

## ECO-FRIENDLY SOLUTIONS FOR POLLUTION PREVENTION AND TEXTILE WASTEWATER TREATMENT

FLOAREA PRICOP<sup>1</sup>, IOANA CORINA MOGA<sup>2</sup>, ALINA POPESCU<sup>1</sup>

<sup>1</sup> *The National Research and Development Institute for Textiles and Leather (INCDTP), Bucharest str. Lucretiu Patrascanu, no. 16, sector 3, floarea.pricop@certex.ro, alina.popescu@certex.ro*

<sup>2</sup> *SC DFR Systems SRL, Bucharest, Drumul Taberei 46, corinamoga@yahoo.com*

The effluents resulted from the textile finishing generate the following pollution problems for the environment: concentration of pollutants in the discharged wastewater that leads to an increase of the main wastewater quality indicators: pH, matters in suspension, COD, BOD, chloride, sulphide, detergents, nitrogen; pollution of groundwater by a concentration of polluting minerals; pollution of soil in the area where textile and leather companies operate; pollution of natural receptors and the compelling of riverside industries to search for other clean water sources; persistence of dyes that are difficult to degrade in the natural receptors; impact on aquatic flora and fauna; decrease in photosynthesis due to water coloration; pollution of ground waters with dissolved solid substances; increase of alkalinity and of the content of mineral, organic substances and of soluble substances. All these problems can be minimized by adopting preventive measures and by pollution monitoring. Both pollution prevention solutions and new environmental technologies applied in the finishing textile processes are presented in this paper. There have been realized comparative studies between the conventional technologies, ecological technologies of textile finishing and advanced treatment technologies of wastewater. The impact of these technologies on the quality of wastewater has been studied with the demonstration of efficiency, through: decreasing of the amount of indicators, cost cutting of the treatment for each m<sup>3</sup> of water, decreasing of the sludge quantity.

Keywords: pollution prevention, textile finishing, wastewater treatment.

### INTRODUCTION

For the last 20 years, due to globalization and trade liberalization, the European textile sector has undergone changes such as the modernization of production processes refocused towards an increase of productivity, of product quality in line with the market and environmental protection requirements. This tendency has significant importance for Romania if we take into account that an important part of the exported products comes from the textile industry. Thus there is a need to diversify textile activities, to win new markets with ECO labeled competitive products, highly specialized products adapted to the demand, obtained through ecological technologies that do not influence the quality of the environment (Clay, 2004; Rupp, 2008).

In companies on the North Giurgiu Technological and Industrial Park - NGTIP studied the correlations between the main pollutants generated by the technological stages, with influences on the wastewater quality indicators and the methods for treating them in the treatment plants, in order to maintain them within the limits established by national and European norms (Pricop *et al.*, 2013; Pricop, 2016). Pollution prevention can be achieved by various methods, as seen in Figure 1.

The textile materials processing uses a broad variety of chemical substances (detergents, alkali, acids, dyes, surfactants, surfactants etc) that contribute to the significant pollution of the environment. Wastewater from textile finishing raise serious problems related to the quantity of sediments, pH, temperature, color (group of dyes), content of organic substances (fiber particles, fiber materials, surfactants, phosphates, auxiliary chemical products, albumin, carbohydrates etc.), content in inorganic

substances (salts, acids, alkali, chlorine, metals etc.). Due to the diversity of the production structure, the quality of wastewater varies not only from one company to another, but also within the same company.

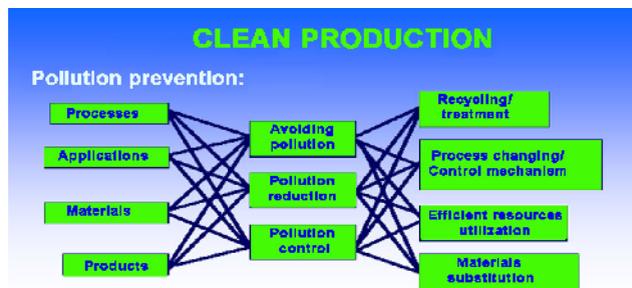


Figure 1. Pollution prevention through the application of clean production concept

## MATERIALS AND METHODS

### Sources of Pollutants in Textile Finishing

Textile finishing can be defined as the multitude of operations (mechanical, chemical and biochemical) that ensure the improvement of textile properties that is their aspect, comfort, durability and functionality. Most of the textile finishing operations can be effected over the entire technological flow on: fiber, sliver, yarn, fabric, knit and garment; however, finishing applied to fabrics or knits is predominant. In a simplified form, a textile finishing technological flow is represented in Figure 2.



Figure 2. Textile finishing technological flow

In companies on the North Giurgiu Technological and Industrial Park - NGTIP the correlation between the main pollutants generated by technological phases was studied with influences over quality indicators of wastewater and the treatment methods in wastewater treatment plants in conformity with National and European Norms.

