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Review

The status of water reuse in European textile sector

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ABSTRACT

The textile finishing industry is known as a very fragmented and heterogeneous industrial sector dominated mainly by small and medium enterprises (SMEs). As with many other industrial sectors in Europe, it is obliged to act more sustainably in regard to increasingly limited natural resources such as water. This paper presents in-depth survey of wastewater reuse programmes over the last ten years covering the European textile finishing industry. Different wastewater treatment solutions developed are presented and discussed. Special attention is given to the project AquaFit4Use (7th Framework Programme), where almost five years of project work has resulted in valuable know-how practices in water reuse for the most water consuming sectors in Europe i.e. paper, food, chemical and textile. Only the latter is discussed in this paper. The main negative impacts by the textile finishing sector on the environment are still related to intensive water consumption and wastewater discharge, characterised by greater amounts of organic chemicals and colouring agents, low biodegradability, and high salinity. End of pipe treatment of such complex effluents in order to produce reusable water is not feasible. Therefore, separation of waste effluents regarding their pollution level and their separate treatment was the basic approach used in the project. As a result waste effluents with a big reuse potential could be effectively treated by combination of conventional treatment technologies. Proposed water treatment scenarios enable more than 40% reduction in fresh water consumption. Since different guidelines of minimum water quality to be safely reuse in textile processes exist at this stage this issue is discussed as well.

1. Introduction

1.1. Water reuse becoming a necessity

Under an average economic growth scenario, global industrial water requirements would increase from 800 billion m^3 in 2009 to 1 500 billion m^3 by 2030 (Water Research Group 2030, 2009). Industrial withdrawals account for 16% of today's global demand and are expected to have increased by a projected 22% in 2030. This increase will come primarily from China. In Europe, the industry and energy sectors account for 40% of the overall water consumption. The largest water user amongst European industries is the manufacturing industry (WssTP, 2011).

Within the Strategic Research Agenda (SRA) of the Water supply and sanitation Technology Platform WssTP (WssTP, 2010) (initially published in 2005 and updated in 2010), closing the water-cycle was regarded as one of the main research topics regarding sustainable water uses throughout different industries. The reasons for this are increasing water demand, water scarcity and droughts, environmental protection and wastewater management needs, socio-economic factors, and public health protection. Water costs are steadily increasing. One reason is increasing water scarcity in certain regions and another is the increasing treatment costs within municipal systems. Water has become an object of taxation for local and national authorities. The water price in EU countries can vary significantly e.g. from 5.63 EUR/m^3 in Denmark to 0.83 EUR/m^3 in Italy (Kjellsson and Liu, 2012).

Increased water shortages, increasing water costs and new environmental policies and regulations have stimulated the significant development of water recycling and reuse programmes over the past few years. Amongst the European legislation in force, the European Water Framework Directive (EC, 2000) has set a demanding aim for sustainable water management.

The status of water recycling and reuse in EUREAU countries is discussed and examples of good practice are presented by Angelakis and Durham (2008).

Moreover, a mapping of (municipal) wastewater reuse projects concerning population rates, treatment levels, treatment plant capacities, and types of reuse and volumes has been a major work of

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the FP5 project AQUAREC-“Integrated Concepts for Water Reuse” (AQUAREC, 2006). Types (purpose) of water reuse and corresponding existing European Directives are presented in the paper from Hochstrat et al. (2008). It seems there is enough legislation at the European level to justify reuse programmes. In the European region the predominant application areas of municipal wastewater reuse are agriculture and urban areas (Bixio et al., 2006, 2008).

In the field of industrial water reuse the picture is slightly different. The degree of water reuse adopted in industry differs very much between various industrial sectors and is strongly dependent on specific situations, such as the applications of the water, types of processes and local circumstances, the places and scales where water is used. In a number of industries, water reuse close to the processes has already been applied for decades (galvanic industry, paper industry, cooling towers, etc.). In contrast, in the textile industry water reuse is not a common practice. The next few paragraphs critically present the status of water reuse implementation within the European textile industry.

1.2. European textile industry

Despite the evident reuse potentials within the textile industry (Visvanathan and Asano, 2009), state of the art indicates that implementation of water reuse is still an uncommon practice. Over the past ten years the European textile industry has gone through a very difficult transition period. In the face of intense global competition European textile companies have been increasingly turning to research and innovation that can ensure sustainable competitiveness. In many larger-end markets such as transport, construction, energy, healthcare or the environment, new textile solutions are continually replacing traditional materials and technologies due to their unique performance and sustainability characteristics. Textiles are thereby being (re-)discovered as highly-engineered high-performance materials with significant long-term growth potentials. The uses of new innovative methods for producing textile materials within different sectors such as medicine, science, architecture, aerospace, transport, and automobiles have opened up new ways for foreign investors to exploit the textile market and cater to the needs of that market (AquaFit4News, 2011).

