OVERVIEW OF ECODESIGN IN TEXTILE DYEING & FINISHING INDUSTRY

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INTRODUCTION

Main environmental impacts of dyeing & finishing industry :
- **High water consumption**
- **Energy use**
- **Wide range of chemicals**

Necessity of **eco-design** → Best Available Technologies (BAT)

- **ENZYMES,**
- **ULTRASOUND-ASSISTED TREATMENTS,**
- **SUPERCRITICAL CO_2,**
- **PLASMA,**
- **Etc.**

Literature about environmental impacts

Life cycle assessment

LIFE CYCLE ASSESSMENT (LCA)

LCA is a tool to **quantify** all the Environmental Impacts of a product from **extraction of raw materials** to its **end of life** through its use

Inventory

- Water consumption
- Energy (including steam)
- Chemicals
- Water pollution (COD, BOD, toxicity)
- Air pollution (VOC, etc.)

→

Environmental impacts

- Resource depletion
- Eutrophisation
- Acidification
- Global warming
- …

Fig 1. Translation of inventory into environmental impacts

LCA are complex and most of the time, scientists do the **inventory** only of **water, energy and chemicals consumption.**

LIFE CYCLE ASSESSMENT (LCA)

An example of life cycle assessment in **cotton finishing**.

Environmental impacts of finishing steps

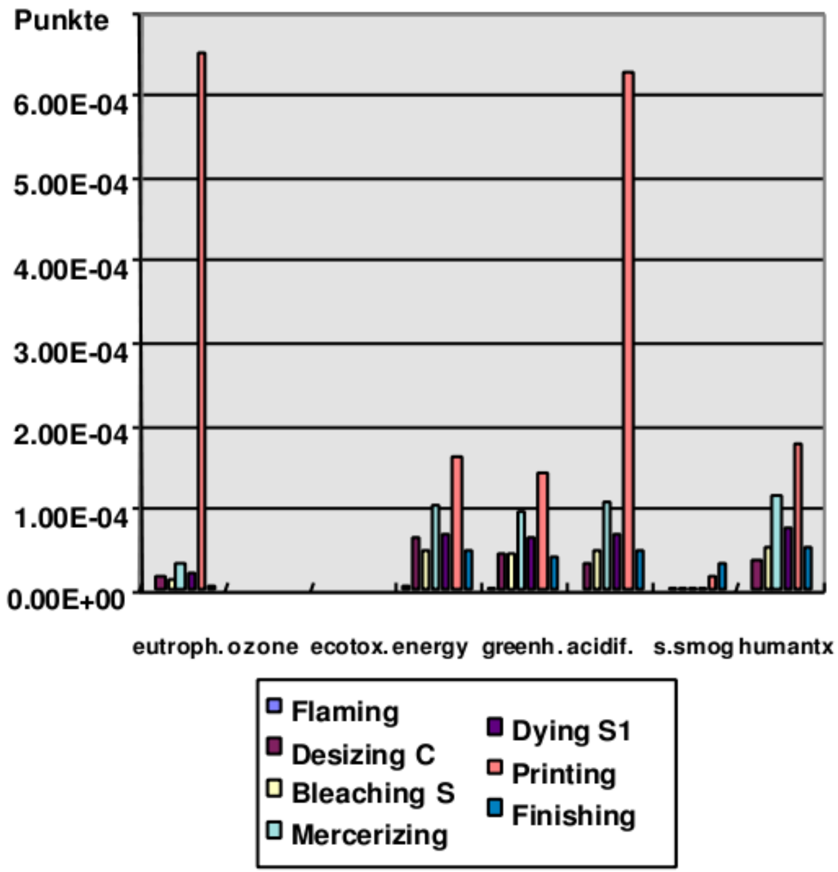


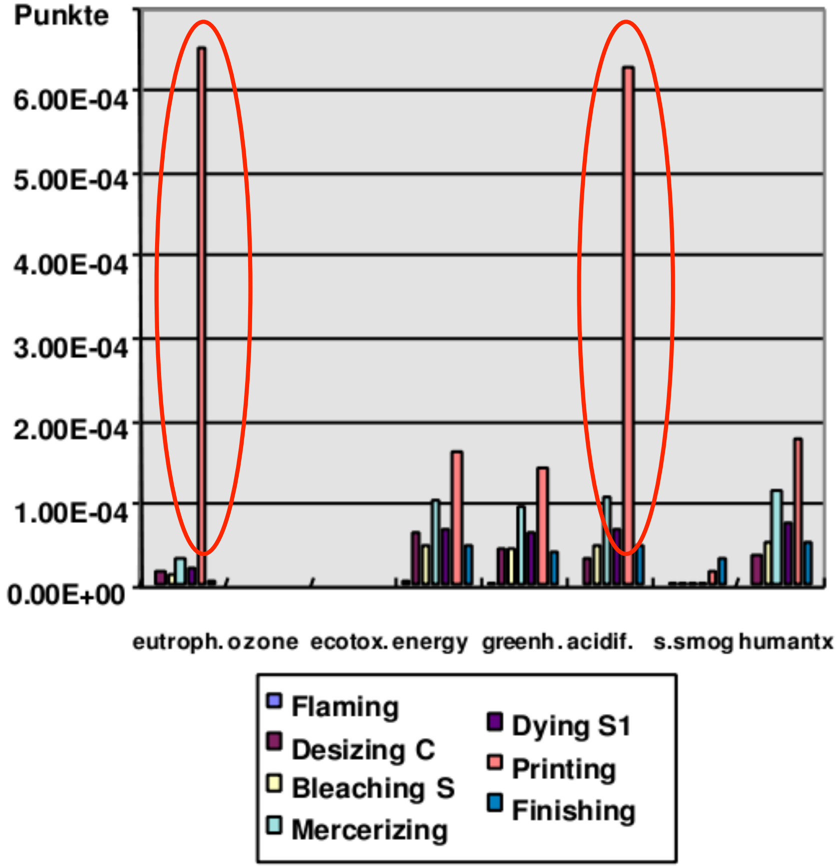
Fig 2. LCA of a finishing formula

M.I. Tobler-Rohr. *Life cycle assessment of a cotton fabric in textile finishing,* ***2000***

LIFE CYCLE ASSESSMENT (LCA)

An example of life cycle assessment in **cotton finishing**.

Printing has the biggest impact on eutrophisation and acidification of water



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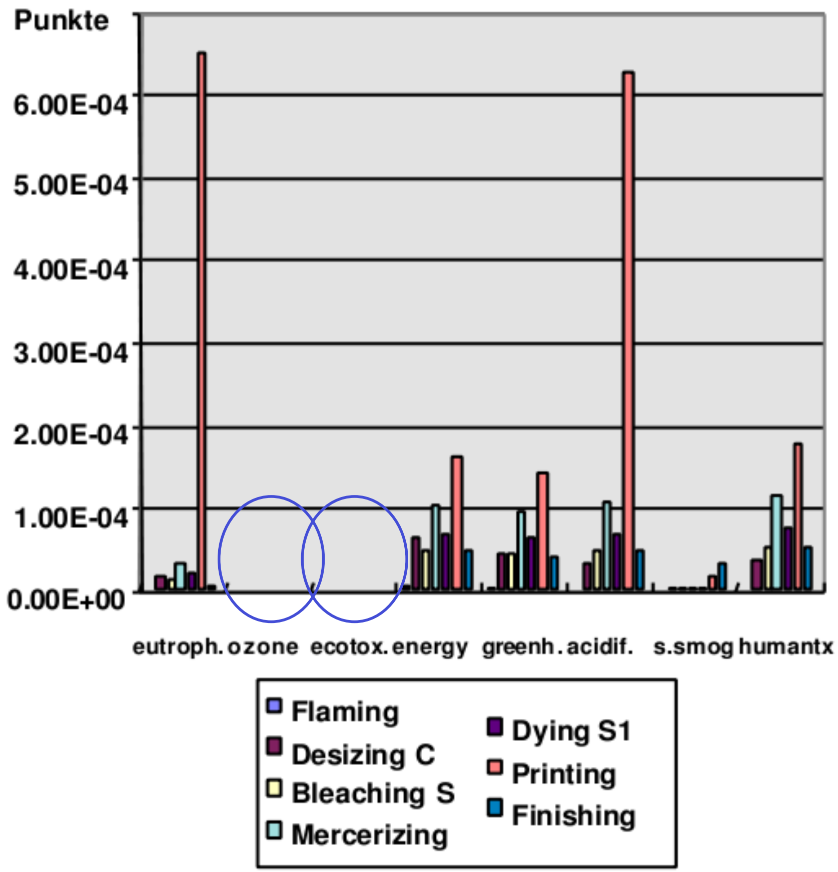
M.I. Tobler-Rohr. *Life cycle assessment of a cotton fabric in textile finishing, **2000***

LIFE CYCLE ASSESSMENT (LCA)

An example of life cycle assessment in **cotton finishing**.

