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European Best Practices in New Sustainable Chemistry, Including Reduction of Chemical Substances

Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide

Marco Sallat / Anna Große

(Saxon Textile Research Institute)

3rd RESET Seminar on
“New Sustainable Chemistry, Including Reduction of Chemical Substances”
Bucharest, 4th April 2017

European Union
European Regional Development Fund

Saxon Textile Research Institute (STFI)

Affiliated institute of Chemnitz University of Technology

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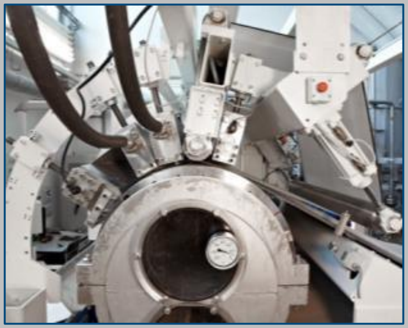
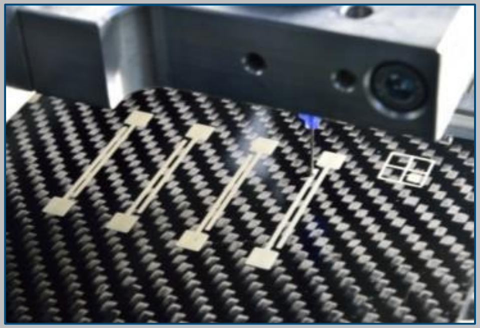
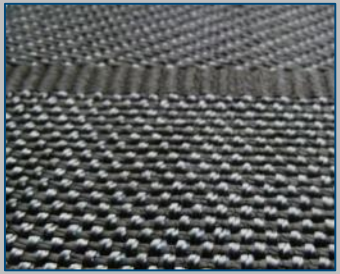
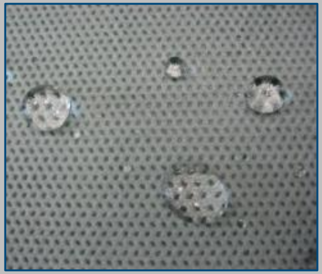
stfi
SÄCHSISCHES TEXTIL FORSCHUNGS INSTITUT e.V.

TECHNISCHE UNIVERSITÄT CHEMNITZ

International Competence
in Nonwovens – Textile Lightweight Engineering –
Technical Textiles


Saxon Textile Research Institute (STFI)

Affiliated institute of Chemnitz University of Technology

- Non-profit, founded in 1992
- Since 2006 associated to Chemnitz University of Technology
- About **150 employees** (researchers, laboratory assistants and technicians)
- More than **100 R&D projects** on regional, and national level are carried out each year (BMWi, BMBF, AiF, SMWA, SMWK, …)
- 5 to 10 **patent applications** are submitted per year
- Member of TEXTRANET, EDANA, European Technology Platform, Euro Textile Region, standardisation working groups, etc.

The institute is located in Saxony.

Profile of STFI – Competencies

Center of Excellence in Nonwovens

- Fibre nonwovens
- Extrusion nonwovens
- Textile recycling

Center for Textile Lightweight Engineering

- Processing of glass, carbon, aramid, basalt
- Manufacturing of pre-forms and composites
- carbon recycling

Innovation Center of Technical Textiles

- Technical Woven & Knitted Fabrics/Reinforcing Structures
- ***Finishing/Coating/Lamination / Ecology***
- Development of materials and testing methods

Services

- Accredited Test Laboratory
- Certification Department for PPE
- Certification Body Geosynthetics

DAkkS Deutsche Akkreditierungsstelle
D-PL-11239-01-00
D-ZE-11239-02-00
D-ZE-11239-03-00

CE 0516

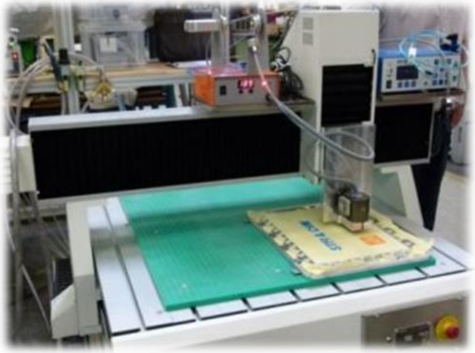
Transfer Center

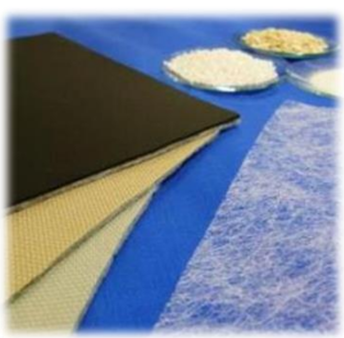
- Communication and process management
- International cooperation

