Send Orders for Reprints to reprints@benthamscience.ae

The Open Conference Proceedings Journal, 2015, *6*, 35-40 35

Open Access

Applying Waste Management in Textile Industry: Case Study an Egyptian Plant

Dalia M. M. Yacout*, M. A. Abd El-Kawi and M. S. Hassouna

Environmental Studies Department, Institute of Graduate Studies and Research, Alexandria University, Alexandria, Egypt

Abstract: Egypt is well-known in the world not only for its old heritage but also for its valued presence in superior quality of textiles. However, the textile industry is both energy intensive and highly polluting. The production of textiles often requires high levels of water consumption and emits large quantities of pollutants to the environment. Therefore, it is very important to minimize its impact on the environment by establishing a proper waste management system. The present study is dealing with developing a "Waste Management System" and implementing it in a real situation. The system was established as a continues improvement cycle following the international standards of environmental management "ISO14001: 2004 and ISO 19011:2002".

The waste management system started with defining waste policy by top management. The established policy focused on reducing solid waste generated in form of waste fiber. The system included: formation of a waste management team, data collection, monitoring reports and audits. An action plan with specific goals was created based on recommendations of the waste management team, and related cost savings were calculated. The main actions of the plan focused on: a) providing a new liquefaction unit to liquefy the solid wastes, and b) reduce waste generation through personnel involvement by implementing waste reduction practices. The implemented actions reflected a direct reduction in waste generation, consequently provided large cost savings.

The investigation revealed that the applied waste management system is an effective tool for minimizing waste generation, reducing negative impact of textile production on the environment and enhance cost savings. Furthermore, the followed waste management system in this study can be implemented in similar industries.

Keywords: Egyptian textile, synthetic fiber, textile industry, waste management.

1. INTRODUCTION

The textile industry has played an important role in the development of human civilization over several millennia. Technological developments from the second part of the eighteenth century onwards led to an exponential growth of the textile industry. At the beginning of the twentieth century, the production of man-made fibers started and grew exponentially [1]. Acrylic fibers are one of the man-made textiles, they are formed from acrylonitrile a petrochemical substance. Acrylic fiber can be used instead of wool and cashmere as its price is lower. In addition, they can be used in many applications in apparels, home furnishings and industrial uses [2].

In 2012 the global production of textile industry increased by 1.9% to reach 88.5 million tons. This increase included raise in manmade fiber while natural fibers were down. Manmade fibers went up from 2011 statics by 6.0% to reach 56.0 million tons of textile production [3]. Moreover, Africa and Middle East are emerging as important consuming regions, accounting together for about 25% of total global demand for Acrylic fibers [4]. As for Egypt, According to the Egyptian Central Agency for Public Mobilization and Statistics, the total production of synthetic fibers reached 109,200 ton in 2011 and raised to 114,700 ton in 2012 [5]. The growing demand in Egypt and the Arab region is met by importing Acrylic fiber from European and South East Asian countries. Egypt is witnessing an 8-10% annual growth in Acrylic production due to superior quality and services.

At the present time, one of most important points addressing the Acrylic fiber industry in the world is to develop an eco-friendly technology and accelerate sustainable development [2]. The textile industry is both energy intensive and highly polluting [6]. The production of textiles often requires high levels of water consumption. Furthermore, industrial processes of textile emit large quantities of pollutants to the environment [7]. Therefore, it is very important to minimize its impact on the environment by establishing proper waste management systems [8].

The study aimed to identify a proper waste management system for the textile industry by establishing and implementing a waste management program in a local synthetic fiber textile plant, consequently, ensure the protection of the surrounding area and environment, by:

*Address correspondence to this author at the P.O. Box 832, Shatby, Alexandria, Egypt 21526; Tel: +201221306958;
E-mail: dalia.yacout@gmail.com

2210-2892/15 2015 Bentham Open

- Investigate means of waste management including minimization policies, waste handling and disposal.
- Make an inventory of wastes generated from the Acrylic fiber industry.
- Establish and implement an applicable waste policy.

2. WASTE MANAGEMENT IN TEXTILE INDUSTY

The objective of implementing an environmental management system is to reduce losses and generated wastes from improper production procedures, packaging, used raw materials and their bad handling, inefficient energy consumption, excess water consumption, and toxics release to the environment. Furthermore, an adopted environmental management system by a company is required to monitor waste and pollution levels, the system should implement both corrective and preventive actions when needed. Accordingly, effective implementation of an environmental management system in textile plants will enhance the usage of the end product, water, and energy. The environmental management system should help in re-design the products or processes in order to optimize the used materials. In other words, the application of an environmental management system leads to cost reduction, quality improvement, waste reduction due to re-design, proper equipment selection, in addition to time savings [9, 10].

