Environmental Performance Evaluation of Textile Wet Processing Sector in Turkey

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Abstract: Today the prominence of sustainable development is recognized by almost all developing countries. Recently, traditional pollution control strategies are being replaced by the preventative approaches. Environmental performance evaluation is an important tool to determine the potential cleaner production opportunities. Appropriate Environmental Performance Indicators (EPIs) are the key elements to review, monitor and evaluate the environmental performance. They are developed to promote Cleaner Technologies (CT) and improve environmental and economical performance. Turkey is among the candidate countries of European Union (EU) and currently in the accessing process. During the accessing process, Turkey has to adopt EU directives, form an environmentally sound approach and a new environmental policy to reduce environmental impacts at the source. However, there is lack of information on the Environmental Performance concept and the tools used to evaluate the environmental performance in Turkey. Therefore, this research has been undertaken to develop and apply the sector specific EPIs to be able to determine the current environmental performance level of the textile sector in Turkey.

To this purpose, site visits were conducted and the necessary data were collected in one of the leading textile mills in Turkey. After evaluating the enterprise, the potential EPIs were defined. Then the most representative EPIs were selected by considering the processes of the mill under investigation. By considering these EPIs, the environmental performance of the textile mill was evaluated. In the context of this study, several textile mills will be investigated. The outcomes of this study could form a base to identify areas of improvement and setting targets in textile sector in Turkey to improve its environmental performance.

Keywords: Environmental Performance; Environmental Indicator; Cleaner Technologies

I. INTRODUCTION

Environmental Performance (EP) is quantitative and qualitative expression of the improvements achieved by an enterprise on its environmental aspects [1].

The task of measuring and evaluating EP of technology and/or activities is accomplished by a set of environmental performance indicators (EPIs). EPIs can be used not only for EP evaluation, but also help company in selecting environmentally friendly techniques, benchmarking, environmental reporting and establishing environmental management system (EMS).

In order to correctly implement an EMS, the company has to equip itself with specific tools that will allow it to measure its results over a certain time period and to undertake eventually corrective or preventive measures [1].

Textile industry is a very diverse sector in terms of raw materials, processes, products and equipment and has very complicated industrial chain. Although there is a large variety of processes and technologies within the textile industry, this sector can be categorized into dry and wet processes. Dry processing includes yarn manufacturing, fabric weaving and knitting while wet processing includes preparation, dyeing and finishing.

The textile industry has always been regarded as a water-intensive sector. The main environmental concern is, therefore, about the amount of water discharged and the chemical load it carries. Other important issues are energy consumption, air emissions and solid wastes and odors, which can be a significant nuisance in certain treatments [2].

Currently, sector specific EPIs, especially those for fostering the application of Cleaner Technologies (CT), are underdeveloped. Most of the existing EPIs have been designed for economic, financial and communication purposes. The ability of such indicators to facilitate wide spread application of CT options is questionable and EPIs suitable for the assessment and the implementation of CT alternatives are still in their infancy [3].

Since the production may vary widely not only during a year (because of seasonal changes and fashion) but even over a single day (according to the production programme), the resulting emissions are even more difficult to standardize and compare. The ideal approach would be a systematic analysis of the specific processes, but data availability is very poor for many reasons, including the fact that legal requirements have tended to focus on the final effluent, rather than on the specific processes [2].
Of the greatest importance, many studies suffer from a shortage of EP data. In most countries, environmental reporting is not mandatory and most companies prefer not to publish quantitative performance data [4].

Textile and ready-made clothing products cover about 34 percent of the export and are important income of Turkey. Turkey is the sixth largest cotton producer in the world. Considerable amount of the textile and ready made products exported are cotton products [5].

As one of the significant providers of textile products to EU, Turkey has to improve its environmental performance in the textile sector and adopt itself to European norms and standards.

EP in the textile sector has been the subject of several studies. For example, in a study by Johansson et. al., EPIs were developed for textile industry at SME level with the objective of a better assessment of the companies existing EP and the improvements they can realize with the application of certain CT options [3]. In another study conducted in Thailand, EPIs for Thai textile sector were developed and compared with reference values from literature [6].

The objective of this study is to introduce the EP evaluation concept in Turkey and undertake a case study for textile sector to define the existing CP opportunities. There is lack of information on the EPIs for industrial sectors. One key aspect of this study is that it will serve as a guide for the EP evaluation to implement cleaner production opportunities for textile sector in Turkey.

Social, economical and management aspects are not within the main focus area of this study.

II. METHODOLOGY

The textile mill under consideration is an integrated one with a daily production of about 55 tones. The company processes 100% cotton fabrics. The main processes are spinning, yarn dyeing, weaving and finishing. Dyeing process in the company is continuous yarn dyeing. For the EP assessment, this four main processes and the sizing process were considered. Company does not perform desizing, scouring, bleaching, printing and mercerizing processes. The main product is denim. Pretreatment (surfactants, complexing agents and caustic applied to the yarn in one bath before dyeing in this step) is implemented during the dyeing operation.