Finishing has no impact on ozone depletion neither on ecotoxicity



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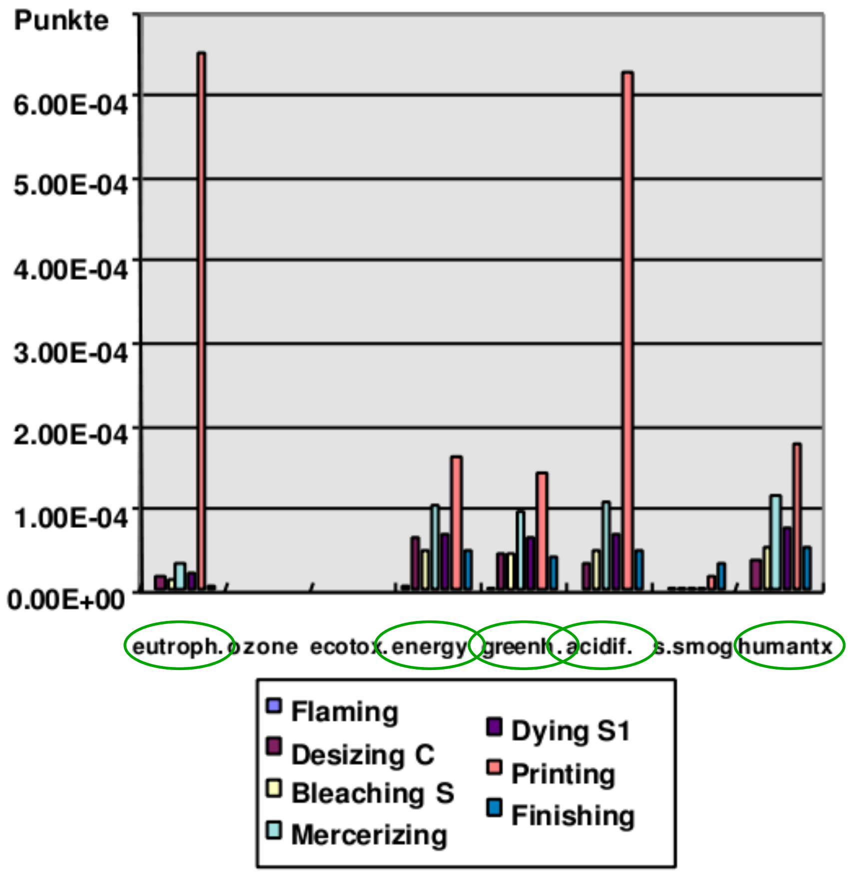
Impacts of most of cotton finishing steps :



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LIFE CYCLE ASSESSMENT (LCA)

This is a bibliographic overview of some best available technologies and their environmental improvements.

Conventional processes compared with best available Technologies in literature :

- LCA
- Data inventory
- Not exhaustive inventory
- Informations on processes

Enzymes

ENZYMES

Used in many processes in the textile industry mostly for natural fibers. *Ex* : desizing, scouring, anti-felting of wool, functionalisation, etc.

Many types of enzymes, all have a specific action.

- Energy savings (lower temperature, shorter time treatment, etc.)
- Removal of hazardous substances,
- Reduction of water consumption (fewer rinses, lower liquor ratio)

Cavaco-Paulo, *Processing Textile Fibres with enzymes: An overview*, ACS Symposium Series, **1998**
Sustainable textile life cycle and environmental impact, **2009**.
J. Chen, *Enzymes and microbial technology*, **2007**.

