LAYMAN'S REPORT

LIFE DeNTreat

Decentralized innovative treatment of ammonium-rich urban wastewater

LIFE16 ENV/IT/000345
LIFE Environment and Resource Efficiency
Project Co-funded by the European Commission
Project Start Date: 1 July 2017

DIGITAL TEXTILE PRINTING AND N-RICH WASTEWATER

In the last ten years Digital Textile Printing (DTP) technologies have been revolutionizing the way textiles are printed, moving from large batches of standardized drawings to one square meter large' lots, where every piece of the textile substrate may have different patterns and colours than the next one. Nowadays, in some European textile districts, DTP acquired more than 50% of the market. Considering the (most advanced) district of Como (Italy), 58% of the printed textiles are now manufactured using DTP. Even if economically (and, partially) environmentally better performing than traditional textile printing, for technical reasons DTP is responsible of an **increase of more than 200% of nitrogen content in wastewater**, resulting in a doubled sludge volume, doubled quantity of carbonaceous substrate and polyelectrolyte. In fact, DTP requires other pre-treatment operations in addition to traditional preparation treatments, as a result of the different physical characteristics of the inks used compared to traditional printing pastes. DTP systems use low-viscous inks to attain high jetting frequency from small nozzles. This implies that some ingredients of the traditional printing pastes have to be put over the fabric before printing. In particular: urea, the ink fixer compound. Actually, DTP is thus a `two-phases' printing as opposed to the `all-in' approach of conventional printing: in the latter case, all the dyes, chemicals and thickeners required are included in the printing paste, whereas in the former some ingredients (urea) are applied in a new pre-treatment process. The problem is that such a pre-treatment requires the impregnation of 100% of the to-be-printed fabric (while in traditional printing technologies, just the areas covered with the ink are actually treated with urea). This drastically increases the amount of urea used per unit of fabric. Urea is then (completely) washed out after printing and results as a pollutant in the company wastewater. Major European textile districts are thus experiencing a drastic increase in the nitrogen content of their wastewater

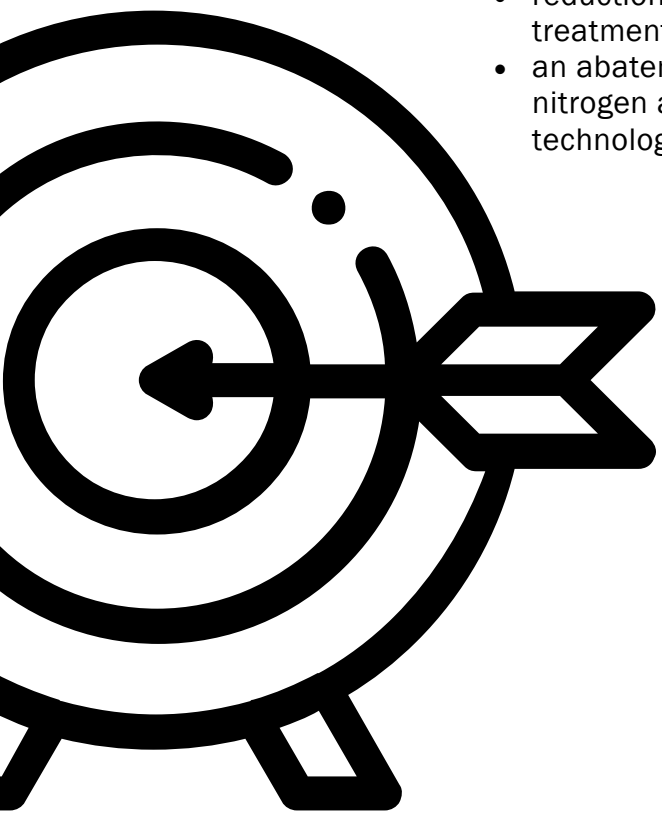
LIFE DeNTreat GOALS

LIFE DeNTreat will sustainably abate the N content from polluting sources resulting in:

