SEAM Project

Textile Sector Report, Egypt

Cleaner Production Opportunities

Ministry of State for Environmental Affairs
Egyptian Environmental Affairs Agency
Technical Cooperation Office for the Environment

***En*tec UK Ltd**
UK Department for International Development

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SEAM Project
Implemented by:

Egyptian Environmental Affairs Agency
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and
Entec UK Limited

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Preface

A. The SEAM Project - An Introduction

Support for Environmental Assessment and Management (SEAM) is a multi-disciplinary environmental project being funded by Britain Department for International Development (DFID). This Project is being implemented by the Egyptian Environmental Affairs Agency (EEAA) through the Technical Cooperation Office for the Environment (TCOE) and *En*tec a UK based engineering and environmental consultancy.

The SEAM Project is made up of 5 components focusing on environmental management issues. These include Industrial Pollution Prevention/Cleaner Production Environmental Impact Assessment Solid Waste Management Environmental Action Plans and development of an Environmental Database.

B. The Industrial Pollution Prevention/Cleaner Production Component

The main goal of the Industrial Pollution Prevention/Cleaner Production component is to show that significant financial savings and environmental improvements can be made by relatively low-cost and straightforward interventions. These consist of pollution prevention through good housekeeping waste minimisation process modification and technology changes. This approach has two benefits - valuable materials are recovered rather than wasted and factories are moved towards legislative compliance. This work is being undertaken in support of the National Industrial Pollution Prevention Programme (NIPPP) and has focused on three sectors: textiles food and oil & soap.

Industrial auditing of 32 factories identified in excess of 200 low cost/no cost pollution prevention measures. Commonly occurring issues were then developed as demonstration projects for each sector whose aims were to show the financial and environmental benefits of the pollution prevention approach.

Thirteen demonstration projects have been implemented in 21 sites as follows:

Textile Sector

- Eco-friendly Processing for an International Eco-label.
- Water and Energy Conservation.
- Combined Processing: Scour and Bleach.
- Bleach Clean-Up using Enzymes.
- Sulphide Reduction in Sulphur Dyeing.

Food Sector

- Installation of Milk Tank Level Controls and Valves.
- Water Conservation in Food Factories.
- Energy Conservation in Food Factories.
- Reducing Waste by Improved Quality Control.
- Recovery and Use of Whey as Animal Feed.

Oil and Soap Sector

- Waste Minimisation in an Edible Oil Factory.
- Oil and Fat Recovery.
- Improving Raw Water Quality to Reduce In-Plant Losses.

Outputs from these projects include industry workshops and seminars demonstration projects with supporting Guidance Notes and Manuals (to enable other factories to implement similar projects themselves) case studies incorporating cost-benefit analyses to demonstrate project feasibility detailed Sector Reports and Guidelines describing how to carry out industrial audits.

C. Industrial Pollution Prevention/Cleaner Production Documents

(i) General Documents

Guidelines for Industrial Audits - A description of the methodology followed in the auditing of 32 factories 10 of which were in the textile sector.

(ii) Sector Reports

A description of 3 industrial sectors in Egypt including information on pollution prevention/cleaner production opportunities the findings of the industrial audits and demonstration projects.

Textile Sector Report Egypt. Cleaner Production Opportunities.

Food Sector Report Egypt. Cleaner Production Opportunities.

Oil and Soap Sector Report Egypt. Cleaner Production Opportunities.

(iii) Case Studies

Case Study: Textile Sector. Ecofriendly Processing and Achieving Ecolabels. Misr Spinning and Weaving Co. Mahalla and Giza Spinning Weaving Dyeing and Garments Company.

Case Study: Textile Sector. Sulphur Black Dyeing: A Cleaner Production Approach. El Nasr Co. for Spinning and Weaving Mahalla El-Kobra Dakahleya Spinning and Weaving Co. Mansoura and Amirtex Co. Sadat City.

Case Study: Textile Sector. Water and Energy Conservation. El Nasr Company for Spinning and Weaving Mahalla El-Kobra and Misr Beida Dyes Alexandria.

Case Study: Textile Sector. Bleach Clean-Up in Cotton Textile Processing using Enzymes. Dakahleya Spinning and Weaving Co. Mansoura and Amirtex Co. Sadat City.

Case Study: Textile Sector. Combining Preparatory Processes - A Low Cost High Productivity Solution. Giza Spinning Weaving Dyeing and Garments Company and Misr Beida Dyes Alexandria.

Case Study: Food Sector. Reduction of Milk Losses. Misr Company for Dairy and Food Mansoura.

Case Study: Food Sector. Water and Energy Conservation. Edfina Preserved Foods Alexandria and Kaha for Preserved Foods Kaha.

Case Study: Food Sector. Recovery of Cheese Whey for Use as Animal Feed.

Case Study: Food Sector. Integrated Quality Assurance and HACCP Approach to Waste Reduction in Food Processing.

Case Study: Oil and Soap Sector. Waste Minimisation at Sila Edible Oil Company Fayoum.

Case Study: Oil and Soap Sector. Pollution Prevention in Tanta Oil and Soap Company Tanta.

(iv) Guidance Manuals

These manuals give a step-by-step description of how the demonstration projects were implemented to allow other interested factories to implement similar projects by themselves. These are illustrated with examples from the demonstration projects and also include detailed cost-benefit analyses.

Cleaner Production for Textiles: Sulphur Black Dyeing. The elimination of 2 hazardous chemicals from the sulphur black dyeing process resulting in a better quality product reduced pollution and improved working conditions.

Cleaner Production for Textiles: Combining Preparatory Processes. This describes how the desize and scour or the scour and bleach steps could be combined to save money reduce processing time and reduce environmental pollution.

Cleaner Production for Textiles: Ecofriendly Wet Processing of Textiles. How to improve textile processing so that it could be awarded an ecolabel certificate which guarantees that the fabric meets specific quality criteria.

Cleaner Production for Textiles: Water and Energy Conservation. How to identify and prioritise water and energy losses.

Integrated Quality Assurance and HACCP Approach to Waste Reduction. How to improve food quality and reduce wastage by improving quality assurance procedures and establishing a quality management plan which incorporates HACCP principles.

Cleaner Production for Food Processing: Water and Energy Conservation. How to identify and prioritise water and energy losses.

(v) Workshops and Training

Industrial Auditing - A Workshop for Auditors. A 5 day workshop describing the auditing process and review potential barriers and how to overcome them.

Industrial Auditing for Companies - A Workshop for the Textile Sector. This consisted of 2 parts one to brief senior management on the benefits of auditing and one to describe the audit process to selected technical staff and a nominated Environmental Champion.

Industrial Auditing for Companies - A Workshop for the Food and Oil & Soap Sector. This consisted of 2 parts one to brief senior management on the benefits of auditing and one to describe the audit process to selected technical staff and a nominated Environmental Champion.

Cleaner Production and Pollution Prevention. A Workshop for the Pulp and Paper Sector. This 5 day workshop illustrated how significant financial and environmental savings could be made through the identification and implementation of low-cost Cleaner Production interventions.

Cleaner Production and Pollution Prevention. A Workshop for the Metal Finishing Sector. This 5 day workshop illustrated how significant financial and environmental savings could be made through the identification and implementation of low-cost Cleaner Production interventions.

1.0 Introduction

The textile sector is one of the largest industries in the world. Individual factories within the sector can range from large modern and highly automated plants to small traditional units focusing on hand-made products. Factories that carry out wet processing are characterised by high water consumption - the Environmental Action Plan of Egypt (1992) states that throughout industry the textile sector is the third largest water consumer and wastewater producer after the food and chemicals sectors. The industry also uses a wide range of process dyes and chemicals some of which may be toxic and hazardous. These frequently escape into the wastewater generating effluents which may be both harmful and difficult to treat.

Therefore water pollution due to the discharge of untreated effluents is one of the major problems associated with the sector. Final effluents are generally hot alkaline and highly coloured. They may also have a high organic load and contain toxic and hazardous chemicals. Discharge of these untreated effluents will reduce the quality of the receiving water possibly causing harm to subsequent users and to aquatic life.

Other issues which are becoming increasingly important include air emissions (especially Volatile Organic Compounds VOCs) noise and workplace safety.

1.1 Cleaner Production - Concept and Definition

Traditionally pollution coming from a factory has been controlled by using end-of-pipe controls such as wastewater treatment plants. This continues to be the most common method of dealing with water pollution in developing countries even today.

An alternative approach to this is to eliminate the problem at the source using the Cleaner Production approach. Unlike end-of-pipe solutions alone cleaner production can generate significant financial savings improve product quality and improve working conditions.

Cleaner Production (CP) can be defined the continuous improvement of industrial process products and services to reduce the use of natural resources to prevent - at the source - the pollution of air water and land and to reduce waste generation - at the source - in order to minimise risks to the human population and to the environment (UNEP 1990).

The operational expansion of this definition states that:

- For **production processes** CP includes conserving raw materials and energy eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes before they leave a process.
- For **products** the strategy focuses on reducing impacts along the entire life cycle of the product from raw material extraction to the ultimate disposal of the product.
- For **services** the strategy incorporates environmental concerns into designing and delivering services.

1.2 The Benefits of Cleaner Production

The CP concept radically differs from the traditional end-of-pipe approach in that CP makes no division between production and the wastes generated by production. It is an integrated approach which attempts to conserve resources by increasing production efficiency whilst meeting environmental requirements. In addition by minimising wastage the required capacity of any wastewater treatment plant will be greatly reduced thus reducing capital operating and maintenance costs.

By adopting the CP approach waste reduction automatically starts to occur. As a result the overall resource utilisation factor improves leading to increased profitability and competitiveness. Against the rising costs and procurement difficulties of resources these benefits may even be greater than the savings made on waste treatment costs.

1.3 SEAM Project in the Textile Industry

The SEAM Project carried out audits of 10 textile manufacturing plants all of which carried out wet processing. These audits focused on identifying low-cost interventions with fast payback periods - a total of 183 such interventions were identified with implementation costs ranging from LE 0 to LE 93000. Savings from implementing these actions ranged from LE 1100 to LE 716900 with average payback periods of less than 1 month. A summary of the types of interventions identified follows:

Type of Intervention	Capital Costs (LE)	Annual Savings (LE)	Average Payback Period (months)
Improved Housekeeping	0 - 2000	580 - 63000	< 1
Water Conservation Recycling and Reuse	0 - 93000	1745 - 716900	< 1
Energy Conservation	1000 - 21000	1400 - 259000	< 1
Process Modification	0 - 10000	2060 - 524900	< 1
Raw Material Substitution	0 - 4200	1100 - 45475	< 1

This auditing work was supported by training given to the audit teams and to factory personnel. These took the form of 3 workshops:

- **Senior management of the factory** - this workshop outlined the financial and economic benefits of implementing CP and broadly described the audit process. The management were also requested to nominate a member of staff to act as the Environmental Champion and point of contact for the audit team.
- **Middle management and technical factory staff** - this workshop was aimed at personnel who would be directly involved in the audit. The aim of the workshop was to demonstrate the benefits of auditing and explain the auditing process. It was also used to brief the factories on the needs of the audit teams.
- **Audit teams** - this workshop presented the audit methodology to the auditors and explained how findings were to be described and quantified. It also outlined the needs and concerns of the factories in relation to the audit process and emphasised the importance of confidentiality.