LCA : traditional scouring VS bioscouring

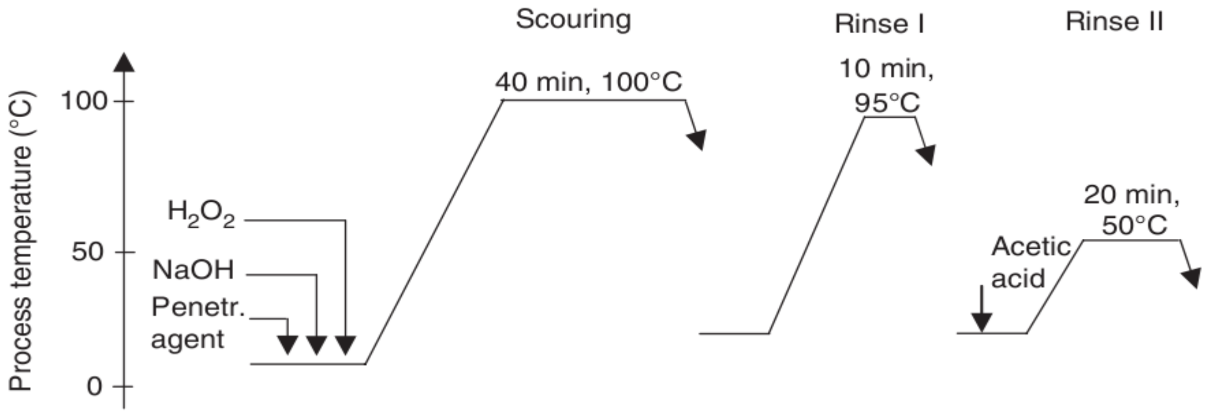


Fig 3. Process diagram for conventional scouring