Building or improving an environmental management system provides an opportunity to assess how the organization manages environmental obligations, and helps in finding better and more cost-effective solutions. By reviewing what the organization does and how well it works, the environmental management system can ensure to be viable and effective, both now and in the future. He added that, an effective environmental management system is built on total quality management concepts. To improve the environmental working conditions, the organization needs to focus not only on what things happen but also on why they happen. Over time, the systematic identification and correction of system deficiencies leads to better environmental and overall organizational performance [11].

European Commission for Integrated Pollution Prevention and Control [12] declared that it is recognized that technology improvements need to go together with environmental management and good housekeeping. Management of an installation that uses potentially polluting processes requires the implementation of many elements of an environmental management system. The implementation of a monitoring system for process input and output is a prerequisite for identifying priority areas and options for improving environmental performance. They also stated that the main environmental concern in the textile industry is about the amount of water discharged and the chemical load it carries. Other important issues are energy consumption, air emissions, and solid wastes.

According to the European Commission for Environment [13] the main purpose of waste management is to give an outline of waste streams and treatment options. Waste management plans are important instruments contributing to implementation and achievement of policies and targets set up in the field of waste management at the national level.

Lo *et al.*, [7] studied the impact of environmental management systems in textile industries and stated that “the production of textile and related products often requires high levels of energy & water consumption and emits large quantities of pollutants to the environment. Therefore, the adoption of environmental management systems is important and could have a significant impact on firms’ operational performance. They also revealed that the adoption of ISO14001:2004 [14], the most popular environmental management systems, improves manufacturers’ profitability.

Briga-Sá *et al.*, [15] investigated the potential of reusing textile wastes. They illustrated that textile wastes are an enormous source of secondary raw material that is not used, but can be re-injected into the market.

The environmental management system [14], requires the control of activities so that any environmental impacts are minimized. That will be achieved: a) by doing in practice what has been stated in the environmental policy, b) recording what has occurred, and c) learning from experience. The environmental management system [14] is based on the implementation of a continuous improvement cycle. Furthermore, experience shows that using a team approach to planning and building an environmental management system is an excellent way to promote commitment and ensure that the objectives, procedures and other system elements are realistic, achievable, and cost-effective [11].

According to [7] there are a few case studies that explore how environmental management systems adoption could improve textiles firms’ performance. For example, [16] analyzed an Austrian textile mill and found that the adoption of ISO14001:2004 [14] helps the firm to reduce solid waste production and thus its overall productivity. At the same time, [17] found that firms that adopt ISO14000 reduce costs, leading to eventual improvement in the overall performance of their supply chains.

3. METERIAL AND METHODS

3.1. Guidelines

Using the guidelines provided by [14] a waste management program was established in a local textile plant in Egypt. The case study plant is the first Acrylic fiber plant in the Middle East, with a total production capacity of about 18,000 Ton fiber per year. The established waste management program was based on the Plan - Do - Check - Act (PDCA) continual improvement framework. The PDCA approach was outlined as following:

- Plan: conduct reviews and establish the baseline, performance indicators, objectives, targets and action plans necessary to deliver results that will improve performance in accordance with organization's policy.
- Do: implement the action plans.
- Check: monitor and measure processes and the key characteristics of operations that determine waste performance against the policy, objectives, and report the results.
- Act: take actions to continually improve performance.

3.2. Methods

3.2.1. Data Collection

Following [18] historical data for waste generation was gathered, it was found that only 2011 information was available in the records. Next the organization started the practice of systematically recording and maintaining daily waste review data starting on January 2012.

The following information was gathered:

- Waste fiber generated (Ton /Day), which represents the total generated waste from production line.
- Low grade fiber generated (Ton/Day), low grade fiber is part of the generated waste from production line that cannot be sold for high quality textile applications, however, it is sold for low quality applications like padding material
- Liquefied waste (Ton/Day), the generated fiber waste is part of the total generated waste from production line which is liquefied in a special unit using a strong solvent, and then used once again in the production process.
- Treated waste water (m^3 /Month), the total waste water treated in the effluent treatment plant before final disposal.
- Total production (Ton /Day), total production of Acrylic fiber from production line.