A correlation between technology stages of textile processing, pollutants and their influence on wastewater quality indicators and treatment methods is presented in Table 1 (Pricop *et al.*, 2013; Pricop, 2016).

Table 1. Correlation between technology stages of textile processing, pollutants and their influence on wastewater quality indicators

| Technology stages generating polluting factors       | Polluting factors and their effect on wastewater   | Influences on wastewater quality indicators  | Methods to remove pollutants   |
|--|--|--|--|
| WARPING  | Dust, fly  | Suspended matter   | -  |
| SIZING   | Sizing products, Starch, Polysaccharides, CMC, APV, Polyacrilates  | COD, BOD, TSS  | physical-chemical treatment, ozonation, biological treatment, filters, membranes                                     |
| PRELIMINARY PREPARATION (Desizing, alkaline boiling) | surfactants, complexing agents, oils, sizing products, fibres, various waxes, mineral or vegetal impurities, enzyme products                       | COD, BOD, TSS, pH  | physical-chemical treatment, ozonation, biological treatment, filters, membranes                                     |
| BLEACHING  | Chlorine or oxygen-based oxidizing agents (chlorite, hydrosulphite, thiosulphite,  | COD, BOD, TSS, pH, sulphites, sulphates, chlorine  | physical-chemical treatment, ozonation, biological treatment, filters, -membranes                                    |
| DYEING   | Wastes of sulfur dyes<br>Wastes of indigosol dyes, Chemical auxiliaries, surfactants, complexing agents, heavy metals, dispersing agents, mordants | pH, color, TSS, metals, salts, temperature, COD, BOD, metals sulphates, sulphites, fixed residue | physical-chemical treatment, ozonation biological treatment, filters, membranes photocatalysis, advanced treatment   |
| ROSS DYEING  | Wastes of sulphur dyes<br>Wastes of indigosol dyes, Chemical auxiliaries, surfactants, complexing agents, heavy metals                             | pH, TSS, metals, salts, temperature, water volume<br>COD, BOD, fixed residue                     | physical-chemical treatment, ozonation biological treatment, filters, membranes photocatalysis, advanced treatment   |
| WASHING/<br>RINSING                                  | Wastes of sulphur dyes<br>Wastes of indigosol dyes, Chemical auxiliaries   | Influence in lower %, COD, BOD, water volume, fixed residue                                      | physical-chemical treatment, ozonation, biological treatment, filters, membranes, photocatalysis, advanced treatment |
| STARCHING  | Starching products (natural and synthetic polymers)  | BOD (biochemical oxygen consumption), COD, TSS   | physical-chemical treatment, ozonation, biological treatment, filters, membranes, photocatalysis, advanced treatment |

## EXPERIMENTAL

The Best Available Techniques (BAT), as well as the emissions associated to these, and/or the consumption level have been evaluated, taking into consideration the following elements: the identification of the elements that are important for the

environment; the analysis of the most relevant general and activity specific techniques; the identification of the best environment performances based on the data that are available at the European and worldwide level; the examining of the conditions in which these performance levels could be obtained; the selection of the BAT techniques at the sector level, depending on the emissions and consumptions associated to these.

Further on, there are briefly presented some technologic possibilities of reducing the impact of the textile finishing over the environment (ecologic technological solutions of preliminarily preparation for cotton textiles, ecological technological solutions of dyeing the cotton textile materials, ecological solutions for final finishing), which can be applied or which have been implemented into the textile enterprises within the companies on the North Giurgiu Technological and Industrial Park – NGTIP.

Desizing the woven fabrics sized with starch with amylolytic enzymes:

- *Ecologic technology of removing the natural and accidental impurities from cotton:* The selection of the auxiliary chemical products depending on the impact over the environment; The enzymatic cleaning of the no cellulose impurities that are present in the cotton fiber.

- *Ecological technological bleaching solutions:* Ecological solutions of bleaching by replacing the sodium hypochlorite and the chlorine compounds; Avoiding the use of certain auxiliary products that are dangerous to the environment; The use of catalases for removing the H<sub>2</sub>O<sub>2</sub> residue from bleaching.

- *Ecological technological solutions of preliminary preparing by cumulating certain stages of the technological process:* Technological processes combined by using enzymes; The usage of certain multifunctional auxiliaries; Employing the continuous processes of preliminary one stage preparing processes by the padding – steaming method;

- *Ecological procedures of dyeing with reagents:* The use of poly-functional reagents having a high fixation degree; The exhaust dyeing with reduced salt quantities; The substitution of salt in the reagent dyeing with biodegradable alternative products; The pad – batch procedure; The procedure of continuous dyeing; The elimination of detergents form the post dyeing washing operations; Enzymatic treatments of removing the hydrolyzed dyestuff after dyeing;

- *Ecological procedures of dyeing with sulphur dyestuff:* The use of sulfur dyestuffs and chemical auxiliaries having a minimum impact over the environment; Ecological procedure of dyeing with PAD-OX sulphur dyestuffs; The optimization of the equipment for continuous dyeing. In order to determine the main quality indicators of the wastewater per classical/ ecologic finishing processes of denim fabrics samples were collected resulting from both processes and environmental efficiency was determined. The comparative analysis of the parameters values (pH, suspension matter, BOD, COD, NH<sub>4</sub><sup>+</sup>, sulfur and hydrogen sulfide, sulfates, free residual chlorine, detergents, fix residue) and ecological efficiency is found in Table 2.