Innovation Center of Technical Textiles

Finishing / Coating / Laminating and Ecology

- Textile functionalization by finishing, coating, printing
- Yarn finishing and coating
- Composites from textile and non-textile materials
- Hotmelt technology; compounding and coating
- Ecology and environmental protection
- Chemical analysis





RESET – 3rd Thematic Seminar

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“New Sustainable Chemistry, Including Reduction of Chemical Substances”

Presentation of Good Practice (GP)

Biological exhaust air purification in textile finishing – pilot plant for biological elimination of cyanide

Marco Sallat / Anna Große
(Saxon Textile Research Institute)

Marco Sallat
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Bucharest, 4th April 2017

European Union
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Biological exhaust air purification in textile finishing

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Background for the implementation of the GP

State of the art – exhaust air in textile finishing

Most important sources of exhaust air in textile finishing:

- Singeing
- Fixing
- Drying
- Printing
- Chemical treatment
- Mechanical finishing
- Coating, laminating

www.textil.monforts.de

Air contaminations originating from fibres, performance chemicals, fuels

Biological exhaust air purification in textile finishing

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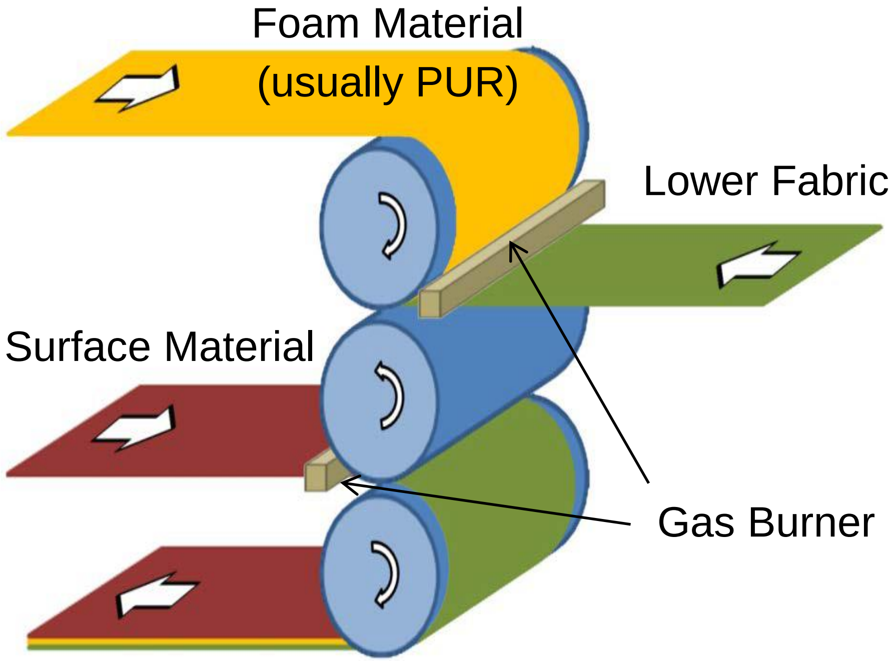
Background for the implementation of the GP

State of the art – flame lamination



- **Composition of the exhaust gases varies extremely:**
  e.g. nitriles, ethers, diisocyanates, aldehydes, halogenated hydrocarbons (CFCs), amines, chlorinated phosphoric acid esters and benzene and 1,2-dichloroethane can be present
- Special attention is given to the **highly toxic hydrogen cyanide** (HCN) which is released during the processing of **polyurethane foams**.

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

State of the art – flame lamination

- Products: broad application field → seat covers, automotive interiors
- Well-developed and simple technology
- Elegant procedure → uses functional compound (foam) as an adhesive, no additional adhesives necessary
- High production speeds possible → up to 4 times faster than the hotmelt process
- Easy and quick material change possible
- Low tendency to undesirable surface effects (e. g. Moiré-effect, orange-peel-effect)
- Cheap method

→ High demand for flame-laminated products

SOLUTION OF EXHAUST AIR PROBLEM NECESSARY!