1.4 Factories Participating in the SEAM Project

AmirTex Company Sadat City is privately owned company with around 100 employees. The factory was built in 1984 and comprises a weaving and knitting department a printing unit and a dyehouse. The main products are cotton knitted fabrics and polyester-blended fabrics. Average annual production is 720 tons of cotton polyester and blended fabrics.

Cairo Dyeing and Finishing Shoubra El-Khema Cairo is a public sector company built in 1964 with a workforce of around 1500. Its main products are bleached dyed and finished fabrics as well as bleached and dyed yarns and socks. In 1996-1997 it processed 4.6 million metres of cotton polyester and cotton/polyester fabrics and around 78000 tons of yarn.

Dakahleya Spinning and Weaving Company Mansoura is a public sector factory with annual production of 11400 tons of spun yarns and ready made garments. The factory was built in 1965 and employs 4000 workers. It comprises three spinning departments an open end spinning unit a tricot plant a dyehouse and a tailoring hall. The main products are cotton yarns, cotton knitted fabrics polyester blended fabrics and ready made knitted cotton garments.

Egyptian Company for Spinning and Weaving Wooltex Mostourod Cairo is a public sector company which specialises in wool processing. It occupies a 9.5 feddan site and employs around 1000 staff. The processing carried out includes raw wool washing tops dyeing and softening fabric pre-treatment dyeing and finishing blanket washing and dyeing. Product type and volume is variable depending on demand.

General Jute Product Company Bilbeis Sharkeya is a public sector company established in 1959 on a 96 feddan site. Approximately 16000 ton jute (1996-1997) are processed annually to produce jute bags string for the carpet industry and ropes according to demand. Decorative articles are also manufactured on request.

Giza Spinning Weaving Dyeing &Garments Company Kafr El Hakeim Giza is a private company located in the Giza Governorate. The factory established in 1984 covers 25 feddans and employs 2400 staff. It has an average annual production of 1500 tons approximately 95% of which is produced for export. The main products are cotton polyester ready-made garments yarns and finished fabrics of which 90% is knitted the remainder woven.

Misr Beida Dyers Kafr El Dawar Alexandria is a public company established in 1938 nationalised in 1957 and occupies a 264 feddan site. The factory pre-treats dyes prints and finishes cotton fabrics and cotton/synthetic blends; processes yarns; scours and dyes wool tops and produces absorbent cotton.

Misr for Spinning & Weaving Co. Mahalla El-Kobra is a public company the largest in the Middle East. It has an average annual production of 48000 tons of which approximately 50% is exported. The factory occupies an area of 600 acres (including residential area) and has a workforce of over 30000. It processes cotton wool synthetics and blends to produce a wide range of products including ready-made garments yarns finished fabrics bandages blankets.

El-Nasr Spinning and Weaving Company Mahalla El-Kobra is a large public sector factory built in 1963 and currently employing 7000 staff. It processes an average of 8000 tons of textiles per year of which 20% are spun cotton yarns 12% are polyester blend yarns and 68% is grey fabric. The main products are cotton or blended yarns white and dyed cotton and blended fabrics. Approximately 52.5 million metres of fabric were produced during 1996/7.

El Seyouf for Spinning and Weaving Company Alexandria was established in 1941 as a private company and was nationalised in 1957. It occupies a 402000m^2 site and employed around 6400 staff (1997 figures). The main products of the company are yarns and fabrics of different qualities - since 1998 the factory has moved from carrying out full processing of these to mainly pre-treatment.

1.5 SEAM Demonstration Projects

The audit findings were assessed to identify the most common and acute problems facing the Egyptian textile industry. A total of 5 projects were implemented in 6 different factories:

Demonstration Project	Factory Name	Location
Ecofriendly Processing	1. Misr for Spinning & Weaving Co.	Mahalla El-Kobra
	2. Giza Spinning Weaving Dyeing & Garments Co.	Giza
Water and Energy Conservation	1. El-Nasr Spinning & Weaving Co.	Mahalla El-Kobra
	2. Misr Beida Dyers	Alexandria
Sulphur Black Dyeing: A Cleaner Production Approach	1. El-Nasr Spinning & Weaving Co.	Mahalla El-Kobra
	2. Dakahleya Spinning & Weaving Co.	Mansoura
	3. AmirTex Co.	Sadat City
Combining Preparatory Processes	1. Giza Spinning Weaving Dyeing & Garments Co.	Giza
	2. Misr Beida Dyers	Alexandria
Bleach Clean-Up in Cotton Textile Processing using Enzymes	1. Dakahleya Spinning & Weaving Co.	Mansoura
	2. AmirTex Co.	Sadat City

The findings of the audit programme and of the demonstration projects are presented in the following sections of this report.

Part A

THE TEXTILE SECTOR

2.0 The Egyptian Textile Industry

2.1 Introduction

The textile industry is one of the oldest in the world. The oldest known textiles, which date back to about 5000 BC, are scraps of linen cloth found in Egyptian caves. The industry was primarily a family and domestic one until the early part of the 1500s, when the first factory system was established. Today, the textile sector in Egypt consists of well over 3,000 companies, ranging from the very small (employing less than 8 labourers) to the very large (greater than 20,000 labourers). These are both public and private sector companies.

The textiles industry is the fifth largest source of foreign earnings; after oil, remittances, tourism and earnings from the Suez Canal. It is the second largest manufacturing sector in Egypt after food processing and represents 25% of total industrial output (excluding petroleum products). Egypt produces 25-30% of the worlds cotton, although there is strong competition from USA, China, India and Israel. Egypt also produces the some of the highest quality Extra Fine cotton in the world, having a 35% share of the world market.

2.2 Textile Manufacturing Companies

The majority of textile factories are located in the Cairo, Kaliobia, Gharbeya and Alexandria Governorates. This is illustrated in Table 2.1.

Table 2.1 Geographic Distribution of Companies in the Textile Sector

	Subsector				
Governorate	**(I) Spinning and Weaving Manufacturing**	**(II) Wool, Natural and Synthetic Manufacturing**	**(III) Dyeing, Printing and Finishing**	**(IV) Tricot Manufacturing**	**(V) Ready-Made garments**
Cairo	132	21	35	301	277
Alexandria	4	10	17	151	72
El-Kaliobia	305	8	16	11	29
El-Gharbeya	128	18	3	15	11
Assyut	2	-	-	2	1
El-Bohaira	19	3	2	-	-
Beni-Suef	2	-	-	-	-
Port Said	1	1	-	1	2
Giza	6	1	1	19	54
El-Dakahleya	21	-	-	27	5
Dumyat	3	-	-	-	1
Sohag	2	1	-	-	-
El-Suez	1	-	-	-	-
El-Sharkeya	2	5	2	3	7
Menofeya	3	3	1	1	1

The Egyptian textile industry is dominated by 31 large public enterprises. The majority of these are primarily engaged in spinning and weaving, although many also carry out dyeing, knitting, finishing and the production of ready-made garments. These public companies account for 100% of spinning, 70% of weaving, 40% of knitting and 30% of the finished goods. They also dominate in terms of labour, volume of production and owned resources. For instance, Misr for Spinning and Weaving is the largest enterprise in the country and generates more than 25% of

There are over 2,300 private sector factories which are members of the Egyptian Textile Manufacturers Federation (ETMF). There are also many small factories and workshops who are not ETMF members, as well as informal workers which are not included in any of these groups. The private sector currently dominates the market in terms of knitted fabrics and ready-made goods. Products commonly consist of T-shirts, beach towels, sports and casual wear, targeting Discount Shops in the USA and Europe.

Statistics on the main resources of a large sample of these companies are presented in Tables 1 and 2 of Appendix 1. This incorporates information on the number of spindles, number of looms, number of employees and the main products manufactured at these companies. Table 3 lists the main producers of knitted goods and ready -made garments both in the public and private sectors.

2.3 Production in the Sector

Commonly used raw materials include:

- natural fibres based on cellulose (e.g. cotton, flax, jute, hemp etc.), or protein (e.g. wool, and silk);
- man-made fibres (e.g. viscose rayon and cellulose acetate);
- synthetic fibres (e.g. polyester, polyamide, polyacrylic, polypropylene, etc.).

Of the natural fibres, cotton is the largest crop produced and processed in the textile industry. Flax represent the second largest source of cellulose for the textile industry is cultivated in Egypt primarily for the production of linen and seed oil. Locally produced wool is used for carpet manufacturing, with the highest quality wool being imported and dewaxed in Misr Beida Dyers, Alexandria.

Viscose, polyester and polyamide fibres are produced locally in Misr Rayon of Kafr-El-Dawar.

There are very few local manufacturers of the chemicals required for the production of man-made and synthetic fibres in Egypt. The majority of the chemicals therefore have to be imported or procured from multinational chemical companies with a presence in Egypt, making it difficult to adopt a CP approach.

A summary of goods produced for the domestic market and their corresponding values (in millions of Egyptian pounds) is shown in Figure 2.1.

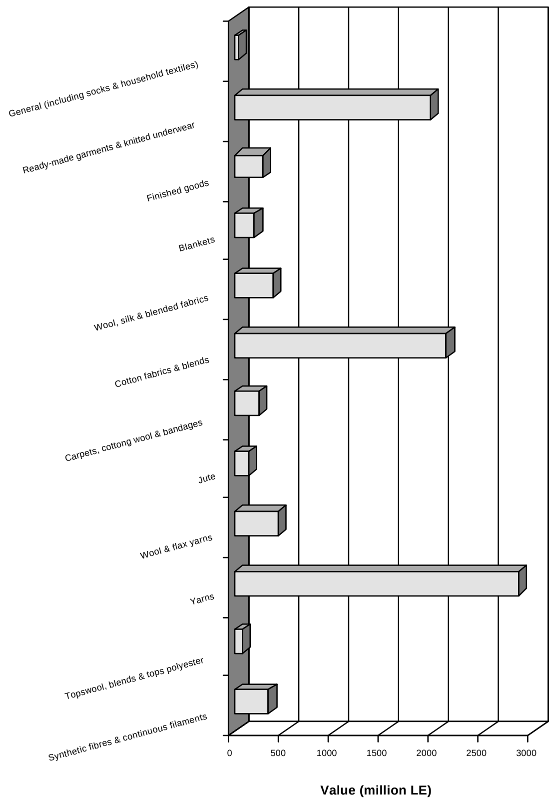
A number of the companies in Egypt cater to the export market and these exported products can be classified as:

- Fibres: medical cotton;
- Yarns: cotton yarns, rayon yarns, flax yarns, wool or acrylic yarns, hanks;.
- Sewing thread;
- Cotton and blended fabrics : grey and dyed, printed and finished;
- Woollen and blended fabrics;
- Ready-made garments;

- Knitted fabrics;
- Gauze bandages;
- Cotton canvas;
- Terry towelling, bed sheets and table covers;
- Carpets and blankets.

Appendix 2 lists the major export companies where these products are manufactured.

