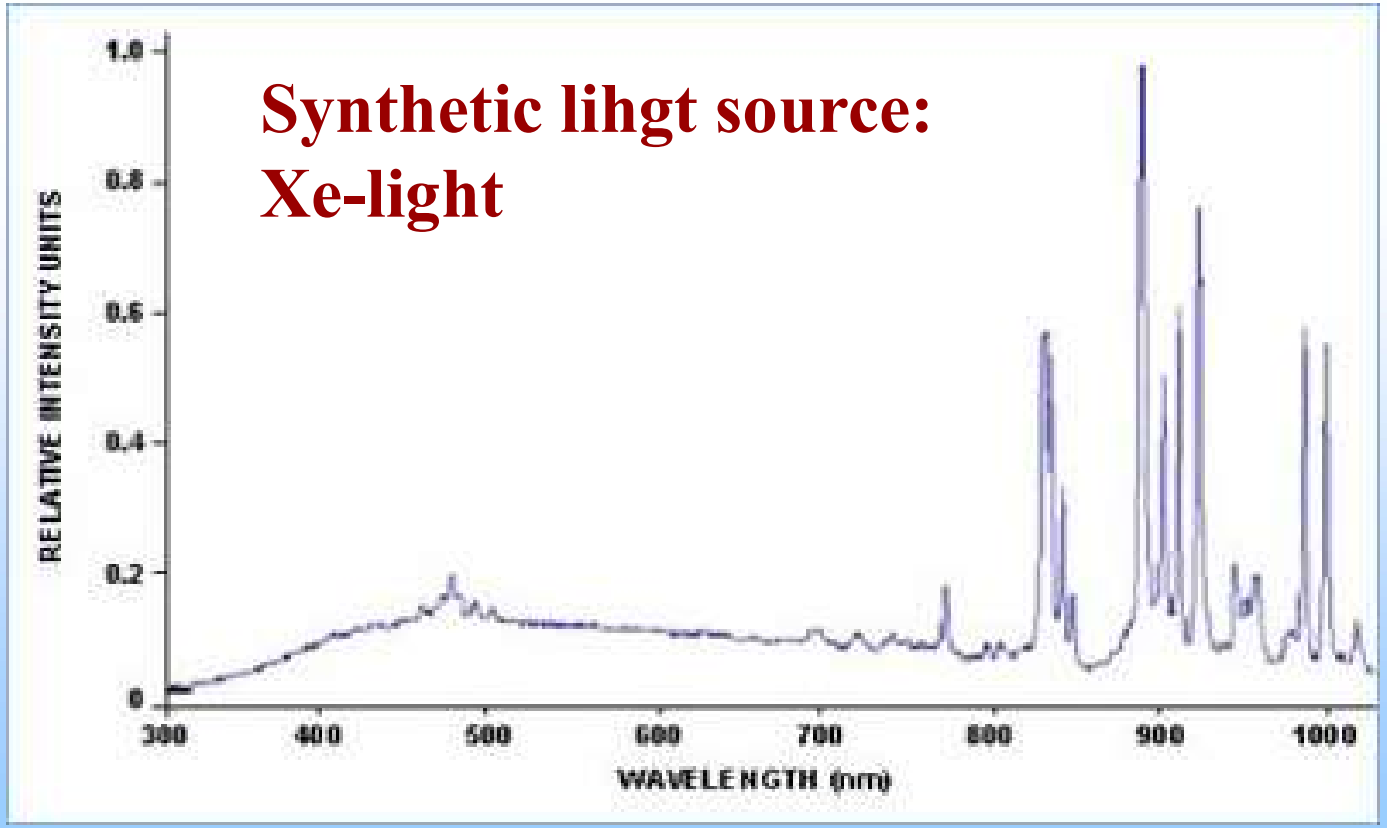
Lighfastness standard	Realative time of color change
1	1
2	2
3	4
4	8
5	16
6	64
7	128
8	256

First changes of color: „grade 1“ = few hours in sun light, „grade 4“ after one week, „grade 7 or8“ stable for years

Lighfastness

Daylight or Synthetic light
(synthetic light = higher stability, higher light intensity (approximately 5x), set conditions including the humidity and temperature…)

Synthetic lihgt source:
Xe-light



Lighfastness

Comparison of test results: polyaester + 0,5 % Terasil Yellow GWL

Test	Light fastenes
standard: ISO 105	7-8
Factra 288h	2-3
SAE J 1885	2

Factra 288h and SAE J 1885 are evaluated according grey scale

Lighfastness

Influence of humidity: wet = wrong fastness

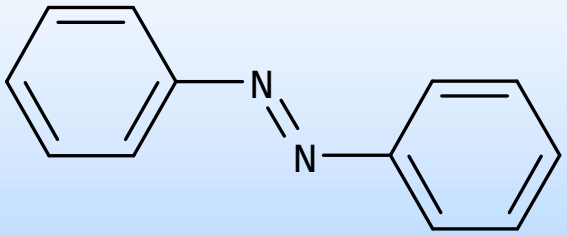
Water is a accelerator of chemical processes – transport of radicals, cause of hydrolyses

Cationic dyes: cotton low ligh fastness (1-2), acrylic middle (4-5) or high (6) light fastness.

Acrylic fibers water contain is 10x lower then in the cotton (second reason: under the Tg are acrylic fibers closed for diffusion – low oxygen inside)

Lighfastness

Dye chemical composition:



Azobenzen derivates	Light fastness
3-nitro-3´-metoxy	7 - 8
3-nitro	7
4-nitro	6 - 7
2-nitro	6
nesubstitovaný	6
4-nitro-2´-hydroxy-5´-methyl	5
2-nitro-2´-hydroxy-5´-methyl	3

Requaired fastness of colored textiles

Required light fastness:
Cloths textiles 4-5 (exposed textiles: more !!!)

Other fastens:
Minimal 3

Influence of color deep:
Dark shades: problems with wet fastness and rubbing

According to fastens of textiles is necessary to set the recommended temperatures of washing, ironing….

fastness of colored textiles

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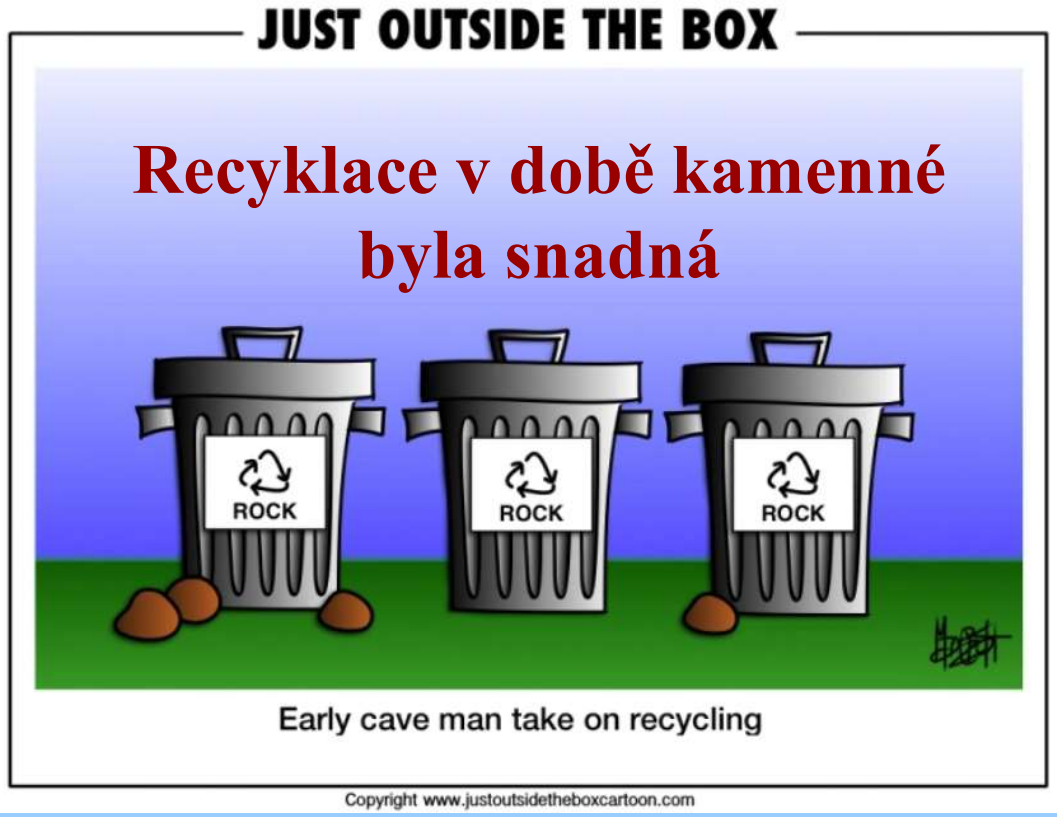
Textile recycling

Recycling is not the worst fate that can meet textiles...