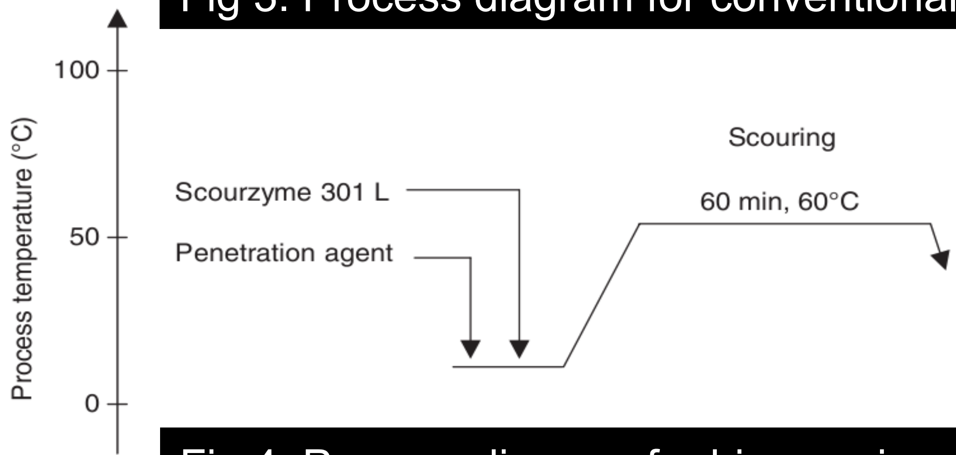
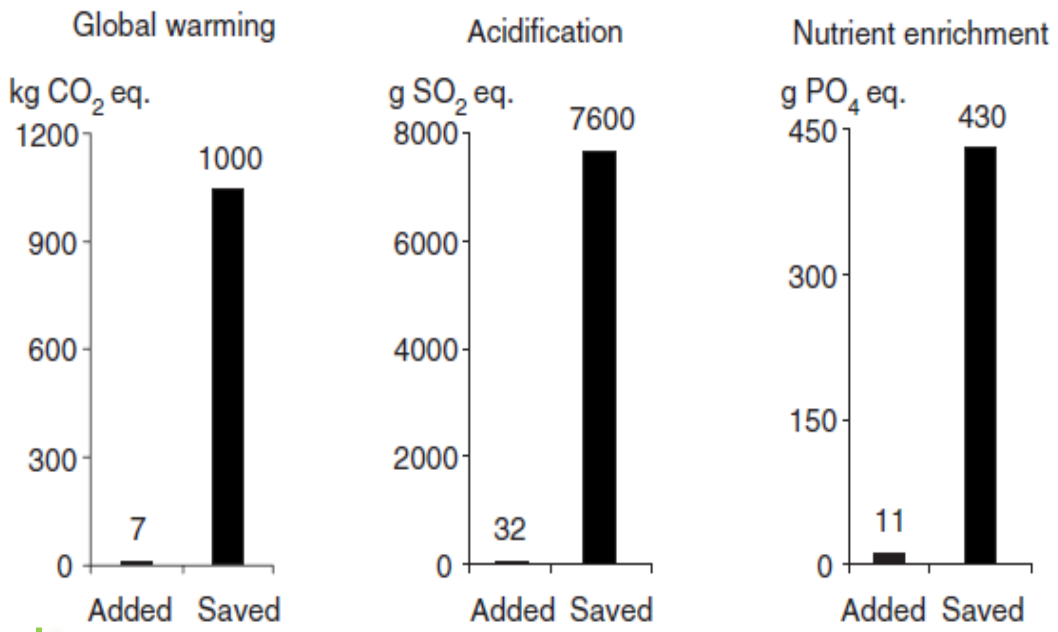
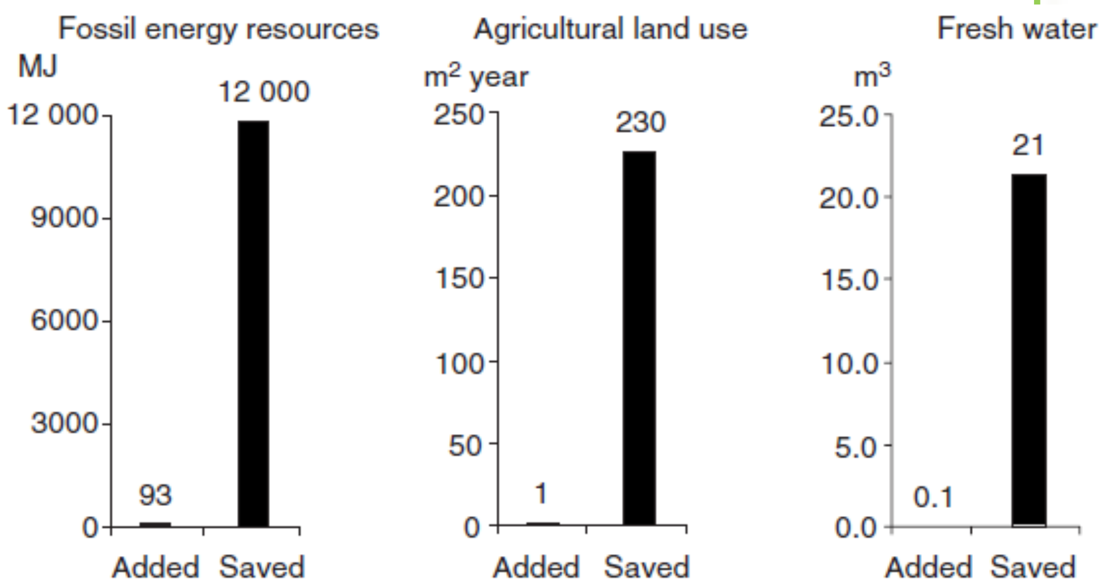