Figure 2.1 Domestic Production of Textile Products (1992/93)



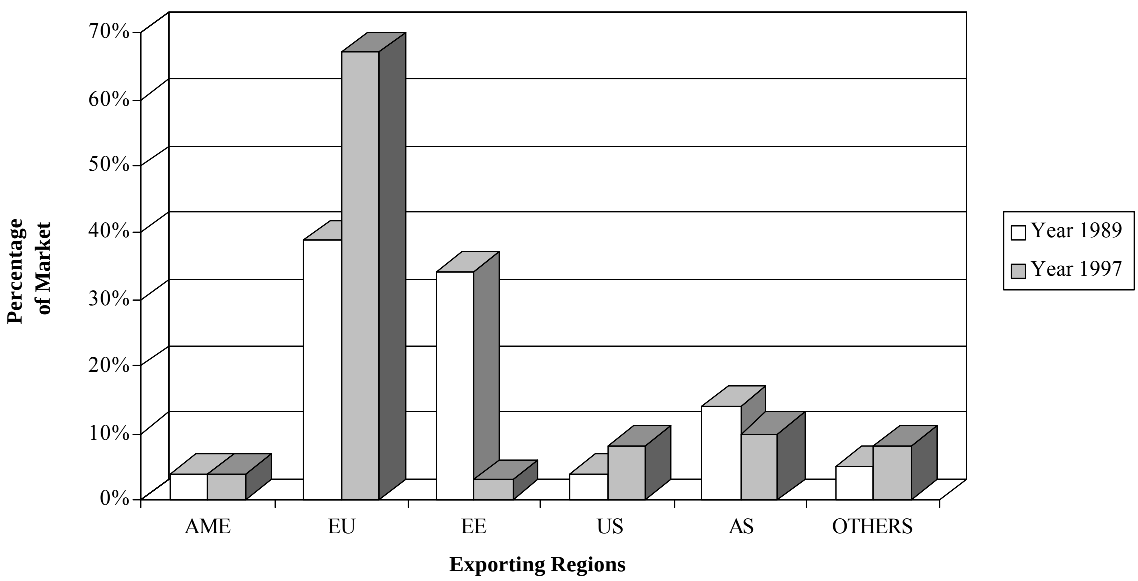
2.4 Export of Egyptian Textiles

In 1997, the total value of textiles produced in Egypt was LE 8 billion. Of this, LE 5 billion was sold in the domestic market and products totalling LE 3 billion were exported (Egyptian Textile Industry and GATT, 1998).

Textiles accounted for nearly half of total export earnings until 1990/91. The value of exports amounted to over LE 2,364 million in 1992 (of which approximately LE 1.7 billion was earned by ready-made garments and knitted products). Export value continued to fall, to around LE 1,909 million in 1993. However, the 1992-97 5-Year Plan anticipated that this trend would be reversed as Egypt enters new non-traditional markets, increasing the value of exports to LE 3.5 billion in 1997.

In the period 1989-97, the market for Egyptian cotton changed dramatically. Figure 2.2 shows that exports to Eastern Block countries decreased by over 30%, down to 3%, corresponding to the break up of the USSR. Conversely, there was a 28% increase in exports to European countries, who are currently the largest purchasers of Egyptian cotton. A slight increase in exports to the US was also noted.

Figure 2.2 Export Trends of Egyptian Cotton (1989 and 1997)



AME: Arab and Middle Eastern countries.
EU: European Union.
EE: Eastern Europe.
US: United States of America.
AS: Asian countries.
Others: Including Asian and African countries, South America, Canada, Australia, free zone areas in Egypt.

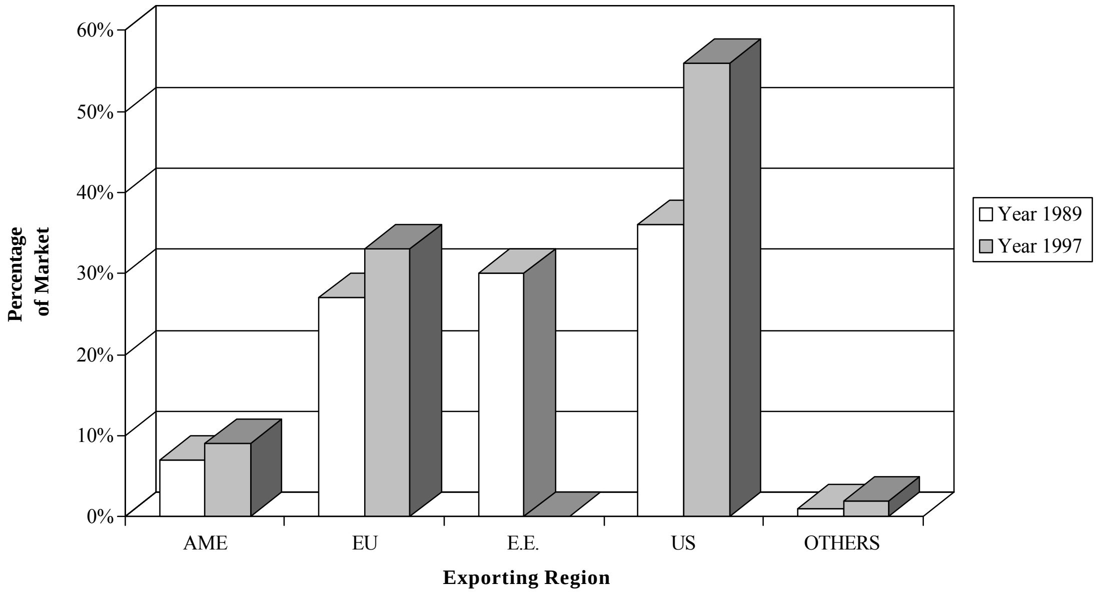
Source: ACCE Egyptian Textile Industry and GATT, Potential and Uncertainty, 1998

Throughout the sector, cotton yarns account for the largest share of total exports, although its share has dropped from 68% in 1980 to 52% in 1992. In contrast, finished garments are obtaining an increasing share of total exports, rising from 3% in 1980 to nearly 15% in 1992.

An increased market share has also been noted for knitted products and to a lesser extent,

household products. It is anticipated that finished garments could represent up to 80% of total exports within the next few years. The change in export patterns for garments and clothing between 1989 and 1997 is illustrated in Figure 2.3.

Figure 2.3 Export Trends of Clothing and Garments (1989 and 1997)



AME: Arab and Middle Eastern countries.
EU: European Union.
EE: Eastern Europe.
US : United States of America.
Others: Including Asian and African countries, South America, Canada, Australia, free zone areas in Egypt.

Source: ACCE Egyptian Textile Industry and GATT, Potential and Uncertainty, 1998

Figure 2.3 also illustrates that the US is the main market for clothing and garments, increasing from 36% in 1989 to 56% in 1997. A drop in exports to Eastern Europe to less than 1% occurred, similar to that observed for cotton products. A slight increase in exports to the EU (7%) and to other Arab and Middle Eastern countries (2.4%) also occurred.

Egypt has no quota restrictions in Europe for finished goods and no yarn or fabric quota restrictions in the US market and many European and American importers are keen to find Egyptian suppliers. However, these importers are faced with problems with establishing long-term relationships as the manufactured goods are variable in quality and timely delivery of agreed volumes often does not occur.

2.5 GATT and Egyptian Export Markets

The General Agreement on Trade and Tariffs (GATT) 1994 Agreement on Textile and Clothing replaces the Multi-Fibre Agreement, which reallocated production to developed countries. Under the GATT Agreement, these quotas are to be progressively removed from total imports - 16% in 1995, 17% in 1998, 18% in 2002 and the remaining 49% by 2005.

GATT has 3 main objectives:

1) To liberalise trade through the elimination of tariff and non-tariff barriers.
2) To promote equality of treatment between all trading countries. This is achieved by requiring that each country treats imported products in the same way as home-produced goods.
3) To ban practices such as dumping and to establish conditions under which a country may resort to anti-dumping measures.

With this removal of trade barriers by the Year 2005, exporters may increasingly face more stringent environmental standards in the international marketplace. One way that this can be assessed by purchasers is by requiring that manufacturers have an Eco-label. This provides brief information on environment-related product qualities. It enables consumers to identify those products which are environmentally safe; that have been manufactured using eco-friendly materials; and do not contain chemicals that are harmful to the user. Since environmental friendliness is an additional product quality it can be used for marketing and advertising purposes.

Experience in Egyptian textile factories has shown that without an ecolabel, buyer preferences were either being directed elsewhere, or the lack of an eco-label was used as leverage to negotiate prices down.

Currently, these are mainly required in Western Europe, with Germany being the most demanding. Other German and Nordic speaking countries will follow closely behind.

3.0 Textile Manufacturing Processes

Broadly defined, the textile industry includes the spinning, knitting and weaving of natural and man-made fibres, the finishing of textiles and the production of ready-made garments. The most common sectors in the Egyptian textile industry are: cotton fabrics, wool fabrics, man-made fabrics, synthetic fabrics and blended fabrics.

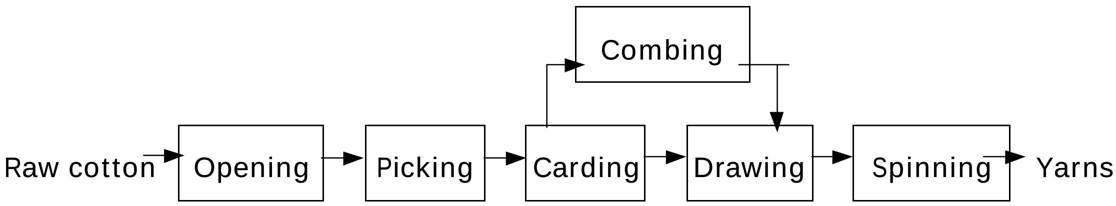
3.1 Processing of Cotton Based Textiles

Cottons and cotton-based textiles are processed through three main stages, comprising spinning, knitting or weaving and wet processing.

3.1.1 Spinning

Spinning is the process which converts raw fibre into yarn or thread. The fibres are prepared and then drawn out and twisted to form the yarn, which is then wound onto a bobbin or cone. The spinning process is entirely dry, although some yarns maybe dyed and finished as a final customer product. The spinning process is illustrated diagramatically in Figure 3.1.

Figure 3.1 Main Stages in the Spinning of Raw Cotton



3.1.2 Knitting

Knitting is carried out by interlocking a series of yarn loops, usually using sophisticated, high speed machinery. This process is almost completely dry, although some oils may be applied during the process for lubrication. These are removed by subsequent processing and enter the wastewater stream.