The waste generation ratio was calculated by dividing Total production by total generated waste per month.

3.2.2. Auditing

Using the guidelines provided by [18] the organization performed internal audits on weekly basis to identify any leakages of water or raw material, in addition to recognize abnormalities or losses. The plant was divided into several areas and each week an audit toke place in one of the areas.

3.2.3. Creation of action plan and Goals setting

Following the [14] a tracking system was followed to review the action plan, it contained: Status of action, Goal description, Actions required, Responsible of implementing the action, Date of completion, and Expected savings. Status of actions was being updated on the system by the assigned persons in coordination with management coordinator and committee manager.

4. RESULTS ANS DISCUSSION

4.1. Waste Generation

In this respect: air emissions, liquid discharge and solid wastes were included. It was found that air emissions include water vapors which are vented to air and chemical vapors scrubbed by a monomer gas absorber which recycles them back to the production system. As for liquid in the current case study the raw water for the plant is received from the Nubariyaa nearby canal. According to the firm's Environmental Impact Assessment [19] the plant consumes about 9000 m^3/day of water. The total raw effluent generated is 3600 m^3/day. The inflows to the treatment plant are generated from two major streams: inflow generated from process plant areas and inflow generated from utilities. The inflow generated from process plant represent 43.3% of the total raw generated effluent and the rest 45.7 % are generated from the utilities [19].

Process plant inflow is generated from: washing of polymer cake containing low molecular weight polymer 1440 m^3/day, 1080 m^3/day from the stretching machine, part of the liquid waste generated in the solvent recovery area is recycled back to washing machine in the production line and 72 m^3/day is sent to the Effluent Treatment Plant (E.T.P.). They represent 40%, 30% and 2% of process plant stream, respectively. The generated flow from the utilities is a mix from: cooling towers blow down 300 m^3/day, Demineralized Water (DW) water regeneration 80 m^3/day, Reverses Osmosis (RO) reject water 920 m^3/day and 140 m^3/day liquid discharge from horticulture irrigation & sanitation, they represent 8.3%, 2.2%, 25.6 %, 16.7% and 3.9% from utilities stream, respectively. Both streams are treated through the effluent treatment plant. On actual inventory it was found that available flow meters only exist for monitoring the overall effluent to the treatment plant [19].

Concerning solid wastes the textile industry produces a variety of solid waste by volume, it is the second largest waste stream after liquid effluent. The source of solid waste includes waste fiber, residues from finishing chemicals, hydrocarbons, dyes and chemicals from solvent recovery systems, sludge from effluent treatment plant, dye containers, chemical containers, pallets, fly ash and general paper trash. In agreement with [20], the quantity and type of solid waste produced depends on the nature of the operation, the efficiency of the processes and the level of awareness about solid waste management.

Furthermore, it was observed that the domestic solid waste runs an independent system. Solid wastes of chemical empty bags and dye empty cans were collected and disposed by a government recognized contractor. The filter pads and waste water treatment sludge are being disposed off by government recognized sites for toxic material. As for the wet and dry fiber waste from the production line, it was recovered and utilized again in the material preparation area. The fiber with lowest grade was liquefied in a recovery unit using a strong solvent.

4.2. Development of Waste Management System

Following the [14], the policy states that organization is committed to achieve continual improvement and prevention of pollution. Top management defines waste policy and ensures that it is appropriate to the nature and scale of the organization's use and consumption.

One of the major wastes generated by the textile sector are fiber wastes. In the current case study, the planned policy focused on solid waste generation aiming to reduce solid waste generated in form of waste fiber to reach less than 1% of the production. A number of preventive and corrective actions were implemented in order to achieve that, as following:

- Avoid generation of waste fiber by avoiding batch discharge, in addition to identify and attend leakages.

Table 1. Generated waste, target and actual.

	Generated Waste		
	2011	**Target**	**2012**
Ton (waste/month)	80.9	15.0	40.2
Generated (%)	5.4	1	2.7

Table 2. Details of the management committee and role of each member.