Fig 4. Process diagram for bioscouring

P.H. Nielsen & al (Novozymes), *Enzyme biotechnology for sustainable textiles,* ***2007***

Results of LCA

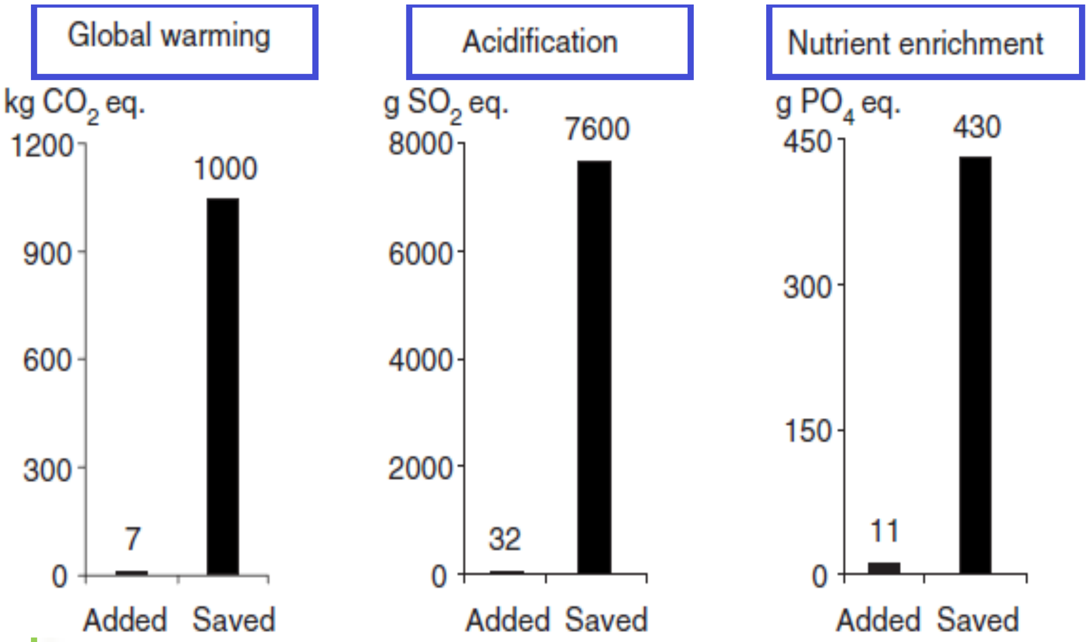


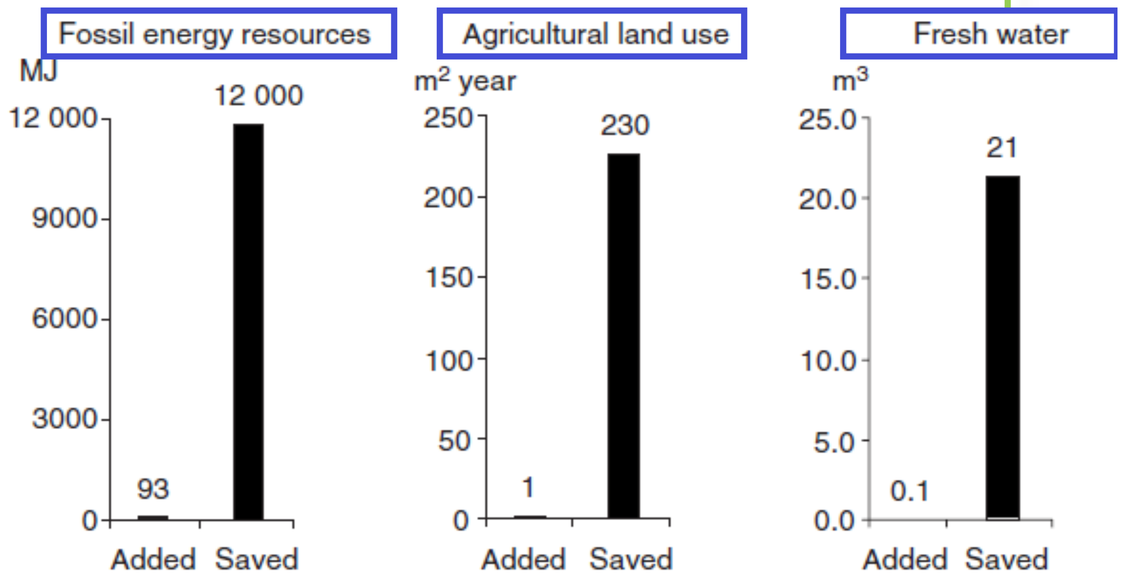


P.H. Nielsen & al (Novozymes), *Enzyme biotechnology for sustainable textiles,* ***2007***.

Fig 5. Added and saved resource consumption and environmental impacts by bioscouring

Results of LCA





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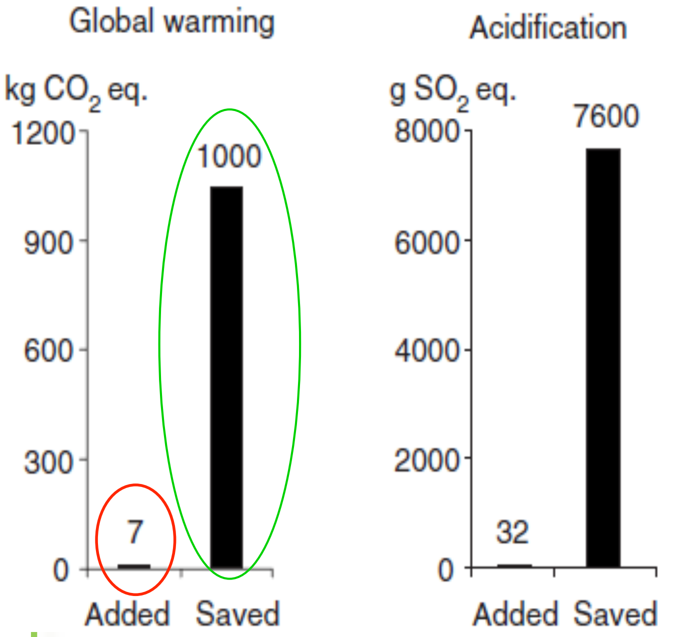