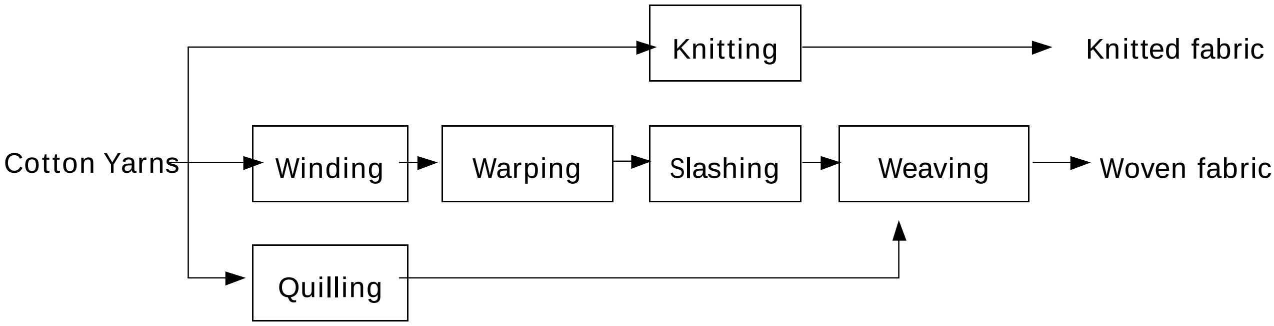
3.1.3 Weaving

Weaving is the most common method used for producing fabrics. The process is carried out on a loom (of which numerous varieties exist) which interlaces lengthwise yarns (warp yarns) with widthwise ones (weft or filling yarns).

Prior to weaving, the warp threads are coated with a size, to increase their tensile strength and smoothness. Natural starches are the most commonly used sizes, although compounds such as polyvinyl alcohol (PVA), resins, alkali-soluble cellulose derivatives, and gelatine glue have been used. The sizing compound is dried on the threads and remains a part of the cloth until it is removed in the subsequent processes. Other chemicals, such as lubricants, agents, and fillers, are often added to impart additional properties to a fabric. This process usually adds on about 10-15% to the woven goods.

The knitting and weaving processes are illustrated diagramatically in Figure 3.2.

Figure 3.2 Main Stages in the Weaving and Knitting of Cotton Yarns



3.1.4 Wet Processing

The stages of wet processing of cotton textiles, both woven and knitted, are shown in Figure 3.3 as follows:

Figure 3.3 (a) Wet Processing of Knitted Cotton Fabrics

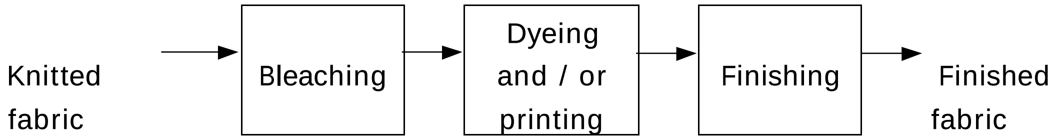
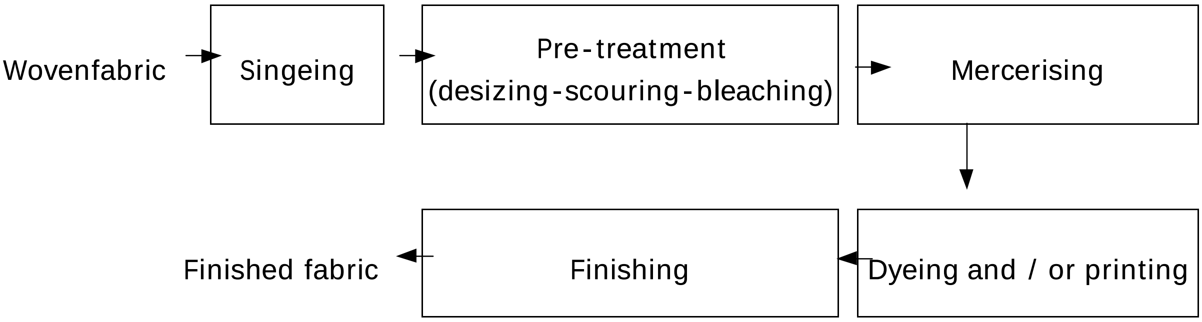


Figure 3.3 (b) Wet Processing of Woven Cotton Fabrics



(i) Pretreatment Processes

Sizing and Desizing: Sizing is carried out before the weaving process to increase the strength and smoothness of the yarn, to reduce yarn breakages. Desizing, either with acid or enzymes then removes size from the fabric, so that chemical penetration of the fabric in later stages is not inhibited. Desizing effluents have very high organic concentrations, contributing 40-50% of the total organic load from the preparatory sequences. Gums and PVA may be removed by a simple hot wash but starch and its derivatives have to be made soluble by soaking with acids, enzymes or oxidants before being removed by a hot wash.

Scouring: Scouring is carried out to remove impurities that are present in cotton, both natural (e.g. waxes, fatty acids, proteins, etc.) and acquired (such as size, dirt and oil picked up during processing). This is usually done at high temperatures (above 100°C) with sodium hydroxide and produces strongly alkaline effluents (around pH 12.5) with high organic loads. They tend to be dark in colour and have high concentrations of Total Dissolved Solids (TDS), oil and grease.

The scouring is normally done either on a Kier, a J Box, or an open width pad roll system, or on open width continuous plant. Common scouring agents include detergents, soaps, alkalis, anti-static agents, wetting agents, foamers, defoamers and lubricants.

Bleaching: Bleaching is used to whiten fabrics and yarns, using sodium hypochlorite or hydrogen peroxide. Many cotton processing factories in Egypt use sodium hypochlorite as it is cheaper than hydrogen peroxide. However, this is highly toxic and is now strictly limited or banned in many countries. It can also break down to form absorbable organo-halogen compounds, which are both toxic and carcinogenic. Bleaching generates effluents with a low organic content, high TDS levels and strong alkalinity (pH 9-12).

Once bleaching is complete, the bleaching agent must be completely removed, either by a thorough washing or using enzymes.

Mercerising: In this process, the cotton yam or fabric is treated with an alkali (sodium hydroxide, NaOH) to improve lustre, strength and dye uptake. It also removes immature fibres. The process is normally carried out on dry fabric; wet mercerisation reduces the steam consumption, but requires stringent control of the operational parameters, such sodium hydroxide concentration.

Excess sodium hydroxide is normally recovered for reuse in either the scouring or other mercerisation stages. The rinse wastes are alkaline, high in inorganic solids and caustic alkalinity, and low in BOD. With the increasing trend toward cotton-polyester blends, much less mercerising is being carried out.

Combined mercerising, where scouring is carried out simultaneously with the mercerisation in hot conditions, is now becoming popular, as the mercerisation increases the rate of scouring. This combined process reduces capital cost, space requirements, energy costs, labour requirement and chemical costs.

(ii) Dyeing

The major classes of dyestuffs used in the textile industry are as follows:

- **Acid Dyes**. Mainly used on wool, silk and polyamide fibres. They give very bright colours, whose fastness ranges from very poor (allowing colours to run) to very good.
- **Basic Dyes**. Usually applied to acrylics and polyesters to produce very bright colours.
- **Direct Dyes**. Commonly applied to rayon and cotton.
- **Disperse Dyes**. Applied to cellulose acetate, polyamide and polyester fibres.
- **Reactive Dyes**. This group produces a range of bright shades, and commonly used for cellulose textiles.
- **Sulphur Dyes**. Most commonly used for dyeing cotton, rayon and cotton-synthetic blends and produce strong, deep colours in the final fabric.
- **Vat Dyes**. These cover an almost full range of shades and are particularly important in the dyeing of cellulose fibres (such as cotton).
- **Azoic Dyes**. Produce deep shades of blue, violet, yellow, orange and scarlet.

More detail on the characteristics of these dyes is given in Table 3.2 at the end of Section 3.1.

(iii) Printing

Printing is a process that is used for applying colour to a fabric. Unlike dyeing, it is usually only carried on prepared fabric where it is applied to specific areas to achieve a planned design. The colour is applied to the fabric and then treated with steam, heat or chemicals to fix the colour on the fabric. The most commonly used printing techniques are:

- pigment printing, commonly used for all fabric types.

- Wet printing uses reactive dyes for cotton and generally has a softer feel than pigment-printed fabrics.
- Discharge printing creates patterns by first applying colour to the fabric and then removing selected areas.

Final washing of the fabric is carried out to remove excess paste and leave a uniform colour.

(iv) Finishing

The finishing process imparts the final aesthetic, chemical and mechanical properties to the fabric as per the end use requirements. Common finishing processes include:

- Wrinkle Resistant/Crease Retentive - using synthetic resins.
- Water/Oil Repellent - using silicones and other synthetic materials (e.g. fluorocarbon resins).
- Flame Retardant - most commonly carried out on synthetic fabrics, by co-polymerisation of the flame retardant into the fabric itself; introduction of an additive during processing; application as a textile finish. Natural fibres such as cotton can only be made flame retardant by applying a chemical finish.
- Mildew Resistance - using hazardous substances such as mercury, copper, arsenic and chlorinated phenols (e.g. PCP).

3.1.5 Commonly Used Wet Processing Equipment

The most common pre-treatment machinery and equipment used in Egyptian textile mills are:

- Rodney Hunt Bleaching Range.
- Farmer Norton Bleaching Range.
- Brugman Line (Rope form).
- Croft Bleaching Range.

Commonly used wet processing equipment includes:

- Jet dyeing machine.
- Pad -thermosol/Pad-steam range.
- Continuous dyeing, washing and drying ranges (knitted fabrics).
- Roll and screen printers.

Most of the machinery is imported, as there are no manufacturers of textile machinery in Egypt. This equipment is often purchased second hand and is almost invariably obsolete. This is again a constraint for implementing CP options involving equipment modification and adaptations.

3.1.6 Summary of Operating Conditions

Process	Conditions
Sizing	Size formulation depends on the type of yarn. Size concentration is governed by the yarn count (8-15%). Temperature ranges from 80-90 degrees centigrade. Drying at 100-130 degrees centigrade.
Singeing	Direct or indirect flames are used to remove fuzzy fibres, followed by quenching.
Desizing	Desize formulation depends on the nature of the sizing agents, i.e. enzymatic or oxidative treatments are used for starch sized fabrics, whilst CMC, CMS or acrylate sizes can be removed by hot water (80-90 degrees centigrade). PVA can be removed by using hot water in the presence or absence of peroxygens.
Scouring	Kier boiling: NaOH 30g/l, wetting agent c. 2g/l, temperature c. 120 degrees centigrade, time c. 12 hours. Continuous scouring: NaOH 30-50g/l, wetting agent c. 2g/l, temp. c. 90 degrees centigrade.
Bleaching	Hypochlorite bleaching: 1.5-2g active chlorine/l, 2g Na_2CO_3/l, room temperature, time c. 2 hours. Peroxide bleaching: 10-16g H_2O_2/l (100%), 2.5g NaOH/l, 2-5gNa_2SiO_3/l, c. 4 g organic stabiliser/l, 2g non-ionic wetting agent/l, temp. 90-95 degrees centigrade, time 45-60 mins.
Mercerisation	20-30% NaOH, 1-2g non-ionic wetting agent/l, temperature 18 degrees centigrade, time 20-40 seconds.
Dyeing	A range of different dyestuff classes can be used for 100% cellulose fibres (e.g. direct, reactive, sulphur, vat, indigo). Dyebath formulation and dyeing conditions depend on the class used.
Printing	The same classes of dyestuffs used in dyeing can also be used in printing. Pigments can also be used.
Finishing	Soft finishing: By using different types of softening agents (e.g. cationic, non-ionic, silicone elastomers) different types of application (exhaustion or padding techniques) can be used. Exhaustion formulation - 2-4% softening agent at 40-50 degrees centigrade for 15-20 minutes at pH6. Resin finishing: Using N-methylol finishing agents in the presence of an acid catalyst using the padding technique.