Table 2. Comparative characterization of the quality indicators of the wastewater resulted from the classic/ecological finishing processes of denim fabrics dyed with sulfur dyes

| Parameter                                   | pH      | Suspension mater | BOD                     | COD                    | NH <sub>4</sub> <sup>+</sup> | Detergents |
|---|---------|------------------|-------------------------|------------------------|------------------------------|------------|
| Admissible values according to NTPA002/2005 | 6.5-8.5 | 350 mg/L         | 300 mgO <sub>2</sub> /L | 500mgO <sub>2</sub> /L | 30 mg/L                      | 25 mg/L    |
| P.1 classical dyeing process                | 12.14   | 962              | 4424.6                  | 7742.8                 | 1.94                         | 120        |
| P.2 ecological process                      | 8.1     | 330              | 410                     | 610                    | 1.14                         | 35         |
| Ecological efficiency (%)                   | 33      | 68               | 91                      | 92                     | 41                           | 71         |

## RESULTS

The technical, economical and ecological advantages consist in: process flexibility and simplicity, good reproducibility, 90÷100% dye fixation, ecological process, less time/ increased productivity, small change of dye shade from batch to batch, great fastening resistance, reduced consumption of reducing agent – decrease of consumption with 40, reduced coloration of the residual water - economies made with water treatment; very low water consumption – water economy of about 50÷70%, reduction of water pollutants - with 15÷25%, reduction of sludge mass - with 10÷20%.

The assessment of the treatment installations from the textiles companies has lead to the conclusion that, in order to increase the pre-treatment efficiency the following upgrades are necessary at the wastewater treatment plant (WWTP): the existing used grills and sieves must be replaced with stainless steel grills and sieves with a greater capacity of retaining the impurities (holes smaller than 10 mm); mechanized scraping devices for impurities; automated systems for reading and adjusting the pH and turbidity; new basins for performing coagulation-flocculation; introduction of aeration systems in the 2nd treatment stage; settling basins and additional pumping plants for sludge will be installed. The efficiency of upgraded WWTP plant is higher than those of the old WWTP by 20÷50%. In the WWTP upgraded the water from the aeration basin is oxygenated by a pneumatic aeration system. Treated water, in a percentage of 94-97%, is separated from the sludge in the secondary settler. For a period of several months was studied the impact of using traditional technologies for textile finishing compared with the ecological technologies. The quality indicators (BOD and COD) for the generated wastewaters were compared for both technologies. A significant reduction in water pollution is found when using green technologies finishing, as seen in Figure 3.

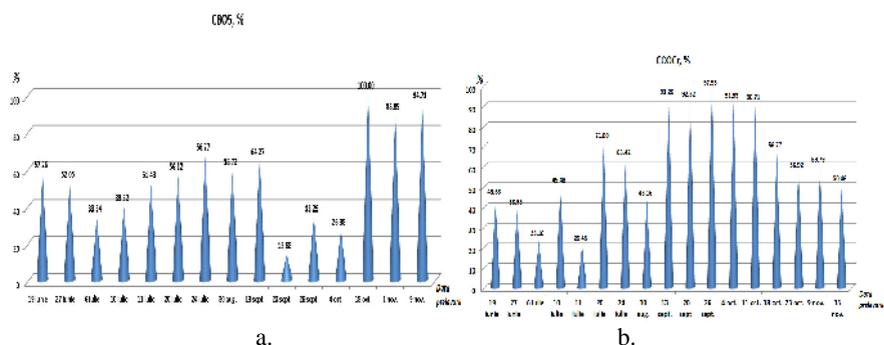


Figure 3. Graphical comparison regarding the treatment degree for: a. BOD, b. COD

## CONCLUSION

The results of the project have benefited companies in the textile industry, which by applying the suggested solutions, manage to comply with the national rules relating to treated water discharge into sewer systems or natural receptors. In the future, in order to comply with the European regulations, which will become more stringent in the coming years, further investment will be need it, to upgrade wastewater treatment plants analyzed, in accordance with the solutions from this paper.

### Acknowledgement

This work was supported by a grant of the National Authority for Scientific Research and Innovation (ANCSI), contract no. 26N/14.03.2016, PN 16 34 01 03.

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