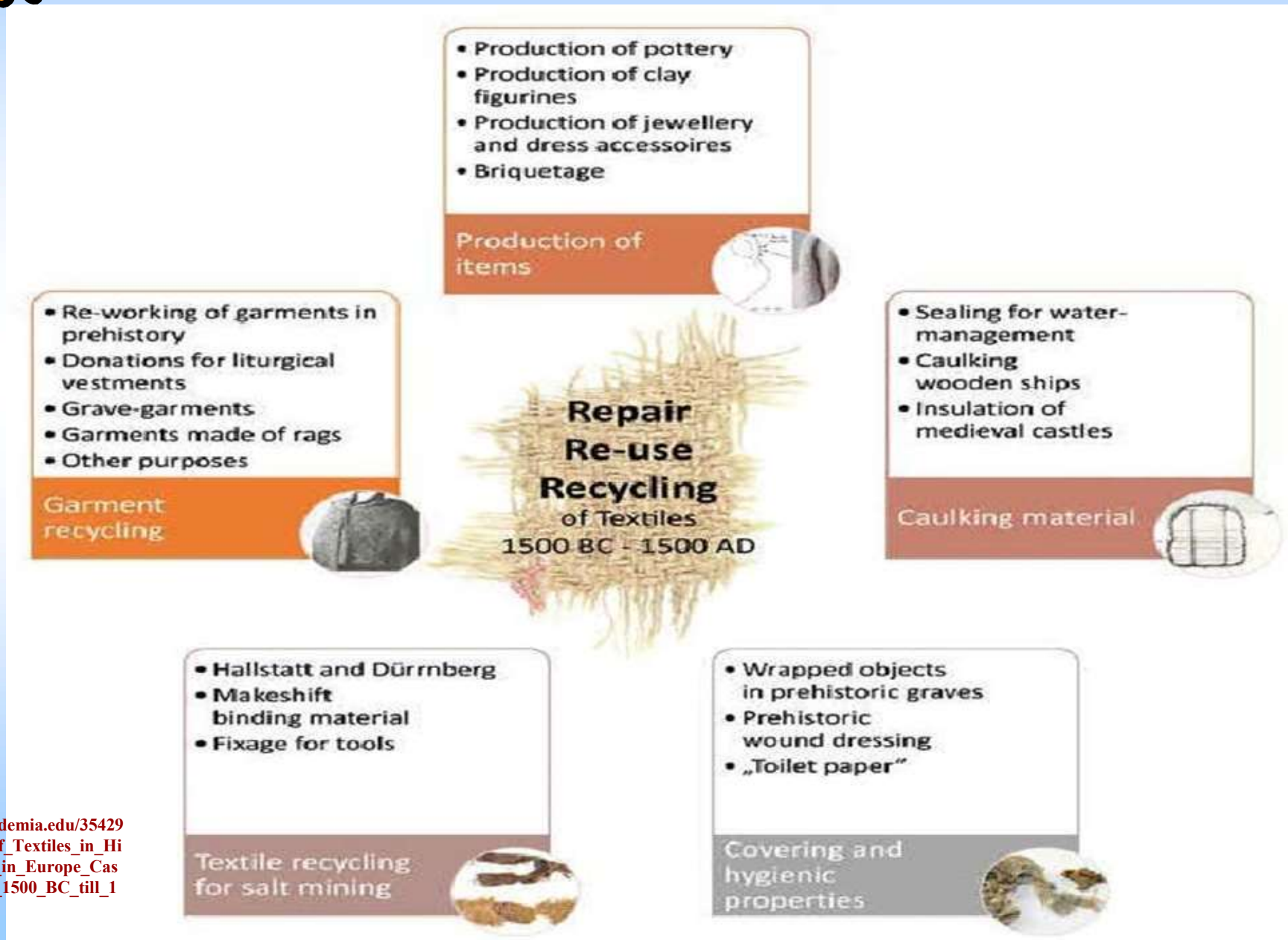
History of recycling

Historically: what was worthwhile was reused/recycled

Textiles have been widely recycled: for clothing applications, as ropes, as "toilet paper", as protective packaging, tool fixings, bandages, for papermaking ...



History of recycling



https://www.academia.edu/35429219/Recycling_of_Textiles_in_Historic_Contexts_in_Europe_Case_Studies_from_1500_BC_till_1500_AD

K. u. k.
Kriegsministerium

Kriegsfürsorgeamt

Zweite

Woll-und Kautschuksammlung.

Die Ergebnisse der Woll- und Kautschuksammlung 1915 sind bereits verarbeitet und der Armee sowie der Bevölkerung durch die Industrie zugeführt worden.

Um dem Mangel an Rohmaterialien im Inland auch weiter abzuhelfen und die Armee im Felde zu versorgen,

spendet noch einmal

Woll- und Baumwollgegenstände sowie Gummiabfälle aller Art!

Spendet alle unbrauchbaren Gegenstände aus

Wolle, Baumwolle, Stoffe, Leinwand, Kleider, Wäsche, Strümpfe, Tücher usw. sowie Gummigegenstände jeder Gattung.

Jedermann bereite eine Spende vor!

Die kleinste Spende ist willkommen!

Hauptsammeltage: 13. und 17. Juni 1916.

An beiden Tagen Abholung der gut verpackten Spenden durch Schüler.

Weitere Auskünfte: Telephon 12516, IX., Berggasse 22.

Entgegennahme von Spenden, sowie Postsendungen jederzeit: Wien, IX., Berggasse 16 und Wien, IX., Währingerstraße 32.

Löbl, FML., m. p.

History of recycling

In the 20th Century the prices of things dropped relatively, so the recycling rate also dropped, the exception being times of scarcity - WW1 and WW2 = almost 100% recycling (paper, metals, glass and oils...)

Banknote containing old clothes (concentration camp, Buchenwald 1942)

Recycling in the home

Recycling can take place by changing:

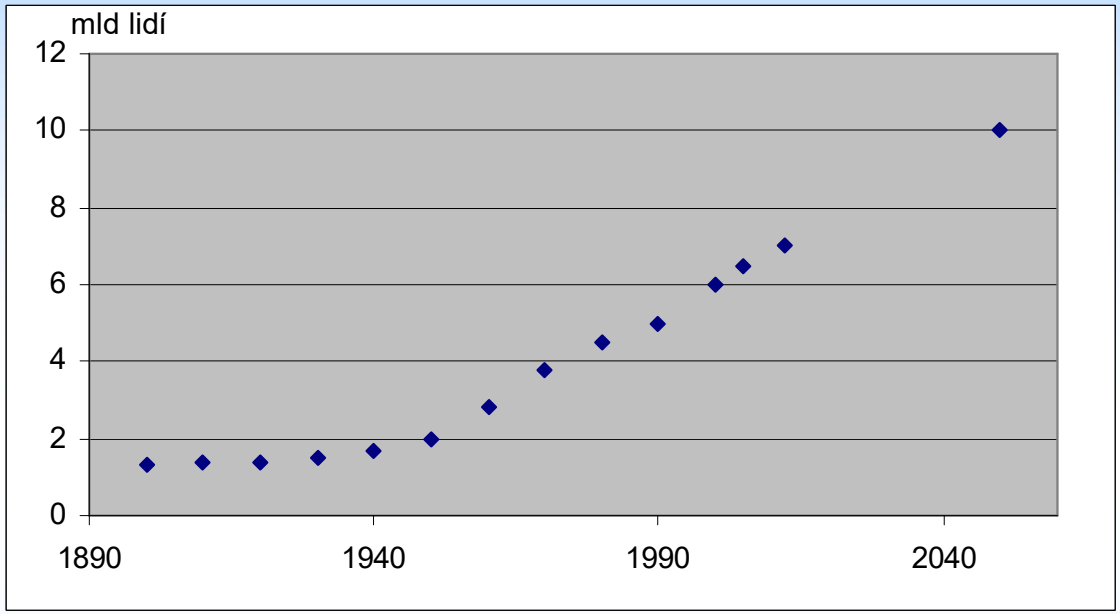
Status: social - domestic - working - disposable

Function: Clothing -Changes in the functionality of the garment (alterations, pairing of sweaters, sizing...) - Cleaning fabric - Fuel

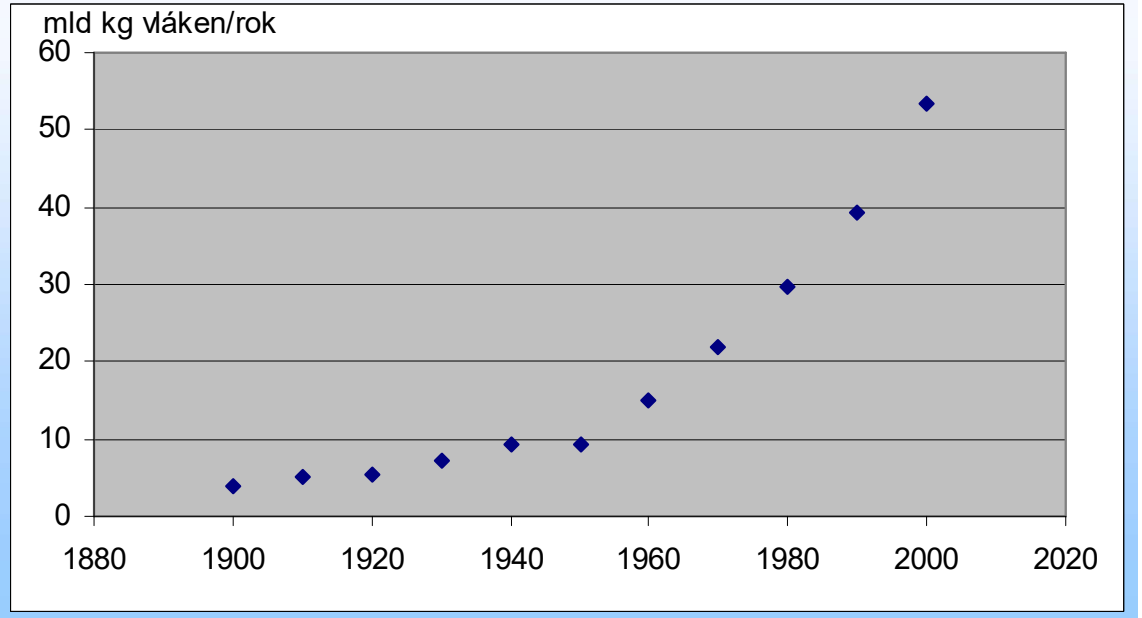
Users: me - transfer to those in need (realistic within the Czech Republic only for children's clothing)

Less common today - fabrics don't last as long and the low price means there is no motivation ...