TABLE 3.2 (SEPARATE FILE)

Table 3.2 Typical Characteristics of Dyes Used in Textile Dyeing Operations

Dye Class	Description	Method	Fibres Typically Applied to	Typical Fixation (%)	Typical Pollutants Associated with Various Dyes
Acid	Water-soluble anionic compounds	Exhaust/Beck/Continuous (carpet)	Wool Nylon	80-93	Colour; organic acids; unfixed dyes
Basic	Water-soluble, applied in weakly acidic dyebaths; very bright dyes	Exhaust/Beck	Acrylic Some polyesters	97-98	N/A
Direct	Water-soluble, anionic compounds; can be applied directly to cellulose fibres without mordants (or metals like chromium and copper)	Exhaust/Beck/Continuous	Cotton Rayon Other cellulose fibres	70-95	Colour; salt; unfixed dye; cationic fixing agents; surfactant; defoamer; levelling and retarding agents; finish; diluents
Disperse	Not water-soluble	High temperature exhaust Continuous	Polyester Acetate Other synthetics	80-92	Colour; organic acids; carriers; levelling agents; phosphates; defoamers; lubricants; dispersants; delustrants; diluents
Reactive	Water-soluble, anionic compounds; largest dye class	Exhaust/Beck/Cold pad batch/Continuous	Cotton Other cellulose fibres Wool	60-90	Colour; salt; alkali; unfixed dye; surfactants; defoamer; diluents; finish
Sulphur	Organic compounds containing sulphur or sodium sulphide	Continuous/ Exhaust	Cotton Other cellulose fibres	60-70	Colour; alkali; oxidising agent; reducing agent; unfixed dye
Vat	Oldest dyes; more chemically complex; water-insoluble	Exhaust/Package/ Continuous	Cotton Other cellulose fibres	80-95	Colour; alkali; oxidising agents; reducing agents

ırce: Best Management Practices for Pollution Prevention in the Textile Industry, EPA, Office of Research and Development, 1995; ıowden-Swan, L.J. Pollution Prevention in the Textile Industries, in Industrial Pollution Prevention Handbook, Freeman, H.M. (Ed.), cGraw-Hill, Inc., New York, 1995.

2 Wool Processing

Wool processing involves the following stages:

- Conversion of raw wool into woollen and worsted yarns (Appendix 3, Diagram a).
- Weaving or knitting (Appendix 3, Diagram b).
- Finishing of woollen or worsted fabric (Appendix 3, Diagram c).

A summary of the operating conditions follows:

Process	**Conditions**
Scouring	NaOH, 1.5-2.5g/l, detergent 1-18g/l, temperature ≈65 degrees centigrade.
Carbonising	100g H_2SO_4 (98%) per 1kg of wool, heating by indirect steam for 45 minutes.
Bleaching	Bleaching of wool can be carried out using sulphur dioxide, hydrogen peroxide followed by optical brightening.
Dyeing	The dye formulation depends on the nature of the dye (acid or metalised dye), grade of wool and the type of dyeing machine being used. Acid dyeing temperature ranges from 60-100 degrees centigrade, whilst the metalised dyeing temperature range is ≈85 degrees centigrade.
Finishing	■ Insect repellent finishes: Mitin, Dieldrin and Boconize for permanent moth-proofing. ■ Water and oil repellent finishes: fluoro-chemicals.

4.0 The Textile Industry and its Effect on the Environment

Textile processing generates many waste streams including wastewater effluents, solid wastes, air emissions and hazardous wastes. Typical waste streams are summarised in Table 4.1.

Table 4.1 Summary of Potential Releases Emitted During Textiles Manufacturing

Process	Air Emissions	Wastewater	Residual Wastes
Fibre preparation	Little or none	Little or none	Fibre waste and packaging waste
Yarn spinning	Little or none	Little or none	Packaging wastes; sized yarn; fibre waste; cleaning and processing waste
Slashing/sizing	VOCs	BOD; COD; metals; cleaning waste, size	Fibre lint; yarn waste; packaging waste; unused starch-based sizes
Weaving	Little or none	Little or none	Packaging waste; yarn and fabric scraps; off-spec fabric; used oil
Knitting	Little or none	Little or none	Packaging waste; yarn and fabric scraps; off-spec. fabric
Tufting	Little or none	Little or none	Packaging waste; yarn, fabric scraps; off-spec fabric
Desizing	VOCs from glycol ethers	BOD from sizes; lubricants; biocides; anti-static compounds	Packaging waste; fibre lint; yarn waste; cleaning and maintenance materials
Scouring	VOCs from glycol ethers and scouring solvents	Disinfectants, insecticide residues; NaOH; detergents, oils; knitting lubricants; spin finishes; spent solvents	Little or none
Bleaching	Little or none	H_2O_2, stabilisers; high pH	Little or none
Singeing	Small amounts of exhaust gases from the burners	Little or none	Little or none
Mercerising	Little or none	High pH; NaOH	Little or none
Heatsetting	Volatilisation of spin finish agents - synthetic fibre manufacture	Little or none	Little or none
Dyeing	VOCs	Metals; salt; surfactants; organic processing assistants; cationic materials; colour; BOD; COD; sulphide; acidity/ alkalinity; spent solvents	Little or none
Printing	Solvents, acetic acid - drying and curing, oven emissions; combustion gases.	Suspended solids; urea; solvents; colour; metals; heat; BOD; foam	Little or none
Finishing	VOCs; contaminants in purchased chemicals; formaldehyde vapours; combustion gases.	BOD; COD; suspended solids; toxic materials; spent solvents	Fabric scraps and trimmings; packaging waste

Source: Best Management Practices for Pollution Prevention in the Textile Industry, EPA, Office of Research and Development, 1995.

Amongst the contributions to wastes, liquid wastes tend to dominate over air emissions and solid wastes in terms of severity of environmental impacts. Liquid wastes arising from the various washing operations contain substantial pollution loads in terms of organic matter and suspended matter such as fibres and grease. These liquid wastes are generally hot and alkaline with strong smell and colours from dyeing processes. Some of the chemicals discharged can also have toxic effects on the receiving environment. Discharge of such effluents into aquatic bodies can cause lowering of dissolved oxygen, damage to aquatic life and expose downstream water users to possible toxic effects. An overall deterioration in the aesthetic value of water quality will also result.

4.1 Wastewater Generation

The textile industry uses high volumes of water throughout its operations, from the washing of fibres to bleaching, dyeing and washing of finished products. On average, approximately 200 l of water are required to produce 1kg of textiles. The large volumes of wastewater generated also contain a wide variety of chemicals, used throughout processing. These can cause damage if not properly treated before discharge to the environment. Of all the steps involved in textiles processing, wet processing creates the highest volume of wastewater.

The aquatic toxicity of textile industry wastewater varies considerably among production facilities. The sources of aquatic toxicity can include salt, surfactants, ionic metals and their complexed metals therein, toxic organic chemicals, biocides, and toxic anions. Most textile dyes have low aquatic toxicity. On the other hand, surfactants and related compounds, such as detergents, emulsifiers, dispersants, are used in almost every textile process and can be an important contributor to effluent aquatic toxicity, BOD, and foaming.

4.1.1 Pollution from Wet Processing Steps

A wide variety of chemicals are used in wet processing which include caustic materials, solvents, metal containing compounds, dyes, salts, detergents, preservatives etc. Some of these are used as process chemicals while others are used as auxiliaries.

(i) Preparatory Processing:

Of all the preparatory processes, desizing (the process of removing size chemicals from textiles) is one of the largest sources of wastewater pollutants and often contributes up to 50% of the BOD load in wastewater from wet processing. The scouring process also has a high BOD and also uses the highest volumes of water in the preparatory stages. The major pollution issues in the bleaching process are chemical handling, water conservation, and high pH.

Other hazardous organic materials include pentachlorophenol (PCP), an anti-mildew agent which is used as a preservative in the size recipe. During scouring, bleaching, dyeing and printing, PCP is removed from the fabric and discharged into the wastewater. It is toxic due to its relative stability against natural degradation processes and is also bioaccumulative.

(ii) Dyeing and Printing:

Dyeing operations generate a large
rinsing processes for disperse, reactive and direct dyeing generate the most wastewater. Throughout the dyeing process, the primary source of wastewater is spent dyebath and washwater. Such wastewater typically contains residual dyes and auxiliary chemicals.

Biological Oxygen Demand (BOD): Dyeing wastes reportedly contribute about 10-30% of the total BOD. Of this, acetic acid (which is used in the dyeing of disperse dyes on polyester, cationic dyes on acrylic fibres and acid dyes on wool, silk and nylon) can account for 50-90% of dyehouse BOD.

Chemical Oxygen Demand (COD): Dyes contribute 2-5% of the COD whilst dyebath chemicals contribute 25-35%. In addition to the high BOD and COD values of dyes, toxicity to aquatic organisms has also to be considered. Out of the 3,000 dyes commonly used, 98% have an LC_{50} value in excess of 1 mg/l. Amongst the different dyes examined, fish toxicity levels vary from less than 1 to more than 500m g/l LC value.

Salts: This has been identified as a potential problem area in textile-dyeing wastewater. Many types of salt are either used as raw materials or produced as by-products of neutralisation or other reactions in textile wet processes. Salt is most commonly used to assist the exhaustion of ionic dyes, particularly anionic dyes, such as direct and fibre reactive dyes on cotton. Typical cotton batch dyeing operations use quantities of salt that range from 20-80% of the weight of goods dyed, and the usual salt concentration in such wastewater is 2,000 - 3,000 ppm. Common salt (sodium chloride) and Glaubers salt (sodium sulphate) constitute the majority of total salt use. Other salts used as raw materials or formed in textile processes include Epsom salt (magnesium chloride), potassium chloride.

Although the mammalian and aquatic toxicity of these salts are very low, their massive use in certain textile-dyeing processes can produce wastewater with salt levels well above the regulatory limits.

Heavy Metals: Metals present in textile wastewater may typically include copper, cadmium, chromium, nickel, and zinc. Sources of metals found in textile mill effluents may include fibre, incoming water, dyes, plumbing, and chemical impurities. Dyes may contain metals such as zinc, nickel, chromium, and cobalt. In some dyes, these metals are functional (i.e., they form an integral part of the dye molecule); in others they are used in the dyeing process e.g., use of dichromate as an oxidising agent for sulphur dyes. However in most dyes, metals are simply impurities generated during dye manufacture. For example, mercury or other metals may be used as catalysts in the manufacture of certain dyes and may be present as by-products. Metals may be difficult to remove from wastewater.

Toxic effects of heavy metals to animal and aquatic life are dependent on physico-chemical form. In dyehouse effluent, heavy metals arise as a consequence of heavy metal salts used in dyeing, use of metal-complex dyes or from presence of impurities in dyestuffs. Metal-complex dyes contain copper, chromium, nickel or cobalt. Hydrogen peroxide or 1,3-di-nitro-benzeno-sulphonic acid is now replacing dichromate, which is used in oxidation of vat dyes in cotton dyeing.

