Best available technique for water reuse in textile SMEs (BATTLE LIFE Project)

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Abstract

The textile sector has a high water demand. Its biggest impact on the environment is related to primary water consumption (80–100 m\textsuperscript{3}/ton of finished textile) and wastewater discharge (115–175 kg of COD/ton of finished textile, a large range of organic chemicals, low biodegradability, colour, salinity). Therefore, reuse of the effluents represents an economical and ecological challenge for the overall sector. A user-friendly technique to improve the environmental performances of textile finishing enterprises is pursued with the BATTLE project presented in this paper.

Keywords: Water reuse; Textile industry; Wastewater treatment; Membrane technology

1. Introduction

According to the IPPC Directive 96/91/CE, the textile BREF (Best available techniques REference document) is addressed to all companies having an average production over the threshold of 10 tons/day. Also SMEs are interested in the BREF recommendations since the document is meant to become a guideline for the whole sector.

The textile BREF contains several BATs (Best Available Techniques) to prevent pollution and reduce the impact in the production processes but only general advice on wastewater treatment and reuse. Water recycling is not exhaustively considered, and available techniques for the purpose are not provided.

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The typical textile SME today does not implement water reuse, while fresh high quality water is used in all the production processes. Furthermore, the process effluents are mixed and discharged after on-site or centralised treatment in conventional Waste Water Treatment Plants (WWTPs).

2. Project objectives

In the context described, LIFE funded project BATTLE (05 ENV/IT/000846) aims at overcoming the obstacles for full implementation of the IPPC Directive, demonstrating the technical–economical feasibility of a water recycling technique, viable for the overall sector. Specific targets are therefore:

- Applicability evaluation of the BATs from the SMEs of the textile finishing sector, as reported in the BREF elaborated by the IPPC bureau;
- Development of prototype application of a clean technology for water reuse, to be proposed as reference BAT for SMEs as well as for large enterprises;
- Raising awareness on benefits and opportunities resulting from the implementation of the new BAT for the European SMEs and decision makers of textile and side sectors.

3. Project description

A preliminary screening step of the textile BREF document for the analysis of the BATs therein reported is carried out in order to evaluate their actual application in large companies and their possible applicability in SMEs. The survey is performed through a questionnaire specifically conceived to gain general information on the sector best practices. The questionnaire is sent to target companies requiring them to provide general data on their management and specific application status/applicability of described measures in their production site. Beside the data collection, further interviews and site visits will allow for a clear picture of European textile sector attitude implementing the BATs. A draft of BAT for water reuse feasible also for SMEs implementation will be formulated.

A complete characterization of the SME Stamperia di Martinengo, partner in the BATTLE Project Consortium, will be carried out by an auditing procedure referred to as PIDACS (Process Identification and DAta Collection Sheet) providing a detailed report on the company and the identification of the main processes and their environmental impact.

The characterization will be completed by the real effluent sample collection and analytical screening (flow rate, temperature, pH, conductivity, organic matter, colour, turbidity, suspended solids, alkalinity, hardness and further parameters significant for the specific effluents).

On laboratory and pilot scale, single effluents treatability will be evaluated and therefore the reusability after on-site treatment will be assessed. Evaluation of parameters will allow the definitive selection of the optimal treatment scheme on a cost/benefit basis. Change in composition of final effluents and its effect on the functioning of the final treatment facility will be assessed as well.

The new BAT for low impact water management in textile industry proposed by BATTLE designs an innovative water scheme implementing effluent reuse: it applies a methodology which integrates the different aspects involved in reuse (data collection, on-line characterization, streams segregation, final effluent treatability evaluation and impact control, reclaimed water reusability evaluation, cost analysis), based on the prototypical multicriteria methodology built up within the EU funded RTD project TOWEF0 (Toward effluents Zero – EVK1-CT-2000-00063).

A start of pipe effluent treatment and reuse scheme is provided following the layout reported
in Fig. 1. The process effluents with suitable characteristics (E1...E4) from different production processes (M1...M4), are mixed and the resulting stream (E5) is diverted to a treatment station for subsequent reuse (W4), after mixing with the required amount of primary water (W2). The effluents not suitable for reuse (D1), mixed with the concentrates produced by the membrane plant (D5, D6), will constitute the inlet of the existing WWTP whose operation needs to be verified, monitored, and, in case, adapted to the treatment of smaller volumes of more concentrated effluents. Specific membrane treatment and reuse facilities (firstly a UF + NF scheme, but suitable alternatives are under investigation) will be designed specifically for the partner company for on-site treatment and recovery of suitable process effluents.