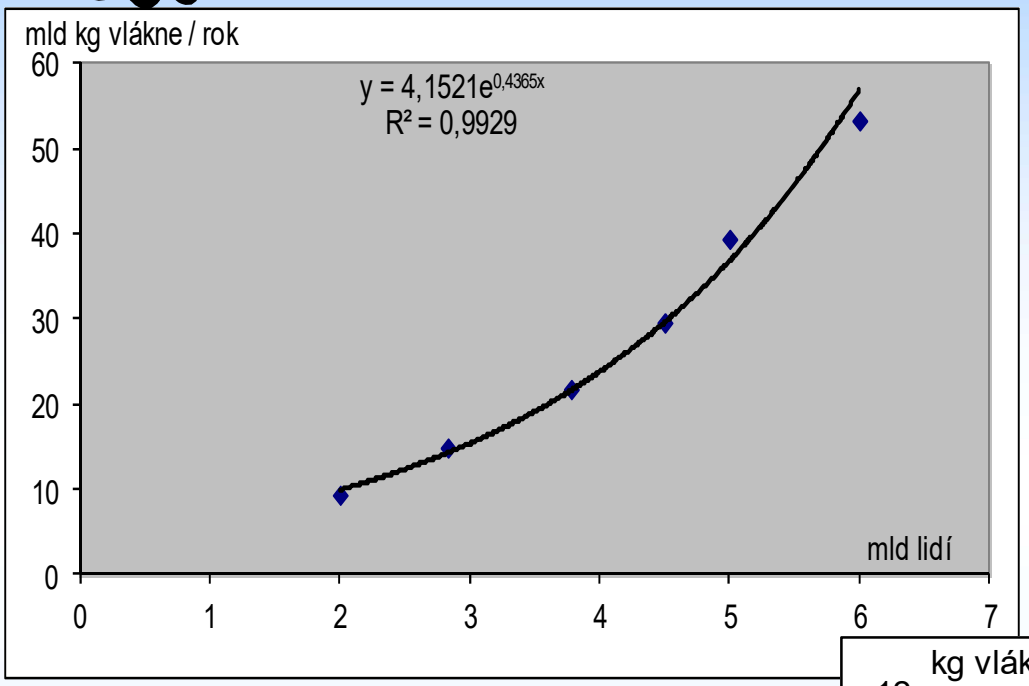
Ecology as a motivation to recycle



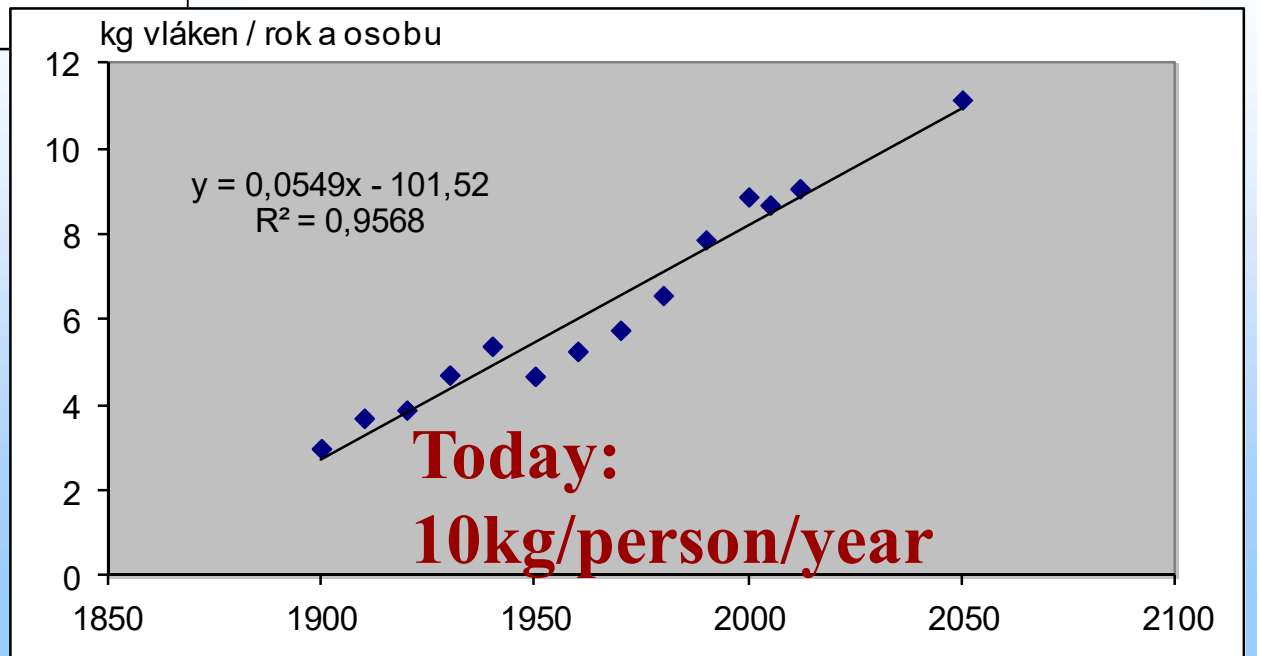
Population growth and consumption



Ecology as a motivation to recycle



Production of textile fibres / number of people



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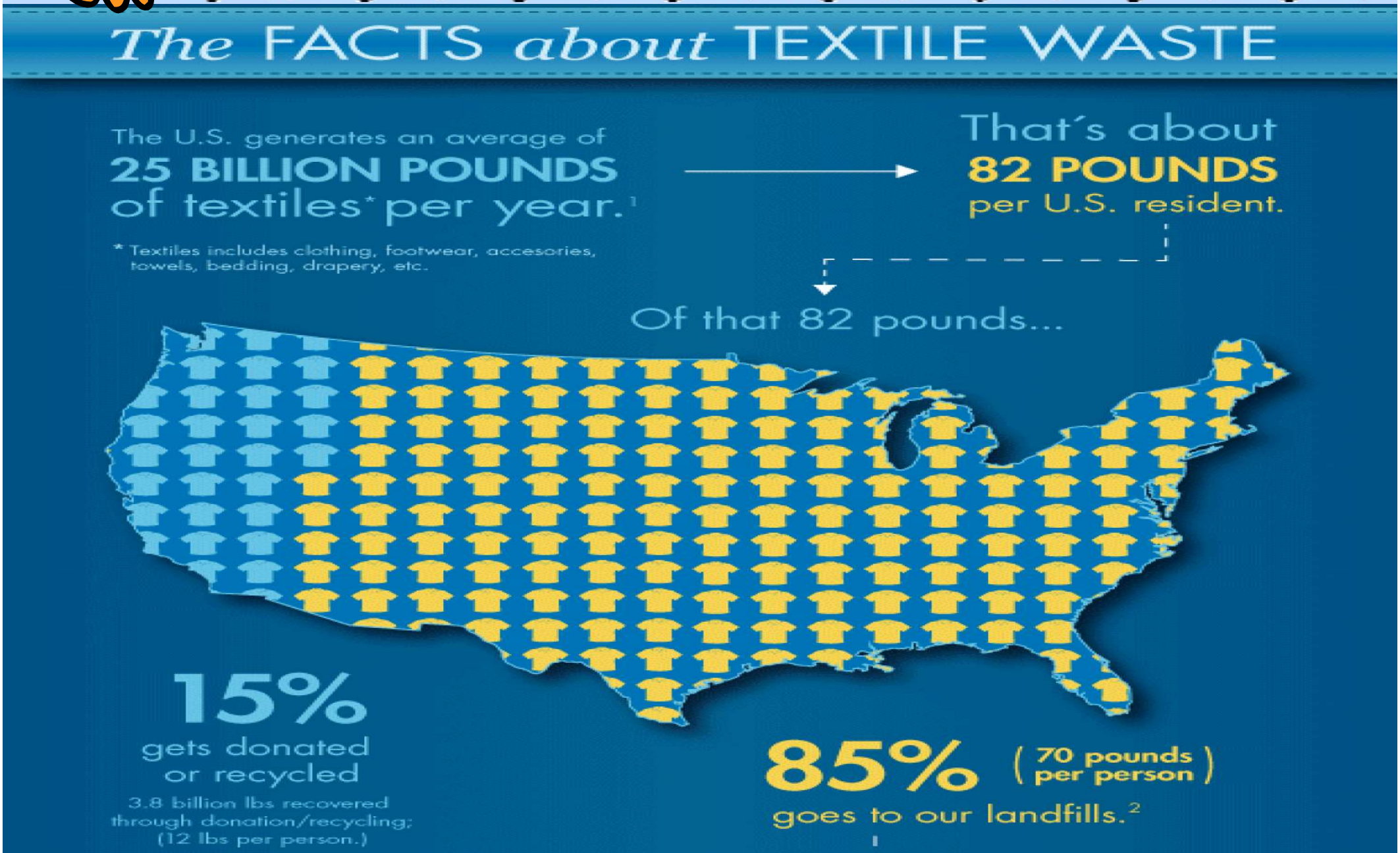
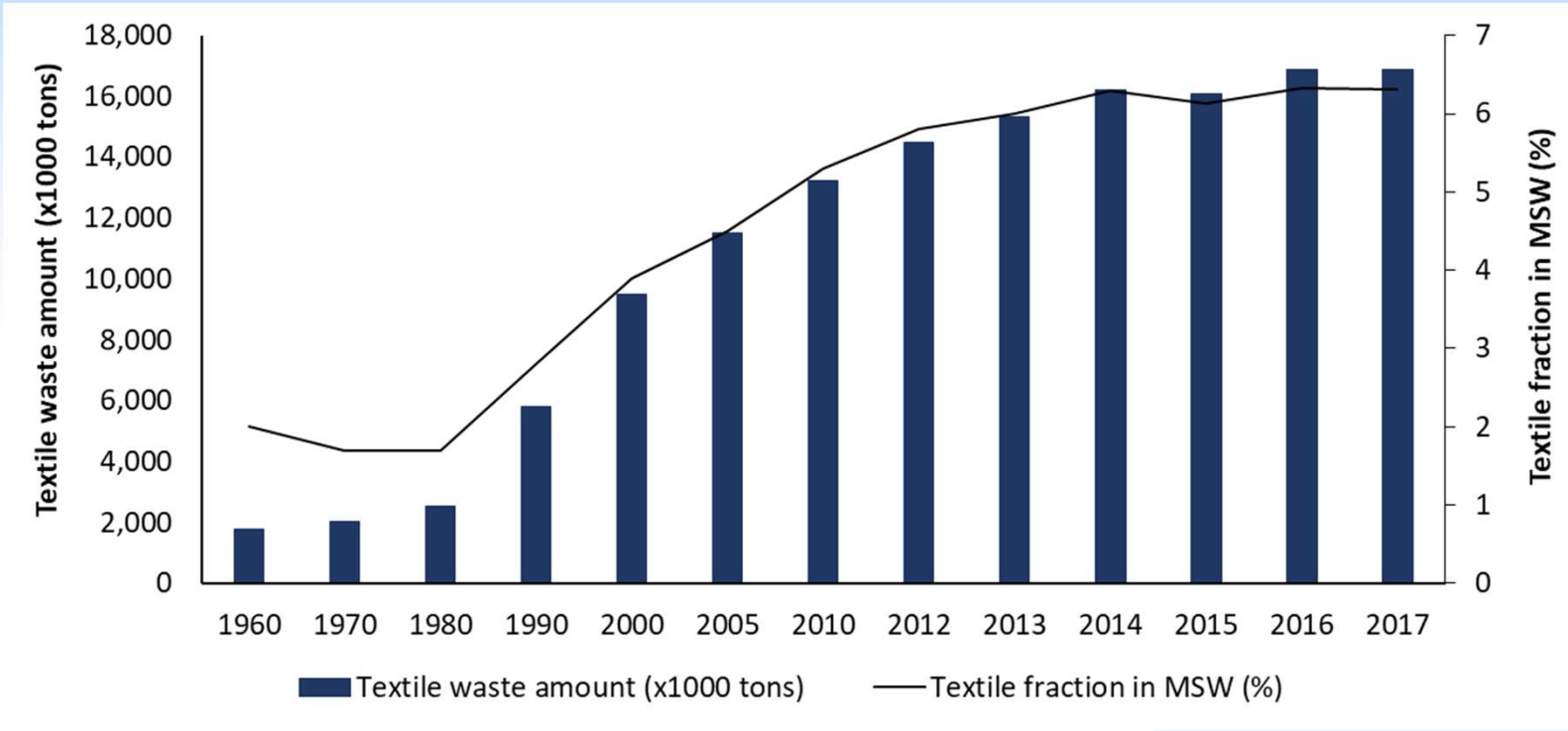
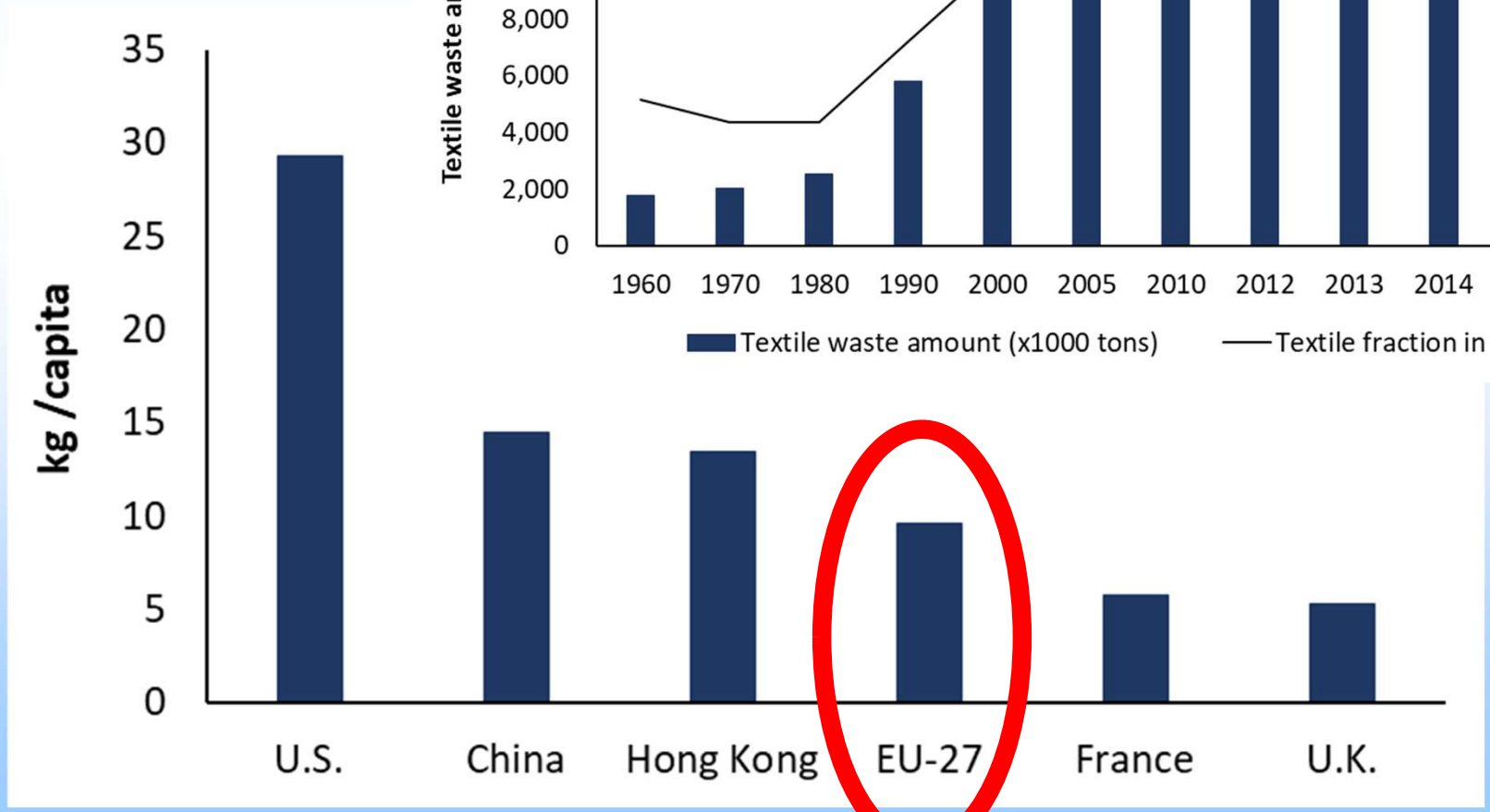