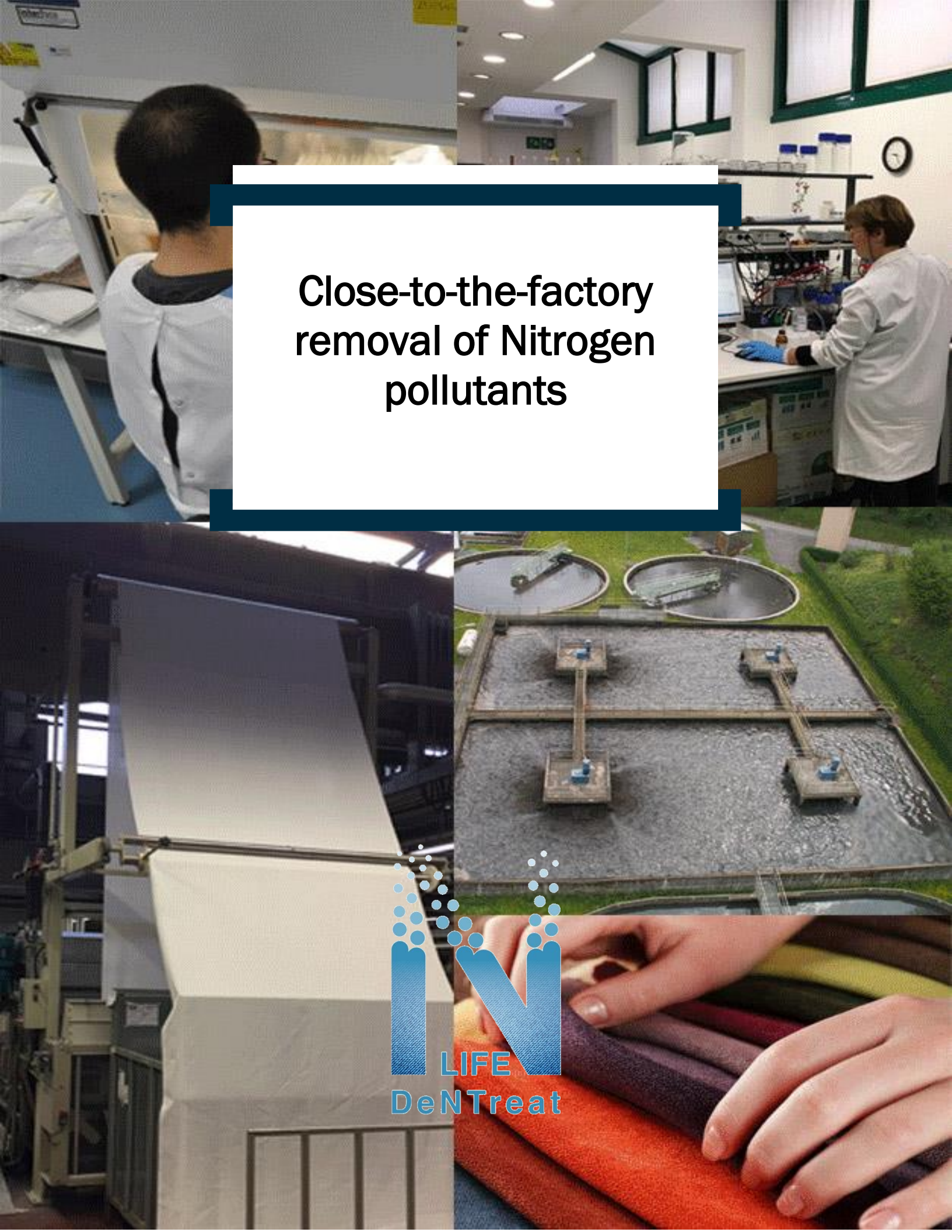
- a residual N content below 100 mg/l in the wastewater released in the collection system
- accomplishing Directive 91/271/EEC art.5 requirements asking to ensure that the minimum percentage of reduction of the overall load entering all urban WWTP in a given area is at least 75% for total nitrogen produced
- respect of residual nitrogen concentration in WWTP discharges, to be maintained below 10 mg/l

With the following impacts:

- pollutants removed close to the factory where they have been produced
- actual savings in nitrogen removal costs
- reduction of the GHG emissions during biological wastewater treatment than of the currently adopted technologies
- an abatement of the sludge produced as a result of the nitrogen abatement process than of the currently adopted technologies.