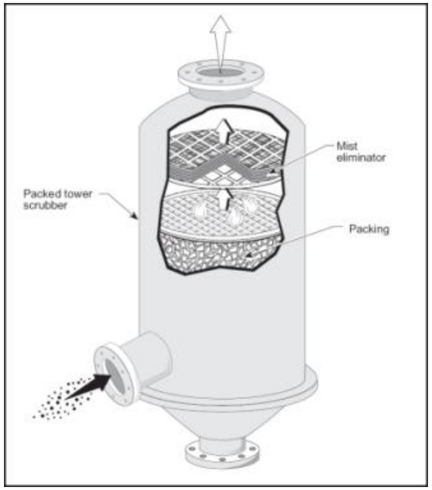
Biological exhaust air purification in textile finishing

Background for the implementation of the GP

State of the art – exhaust air purification in textile finishing

Currently various methods are known for cleaning exhaust air containing cyanide:

- ***Thermal treatment*** (co-incineration)
- ***Oxidation*** in the low temperature plasma
- ***Catalytic detoxification*** using Cu-doped activated carbon
- ***Absorption of HCN*** in alkaline medium (e.g. NaOH) and subsequent chemical detoxification via oxidation (with hypochlorite or hydrogen peroxide) to cyanates
- ***Biological treatment*** (biofilter, bio trickling filter)

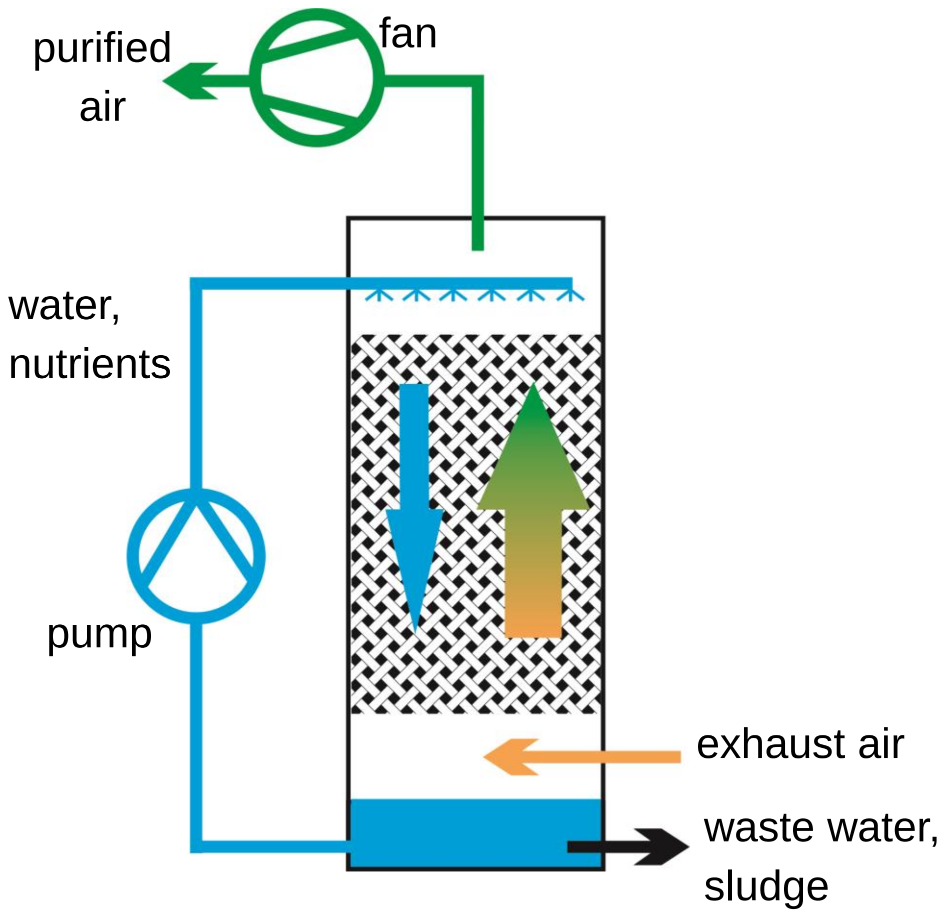


https://en.wikipedia.org/wiki/Wet_scrubber

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

General principle of exhaust air purification by a biological trickling filter



Biological trickling filter

- (harmful) substances need to be water-soluble
- gaseous substances are dissolved in water by scrubbing
- the water trickles over an (inert) packed bed; dissolved substances are utilised by immobilised microorganisms
- nutrient supply by exhaust air and trickling water