Colour: Dyes and pigments from printing and dyeing operations are the principal sources of colour in textile effluent. They are highly coloured materials used in relatively small quantities (a few percent or less of the weight of the substrate) to impart colour to textile materials. In typical dyeing and printing processes, 50 to 90% of the colour is fixed on the fibre. The remainder is discarded in the form of spent dye-baths or in wastewater from subsequent textile-washing operations.

(iii) Finishing:

Finishing processes typically generate wastewaters containing natural and synthetic polymers and a range of other potentially toxic substances.

4.1.2 Pollution Specific to Processed Fibres

Of particular relevance to the Egyptian textile industry are the environmental implications of cotton textile processing, due to its predominance in the domestic textile market as well as the national export shares. Cotton and blended yarns and cotton and blended fabrics are among the highest contributors to domestic production of textile products (as per 1992/1993 figures) amounting to about LE 3,000 million and LE 900 million respectively. The 1993 figures for the total national export of textiles from Egypt indicate that 47% of the income is generated from cotton yarns and raw cotton.

(i) Wet Processing of Cotton-based Textiles

In Egypt, the cotton crop is usually sprayed before the pod opens. Therefore little, if any, pesticide is taken up by the cotton fibres themselves and rarely occurs in the wastewater.

The sources of wastewater for the wet processing of cotton-based textiles, main pollutants, volumes, wastewater characteristics and pollution impact are summarised in Table 4.2.

Table 4.2 Wastewater Flows and Characteristics of Cotton-based Textiles

Process	Source	Major Constituents	Water Use (l/kg)	Characteristics	Pollution Impact		
					L	M	H
Sizing	Cleaning of: slasher boxes, rolls, make up vessels	■ Starch derivatives. ■ Semi-synthetic sizing agents (CMC, CMS). ■ Synthetic sizing agents (PVAs, polyacrylates). ■ Additives: ➤ urea. ➤ glycerin ➤ waxes and oils. ➤ preserving agents (PCP).	10-90	BOD COD Temp.	✓	✓ ✓	✓ ✓ ✓ ✓
Desizing	Washing of sized fabrics (desizing contributes the largest BOD for all cotton wet processes, c. 45%)	■ Hydrolysed sizing agents (e.g. starch: high BOD, PVA, CMC; low BOD). ■ Enzymes or oxidants. ■ Wetting agents.	30-110	BOD (34-50% of total). COD. Temp. (70-80°C)			✓ ✓
Scouring	Washing of cotton waxes and impurities is the second largest BOD contributing process (c. 31%)	■ Saponified waxes, oils, fats. ■ Surfactants. ■ Alkalies. ■ High temperature.	200-400	Oily fats. BOD (30% of total). pH (high). temp.(70-80°C). Dark colour.			✓ ✓ ✓
Bleaching	Washing after bleaching contributes the lowest BOD in cotton wet processing	■ Residual bleaching agents. ■ Stabilisers. ■ Surfactants. ■ Wetting agents. ■ Mild alkalinity.	50-150		✓	✓	✓
Mercerisation	Washing effluents	■ Alkali (NaOH). ■ Surfactants. ■ Dissolved matter.	-	BOD. pH (high).			✓ ✓ ✓
Dyeing	Spent baths. After-washing	■ Dyestuffs (direct, vat, reactive, sulphur, pigment) ■ Electrolytes. ■ Carriers. ■ Acids and alkalies. ■ Heavy metals. ■ Oxidising agents. ■ Reducing agents. ■ Surfactants.	100-350	Toxicity. BOD (6% of total). dissolved solids pH. Strong colour.			✓ ✓ ✓ ✓ ✓

Process	Source	Major Constituents	Water Use (l/kg)	Characteristics	Pollution Impact		
					L	M	H
		▪ Levelling agents.					
Printing	Equipment washing and printed fabrics (except in emulsion printing).	▪ Dyestuffs. ▪ Alkalies. ▪ Acids. ▪ Reducing agents. ▪ Thickeners. ▪ CH_2O. ▪ Urea. ▪ Salts		Toxicity. COD. BOD. pH. Dissolved solids. Strong colour.		✓ ✓	✓ ✓ ✓ ✓ ✓
Finishing	Washing of the finishing bath, rolls, make-up vessels. After washing.	▪ Finishing. ▪ Acid catalysts. ▪ Surfactants. ▪ Softeners. ▪ Lubricants. ▪ Metal salts. ▪ Pentachlorophenol (PCP). ▪ Anti-mildew.	10-100	Alkalinity. BOD (low). Toxicity.	✓ ✓		 ✓

4.1.2 Processing of Wool and Blends

The sources of wastewater for the wet processing of wool and blends, main pollutants, volumes, wastewater characteristics and pollution impact are summarised in Table 4.3.

Table 4.3 Wastewater Flows and Characteristics of Wet Processing Wool and Blends

Process	Source	Major Constituents	Water Use (l/kg)	Characteristics	Pollution Impact		
					L	M	H
Scouring	Spent bath - after washing.	materials.	55-120	BOD (high) high grease high alkalinity temp. (40-50°C)			✓ ✓
Bleaching	Spent bath - washing	Sulphur dioxide or H_2O_2 and/or optical brighteners	8-10	low BOD			
Dyeing	Spent bath - after washing.	Acid or metallicised dyes, acetic acid or H_2SO_4, salts, surfactants, insect-proofing agents.	38-83	pH (low) relatively high BOD5 Possibly toxic AOX.			✓ ✓ ✓
Washing			48-192	High BOD high oil content temp. (40-60°C)			

4.1.3 Processing of Synthetic Fibres

The sources of wastewater for the wet processing of synthetic fibres, main pollutants, volumes, wastewater characteristics and pollution impact are summarised in Table 4.4.

Table 4.4 Major Pollutants in the Wet Processing of Synthetic Fibres

Fibre	Process	Liquid Waste Pollutant
Rayon	Scour and Dye	Oil, dye, synthetic detergent and anti-static lubricants.
	Scour and Bleach	Synthetic detergents and hydrogen peroxide.
	Salt Bath	Synthetic detergents, chlorine or sulphate.
Acetate	Scour and Dye	Anti-static agents, dye, sulphonated oils, synthetic detergents, esters and softeners.
	Scour and Bleach	Synthetic detergent, hydrogen peroxide or chlorine.
Nylon	Scour	Anti-static lubricants, soap, tetrasodium pyrophosphate, soda and fatty esters.
	Developed disperse dye	Dye, $NaNO_2$, hydrochloric acid, developer and sulphonated oils.
	Bleach	Peracetic acid
Acrylic/modacrylic	Dye	Dye, formic acid, wetting agents, aromatic amines, retarding agent and sulphates.
	Thermosol	Acid
	Bleach	Chlorite
	Scour	Synthetic detergent and pine oil
Acrylic/modacrylic	Dyeing	Chlorobenzenes, hot water and dye, or phenylmethyl carbinol, dye and hot water, or orthophenylphenol and dye.
	Scouring	Anti-static lubricants, chlorite or hypochlorite and non-ionic synthetic detergents.
	High temperature and pressure dyeing	Dye and hot water.
	Bleach	Chlorite, $NaNO_2$, acetic acid, oxalic acid, nitric acid, bisulphite, proprietary bleaches.

4.2 Air Emissions

Although the textile industry is a relatively minor source of air pollution as compared with many other industries, it emits a wide variety of air pollutants, making sampling, analysis, treatment, and prevention more complex. Operations that represent the greatest concern as sources of air emissions are coating, finishing, and dyeing operations. Textile mills usually generate nitrogen and sulphur oxides from boilers.

Other significant sources of air emissions in textile operations include resin finishing and drying operations, printing, dyeing, fabric preparation, and wastewater treatment plants. Hydrocarbons are emitted from drying ovens and from mineral oils in high-temperature drying/curing. These processes can emit formaldehyde, acids, softeners, and other volatile compounds. Residues from fibre preparation sometimes emit pollutants during heatsetting processes.

Carriers and solvents may be emitted during dyeing operations (depending on the types of dyeing processes used) and from wastewater treatment plant operations. Carriers used in batch dyeing of disperse dyes may lead to volatilisation of aqueous chemical emulsions during heat setting, drying, or curing stages. Acetic acid and formaldehyde are two major emissions of concern in textiles.

Other potential pollutants can include solvent vapours containing toxic compounds such as acetaldehyde, chlorofluorocarbons, p-dichlorobenzene, ethyl acetate, and others. Some

process chemicals, such as methyl naphthalene or chlorotoluene, may exhaust into the fibres and are later emitted from dryers as VOCs. Formaldehyde might be emitted from bulk resin storage tanks, finished fabric warehouses, dryers, and curing ovens located at facilities that apply formaldehyde-containing resins to cotton and polyester/cotton blends.

Textile manufacturing can produce oil and acid fumes, plasticisers and other volatile chemicals. Acetic acid emissions may arise from storage tanks, especially from vents during filling. Carbonising processes, used in wool yarn manufacture, may emit sulphuric acid fumes while decating, a finishing process applied to wool fabrics to set the nap and develop lustre, produces formic acid fumes. Table 4.5 summarises major sources of air pollution in the textile industry.

Table 4.5 Major Gaseous and Particulate Emissions in the Textile Industry

Source	**Pollutants**	**Pollution Impact**		
		L	M	H
Cotton handling activities (carding, combing, preparation and fabrics manufacturing).	Particulates			✓
Sizing of natural cellulosic fabrics	Nitrogen oxides, sulphur oxide, carbon monoxide	✓		
Bleaching with chlorine compounds	Chlorine, chlorine dioxide		✓	
Dyeing:				
▪ Disperse dyeing using carriers	Carriers			✓
▪ Sulphur dyeing	H_2S			✓
▪ Aniline dyeing	Aniline vapours			✓
Printing	Hydrocarbons, ammonia			✓
Finishing:				
▪ Resin finishing	Formaldehyde			✓
▪ Heat setting of synthetic fabrics	Carriers - low molecular weight Polymers - lubricating oils			✓

4.3 Solid Wastes

The primary residual wastes generated from the textile industry are non-hazardous. These include scraps of fabric and yarn, off-specification yarn and fabric and packaging waste. There are also wastes associated with the storage and production of yarns and textiles, such as chemical storage drums, cardboard reels for storing fabric and cones used to hold yarns for dyeing and knitting.

Cutting room waste generates a high volume of fabric scraps, which can often be reduced by increasing fabric utilisation efficiency in cutting and sewing.

The following table summarises solid wastes associated with various textile manufacturing processes.