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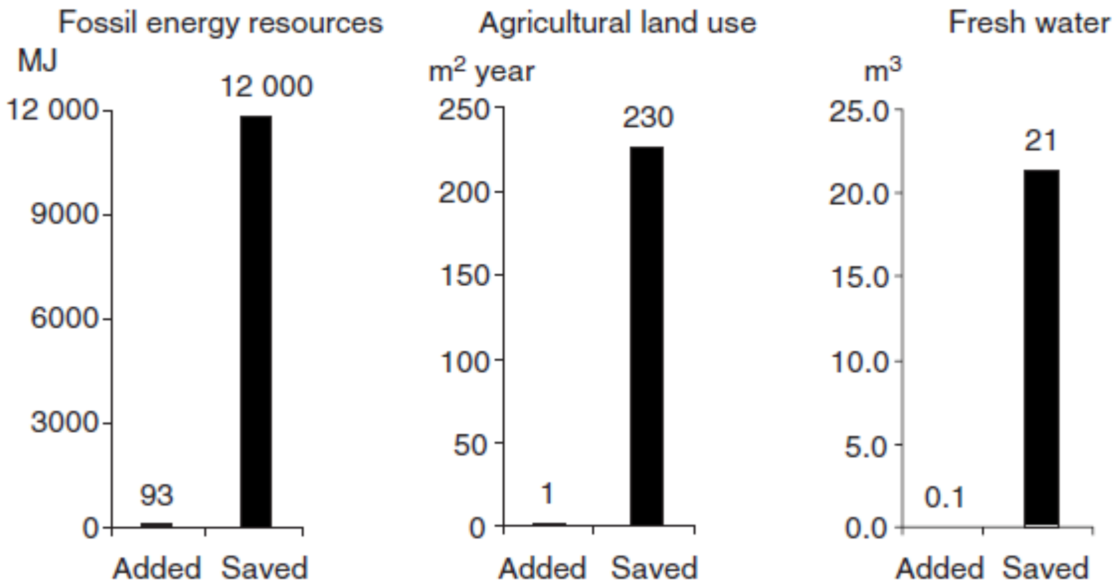

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Ultrasound assisted treatments

Ultrasound assisted treatments

– Use of **ultrasounds** during wet processes intensifies phenomena of dispersion and washing due to the **cavitation**.

  – Increases effectiveness of traditional treatments thereby reducing their environmental impact.

    _ Used in **pretreatments** (de-oiling, scouring) and **dyeing** (silk, cotton, etc.)

S.R. Shukla & al. *Journal of the Society of Dyers and Colourists*, **1995.**

S. Vajnhandl & al, *dyes and pigments*, **2005**

ULTRASOUND - Pretreatments

Example of a pretreatment : comparison of the inventory of polyamide de-oiling with and without ultrasounds

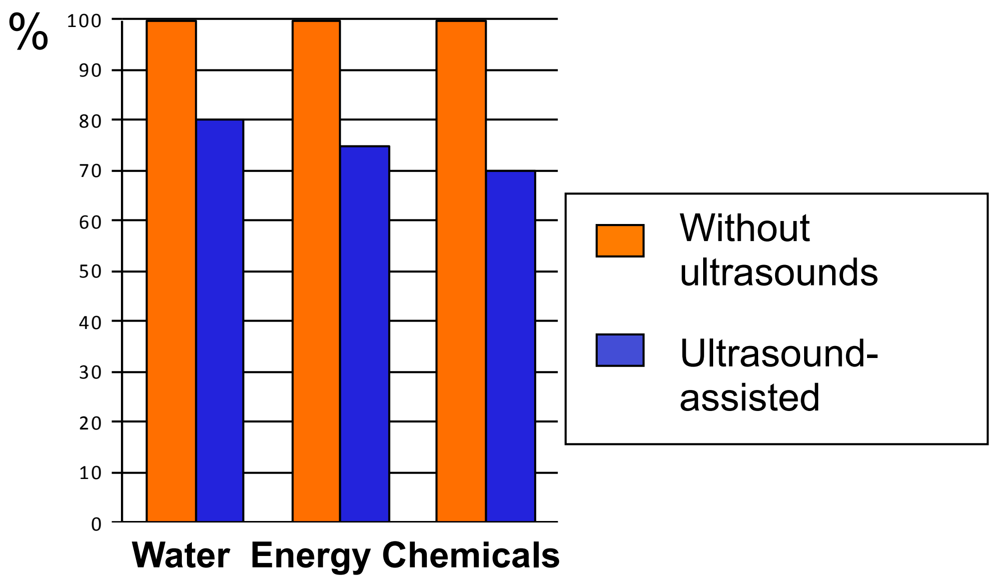

Fig 6. Environmental improvements with ultrasound (polyamide de-oiling)