Ecology as a motivation to recycle

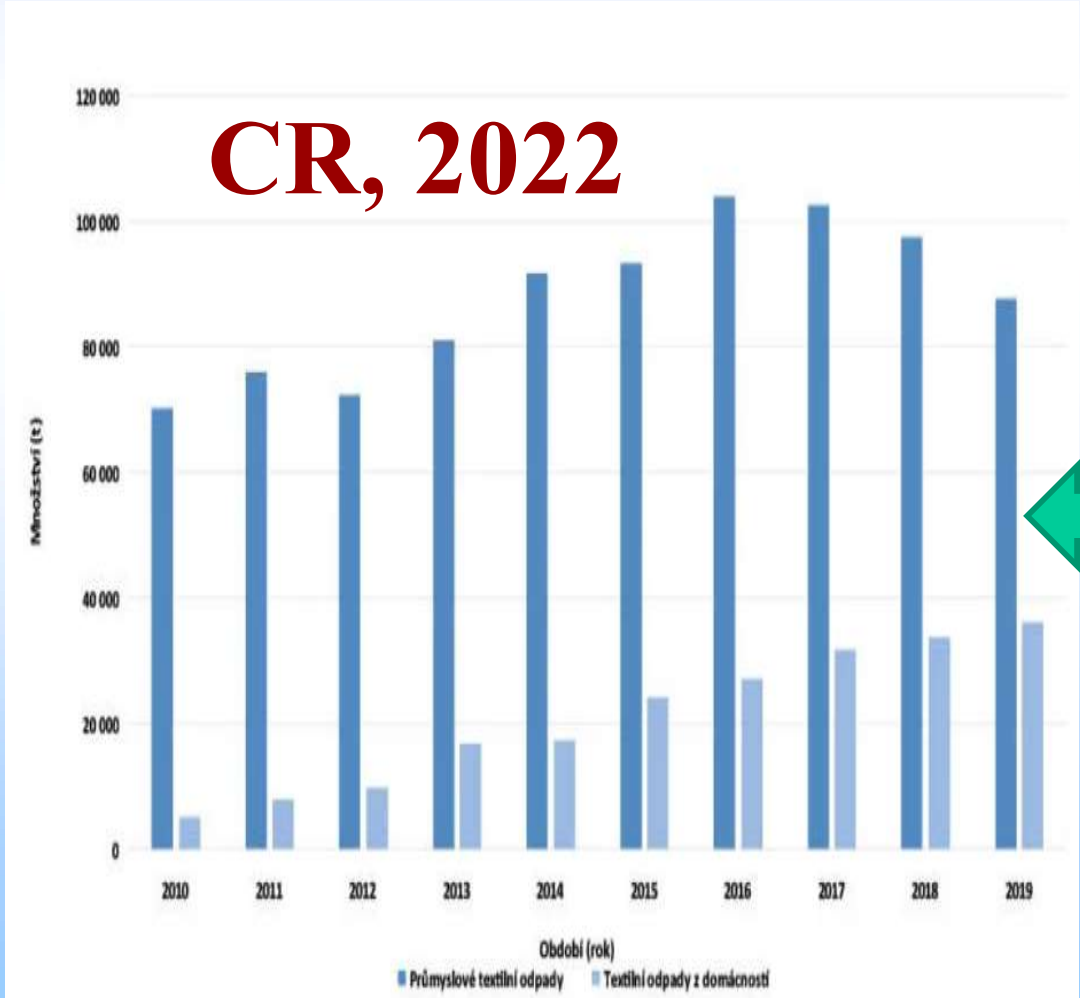




https://encyclopedia.pub/entry/history/show/50107

Ecology as a motivation to recycle

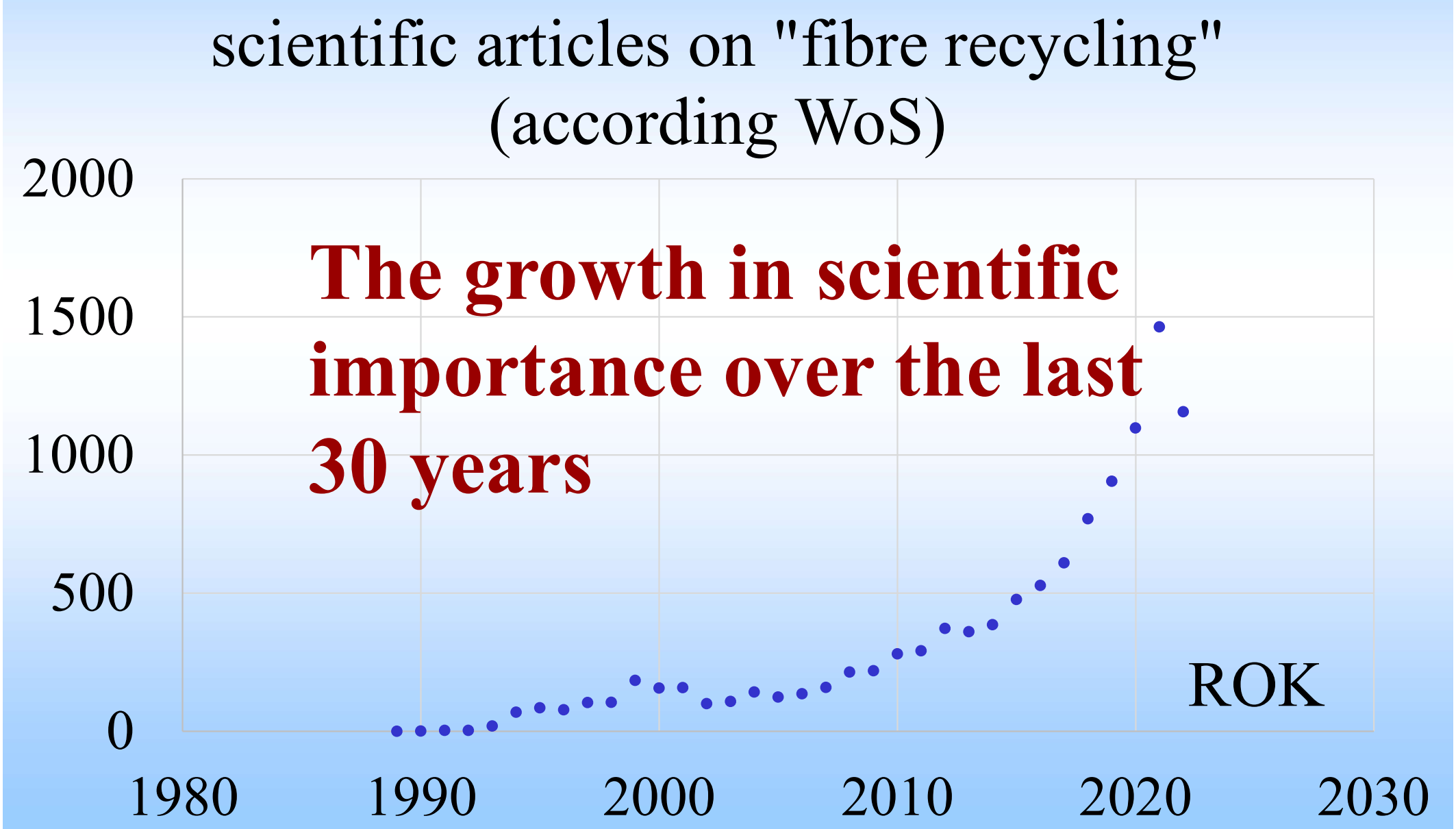
Specific numbers are usually poorly defined and out of context



https://odpady-online.cz/casopis-odpady-textilni-odpady-z-domacnosti-v-cesku-za-posledni-dekadu-narostly-desetinasobne/

E.g. here: industrial waste is about 4 times more than household waste. This corresponds to a situation where a company produces 4 t-shirts, throws 3 of them in the garbage and sells the 5th t-shirt to a customer. This probably does not describe the real situation.

the importance of recycling



the importance of recycling

The global textile recycling market was worth USD 5.02 billion in 2021.