A treatment demonstration plant (about 500 m$^3$/day of wastewater treated) will be built according to the final design, employing commercially available membranes or equivalent. The extreme variability of the production processes in a textile SME, and consequently in its effluents, requires implementation of on-line control. For this purpose, a prototype Expert System (ES) will be developed and programmed.

The ES, fed by a continuous on-line analytical control (e.g., TOC, colour, conductivity and flow-rate) on the different process effluents, will perform the selection of the most suitable effluent streams for the next treatment and the reuse. The
ES will communicate with the plant through sensors and devices for on-line monitoring, and it will be programmed during the start-up phase to be able to adapt to different production conditions, allowing a reliable automatic mode of operation of the prototype plant. It will also indicate how much fresh water has to be mixed with the permeate, with the purpose of water reuse maximisation not hindering the production quality standards.

Feasibility and efficiency of the BAT will be shown by its demonstration application in the partner company Stamperia di Martinengo, as a case study and first enduser of the proposed technique. In Fig. 2 the effluent treatment scheme of Stamperia di Martinengo is reported. No reuse of water is actually implemented; therefore, all production processes are supplied with primary water, in some cases pre-treated by softening.

Steam is produced continuously from demineralised water to be used in the steamers. Six rotative printing machines (R1...R6), using the most common dyes (reactive, disperse, acid, indanthrene) and pigments, produce a continuous effluent discharge due to printing carpet washing and a batch stream due to the final washing operations of the equipment.

Two washing lines (W1–W2) for continuous rope washing are used for printed fabrics washing. They produce a continuous effluent discharge during operations and a batch stream due to the equipment washing. Continuous dyeing equipment discharges the exhausted dyeing baths after each dyeing cycle.

Hand printing for preliminary check of the printing results generates only small amounts of wastewater used for cleaning operations. Discharged effluents are collected in two
separated storage tanks and mixed together before final treatment and discharge.

With the new BAT application, a water treatment and reuse scenario appear as in Fig. 3. Once functioning tests and security check are completed, the new plant will be started up in a semi-automatic mode in order to allow a full scale completion of the ES instruction, and finally it will operate for a sufficient time (at least 4 months) in a fully automated operation system.

The proposed BAT will be evaluated through its prototype. On the basis of the results of the above actions, a handbook will be released with guidelines on the water reuse in the textile sector. Arrangement of on-site visits to the demonstration plant and info-days will help the dissemination of information on the project activities and its results.

4. Expected results
- “BREF type” guidelines for optimisation of water cycle in textile SMEs and further submission to the IPPC bureau.
- Handbook of the proposed BAT.
- A saving of at least 50% of fresh water by substitution with reclaimed effluents is expected. To reach the standards for reuse, which will be determined by production requirements, the treatment system performance is expected to comply with the following targets 80–90% removal of total organic matter, 99% for total suspended solids 95–98% for colour and 80% for surfactants.
- Sensitization of at least a hundred European companies in view of implementation of the technique in their factories.
5. BATTLE’s Life Project

Project beneficiary:

- **ENEA**, the Italian National Agency for Energy, New Technology and the Environment. ENEA is a public research organisation whose specific mission is in applied research activities, technology transfer and dissemination of innovations to companies thanks to its expertise in new technologies, energy and the environment.

Partners:

- **ANOVA s.a.s.**, Napoli, Italy. ANOVA — Knowledge Based Software Solutions is a private R&D Laboratory, operating in knowledge engineering and artificial intelligence, software applications in environmental and agro-industrial fields.

- **CENTEXBEL** (Wetenschappelijk en technisch Centrum van de Belgische Textielen), Brussels, Belgium: The Scientific and Technical Centre of the Belgian Textile Industry Centexbel is a non-profit organisation with a private structure. Centexbel supports finishing companies in Belgium to optimise their water management.

- **CENTRO IMPRESE DEPURAZIONE ACQUE S.p.A.**, Fino Mornasco (Como) Italy: CIDA is a private consulting company for the textile sector waste minimisation, design, upgrading of the centralised wastewater treatment plants, restructuring of the industrial aqueduct, upgrading sludge treatment and disposal plants, studies and experimental investigation of advanced tertiary wastewater treatments and polishing treatments for water reuse, water service (plants and networks) management of the Como area.

- **Stamperia di Martinengo s.r.l.**, Martinengo (Bergamo), Italy: SdM is a medium-sized textile printing and dyeing company, treating around 10,000 metres of textiles per year and employing 140 workers. In its production, SdM treats the main types of fibres and dyes of the textile sector.

- **Università degli Studi di Firenze, Dipartimento di Ingegneria Civile**, Florence, Italy: The Department carries out academic and research activities in the field of civil and environmental engineering in ten specialized laboratories.