In the first part of the study, literature review was carried out to gather relevant data of the EPIs for the textile sector. This review provided a basis on which the EP of the textile mill under investigation will be assessed.

The collection of the available data on water, energy and raw material usage, products and wastewater produced and its characteristics for the textile mill under investigation constituted the second part of the study. A site visit was performed to the mill investigating all process lines, raw materials and products. Wastewater samples taken from the dyeing process and from the discharge to the wastewater treatment plant were analyzed for their Total Suspended Solids (TSS) and Chemical Oxygen Demand (COD) contents by using the Standard Methods [7].

Then the EPIs for the company were developed in order to evaluate the EP. EPIs for the three main environmental concerns in the textile wet processing namely water use, energy use and pollutants in the wastewater discharge were considered in this study.

The EPIs developed for the water use, energy use and the pollutants as well as their reference values from the literature are given in Tables I, II and III, respectively.

Finally the comparison and evaluation of EPIs in each category were presented.

A. Calculation of EPIs

Specific water consumption, energy consumption and pollutant load calculations were performed by making use of the data obtained from the mill.

Specific Water Consumption Calculations

Information on the specific water consumptions and the yarn processed in the company for the year 2005 was obtained. By using this information on the water use in finishing, sizing and the total water consumption of the company were calculated.

The specific water consumption for the dyeing process was calculated by using the dyeing recipes obtained from the company not the annual water consumption data. Since the annual data given on water consumption for the dyeing process covers the pretreatment.

The specific water consumption for dyeing process was calculated by using six different dyeing recipes. The average of these values was presented in Table I.

Specific Energy Consumption Calculations

The company provided total steam and electricity consumption data for the year 2005. In addition, data covers specific steam consumption for the existing processes. By using this data and the production data, the total specific steam and energy use were calculated. Specific information on the electricity consumption for individual processes was not available.
Specific Pollutant Calculations

Wastewater characterization in the dyeing process of the company was performed. The characteristics of the wastewater from finishing process are not analyzed yet. This is mainly due to the fact that different products undergo different finishing processes, and therefore demand varying amounts of inputs. Further studies will be carried out to determine pollutant level of the finishing wastewater and other wet processing units. Therefore, their EPIs will also be calculated and compared with the reference values from the literature.

B. Development of Environmental Performance Indicators

During the selection of appropriate EPIs, the existing processes, raw materials used, machine types used are considered.

Reference EPIs for Water Use

As mentioned earlier, the high water consumption constitutes one of the most important environmental concerns. Therefore, it is important to select the correct indicators to evaluate the performance of the company correctly. The reference values from literature selected for the performance evaluation are presented in Table I.

For the sizing process, Reference 10 provides the specific water consumption values for the cotton wet processing operations. Since the company manufactures %100 cotton products the data given by Reference 10 was selected for the comparison of the EP of the company with the reference values from the literature.

The specific water use for dyeing process is given in two bases, for different machines and for different dyes. Since the company uses continuous dyeing machine, specific water consumption value for continuous machines which was provided by Reference 9 was found to be comparable. Specific water consumption value with respect to dye used, provided by References 8 and 10 are taken into consideration to determine performance, since Vat(indigo) and Sulphur dyeing operations are performed in the company.

Reference 11 gives data for the cotton woven fabric finishing and the Reference 8 gives specific water consumption for woven fabric finishing. Since woven fabric finishing is performed in the company, the specific water consumption data provided by both References 8 and 11 are comparable with the process of the company.

Reference 10 is comparable with the process of the company but there are different processes carried out in the company such as bleaching and mercerizing. But these processes are not continuous, depends on the consumer’s requests, so the denim manufacturing process which is produced continuously is considered during the evaluation.

The final product of the company is cotton woven fabric so the Reference 8 which provides EPIs on total specific water consumption for woven fabric was selected for the performance comparison. The results of the comparison of EPIs on water use are presented in Table I. As seen, the water consumptions in the plant are in acceptable range given in the literature.

<table>
<thead>
<tr>
<th>Processing Subcategory</th>
<th>Previous Studies</th>
<th>Present Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sizing (l/kg product)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyeing (l/kg product)</td>
<td></td>
<td>Continuous 9.4-63</td>
</tr>
<tr>
<td></td>
<td>Sulphur 24.2-213.6</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Vat 8.4-166.9</td>
<td>21</td>
</tr>
<tr>
<td></td>
<td>Indigo Dyeing 8.4-50</td>
<td>21</td>
</tr>
<tr>
<td>Finishing (l/kg)</td>
<td></td>
<td>Cotton woven fabric finishing</td>
</tr>
<tr>
<td></td>
<td>Woven complex processing</td>
<td>10.8-276.9</td>
</tr>
<tr>
<td></td>
<td>Total (l/kg product)</td>
<td>5-508</td>
</tr>
</tbody>
</table>

During the calculations for dyeing process, specific water consumption was calculated for kg yarn produced since yarn dyeing process is performed in the company. On the other hand, in the finishing line, the specific water consumption was calculated for kg fabric produced because woven fabric finishing is performed.