Role	Responsibility
Committee Manager	- Responsible of program implementation. - Reports the progress to top management - Provides direction to the program - Facilitates any obstacles
Coordinator	-Coordinates different activities of the program. - Follow-ups the implementation of agreed points in the action plan. - Monitors energy consumption or waste generation and checks reasons of abnormalities - Frequently updates information and documents related to the program
Technical team (3-5 Cross functional members)	-Provides technical backup in the necessary engineering disciplines. -Implements goals of the action plan

- Reduce fiber wastes by using continuous flow operations instead of batch operations.
- Reduce waste generation through awareness raising by introducing importance of waste management to operators and training them on waste reduction practices.
- Reuse non-hazardous solid wastes such as papers, and plastics.
- Recovery of steam condensates and reuse them for heating purposes.
- Recycling of waste fiber by liquefying them and re-inject them back into the process.

Shown in Table (**1**) the generated waste in 2011 before the establishment and implementation of the waste management system, the targeted reduction and the actual reduction after the implementation in 2012. Data analysis indicate that the generated waste in 2011 reached 5.4% of the production (average per month), after the implementation of the waste management program the generated waste reduced to 2.7% of the production (average per month). In terms of money the estimated saving of this reduction is equal to 122,100 US$ as calculated below by equation (1).

Direct Saving from waste reduction (US$/Year)

= Cost of acrylic fiber (1000 US$/Ton) x Amount of reduced waste (2012 – 2011) (Ton)…(1)

4.3. Implementation of Waste Management System

4.3.1. Establishing Working Groups

According to [11] an effective implementation team is essential to the success of any organization. In agreement with [14] waste management team was appointed with appropriate skills and competence. Their roles were defined and included: waste monitoring, reporting, identifying and implement improvement actions. The committee consisted of a manager, coordinator and a cross functional technical team from different departments such as material preparation, production, utility, safety and mechanical. Details of the waste management committee and role of each member are shown in Table (**2**). The selected members for the committee were assigned to the program and the committee started their work on January 2012.

Weekly audits were conducted by the members to identify leakages of raw materials and water, a monthly review meeting was held as well to identify abnormalities, suggest improvement areas, set targets and review taken actions. Moments of meetings were being documented and circulated to all concerned. Recommendations of these meetings were being discussed and the agreed goals set in the action plan.

4.3.2. Monitoring and Performance Assessment

Evaluating performance involves the regular review of both waste use data and the activities carried out as part of the action plan. Moreover, performance assessment and goals setting cannot be done without analysis of proper data. This was best achieved through an effective and efficient system of reporting. The monitoring system of solid waste included daily data collection of production, waste fiber generated from the production line, low grade fiber and daily liquefied fiber. Fig. (**1**) presents the amount of generated waste from production in 2012. It can be noticed that the generated waste was more than 1% in all months, highest percentage in April, July and December due to repeated

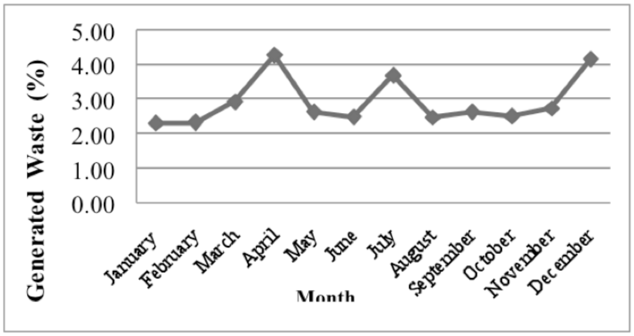

Fig. (1). Generated waste from production lines in 2012.

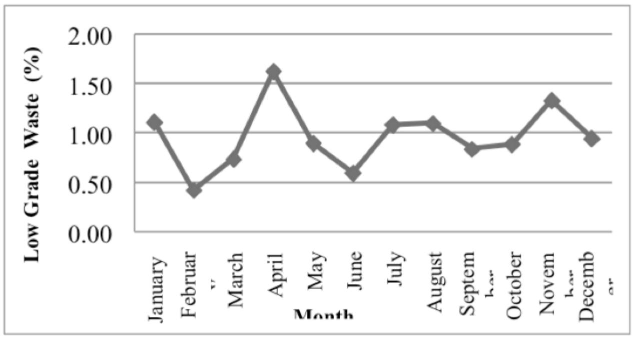

Fig. (2). Low grade waste in 2012.

steam failures and forced shut downs in line, in these cases the fiber in manufacturing process is considered as waste fiber and is being stored for recycling.