M. Vouters & al. Ultrasonics sonochemistry, **2003.**

ULTRASOUND - Dyeing

Dyeing silk with ultrasound -> **better dye uptake** and less energy needed :

	Absorbance	Temperature	Process time
not ultrasound assisted	0.028	85°C	60 min
ultrasound assisted	0.039	50°C	15 min

Fig 7. Comparison of temperature and process time of a silk dyeing with and without ultrasonic assistance

Process conditions not translated

S. Vajnhandl & al, *dyes and pigments*, **2005**

Supercritical CO_2

Supercritical CO2

Supercritical CO2 technologies can replace water treatments

Supercritical CO2 can be used for **dyeing of polyester (PET), polypropylene (PP).**

Still in research step : pretreatment, dyeing natural fibers and surface functionalisation

No exact comparative LCA study has been conducted

E. Bach & al. *Rev. Prog. Color,* **2002**.
R.M. Christie, *Environmental aspects of textile dyeing*, Cambridge, UK, **2007**.
L.E. Bowman & al,*Textile Research Journal*, **1996**.
N. P. Prorokova & al, *fibre chemistry*, **2009**.
A. Hou & al, Journal of Cleaner Production, **2010**.

PET and scCO2 are both **non polar**

Diffusion of non polar dyes in PET **through scCO2**

Environmental improvements :

- **Water** consumption is **zero**,
- CO2 and non fixed dyes **recycled**
- No need for leveling and dispersing agents

> Energy is the main impact of scCO2

E. Bach & al. *Rev. Prog. Color,* **2002**.
R.M. Christie, *Environmental aspects of textile dyeing*, Cambridge, UK, **2007**.
A. Hou & al, Journal of Cleaner Production, **2010**.

Plasma

Plasma treatments in textile

In the low plasma temperature, the electrons are able to **break covalent chemical bonds**

-> physical and chemical changes of the treated surface.

- Modification of wetting of the fiber,
- Desizing of fabrics,
- Anti-felt finishing of wool,
- Deposition of fiber coatings, etc.

R. Morent & al, *surface & coatings technology*, **2007.**
R. Shishoo, *Plasma technologies for textiles*, **2007**.
Sustainable textile life cycle and environmental impact, **2009**.

Comparison of 2 processes of PET functionalisation

Oil repellent functional layer on a polyester textile by fluorocarbons

- **Wet process :** padding then drying

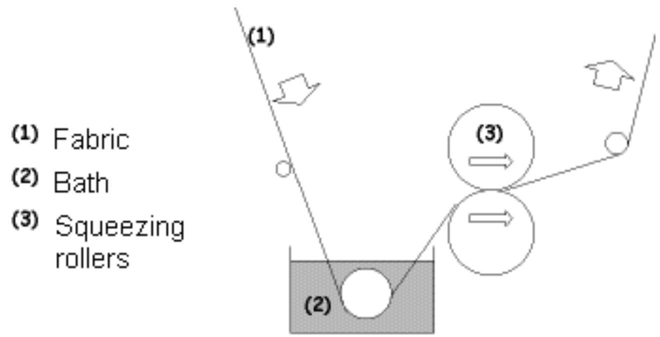

Fig 9. Padding

- **Plasma process** : plasma polymerisation at atmospheric pressure

Environmental advantages of plasma :

Water consumption negligible (so no polluted effluent)
10 times less energy required

T. Stegmaier & al. Environmentally friendly plasma technologies for textiles, **2007**

CONCLUSION

In a context of **ecodesign,** the use of **Best Available Technologies** is an interesting way.

Quantifying the reduction of environmental impacts between conventional processes and BAT **means an accurate comparative study.**

Future researches should after having established a framework, collect data exhaustively in order to get comparable environmental impacts