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

General principle of biological elimination of cyanide

- Bacterial strain "***KS-7D*** " isolated by scientists of the Fraunhofer Institute for Interfacial Engineering and Biotechnology (Fraunhofer IGB)
- Mixed culture of ***Cupriavidus basilensis*** and ***Cupriavidus eutrophus*** from the Burkholderiaceae family
- Degradation occurs by ***cleaving cyanide*** by the enzyme cyanide hydrolase and producing ammonia and formic acid
- Isolated strains are able to use both products as nitrogen or carbon source
- Mixed culture is very ***tolerant to cyanide*** and can withstand concentrations up to 1.4 g cyanide / liter (55 mM).

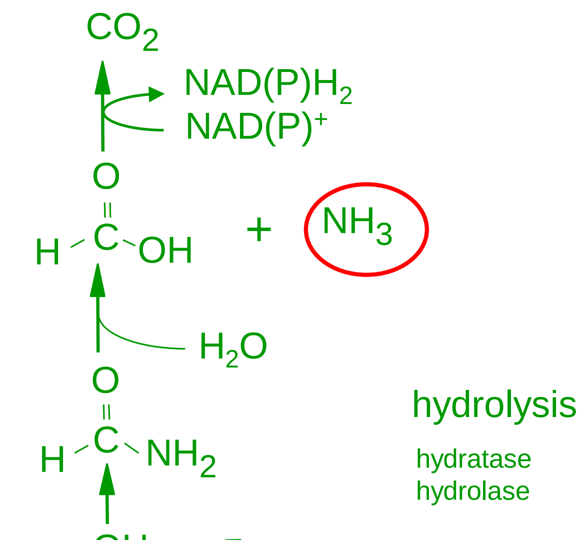
Biological exhaust air purification in textile finishing

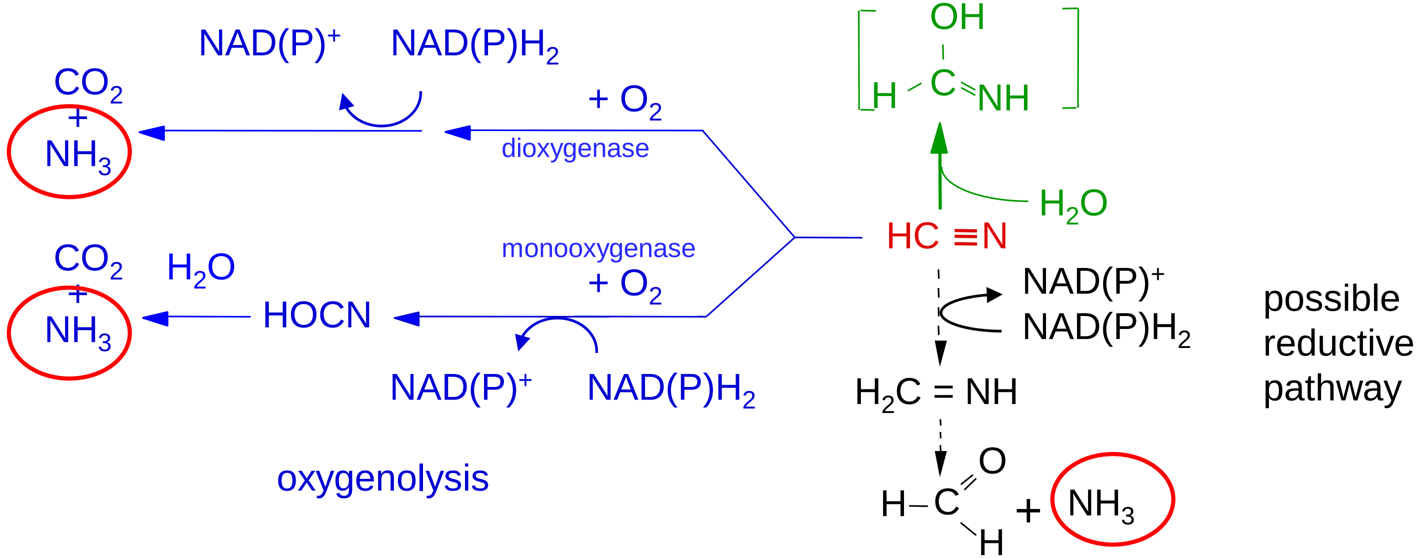
Background for the implementation of the GP