Close-to-the-factory removal of Nitrogen pollutants



LIFE DeNTreat

The DEMONSTRATION Plant

The central output of the LIFE DeNTreat project is a pre-industrial wastewater treatment Demonstration plant based on a partial nitrification / anammox bioreactor, demonstrated in a representative operational environment processing 40 m^3/day of wastewater

NOT TREATED WASTEWATER
The wastewater treated by the pilot plant comes from the equalization tank already existing end-of-pipe of the company discharges and is pre-treated through a basket filter to prevent the entry of any threads into the storage tank.

FEEDING TANK
The tank is used to store and homogenize the wastewater to be treated, through a dedicated recirculation pump, and to regulate the temperature. This parameter is kept in the range 35°-38°C thanks to a cooling/heating system, consisting of a coil fed with service water for cooling, and a steam jet for heating.

SBR
In the reactor the contact between wastewater and bacterial granules takes place. Being a batch-type process, it is structured in phases, whose complete cycles consist of loading, reaction, sedimentation, unloading and stand-by. The tank has a recirculation system for in-line measurement of chemical parameters and a nitrogen gas recirculation system for mixing. The tank is equipped with electric tracing and insulation to maintain the temperature, and with pressure, level and temperature gauges.

GASOMETER
The gasometer is connected to the reactor by the nitrogen recirculation and is used as a volumetric compensation of the gas phase. It is equipped with a fan and a hydraulic guard to maintain the pressure in the reactor between 20 and 25 mbar.

ON-LINE ANALYSIS
The chemical parameters are continuously monitored thanks to in-line measurements given by pH, dissolved oxygen, RedOx, ammonia and nitrates probes installed on reactor recirculation.

REAGENTS
In the reactor recirculation system, reagent dosing points for pH and foam control are installed. In the feeding tank there is a phosphoric acid dosing point to satisfy the phosphorus request.

SAMPLING
During the loading and unloading phases, the wastewater is sampled in order to carry out further analyses of the chemical parameters in the laboratory.

TREATED WASTEWATER
The treated wastewater is discharged into two tanks arranged in sequence whose function is to avoid the accidental uncontrolled loss of biological sludge.

PLC
The plant is equipped with automation and remote-control system

General design data
Design flow rate: 40 m^3/d
Operating flow rate: 10 – 40 m^3/d
Influent concentration: 130 – 260 mgN_{tot}/l; avg ± st. dev.: 176 ± 44
Target effluent concentration: < 50 mgN_{tot}/l (5%-ile = 100 mgN/l); < 0,6 $mgN\text{-}NO_2/l$.

Application study

The processed wastewater comes from a company that prints fabrics mainly with DTP. The prevalence of DTP leads to a decrease in the COD/N ratio and to a substantial increase in the nitrogen load discharged to the public sewer. At present, the concentration of nitrogen in the wastewater is higher than the regulatory limit of 100 mgN/l and the company obtained a specific derogation to be allowed to continue with their activity.
The company only provides a partial equalization of the volumes discharged by all production processes but does not provide any specific treatment.
The nitrogen that is discharged into the equalization tank is mainly in organic form, resulting from the use of urea, which is partially decomposed into ammoniacal nitrogen, by ureolysis that occurs spontaneously in the tank. In 2018, at the start of the Project, the COD/ TKN ratio, was 6.4 but over time it decreased down to 4.7 gCOD/gTKN favouring the PN/Anammox process over the conventional nitro-denitro process. Another characteristic of the wastewater is that it has a rather low alkalinity, in spite of a high pH, around 8.5-9.3, which may lead to a scarcity of inorganic carbon, which is essential for the growth of autotrophic organisms. For some processes, the company uses quaternary amines and amines, substances recognized in the literature as biocides, which are subsequently found in the wastewater: the direct effects on the Anammox component are not yet known, but they have an inhibiting effect on the AOB organisms.