The market will reach USD 5.86 billion by 2027, growing at a CAGR of 2.6% between 2022 and 2027 (https://www.researchandmarkets.com/reports/5547106/textile-recycling-market-global-industry-trends)

Currently, we recycle about 1% of textile waste globally using the "textile to textile" method and about 4% using the "textile to disposable product" method.

Textile recycling in the Czech Republic

Využití sesbíraného textilu
(v procentech)

Směsný komunální odpad celkem

3 mil. tun

200 tisíc tun
z toho připadá na textil

20kg/osobu

97 %
končí na skládce

https://www.idnes.cz/ekonomika/domaci/recyklace-textilu-stare-obleceni-indie.A170725_2340789_ekonomika_rts

Textile waste

- Are used textiles waste ?
- In my opinion, unequivocally YES, but only until you read the Waste Act, where waste is defined and "cursed". Textiles as waste can never be used again, that we must not take them anywhere and that they must be strictly registered...
- I'll stick to the term "textile waste", but for officials it should be exclusively "used textiles"
- Maybe new terms: before recycling "precycled" - and after recycling "recycled"

Textile waste

What is textile waste?

From an environmental point of view, all products and materials containing textile fibres that are no longer used for their original purpose

Examples: clothing, home textiles, waste textiles, agro-textiles, car coatings and car interior textiles, medical textiles, hygiene products ...

That is to say, everything made with fibre content, except textiles intended for targeted degradation such as some geotextiles, absorbent surgical material ...

Textile waste collection

Existing sources = charity containers + industrial waste

- **Industrial: pieces of thread, fibre, fabric, nonwovens, offcuts - non-fluctuating quality, larger quantities of the same fabric, often undyed, unmixed, without zips, buttons...**

- **Private: garments, home textiles... - Fluctuating quality, only one piece of the same, dyed, printed, mixtures of fibres, zips, buttons ... (today's waste is charity, washed, ironed, ready for the next wear)**

Textile waste collection

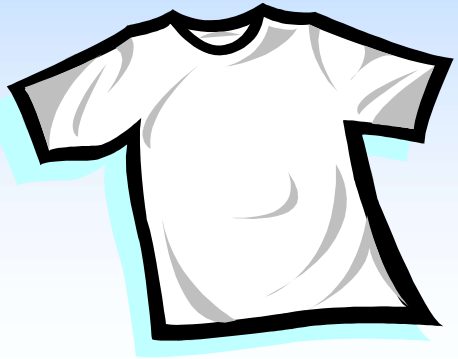
According to EU regulation after 2025 = all textile waste = average quality will deteriorate significantly

Volume increase: approx. 20 times more than today, but the usable textile content will decrease significantly

So will include: socks, carpets, torn items, soiled and unwashed textiles, bacteriologically contaminated textiles, agrotextiles, home textiles, upholstery fabrics ...

Textile waste collection

- **Collection**
- **transport**
- **sorting**
- **Just for something: mechanical and chemical recycling processes**



Garment reuse

The most common method of textile waste recovery today

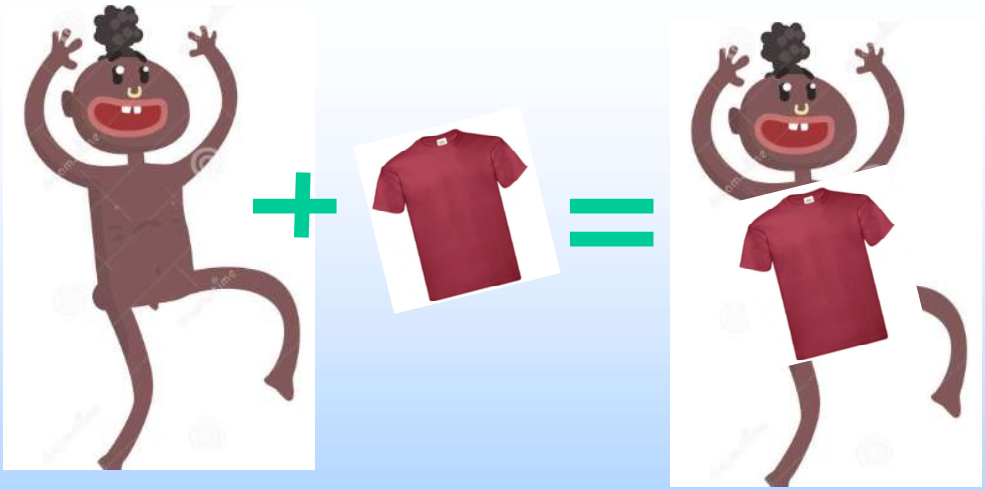
Presented as "charitable" (voluntary charitable assistance to suffering people) - especially when collecting from the public
In reality, it is a commercial resale - cities pay for the placement of containers, the contents of the containers are resold for sorting, the sorted textiles are distributed to European secondhand shops or to Africa or Latin America depending on quality, age and size. (40%) Possibly to the Middle East, where it is also repaired. Cotton textiles are used as cleaning rags. (20%) Another part of the textiles is ground up and used as insulation or textile filling. (20%) The rest of the textiles are landfilled or incinerated. (20%)

The specific recovery percentages depend on the origin and quality of the waste.

Garment reuse

Usually oversold to the south or east (always in the direction of falling VAT)

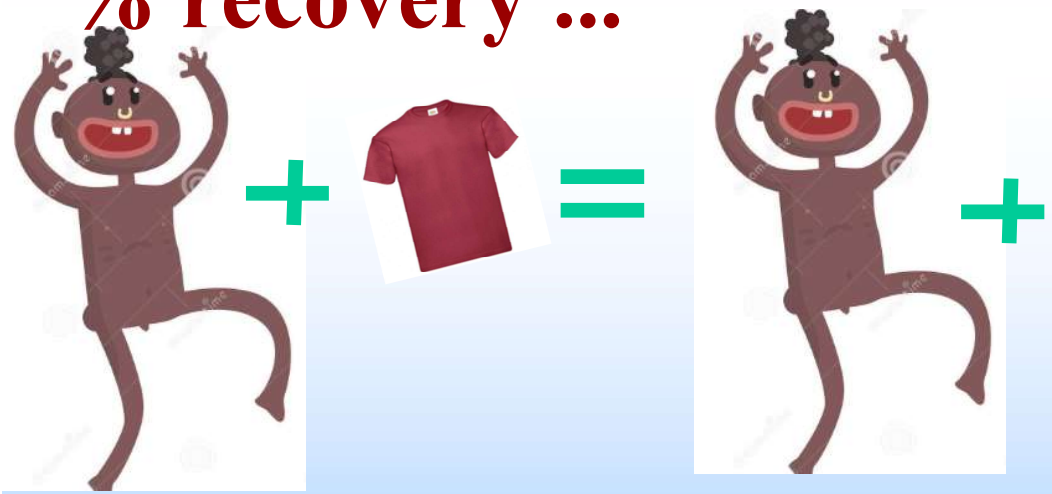
Tzv. REUSE



E.g. 40% of textiles collected in France go to Africa

Garment reuse

Very bad references: giant landfills, incineration, unknown % recovery ...



Often it is a mission of real impact that is no longer possible to use

Garment reuse

Commercial approach to distrubution essential - if you give something to someone, they will probably throw it away.
If they buy it, they'll appreciate it more and actually use it.

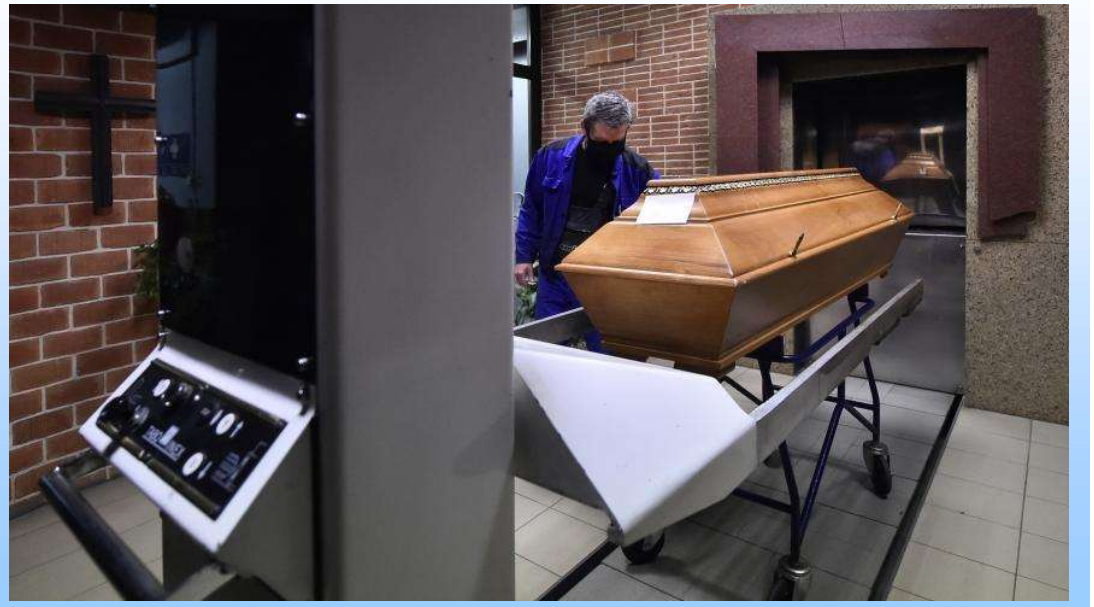
Garment reuse to the best method from an ecological point of view - we reuse textiles for their original purpose

We extend the life cycle of the product and delay the start of real recycling.