Table 4.6 Sources of Solid Waste in Textile Manufacturing

Source	Type of Solid Waste	Pollution Impact		
		L	M	H
Mechanical Operations of Cotton and Synthetics:				
▪ Yarn preparation.	Fibres and yarns.	✓		
▪ Knitting.	Fibres and yarns.	✓		
▪ Weaving.	Fibres, yarns and cloth scraps.	✓		
Dyeing and Finishing of Woven Fabrics:				
▪ Sizing. Desizing mercerising, beaching, washing and chemical finishing.	Cloth scraps.	✓		
▪ Mechanical finishing.	Flock.	✓		
▪ Dyeing and/or printing.	Dye containers.			✓
▪ Dyeing and/or printing (applied finish).	Chemical containers.			✓
Dyeing and Finishing of Knitted Fabrics.	Cloth scraps, dye and chemical containers.			✓
Dyeing and Finishing of Carpets:				
▪ Tufting.	Yarns and sweepings.			
▪ Selvage trim.	Selvage.			
▪ Fluff and shear.	Flock.			
▪ Dyeing, printing and finishing.	Dye and chemical containers.			✓
Dyeing and Finishing of Yarn and Stock.	Yarns, dye and chemical containers.			✓
Wool scouring.	Dirt, wool, vegetable matter, waxes.			✓
Wool fabric dyeing and finishing.	Flocks, seams, fabric, fibres, dye and chemical containers.			✓
Wastewater treatment.	Fibre, wasted sludge and retained sludge.			✓
Packaging.	Paper, cartons, plastic sheets, rope.	✓		
Workshops.	Scrap metal, oily rags.	✓		
Domestic.	Paper, sheets, general domestic wastes.	✓		

4.4 Waste Management Practices

In Egypt, waste management can be summarised as follows:

1. **Wastewater** is collected in one stream and either treated in wastewater treatment plant in the factory or discharged to the public sewers, whereby local authorities treat it with domestic wastewater. Some other factories discharge either effluents to the drainage canals that end to the sea.
2. **Solid wastes** are mostly collected for reprocessing or selling.
3. **Gaseous emissions**, especially particulates (dust and fibres), are collected and reprocessed.

The total pollution load may have a number of different origins. These may include natural impurities present in fibres, pesticides and herbicides (in natural fibres) and chemicals from the textile manufacturing process. In cotton and wool, the natural impurities are the major source of pollution, whereas in the processing of synthetic fibres, the process chemicals are the major source of pollution. Of all of these, wool fibres are usually considered to have the strongest wet processing wastes.

Current waste management practices in the Egyptian textile industry are summarised in Table 4.7. This illustrates that:

- Solid wastes are almost completely sold for secondary uses or small scale industries.
- Wastewater treatment is still very primitive and limited to equalisation and chemical precipitation.
- Most of the textile companies discharge their wastewater into a soak way and in few cases to streams of potable water.

Table 4.7 Current Waste Management Practices

Section	Waste	Composition/Characteristics	Management
Spinning, Weaving (or knitting).	Solid.	Fibres, yarns, fabrics.	Collected, stored and reprocessed or sold as is.
		Particulates.	Collected by suction and classified for reprocessing or sold as is.
Ready-made garments.	Solid.	Fabric due to cutting.	Used for the production of non-wovens, geotextiles, blankets, carpets.
Sizing, desizing.	Liquid.	Starch-based materials (high BOD).	To public sewers or treatment plant.
		Modified carbohydrate soluble synthetic polymers (low BOD, high COD).	Reused or sold.
	Solid.	Containers.	Reused or sold.
Scouring, mercerisation.	Liquid.	Dissolved solids (high pH)	Alkalis are recycled (especially from mercerisation).
		Suspended solids: - fibres. - cotton waxes. - wool waxes.	■ Wool wax is recovered, purified and sold. ■ Some factories neutralise high pH effluent streams before discharging to public sewers.
Bleaching.	Liquid.	Low BOD - residual bleaching agents, stabilisers, surfactants and dissolved solids.	■ Discharge to public sewers. ■ Discharge to wastewater treatment plant.
	Gas.	Chlorine gas and oxides in case of hypochlorite and chlorite bleaching.	Disposed to air.
Dyeing and / or printing.	Liquid.	Dyes and auxiliaries, salts and carriers.	Discharge to wastewater treatment plant, public sewers or drainage canals.
	Gas.	Kerosene in pigment. Printing.	Discharged to air.
	Solids.	Dye and chemical containers.	Collected and sold.
Chemical finishing.	Gas.	Formaldehyde, carriers, oligomers, ammonia.	Discharged to air.
	Solid.	Chemical containers, residual finishing agents, surfactants, acidic pH, softeners.	■ Collected and sold. ■ Discharge to wastewater treatment plant or public sewers.
Packing.	Solid.	Cartons, polyethylene sheets and bags, wrappings, etc.	Collected and sold.
Workshops.	Solid & liquid.	Scrap metal, used motor oils.	■ Scrap metal collected and sold. ■ Motor oils collected and sold, or refined and reused.

Examples of wastewater treatment practices are given in Table 4.8.

Table 4.8 Wastewater Management in Selected Egyptian Textile Factories.

Company	Treatment Facilities
Misr Helwan Spinning and Weaving Company	Oil separation, clarification and drying beds.
El Nasr Spinning, Weaving and Dyeing Company, Mahalla El-Kobra.	Screening, equalisation, surface aeration, thickening, belt filter.
Misr Spinning and Weaving Company, Mahalla El-Kobra.	Screening, oil separation, surface aeration, settling, pH adjustment, belt filter press.
El Nasr Wool and Selected Textiles Company (STIA).	Primary treatment.
Misr Beida Dyers, Alexandria.	(Under investigation, 1995).
National Spinning and Weaving Company, Alexandria.	(Study completed, 1995).
Abou El-Hole, Assyut.	(Under construction, 1995).
South Egypt Spinning and Weaving Company.	Primary treatment.
El-Amereya Spinning and Weaving Company.	Integrated treatment (not fully utilised).
Arabia and United for Spinning and Weaving Company.	(Study completed, 1995).

4.5 Effects of Major Process Chemicals on Human Health

A summary of these effects are given below in Table 4.9.

Table 4.9 Process Chemicals and their Effects on Human Health

Substance	Process Chemical	Emission	Action	Toxic Effect
1. Acids				
Acetic acid	✓	✓	Irritant and corrosive	Exposure to gas or spray can cause intense irritation of the eyes, nose and throat and causes skin damage. TLV 5ppm.
Boric acid	✓		Mild antiseptic	Mildly cytotoxic. Estimated lethal dose for an adult 10g.
Formic acid	✓	✓		vapour irritates respiratory tract and eyes. Liquid burns the eyes and skin and produces severe gastro-intestinal irritation if swallowed. TLV 5ppm. Estimated lethal dose 30g.
Hydrochloric acid	✓		Irritant and corrosive	Exposure to gas or spray can cause intense irritation of the eyes, nose and throat and causes skin damage. TLV 5ppm.
Oxalic acid	✓		Reduces ionisable calcium in the body.	Acid mildly corrosive and hypocalcaemic. Estimated lethal dose for adults 2-5g. TLV1mg/m^3
Sulphuric acid	✓		corrosive	Stains the skin brown to yellow. Can cause severe eye damage. Lethal dose 5ml, but 1ml can cause lethal shock. TLV 1mg/m^3

Substance	Process Chemical	Emission	Action	Toxic Effect
2. Bases				
Ammonia	✓	✓	Powerful irritant and moderately corrosive to skin.	Vapour severe irritant to eyes. 100ppm causes irritation, vomiting, diarrhoea, sweating and coughing. High concentrations can cause respiratory arrest. Splashes in the eyes can cause severe pain and damage. Lethal dose 10ml.
Sodium hydroxide	✓		Powerful corrosive. Solids can burn skin in presence of water.	Skin damage on repeated or prolonged exposure. Dust can cause severe eye damage.
3. Bleaching Agents				
Hypochlorite	✓		Severe irritation, skin and mucous membrane damage.	Chlorine gas released, causing severe irritation of respiratory tract and eyes. Lethal dose of Cl_2 500ppm, TLV 1ppm.
Hydrogen peroxide	✓		Oxidising agent.	Strong solutions can produce burns if left on the skin. TLV 1ppm.
4. Carriers				
Perchloro-ethylene	✓	✓	narcotic	Can cause dizziness and affect kidney and liver.
Methyl salicylate	✓	✓	irritant	Prolonged exposure may cause kidney and liver degeneration. Skin irritant.
Chlorinated aromatics	✓	✓		Carcinogenic
5. Detergents (surfactants)				
Anionic	✓			Ingestion can increase absorbtion rate of other chemicals. May cause bloating and
Non-ionic	✓			Diarrhoea. Irritant to eyes and skin.
Cationic	✓			Significantly more toxic and irritating than other detergents. Estimated lethal dose for a quaternary ammonium surfactant for adults 1-3g.
6. Dyestuffs				
Non-benzidinium direct	✓			Non-toxic
Vat	✓			Non-toxic
Benzidinium	✓			Carcinogenic
Reactive	✓			Toxicity depends on structure
Acid	✓			Mostly non-toxic, except:: acid black 52, acid yellow 38, acid blue 113, acid green 25, acid blue 25, acid yellow 151
Disperse	✓			Mostly non-toxic, except for example disperse blue 33 and disperse blue 7.
Basic	✓			Generally toxic, particularly those used on triphenyl methane (e.g. crystal violet)
Aniline black:				
(a) aniline	✓	✓	Irritant, depressant	Lethal dose 1-4g. TLV 5ppm
(b) potassium dichromate	✓		Cytotoxic and irritant	Can cause dermatitis and ulceration. Carcinogenic.
(c) sodium chlorate	✓		Convulsant	Moderately irritating to skin.

Substance	Process Chemical	Emission	Action	Toxic Effect
7. Finishing Agents				
Formaldehyde-based resins	✓	✓	Formaldehyde kills tissues and depresses cell functions	Intense irritation of eyes and nose and headaches. Carcinogenic. Lethal dose around 50ml. TLV 5ppm.
Flame-proof finishes	✓			Organophosphorus is highly toxic and carcinogenic.
8. Sequestering Agents				
Polyphosphates	✓		Irritant	Vomiting, bladder irritation.

Fumes and dusts may also be generated during processing. A summary of some of the most common and their effect on human health are shown in Table 4.10:

Table 4.10 The Impacts of Dust and Fumes on Human Health

Substance	Process Chemical	Emission	Action	Toxic Effect
Carbon disulphide		✓	Narcotic, hemolytic, neurotoxic	Contact with skin can cause severe pain and damage Contact for more than a few minutes can cause second degree burns. Inhalation of 100-1000ppm can cause fatigue, vomiting, headaches and constipation. Lethal dose around 10ml. 150ppm in air is dangerous, TLV 20ppm.
Carbon monoxide		✓	Reduces blood oxygen-carrying capacity.	Dizziness, weakness, headache. Concentrations above 1000ppm can be fatal within 1 hour. TLV 50ppm.
Hydrogen sulphide		✓	Irritant and narcotic	Violent headache, muscular weakness and feeble pulse. TLV 50ppm.
Kerosene	✓	✓		Nausea, vomiting, coughing, leading to respiratory paralysis.
Nitrogen oxides		✓		Sever irritation of eyes and respiratory tract. High concentrations can cause immediate asphyxia. TLV 5ppm.
Sulphur oxides		✓	Irritant	Inhalation of low concentrations causes rhinitis and burning pain in chest.
Particulates		✓	Irritant	Irritation of respiratory system. Fever and coughing are frequent symptoms.

Part B

CLEANER PRODUCTION AND THE SEAM PROJECT:

Implementation in the Egyptian Textile Industry

5.0 Cleaner Production Audits

5.1 Introduction - What is a Cleaner Production Audit?

A Cleaner Production Audit can be defined as:

A systematic review of a company's processes and operations designed to identify and provide information about opportunities to reduce waste, reduce pollution and improve operational efficiency.