Plant criticalities

The main critical isues of the plant have been due partly to plant problems and partly to the composition of the wastewater. First of all, it has not been possible to get continuous data of ammonia and nitrate concentration, because the dedicated probes were installed on an external recycle circuit that caused degranulation of the biomass. In addition, these probes could not be installed directly in the reactor, not allowing the automatic control of the oxygen dosage, which had to be managed manually. Another problem at the plant level is due to limitation in the oxygen transfer capacity, which was not sufficient for both nitritation and oxidation of the COD, head during the loading, reaction and unloading cycles. Also, the high variability of the chemical characteristics of the wastewater posed operational problems, mainly due to frequent scarcity of ammonia in input, the presence of inhibitors used in the processes and conditions of low concentration in the feed during shutdown periods.

Implemented solutions

Those issues faced during the experimentation and the implemented resolution strategies led to several important results:

- Suppression of NOB biomass and excellent control on nitrate production: from September 2020, with new biomass inoculated and improved pH and DO control, the average nitrate concentration is 1.6 mg/l, with a peak of 25.7 mg/l. The ratio of NO3-N produced over TKN removed was 0.039±0.01
- The average removal rates of TKN is 166 g/m^3/d and the removal efficiency up to 85%;
- If the ureolysis does not take place in the equalization tank, it was observed to take place without problems in the reactor and the recorded ureolysis rates were as high as 611 g/m^3/d
- The granular biomass did not degranulate, despite all the issues encountered, and thanks to the washout of flocculent biomass
- The COD removed inside the reactor was on average 260 mg/l, analysed on the filtered sample, with an average inlet concentration of 692 mg/l.

Conclusions

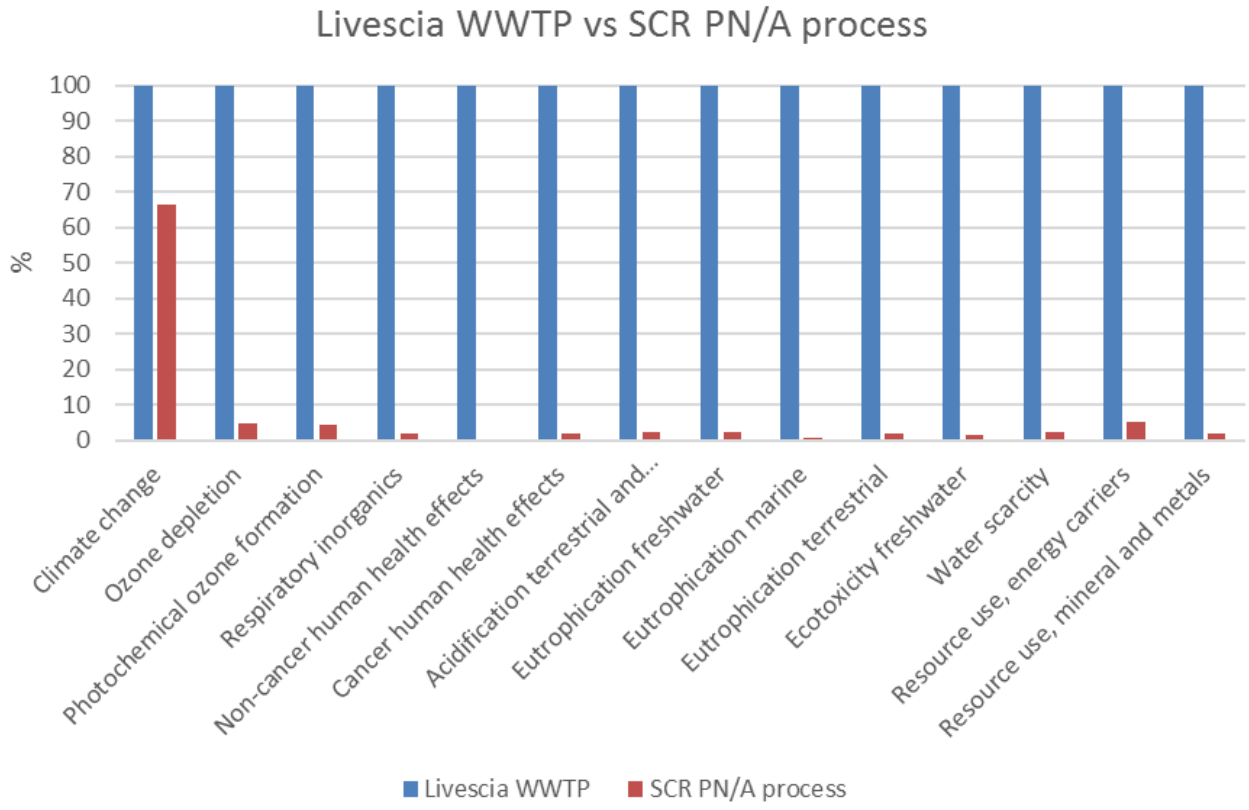
Thanks to the experimentation it is possible to state that the wastewater is treatable with the PN/Anammox process. Its severe variations in the chemical-physical and toxicological characteristics determine a difficult operational stability, which requires a precise and careful process control. The project made it possible to identify all the countermeasures to all the critical issues.