Recycling methods

- **Material recycling = functional recovery of waste**
- **Energy recycling = incineration**

Combustion is a system failure. Allowed in legislation unless there is no other option. It is always possible to recycle, but recycling is not always economically viable.

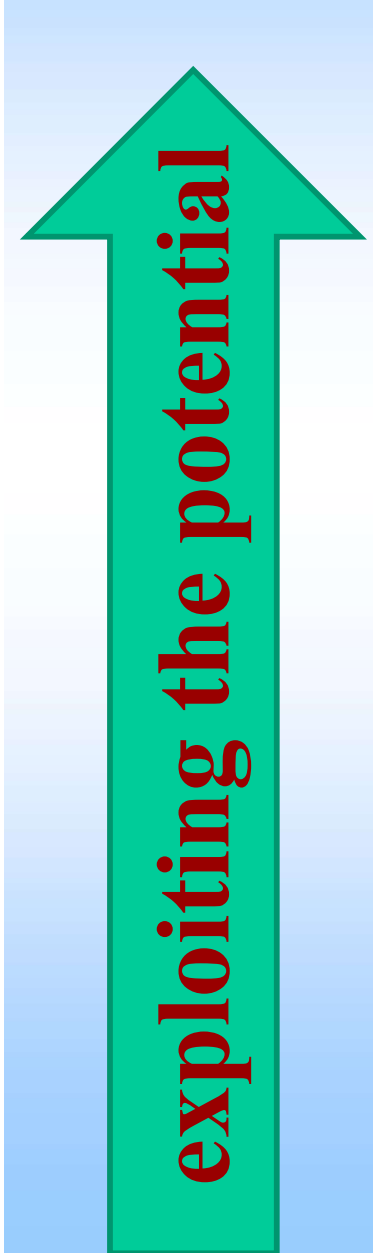


Composting textiles

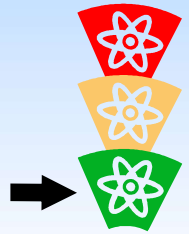
Produkt je využit v rostlinné výrobě
Optimální využití biomasy, zbytků potravin...

Synthetic polymers are virtually eternal in compost conditions, cotton/linen will break down in about 4 weeks
Problem: dyes and finishing
Problematic benefit: how is composting better than incineration?
What do textiles bring to the compost?
The only fibre that is beneficial to plants is wool, but this takes a very long time to decompose in the compost. But it can be made into fertilizer....

Material recycling - by level



- **Product (from tapestry carpet)**
- **Panel fabric (from T-shirt cleaning cloth)**
- **Long fabric (from knitted yarn)**
- **Textile shred (I cut the fabric into pieces)**
- **Fibers (I tear until loose fibers are formed)**
- **Polymer (I melt or dissolve and can soften again)**
- **Monomer (I break it down into monomers and polymerize them again)**
- **Decomposition products (I decompose into methane, ethanol... as fuel or for synthesis)**
- **Carbon (by carbonization I create carbon as a sorbent)**



Problems of material recycling

- **a rapidly growing sector**

- **Issues:**
- **Identification of inputs and their composition**
- **Trade-offs (non-ecological)**
- **Bacterial and other contamination**
- **Microplastics**
- **Legislation**
- **Exploiting the potential of recyclates**
- **Economics**

Material recycling issues

Fabric marking

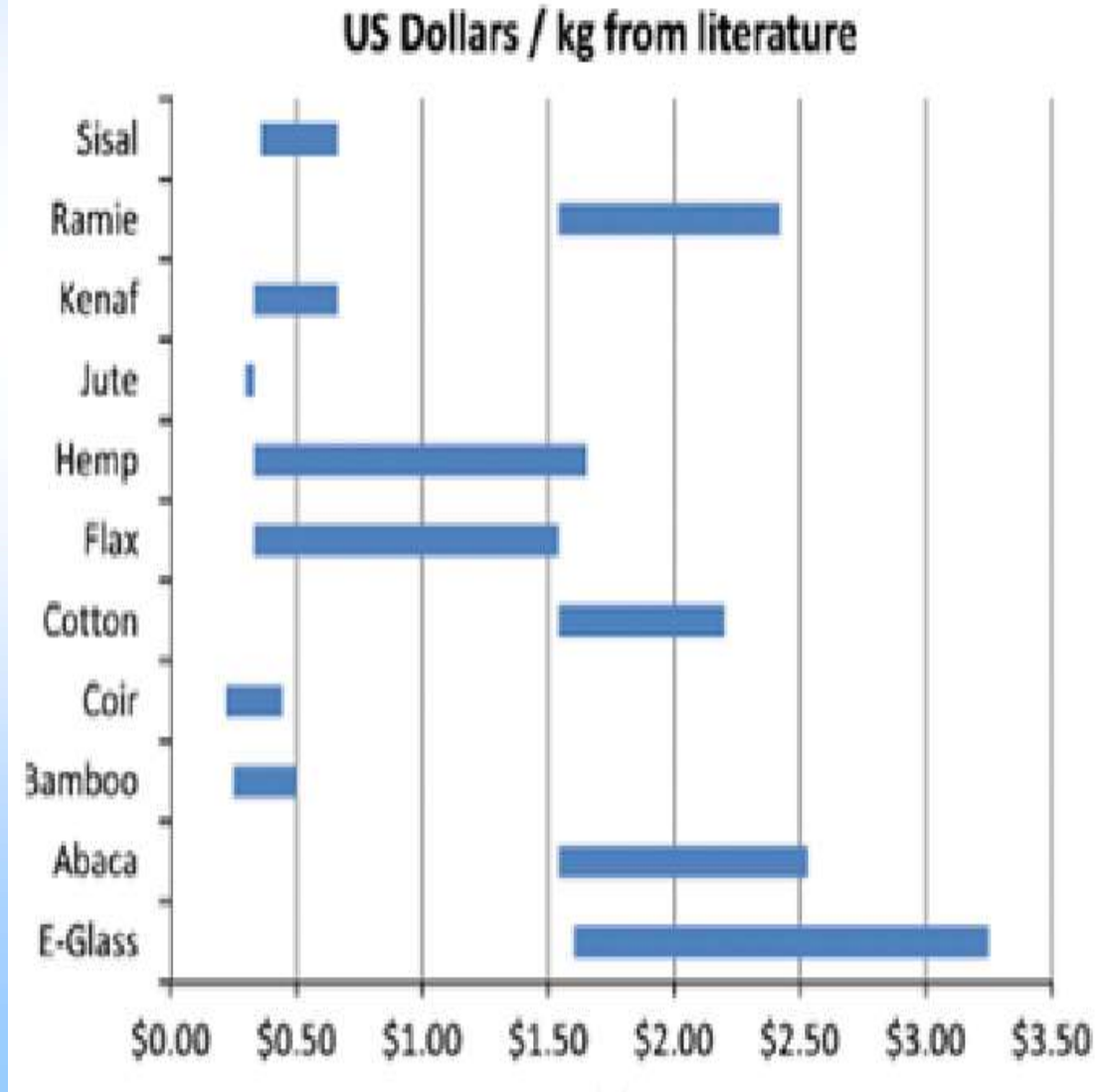
150 years ago - 2 types of fibre - cellulose and protein.

In the last 100+ other fiber materials + their blends.

- **Fabric marking - the existing one is not functional**
- **Fibre identification - already commonly using FTIR**

Material recycling issues - The price of fibre

Separately recycle only if they are common and expensive



Fiber Textiles (Plain Weave)	Approximate Price ($/kg) (January 2019, Elaborated from Alibaba)
Carbon	35–60
E-glass	1–2
S-glass	3–7
Kevlar	50–150
Basalt	20–70
Flax	12–20
Hemp	5–13
Kenaf	1–3
Jute	0.50–1.50
Sisal	1.50–2.50
Coir	3–8

2009 https://www.researchgate.net/publication/263685942_Review_Raw_Natural_Fiber-Based_Polymer_Composites

Material recycling issues - The price of fibres

Price of textile waste per kilogram (Brazil, 2018)

Mixed waste 0,5 CZK/kg

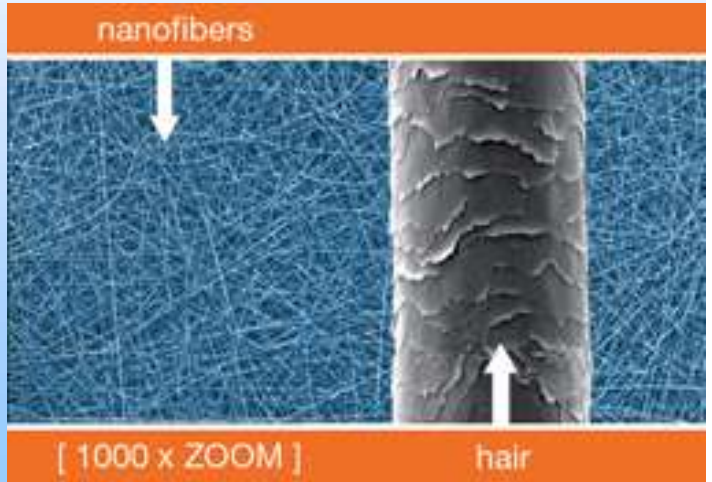
Cotton waste (jeans) 0,75 CZK/kg

coloured 100% cotton fabric 3 Kč/kg

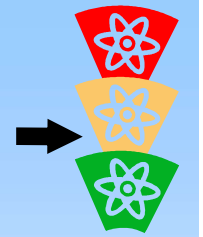
acrylic or polyamide fibres 5 Kč/kg

white 100% cotton fabric 7 Kč/kg

??? Special fibres



Material Recycling Issues - Fibre Purity



100% white cotton

100% color textile – 100% PEs

Nitě z jiné ho materiálu

White blend co/PES

Color blend co/PES

RECYCLING COMPLICATIONS

Zippers and buttons

laminate PES / PUR

ba/PES + coating

Multi-fibre composite with non-removable matrix

Material Recycling Problems
Fibre Purity

We can recycle

We can't recycle

Options:

1) If we can't recycle it, we have to learn to recycle it.