The production data obtained from the records of the company was in the basis of meters of fabric, for the evaluation of specific water consumption this data was converted to kg basis. As a result of interview preformed with the responsible person from the company, conversion factor was given as 0,6 to convert meter fabric to kg fabric. When this factor was compared with the values given in the literature [12] it is seen that the value given by the company was relatively high. This can cause water consumption to seem less then the actual value. This value will be double-checked in the future parts of the study.

Reference EPIs for Energy Use

Specific steam and electricity consumption indicators are selected by considering the process type, machinery and type of raw material used in the company. In the company, steam is used for the heating purposes. In addition to this, large amounts of natural gas and fuel are also consumed.
The selected relevant specific electricity and steam use indicators are presented in Table II.

### TABLE II: SPECIFIC ENERGY CONSUMPTION

<table>
<thead>
<tr>
<th>Process</th>
<th>Previous Studies</th>
<th>Present Study</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[13]</td>
<td>[14]</td>
</tr>
<tr>
<td>Sizing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Steam consumption (kg/kg of product)</td>
<td>2.2-2.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specific Steam consumption (kg/kg of product)</td>
<td>10.0-40.0</td>
<td></td>
</tr>
<tr>
<td>Specific electricity consumption (kWh/kg of product)</td>
<td>13.9-26.4</td>
<td>7.5</td>
</tr>
</tbody>
</table>

In addition, company consumes large amount of fuel for processes. But data on the fuel consumption is not available but further studies will be carried out to calculate specific energy and fuel use for the processes.

*Reference EPIs for Wastewater Characteristics*

Wastewater characteristics vary due to raw material used and the process types. After obtaining the indicators from the literature, the indicators which are not relevant and which the relevant data could not be obtained from the company are eliminated. Table III depicts the results of the study on the specific pollutant levels on the dyeing wastewaters and also the total wastewater stream originating from the mill.

### TABLE III: SPECIFIC POLLUTANT LOAD

<table>
<thead>
<tr>
<th>Process</th>
<th>Previous Studies</th>
<th>Present Study</th>
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<tbody>
<tr>
<td></td>
<td>[16]</td>
<td>[17]</td>
</tr>
<tr>
<td>Dyeing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effluent Volume (l/kg of product)</td>
<td>50</td>
<td>22</td>
</tr>
<tr>
<td>TSS (kg/t of product)</td>
<td>25</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COD (kg/t of product)</td>
<td>&lt; 25</td>
<td>163</td>
</tr>
<tr>
<td>TSS (kg/t of product)</td>
<td>70</td>
<td>33</td>
</tr>
<tr>
<td>Chromium (mg/kg of product)</td>
<td>&lt; 50 (After Treatment)</td>
<td>4 (Before treatment)</td>
</tr>
<tr>
<td>Nickel (mg/kg of product)</td>
<td>&lt; 75 (After Treatment)</td>
<td>1.6 (Before treatment)</td>
</tr>
<tr>
<td>Copper (mg/kg of product)</td>
<td>&lt; 75 (After Treatment)</td>
<td>2 (Before treatment)</td>
</tr>
</tbody>
</table>

As can bee seen from Table III, dyeing wastewaters do not contain high concentration of TSS. On the other hand overall wastewater from the mill is high in its COD load but low in its TSS and heavy metals when compared with the EU-Ecolabel [17], standards.

On the other hand, the specific TSS discharged is relatively low when compared with the data of World Bank, [16]. But the analyzed wastewater from the dyeing process does not cover the dye bath analysis. Studies are continuing on characterization of the discharged water from processes.

EPIs on wastewater pollutant loads were determined for the company basing on the wastewater characterization which was started with the dyeing processes. Since it is one of the processes cause serious pollutant concentrations. Also the characteristics of the discharged water from the company were analyzed.

### III. CONCLUSION

EP evaluation enables companies to observe their performance clearly and to determine the problematic parts of the processes. It is important to use appropriate and sector specific EPIs as a tool of environmental performance evaluation for a sector.

This study aimed to determine the viable indicators for Textile Sector in Turkey and promote the use of Performance Evaluation. When completed, this study will indicate the EP of several textile mills at different scales in Turkey and provide guidance for further similar studies.

As a result of the investigation of company under consideration it was seen that EP of the company was relatively good, because this company is open-minded to cleaner production concept.

For example, the company performs continuous dyeing process which is one of the reasons for the low water consumption values. In addition to this, dye baths of indigo dyeing are stored then reused, since indigo dye is the main dye used in the company this enables them to achieve low water consumption. Also reuse of dye baths instead of discharging results in low pollution loads of dye wastewater.

In finishing line counter-current washing was applied which results in lower water consumptions in this process.

Further studies will be conducted for the company, wastewater analysis and energy computations will be carried out. This study will continue with the EP evaluation of three more companies with different sizes to be able to have an understanding of the EP of textile sector in Turkey.
REFERENCES