Environmental benefits

For environmental impacts assessment, an LCA-based approach was adopted following the ISO/EN 14040 standard and using SimaPro 9.0. Data gathered from the Demonstrator and from lab-scale studies are compared with impacts of a traditional wastewater treatment plant. Main results on inventory and impacts and are included in the table and chart below.

	TRADITIONAL WWTP	PN/ANAMMOX PROCESS	% VARIATION
Sludge production (kgSS/kgN removed)	1.1*	0.15***	-86.4
Substrate usage (kg pure glycerol/kgN removed)	2.6*	0****	-100.0
Electricity consumption (kWh/kgN removed)	14.82*	1.50***	-89.9
GHC emission (kg CO_2/ kgN removed)	15**	9.93**	-33.8

* Raw data obtained from Livescia WWTP
** Data from LCA and N_2O monitoring campaign
*** Estimated from literature
**** From the pilot plant



Project Legacies

At the end of the project, the tools available to make easy the transferability of technology to the field are:

- the experience gained with the SCR case study
- the "**if – then schema**" as a logical process to evaluate the treatability of wastewater intended for prospective adopters
- the "**Hardware Development Kit**" supporting the replicability of the project
- a procedure for testing Anammox biomass activity on specific wastewater
- a **lab-scale pilot** for testing wastewater samples and providing a reliable feasibility feedback
- the **demo plant** that can be installed from time to time in companies interested in adopting the new process after the end of the project
- scale-up **designs** to shorten the manufacturing of new industrial-scale plants.

LARIANA DEPUR SPA

coordinator

At the beginning of the '70s in order to face water pollution, local public Authorities and the Como Industrial Association signed an agreement for the construction and the managements of the wastewater system. Several companies, as Lariana Depur, were founded for this scope. Now Lariana Depur SpA is a private company of 146 firms (99% of shares) located in the textile district of Como, most of which are textile dyeing and printing factories, with a minor public participation. Their relation to the textile companies enables Lariana Depur to mutually seek for economically sound environmental solutions. The company is responsible for the construction and management of two wastewater treatment plants treating domestic and industrial wastewater (60%) with a total capacity of 30,000 m3/day and it carries out also consulting and design activities related to the upgrading of the centralised wastewater treatment plants, studies and experimental investigations of new wastewater treatments, surveys and feasibility studies aimed at minimising emissions from textile industries. Lariana Depur works on the basis of an integrated management system in accordance to ISO 9001:2015, ISO 14001:2015, ISO 50001:2011 and OHSAS 18001:2007. The company has participated in national and international projects, and it has stable cooperation with the Polytechnic of Milan and Italian research centres (Enea, IRSA-CNR). Lariana Depur participated in the research project "TOWEF0 – Towards Effluent Zero Project (Contract n° EVK1-CT-2000-00063) supported by the European Commission under the Fifth Framework Programme. Throughout CIDA, an engineering company owned by Lariana Depur, coordinated the EU RTD project "INTEGRATEX – Integrated water recycling and emission abatement in the textile industry" (Contract ENV4950064, 1996-1999, IV EU FP – ENV 2C) and participated in the LIFE Project "BATTLE – Best Available Technique for water reuse in TextiLE SMEs" (Number LIFE05 ENV/IT/000846).