General principle of biological elimination of cyanide

source:
Bryniok, D., 2004. Biologischer Abbau von Cyanid und komplexen Cyanidverbindungen. Internetveröffentlichung, http://www.igb.fraunhofer.de/WWW/GF/Bioremediation/dt/GFBU_24_Cyanid.dt.html

HCN = nitrogen source





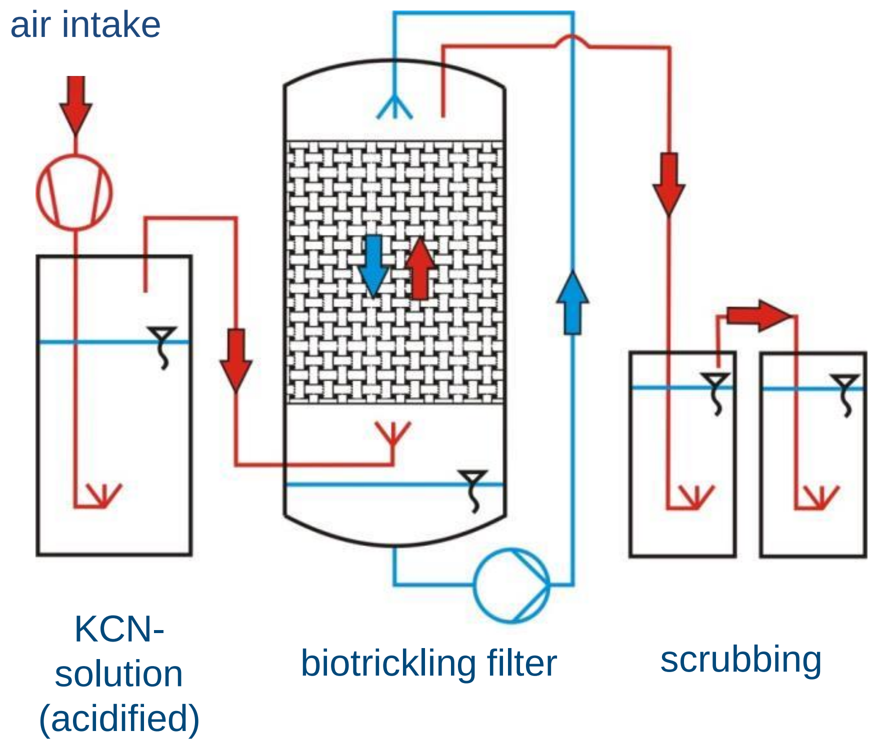
Biological exhaust air purification in textile finishing

Background for the implementation of the GP

General principle of biological elimination of cyanide

Process development

Lab Scale



Background for the implementation of the GP

General principle of biological elimination of cyanide

Process development

Pilot Scale

1 m³ packed bed reactors

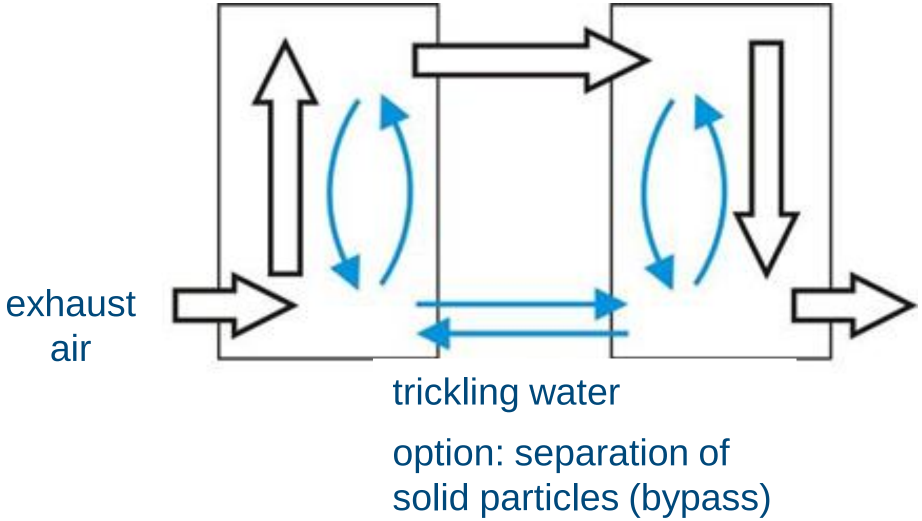
- various packing materials
- various flow and trickling conditions