Fig. (**2**) shows the percent of low grade fiber, Fig. (**2**) is closely similar to Fig. (**1**) as low grade fiber is part of the generated waste. Both wastes should be minimized by reducing the generated waste from production in first place. This can be achieved by reducing machines breakdowns through improving planned maintenance.

Furthermore, Fig. (**3**) shows the liquefied waste. The generated fiber waste is liquefied in a special unit using a strong solvent and used once again in the production process. The monthly liquefied amount is independent of the generated waste from the production line; it depends on the operation stability of liquefying unit. It can be noticed that the liquefied amount of waste increased especially within the last quarter of the year. This was achieved by installing a new unit for waste liquefaction. The installation of this unit was one of the goals set in the action plan for waste reduction.

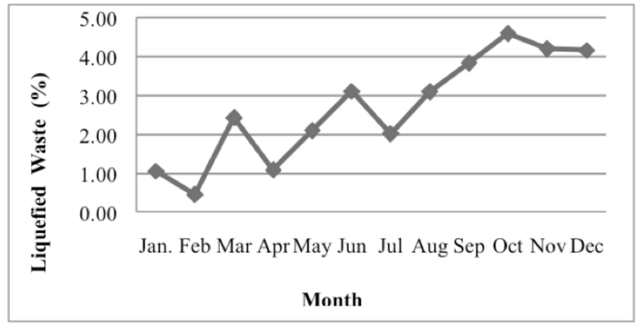

Fig. (3). Liquefied waste in 2012.

4.3.3. Implementation of Action Plan

Using the guidelines provided by [14] an action plan for the waste management system was established. Covered points by the waste management team included: avoiding batch discharge, identifying and attending leakages, reduce fiber wastes by using continuous flow operations and through awareness raising by introducing importance of waste management, reuse non-hazardous solid wastes, recovery of steam condensates, and recycling of waste fiber.

4.3.3.1. Recycling of Waste in the Liquefaction Unit

Chemical use may be reduced through recovery and reuse [21]. In order to recover a portion of the waste generated fiber a special unit is used to dissolve that waste fiber using a strong solvent and use it once again in the production process. This liquefied amount is independent of the generated waste from the production line, it depends on the operation stability of the liquefying unit.

One unit was already in operation, it consisted of two tanks for liquefaction. However, it did not meet the liquefaction requirements due to the high percentage of waste fiber from production. Installation of a new liquefaction unit was set as a goal in the action plan of waste reduction. The new unit was manufactured on site using a 30 m^3tank, proper agitator and a motor for the agitator were provided. The tank was installed in the material preparation area close to the existing liquefying unit. Two sets of pipes were installed: Inlet pipes for solvent addition and out let pipes for recycled liquid transfer. Operation tests were done during September and actual operation of the unit started in October. Table (**3**) shows the amount of liquefied fiber by the new unit. It can be noticed that the liquefied fiber by the new unit is almost double the liquefied amount by the existing unit. That was due to the high capacity of the new unit and frequent break downs in the existing unit.

Table 3. Liquefied fiber by new unit.

Month	Unit	Sep	Oct	Nov	Dec
Production	Ton	1307	1433	1431	1326
Liquefied in Tank 1 (Existing)	Ton	12.00	15.00	14.50	16.50
Liquefied in Tank 2 (Existing)	Ton	6.20	10.00	7.10	6.40
Liquefied in Tank 3 (New)	Ton	31.80	40.80	38.40	32.10
Total Liquefied waste	Ton	50	65.8	60	55

4.3.3.2. Development of Awareness Raising

An awareness campaign was launched in the facility to introduce the importance of waste management to involved employees. The campaign consisted of training to shop floor employees about waste reduction, started the practice of recycling and reusing some waste materials and spread awareness about different environmental issues such as going green and waste reduction through awareness competitions.

5. CONCLUSION

Using the guidelines provided by the ISO 14001:2004 standard a waste management program was developed based on the continual improvement framework in a textile plant for Acrylic fiber. The system aimed to reduce the negative environmental impacts of the manufacturing process by minimizing waste generation. The planned policy was to reduce solid waste generated in form of waste fiber to reach less than 1% of the production.

The established system for daily monitoring indicated that the generated waste was more than 1% in all months before the implementation of the system. Accordingly, an action plan was created and implemented to reduce the generated waste. The action plan included: identifying and attending leakages, avoid batch discharge, switch to use continuous flow operations instead of batch operations, recycling of solid waste and development of awareness raising among shop floor employees. The implementation of the action plan reduced the generated waste from 5.7% to 2.9% of the production, with a monetary saving of 122,100 US$.