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CITEVE – Centro Tecnológico Industrias Têxtil Vestuário

partner

CITEVE is the Technological Centre for the Portuguese Textile and Clothing Industry, created in 1989, as a private non-profit organization with around 600 associate companies and more than 2000 active customers. Its mission is to support the technical and technological development of the textile & clothing industry, promoting innovation and inducing new capacities and new competences as well as helping on the definition of industrial public policies. CITEVE offers technological services in different areas: laboratorial activities, technological consultancy & development, R&D + Innovation, technology Watch, product standards and certification, training and fashion intelligence. At consulting and technological development item, its services includes the sustainable production area, integrating services and expertise in LCA, environmental technologies, water and energy management, circular economy, health and safety and quality management, wastewater characterization and treatment. This knowledge is based in a specific Department, which is also responsible for the STEP© (Sustainable Textile Production Certification), Green Textiles Initiative© and the Green Target Methodology©. The R&D and innovation is one of the major strategic lines of CITEVE and in the last two decades CITEVE has taken part in more than 100 R&D projects involving more than 200 companies (Portuguese and European). The development of CITEVE in the field of applied research and technology transfer is also strengthen by its active participation in several networks, such as: The European Technology Platform For The Future of Textiles and Clothing; Textranet or Oeko-Tex® Association. With a very close relation with companies and a high-level knowledge of the sector performance and reality, CITEVE plays an important role in the definition and implementation of public policy, through a close cooperation of national public governmental organizations.

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POLITECNICO DI MILANO

partner

The Laboratory of Environmental Engineering Section dates back to 1958 and includes three sections: sampling of environmental matrixes (air, water, and soil, as well as wastewater, gaseous emissions and wastes), analysis (preparatory, analytical and instrumental chemistry, and biology) and – the pilot plant sector, with equipment for testing the treatability of wastewater and wastes, instrumented lab- and pilot-scale bioreactors. Pilot plants are also located at full-scale plants outside the University campus. The laboratory takes part in inter-calibration activities at both national and international levels and to the development of analytical methods in ISO and UNICHIM working groups. The laboratory has developed the super-site for fine and ultra-fine atmospheric particulate (located at the Laboratory for Energy and the Environment in Piacenza) and the Laboratory of the Energy Factory, located in Cremona, which is specialized in anaerobic digestion of different organic substrates. The research group on "Water and Wastewater Treatment Technology" at the Environmental Section of Department DICA promotes research and development for advanced waste water treatment and technologies and has its core activity in translational research due to close relationships between POLIMI and industrial partners of the University.

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EURATEX

partner

EURATEX is the European Apparel and Textile Confederation representing the interests of the European textile and clothing industry at the level of the EU institutions. As the voice of the European industry, EURATEX aims to create favorable environment within the European Union for manufacturing of textile and clothing products. Textile and apparel manufacturing is an essential pillar of local economy across the EU regions. EURATEX' member federations represent in the EU some 177.700 companies with a turnover of €171 billion, employing 1.7 million workers. The EU is the world's second biggest exporter of textiles and clothing with 22% and 25% of world sales respectively in 2016. The textile and fashion products made in the EU are exceptional in regards the respect of environment, consumer safety and labour rights.