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

General principle of biological elimination of cyanide

Process development
Large scale



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Background for the implementation of the GP
Legal framework

"First General Administrative Directive for the Federal Immission Control Act" of the German Federal Government
("***TA Luft***" - Technical Instructions on Air Quality Control)

- Specifies ***legal requirements*** for plants which need an approval for operation
- Sets ***limit values*** and specifies ***calculation rules for air pollutants*** (gases, dust, carcinogenic/mutagenic/reproductive toxic substances, odour, soil contaminating substances)
- Exists since 1986
- Revised in 2002: new ***limit value*** for hydrogen cyanide ***3 mg/m³ or 15 g/h*** (formerly: 5 mg/m³ or 50 g/h)
- Transition ended in ***2007***: limit values must not be exceeded
- Second revision planned in 2017 (e.g. new limits for dust and formaldehyde)

Biological exhaust air purification in textile finishing

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Background for the implementation of the GP

Advantages of biological exhaust air purification

- ***No use of hazardous substances*** such as acids, alkalis, oxidising or reducing agents
- ***Performed at ambient temperatures*;** additional power supply is only needed for sprinkling and, if necessary, for anti-freeze protection (heating)
- ***Real (biological) degradation of hydrogen cyanide*** (no transformation into other problematic substances or transfer of the problem into waste water)

→ ***Sustainable and low energy consuming process***

- ***Plant operation is robust*** against (sticky) dusts and accompanying gaseous emissions; dusts are separated by the air scrubbing and can be disposed together with the resulting excess biomass
- ***Low maintenance*** (1-2 services per year at 24/7 operation)