In conclusion, the textile industry is highly polluting, textile processes often requires high levels of water consumption and emits large quantities of pollutants to the environment. At the same time, the textile industry has a lot of potential for waste saving opportunities, which will minimize its impact on the environment. The implemented waste management system in this study not only reduced the negative impacts of Acrylic fiber production by minimizing waste generation, but also was cost-effective as it achieved a number of direct cost savings. Furthermore, the established system in this study can be implemented in different industries as well.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

ACKNOWLEDGEMENTS

Declared none.

REFERENCES

[1] Schönberger H, Schäfer T. Best available techniques in textile industry. Environmental research of federal ministry of the environment. Berlin, Germany, Umweltbundesamt Publications 2003.

[2] Xibin S. Analysis of acrylic fiber industry & development of new type fibers. Paper presented at the 7th China International Acrylonitrile & Acrylic Fiber Forum 2010.

[3] Engelhardt AW. World survey on textiles and nonwovens. The Fiber Year GmbH Consulting, 2013, Issue 13.

[4] World Acrylic Fibre. Industry report: Trend in Demand & Supply, India, Centerac Technologies Limited 2013.

[5] CAPMAS. Egypt in figures report. 2014, Central Agency for Public Mobilization and Statistics 2014.

[6] Rock MT, Angel DP. Grow first, industrial transformation in East Asia. Environment 2007; 49: 10-19.

[7] Lo CKY, Yeung ACL, Cheng TCE. The impact of environmental management systems on financial performance in fashion and textiles industries. Int J Prod Econ 20; 135: 561-7.

[8] Ozturk HK. Energy usage and cost in textile industry: A case study for Turkey. Energy 2005; 30: 2424-46.

[9] Vandevivere PC, Bianchi R, Verstraete W. Treatment and reuse of waste water from the textile wet processing industry: review of emerging technologies. J Chem Technol Biotechnol 1998; 72: 289-302.

[10] Melnyk SA, Sroufe RP, Calantone R. Assessing the impact of environmental management systems on corporate and environmental performance. J Oper Manag 2003; 21: 329-51.

[11] Stapleton JP, Margaret AG, Davis SP. Environmental management systems: an implementation guide for small and medium-sized organizations, Maryland: Glover-Stapleton Associates, Inc 2001.

[12] IPPC, Integrated Pollution Prevention and Control (IPPC). Reference document on best available techniques for the textiles industry. Seville – Spain, European Commission, Institute for Prospective Technological Studies, Technologies for Sustainable Development, European IPPC Bureau 2001.

[13] ECE, European Commission for Environment (ECE). Preparing a waste management plan, a methodological guidance note. Munich, Ekotoxikologické Centrum, Bratislava, European Commission, Directorate-General Environment, Umweltbundesamt GmbH, Vienna, BiPRO GmbH 2003.

[14] ISO 14001. (2004). International Organization for Standardizations: Environmental Systems Handbook: Geneva, Switzerland. Elsevier Butterworth-Heinemann 2004.

[15] Briga-Sá A, Nascimento D, Teixeira N, *et al.* Textile waste as an alternative thermal insulation building material solution. Constr Build Mater 2013; 8: 155-160.

[16] Fresner J. Starting continuous improvement with a cleaner production assessment in an Austrian textile mill. J Clean Prod 1998; 6: 85-91.

[17] Brito MPD, Carbone V, Blanquart CM. Towards a sustainable fashion retail supply chain in Europe: organization and performance. Int J Prod Econ 2008; 114: 534-553.

[18] ISO 19011. International Organization for Standardizations: Guidelines for Quality and/or Environmental Management Systems Auditing. Geneva, Switzerland 2002.

[19] EIA, El-Raey M, Shalaby E, El-Hattab M, Hadidi Al. Environmental impact assessment for acrylic fibers plant extension: ENVIRO-INFO Consultants. Alexandria, Egypt 2007.

[20] Best Management Practices for Pollution Prevention in the Textile Industry, US: Environmental Protection Agency 1996.

[21] Barclay S, Buckley C. Waste minimisation guide for the textile industry: A step towards cleaner production. Volume II. Water Research Commission of South Africa. Durban, South Africa, University of Natal 2000.

Received: October 16, 2014 Revised: January 30, 2015 Accepted: May 05, 2015