EURATEX has an ambitious programme to enhance sustainable growth of the European textile and clothing industry.

EURATEX provides the EU institutions with accurate data and useful tools for making the policies that enhance Europe's economic growth and facilitates jobs creation. We are committed to facilitate access of our companies which are predominantly SMEs, to the European actions.

EURATEX is focused on a few clear priorities: genuine industrial policy, research and innovation support, free and fair trade and sustainable production. EURATEX was officially created in 1996 by a merger of three organisations present in Brussels since the early '60s to promote the industry. EURATEX is registered under the European Union 'Transparency Register' – ID number : 7824139202-85

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EURATEX
THE EUROPEAN APPAREL AND TEXTILE CONFEDERATION

STAMPERIA di CASSINA RIZZARDI

partner

Stamperia di Cassina Rizzardi S.p.A. has been working for over 30 years in textile fabrics printing and finishing, with two factories and a current total workforce of 260 people. The two company premises are in Cassina Rizzardi (in the Como silk district), where processing, printing, steaming, washing and finishing operations are carried out, and in Città della Pieve (Perugia) where purification, dyeing, steaming, washing and finishing operations are performed. As for today, the two production sites have a total production area of approximately 35'000 m2. The current daily production capacity is about 110'000 meters for printing and approximately 60'000 meters for dyeing, with an endowment of 25 traditional digital printing machines, two "single pass" digital printing machines, rotary table, rotating table, 52 dyeing machines, 11 rameuses, 1 plasma treatment line, 5 steaming equipment, 2 open-width washing, 2 rope wash, 3 boat wash, 2 automatic color kitchens, 1 sanfor, 2 calenders for transfer / laminating, 1 free steaming, 1 carbon brush, 1 grip, 1 cutters; in addition to control tables, rollers, etc.

Over the past decade, Stamperia di Cassina Rizzardi strongly invested in the emerging Digital Textile Printing technology, improving their offer to the final customers with a sensible reduction of batch sizes, flexibility and shortened lead time. These investments allowed the company to become one of the most important player in this area. Further investments performed in the last years allowed to vertically extend the company offer to pre-print and post-print services (including fabric preparation, steaming, washing and finishing) in order to provide their customers a comprehensive plethora of value-adding treatments they can apply on a wide set of different fibers.

Recently the company management has decided to invest in the so-called "single pass" digital textile printing machines, that allow to further reduce production times by up to 100 times compared to competitor technologies, merely implementing a different concept of color deposition on the fabric. Two of these machines (the "LARIO", MS Printing Solutions) have been adopted and all the production system of Stamperia di Cassina Rizzardi has been adapted.

The company has also invested in the field of energy saving and energy consumption optimization by installing two photovoltaic plants, one for each plant, and a gas-fired cogeneration plant at the Cassina Rizzardi plant. These plants have a nominal total power of about 2'400 kW

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WHAT IS THE PROBLEM?

Digital textile printing (DTP) has recently become a widely used printing technology in many European textile districts. Although it brings certain environmental advantages, DTP requires dipping the entire fabric in urea, which is then completely washed out after printing and ends up as **nitrogen residue in wastewaters**.

Certain European textile districts experience nitrogen-rich wastewater in concentrations not efficiently supported by the local wastewater treatment plants.

HOW CAN DENTREAT ADDRESS THE PROBLEM?

Life DeNTreat technology aims at reducing the amount of nitrogen content in urban wastewater in a **sustainable and cost-efficient** way using an on-site wastewater treatment module based on the **anammox** microbial process.

WHAT ARE THE BENEFITS OF DENTREAT TECHNOLOGY?

Saving of up to 40% in investment and operational **costs**

Reducing nitrogen content below 100 mg/L in the processed wastewater

Maintaining **residual nitrogen concentration** in wastewater treatment plants **below 10 mg/L**

Abatement of the sludge produced to less than 25%

For more information visit
www.life-dentreat.eu

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