At the same time textile finishing companies over recent years have make important strides in the direction of pollution prevention and waste minimisation by e.g. the implementations of lower liquor-ratio dyeing machines, low/no-water textile processing, replacement or abandoning of hazardous chemicals, etc. On the other hand, for efficient wastewater management within the textile sector several obstacles still need to be overcome. On-site wastewater treatment and recycling in the textile finishing sector is a real challenge for companies themselves, especially given the fact that the majority of textile plants are categorised as small to medium sized enterprises (SMEs). These plants, in particular, have limited resources for acquiring closed water-loops.

The main negative impacts of the textile finishing sector on the environment are mainly related to primary water consumption and wastewater discharge, characterised by significant amounts of organic chemicals and colouring agents, low biodegradability, and high salinity. The estimated annual consumption of fresh water at the European level is 600 million m^3. On average, 90% of the water input in textile finishing operations needs to be treated end-of pipe. In Europe, 108 million tons of wastewater is produced on a yearly basis and 36 million tons of chemicals and auxiliaries have to be removed from textile wastewater (Volmajer Valh and Majcen Le Marechal, 2009).

The manufacturing of several textile products involves the uses of numerous different dyes and auxiliary chemicals (e.g. salts, organic compounds) within many different industrial processes (dyeing, bleaching, printing, washing, etc.) that produce wastewater with complex and extremely variable characteristics that makes their treatments particularly difficult. Wastewater characteristics can vary significantly, e.g. pH 2–13, conductivity 0.1–120 mS/cm, suspended solids 5–9000 g/cm^3, turbidity 0-200 NTU, total COD 0.3–60.000 g/m^3, absorbance up to 200.

The textile industry is also one of the more water-consuming industrial sectors: for instance, the textile dye process consumes even more than 100 L/kg of the fabric processed. Another characteristic is its extremely high variability regarding frequently changeable (seasonally, even daily) wastewater compositions that could substantially differ from company to company.

The current situation reflects that the typical textile company prefers to use high quality fresh water during all production operations and mostly discharges wastewater into the sewage system without any pre-treatment, as sophisticated wastewater treatment technologies are mainly unaffordable for small and small to medium-sized textile companies.

A realistic picture of the number of SMEs implementing (waste) water reuse within the textile sector is quite difficult to attain. In Germany the data were found to be rather scarce and out-of-date. Out of a total of 127 textile companies 14 (11%) of the plants discharged their wastewater directly into surface waters and 113 plants into municipal wastewater plants (Böhm et al., 2000; ENV/JM/MONO, 2004).

Another obstacle relates to the investment costs for wastewater treatment technologies and the often too long payback periods. In regard to the treatment of textile wastewater, various physical, chemical and biological methods have been investigated and proposed; every one presents limitations, advantages, and disadvantages. Excerpts of these methods are presented in a book chapter by authors (Volmajer Valh and Majcen Le Marechal, 2009; Volmajer Valh et al., 2011).

On the other hand, the textile BREF document from 2003 contains several Best Available Technologies (BATs) for production processes but only general advice on textile wastewater treatment and reuse.

2. Review of European water reuse programmes

Some previous European projects have successfully tackled issues relating to the textile wastewater treatment for reuse purposes. The more representative over the last ten years are collated in Table 1 followed by short descriptions and the main achievements of each with the exception of the AquaFit4use project, which is presented more exhaustively.

2.1. The FOTOTEX project

The FOTOTEX project examined and demonstrated the effectiveness of photo-oxidation techniques for the removal of biodegradable and non-biodegradable organic compounds from textile wastewater.

Photo-oxidation treatment system presented in the FOTOTEX project require simple lighting installation and accessible re-agents for removing biodegradable and non-biodegradable organic compounds from the textile wastewater, but is unable to decrease the level of salinity, and unable to achieve a quality parameters that water must have in order to be reused in the production process of the textile enterprises. A single treatment system is not effective to overcome all problems so a combination of membrane system, such as microfiltration and nanofiltration would be necessary (FOTOTEX, 2005).

According to the achievements within the FOTOTEX project, the use of universal wastewater treatment system in textile industry