2) What we can't recycle, we won't produce

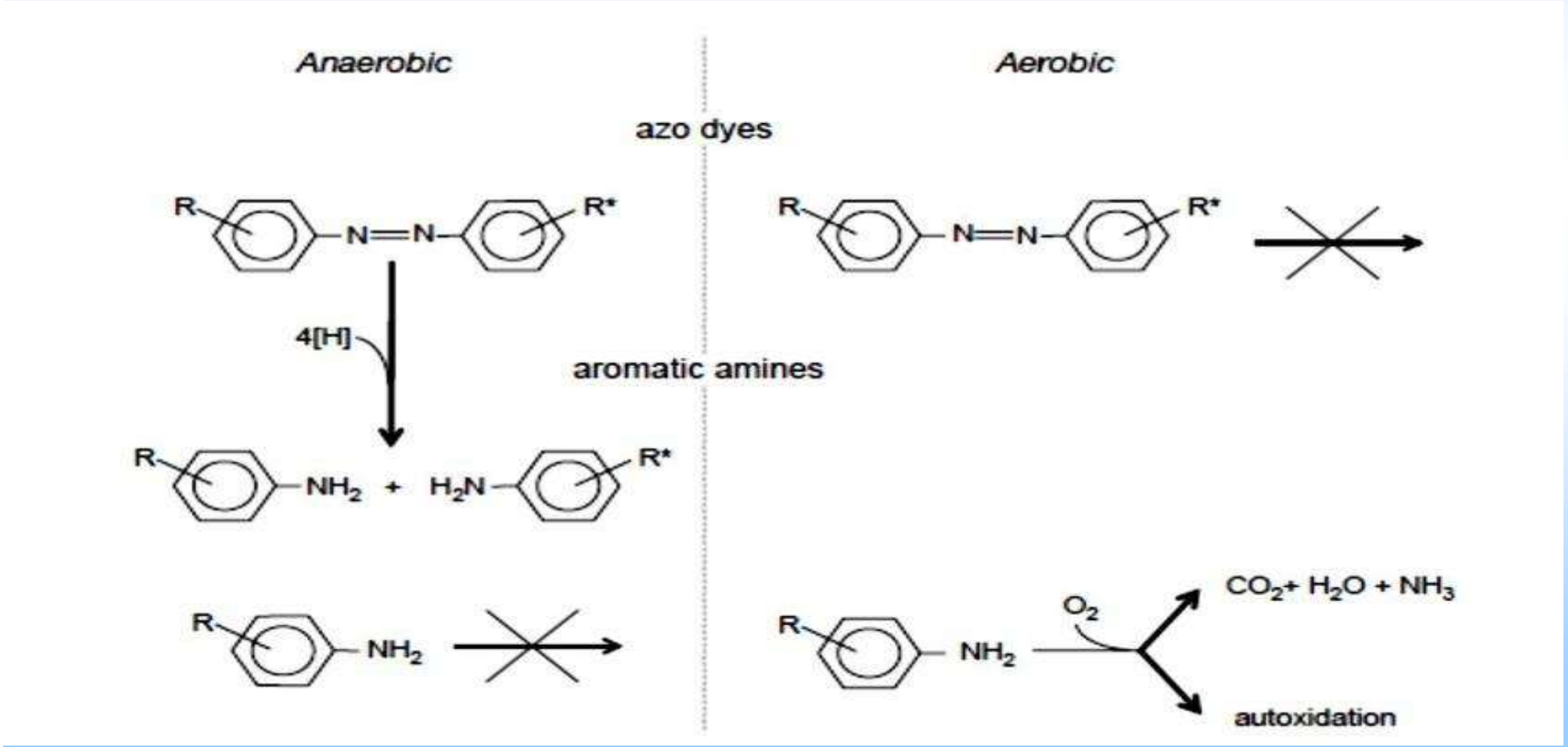
Non-recyclable products should be suppressed as much as possible

Material Recycling Problems
Fibre Purity - Dyes

- The dyes are harmless and do not pose any threat to the user of the fabric. This has been known for about 100 years, but every few years dyes that have been proven to be toxic or carcinogenic are quietly withdrawn from the market. In recent years, this has been particularly the case with azo dyes and the aromatic amines they release, including carcinogens. Last year's dye may no longer be a dye this year, but it is a dangerous carcinogen
- This is one of the key issues in real textile recycling - how to verify that the dyes banned here and now are not part of the recyclate? It is not possible to test every piece of fabric entering recycling for the content of now banned dyes.

Material Recycling Problems
Fibre Purity - Dyes

Dyes = very bad contaminants that make the recycling process difficult and complicated



https://www.researchgate.net/figure/General-overview-of-the-fate-of-Azo-dyes-and-aromatic-amines-during-anaerobic-aerobic_fig1_262564975

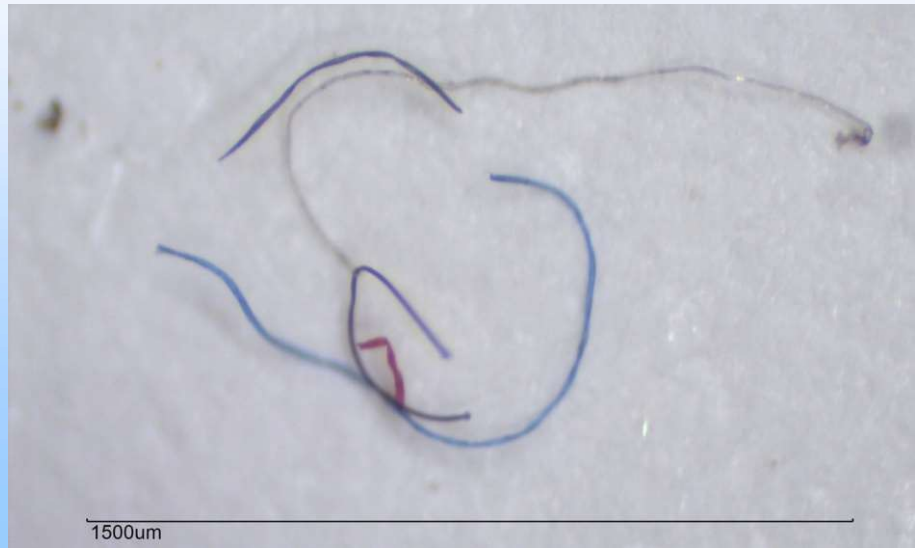
Problems of material recyclingmicroplastics in mechanical recycling

Mechanical destruction of textiles = emission of dust/textile microplastics

Must be eliminated by air conditioning, filtration ...

Toxicity:

lenght/diameter	> 3
Fibre lenght	> 5 μm
Fibre diameter	< 3 μm



Material recycling issues - biological contamination

Disposable products for personal hygiene:

diaper panties

wet wipes

incontinence products

feminine hygiene products

Disposable clothing (e.g. protective clothing)

Medical textiles in general

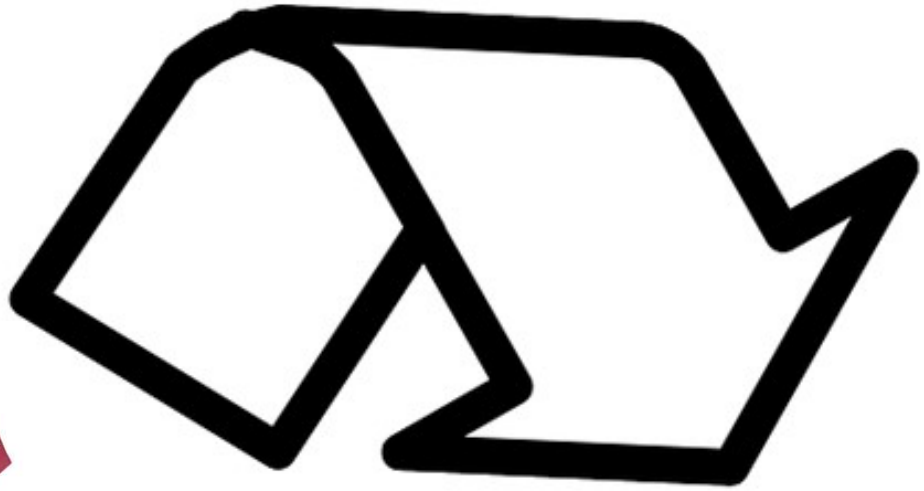
Key question: disinfection ?

Limity recyklace

Kolikrát ?

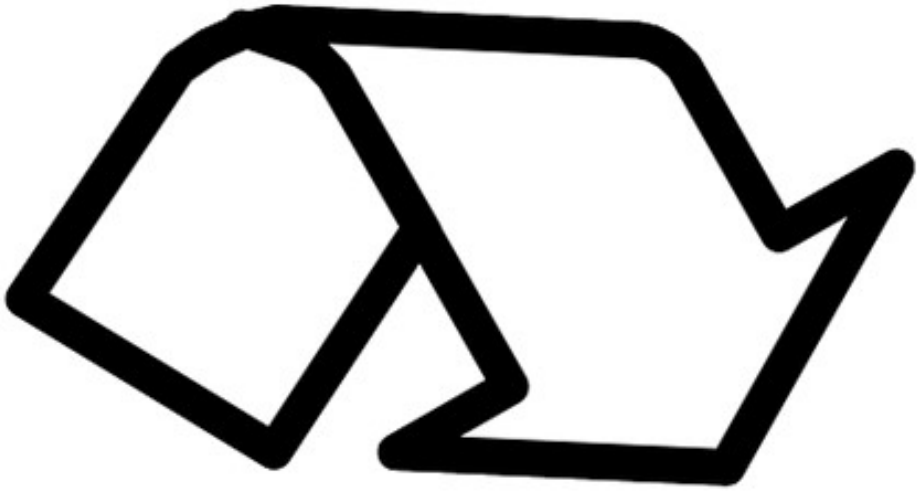
Co z čeho ?

?