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

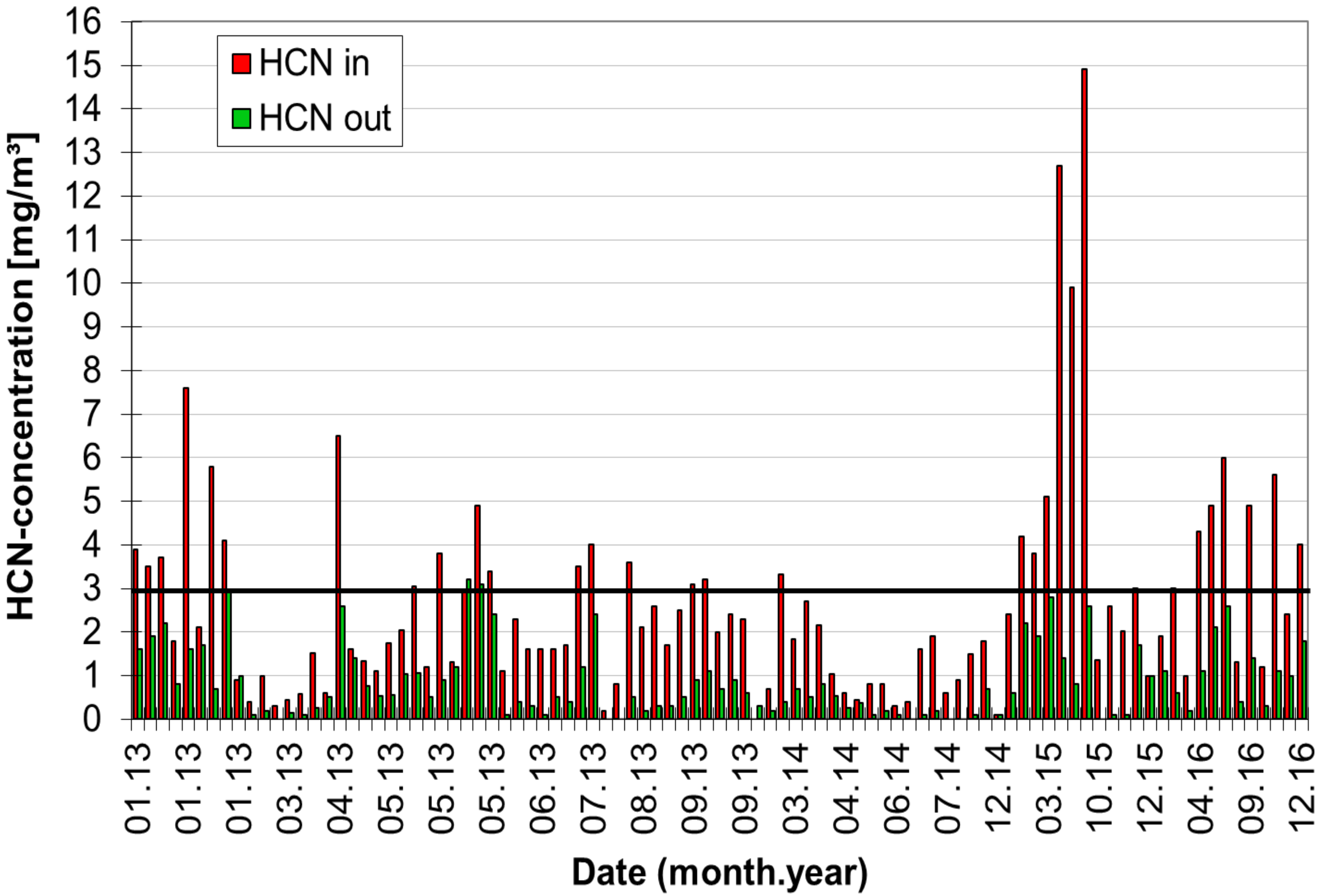
Evidence of success

- Operation since 2009
- ***Reliable purification*** of exhaust air from flame lamination processes
- ***National emission limits*** for hydrogen cyanide in the exhaust air are exceeded only in a few cases.
- Estimating 8.400 operating hours per year, emissions of approx. ***200 kg of hydrogen cyanide*** and ***125 kg of dust*** can be ***avoided*** per year.

Biological exhaust air purification in textile finishing

Background for the implementation of the GP

Evidence of success



Biological exhaust air purification in textile finishing

Transferability of GP - Success factors

- GP is ***transferable to other regions*** assumed that the requested investment for machinery is available
- Both the design and the construction of the biological trickling filters need to be ***adapted to the local conditions*** (ambient temperature, air humidity, etc.) and ***to the specific flame lamination plant parameters*** (volume flows, air temperatures).
- HCN elimination grades vary between 60 an 80 %.
  → Applicability of GP in EU depends on ***legal requirements of each member*** regarding the cyanide values in exhaust air (e.g. Germany: 3 mg/m³ ←→ Italy 0,5 mg/m³).
- Development of ***sustainable processes***
- High ***economic efficiency***
- Technical solutions are also ***transferable to other industrial sectors*** (e.g. electroplating: detoxification of cyanide-containing sewage)

Biological exhaust air purification in textile finishing

Effect on “New Sustainable Chemistry, Including Reduction of Chemical Substances”

Biological cyanide elimination is ***resource efficient*** and ***low energy consuming***:

- Process works without any additional harmful chemical substances like acids, bases, organic solvents or toxins.
- Harmful substance (HCN) is eliminated by (natural) biological degradation processes.
  → reputation as an ecological technology
- The energy supply is restricted to electrical power for pumps and, if necessary, heating devices (anti-freeze protection).
- Low maintenance effort and costs (1-2 main services per year)

→ Provides companies with flame lamination plants the possibility ***to comply with legal requirements*** regarding the cyanide content in exhaust air.

Biological exhaust air purification in textile finishing

Good Practice value added at regional and transregional (EU) levels

- SMEs: Gaining ***expertise in a specialized technological field*** (that is not processed by “global players”)
- Establishing ***innovative*** and ***environmental-friendly technologies***
- ***Protection of environment*** (quality of life ↗)
- Textile industry: ***saving*** of both ***jobs*** and ***regional production sites*** (short delivery times and ways)
- ***Transferability*** of Good Practice to other (European) regions and to other industrial sectors (e.g. electroplating: waste water treatment)

Biological exhaust air purification in textile finishing

GP Contact

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Thank you!

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