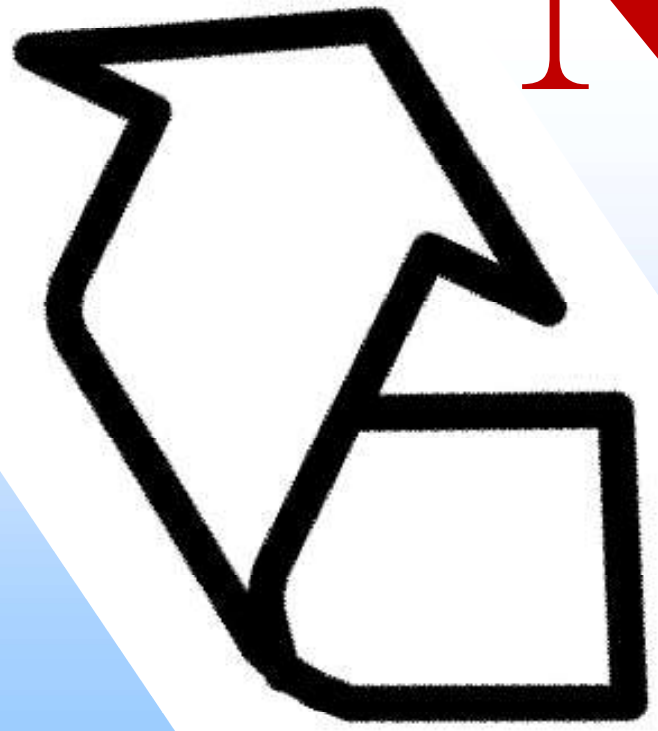


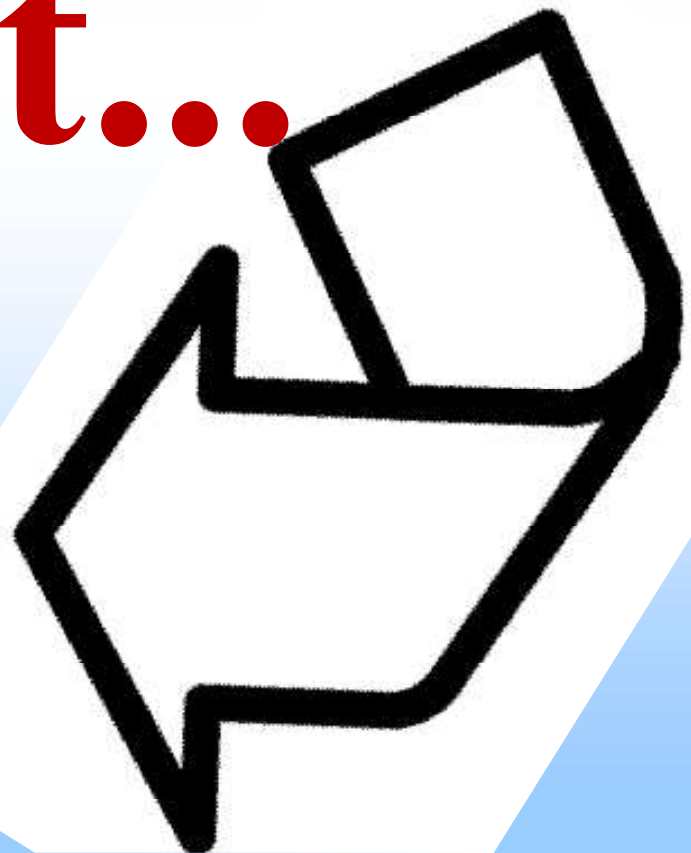
Yes, but...

For textile people:

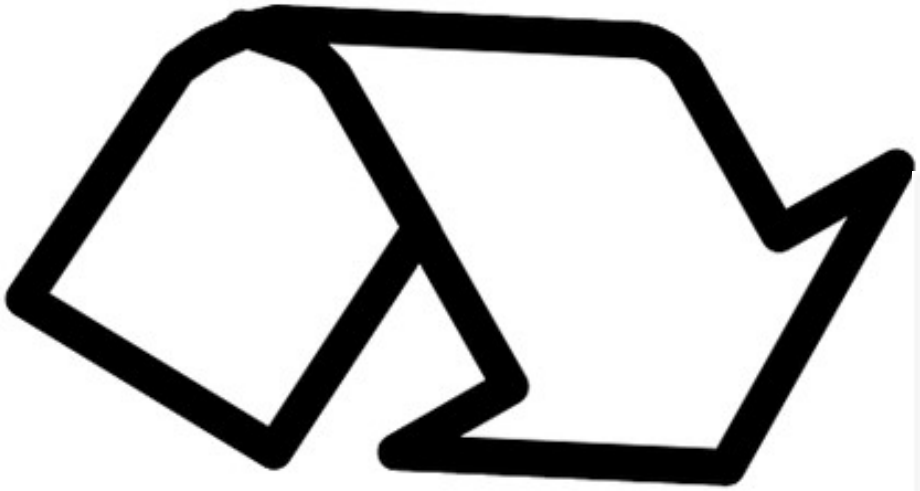


No, but...

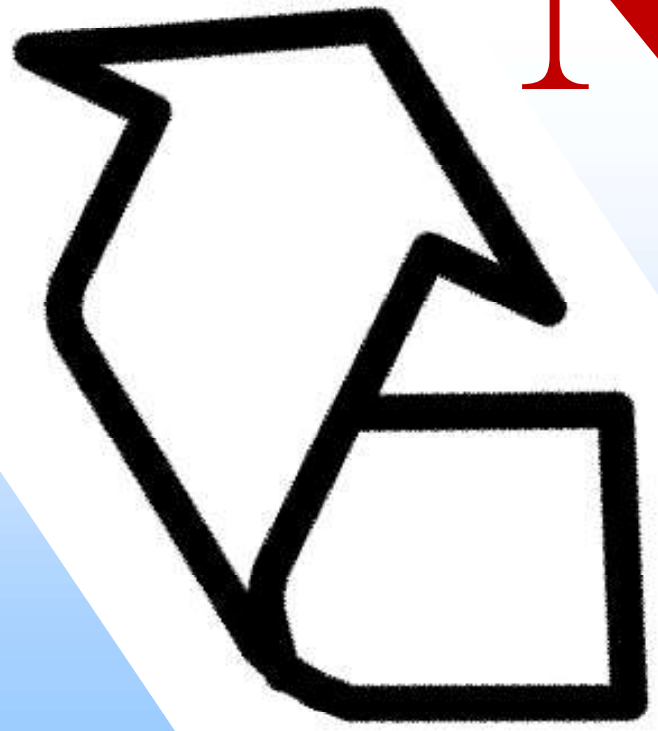


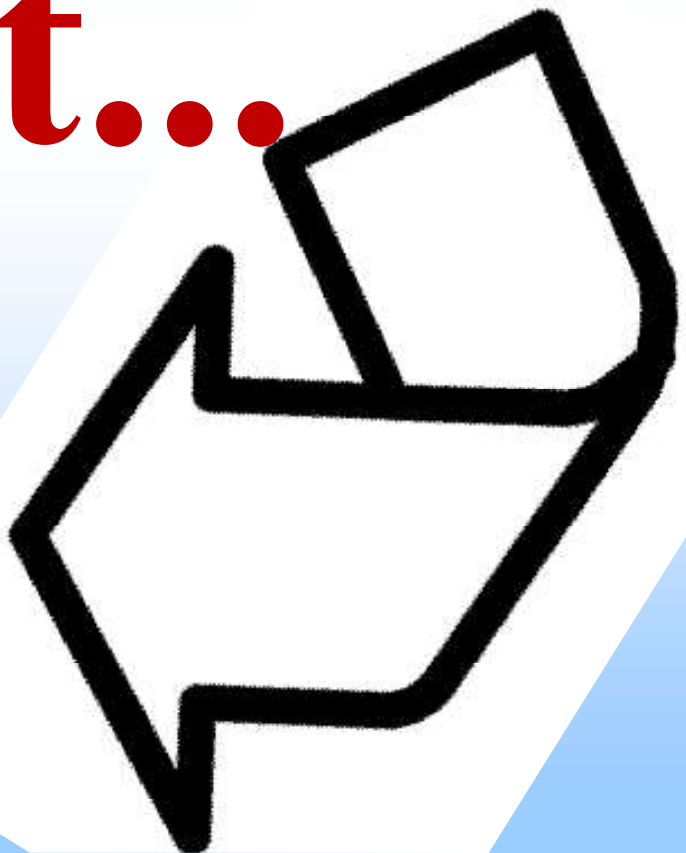


For non-textile people:

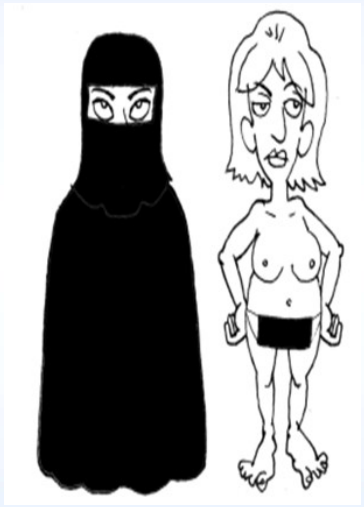


No, but...





Recycling in the concept of artists



Gary Harvey –

Dress made from recycled sweet wrappers!

Gary Harvey –

Denim dress made from 42 pairs of Levi jeans!

The psychology of recycling

It is difficult for a reasonable person to throw away an item for which he or she has no use - for example, a threadbare T-shirt. A rational person knows that the discarded item will be a waste, a burden on civilization and the planet, and will try to wear the T-shirt longer and then use it as a rag when cleaning

Recycling psychologically reduces the severity of discarding textiles as waste. It is easy to throw it away because it will be recycled, I will not burden the environment.

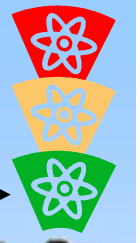
You know this about yourself - as long as there were ordinary light bulbs everywhere, everyone was saving and turning off the lights. Now we have energy-saving bulbs that nobody turns off and are on almost all the time.

Recycling is not enough...

Recycle	Reuse of waste as raw material
Reuse	Product reuse
Reduce	Reduction of consumption
Revolver	For those who don't follow it.
Recover	Energy recovery in waste

Textiles must be cared for, recycling must be the last option.

Vision of the ideal state (year 2035?)



???

Our environmental activities

Enzymatic degradation of fibres
Energy savings
Nanocellulose
Bacterial cellulose
Microplastics and their prevention
Optimal wardrobe
Eco-friendly finishing
Savings on binders in composites production
...

Recycling in the Czech Republic - multistream

PET recycling steps

1.Collection of PET bottles

2.Sorting and sorting of PET bottles

3.PET bottle shredding

4.Washing of crushed PET, removal of impurities - production of PET Flakes

5.Processing of PET Flakes into various products / PET staple, PET tape, PET film, PET granulate etc./

Recyklace PET

Colour-sorted PET bottles are transported to the recycling process, crushed into fractions of a maximum size of 14 mm. This material contains residual particulate matter, paper and plastic labels, residual adhesives, caps, etc. The aim of the whole process is to clean the PET material from other plastics, dirt, adhesives, paper, so that the quality of the output material is comparable to the PET raw material. The processed material is initially cleaned in a so-called dry way, where the light parts are separated from the heavier PET parts by means of an air stream. This is followed by a so-called wet process, where a series of different washing machines are used to separate the remaining unwanted particles using centrifugal forces and different specific densities of the materials. Finally, the material is dried and packed into bulk bags. The product of the production process is pure PET flakes, which are further used in various industries in the Czech Republic and abroad.

http://www.grau.cz/balador-eko/technologie.htm

We still have a little time - the boat doesn't leave for another 5 minutes...

Thank you for your attention