A good Cleaner Production Audit will:

- Present all available information on unit operations, raw materials, products, water and energy usage.
- Define the sources, quantities and types of waste generated.
- Clearly identify where process inefficiencies and areas of poor management exist.
- Identify environmentally damaging activities and report on legislative compliance (A list of applicable Egyptian legislation and regulations is shown in Appendix 5.)
- Identify where Cleaner Production opportunities exist, outline how much these will cost to implement and quantify the benefits.
- Prioritise the Cleaner Production opportunities identified. Priority should be given to low cost/no cost measures and those with relatively short pay-back periods.
- Incorporate an Action Plan, which will describe how the Cleaner Production measures can be best implemented at the factory.

> The SEAM Project carried out Cleaner Production audits in 10 textile wet manufacturing plants. These audits focused on identifying low-cost interventions with fast payback periods - a total of 183 such interventions were identified, with implementation costs ranging from zero to LE93,000. Savings ranged from LE1,100 to LE716,900, with average payback periods of less than 1 month.

5.2 Carrying out an Industrial Audit: A Step by Step Description

A key word in the Cleaner Production Audit definition is systematic. A systematic approach will ensure that as much information as possible is collected and assessed to develop financially and technically feasible Cleaner Production opportunities. A step-by-step guide to carrying out a Cleaner Production Audit follows.

Step 1 Management Commitment

The key to success of any Cleaner Production audit depends on the interest, support and commitment of top management. This will only be gained if they are convinced of the benefits and can see that it will reduce costs. Top management support and commitment is essential in:

- Allocating appropriate human resources for carrying out the industrial audit and implementing the viable CP options.
- Facilitating the release of detailed process and financial information from all departments to the Team.
- Encouraging the factory staff to implement any changes identified.
- Providing the financial resources for CP implementation where necessary.

Step 2 Appointing a Cleaner Production Team

Before any work can be carried out, a Team needs to be formed which will carry out the Audit and identify CP opportunities. The size and composition of the Team will vary, depending on factory size and organisational structure, but should include representatives from each production and support department. An external consultant with experience in identifying and implementing CP interventions may also be a useful Team member.

Once the Team has been formed, specific roles and responsibilities should be assigned, including a Team Co-ordinator who will be responsible for managing the various responsibilities and tasks.

A general guide to Team composition and general duties follows:

Audit Team Member	Main Inputs and Duties
Production Departments: ■ Pre-Treatment ■ Dyeing ■ Printing ■ Finishing	Flow diagrams, raw material use and transfer from storage to process, production schedules, process descriptions and recipes, operating manuals, cleaning and routine maintenance.
Stores and Purchases Department(s)	Volume and frequency of substances purchased, storage, inventory control, main users of each substance.
The Quality Control Department (including a representative from the laboratory)	Quality control procedures, fabric and process chemical information, analytical capabilities.
The Utilities Department	Types, production and consumption rates of water, energy and steam etc., wastewater treatment cleaning and routine maintenance.
The Maintenance Department	Maintenance schedules and records, identification of areas needing high levels of maintenance.
The Financial Department	Purchasing costs (fibres, process dyes and chemicals, machinery, etc.), selling costs, downgraded products. Assist with cost-benefit calculations.
The Environmental Department (if this exists)	Air emissions, solid and liquid wastes, legislative compliance, safety records.

For each department, individuals having the best understanding of the department as a whole should be selected as the representative. This individual will be in the best position to describe and quantify the processes carried out, as well as being in the best position to make estimates where necessary.

Note: It may not always be possible to get precise information but it is the function of the Audit Team to make their best judgements and estimates if specific data are not available.

Step 3 Collection of Baseline Information

All information that is readily available in the factory should be collected by the Audit Team. This information may consist of:

- Site layout and plans showing buildings and functional units, location of drains and sewers, chimneys, vents and discharge points.

- Listing of all processes carried out and process flow diagrams (if available), including materials storage and handling information, product packaging and dispatch. Cleaning processes, particularly where these involve the use of chemicals, should also be included.
- Operating manuals of machinery, particularly with reference to the design conditions as recommended by the manufacturer.
- Raw material and product information, including by-products.
- Financial information, including purchase costs of chemicals and utilities, product and by-product selling prices (including downgraded goods), operating and maintenance costs. A summary of the cost elements in the total production costs would also be useful.
- Environmental information, for example wastewater quality, details of existing wastewater treatment system, air emissions, the production and fate of solid wastes and environmental reports and licenses.
- Health and safety records.

This information may not be readily available and in some cases, may be scattered throughout the factory. It is important that as much information as possible is collected at this stage, to minimise the amount of investigative work needed later.

It is important that the information collected is as accurate as possible - where assumptions have been made, these should be clearly stated.

Step 4 Understand Factory Operations and Processes

This following general information will need to be obtained or derived:

- Construction of a flow diagram for each process (example given as Figure 5.1). This should identify all steps that are carried out and list all of the inputs (including raw materials, process chemicals, steam, water and energy, etc.), outputs (products, by-products, solid, liquid and gaseous emissions) and any recycling steps. If flow diagrams have already been collected in the Collection of Baseline Information step, they will need to be carefully checked for recent and/or unrecorded modifications.
- The information gathered so far should then be verified by conducting a walk through of the factory. This walk through can also be used to identify and record obvious losses that are occurring, such as leaks and spills. High noise levels should also be noted as these may indicate that equipment maintenance is required. The information gathered should also be discussed with Production staff from each department, as they will be able to give a good account of actual operating conditions and problems.

Note: A walk through, or discussions with production staff should be carried out whenever data is missing, or there appears to be a conflict between 2 different sources of data.

- If on-site laboratories exist, they should be assessed to determine what can be analysed and which specific tests can be carried out, for example:
  - ➔ raw fibres (e.g. pesticide content);
  - ➔ quality of incoming dyes and chemicals (e.g. heavy metals content);
  - ➔ quality of the finished products (e.g. tensile strength, whiteness, washing fastness), and
  - ➔ wastewater quality (e.g. pH, BOD, COD, heavy metals).

Examples of Questions for Production Staff:

? How much time is needed to complete each stage of the process?

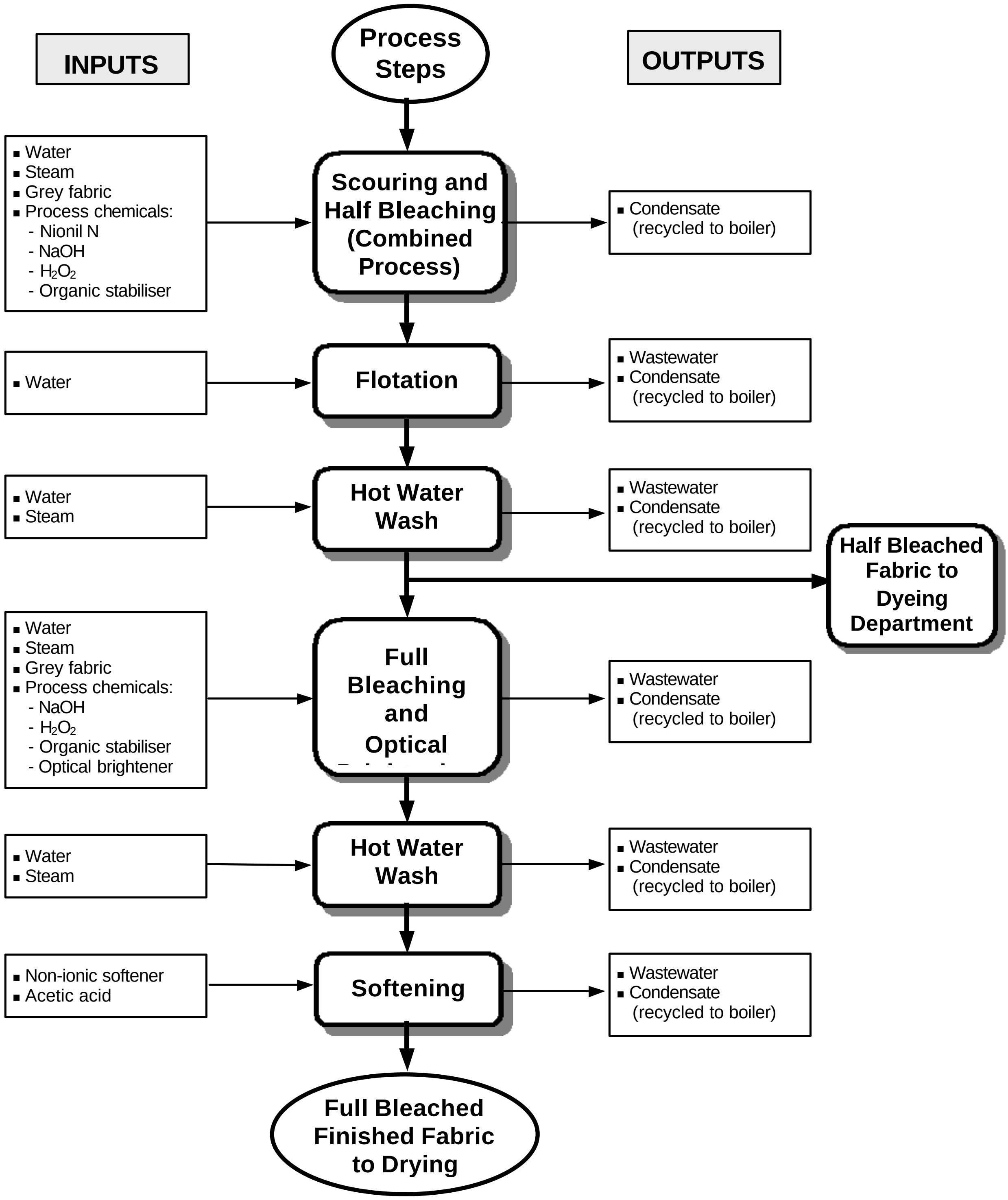
? What are water and energy requirements for each step?

? What raw materials are used? How are these weighed and transported to the production area?

? What rejects are there and what is their volume? What happens to these rejects?

? How close are operating conditions to design conditions?

Figure 5.1: Example of a Process Flow Diagram (Half and Full Bleaching)



Step 5 Define Inputs

Using the process flow diagrams developed in Step 4, the inputs for each department need to be quantified. This may include:

- The amount of electrical power supplied;
- The amount of fuel that is directly consumed by each department (the largest consumer here will probably be the boiler house);
- The volume of steam consumed (steams of different pressures should be accounted for separately);
- The amount of process dyes and chemicals used;
- The amount of other chemicals used (e.g. cleaning chemicals);
- The volume of water consumed (the different types of water consumed should be separately recorded e.g. city water, softened water, groundwater, water pumped from the river, canals or lakes);
- Current levels of reuse and/or recycling both within each department and between departments.

The units used for each of these must be clearly identified.

If specific data are not available, best estimates should be used and the basis for these estimates clearly stated. Other issues that should be quantified include storage and handling losses of raw materials and existing reuse and recycling steps.

Step 6 Define Outputs

The outputs identified in the process flow diagram need to be quantified. As with the inputs, if specific data are not available, best estimates should be used and the basis for these estimates clearly stated. The following outputs should be considered:

- Process outputs, including final and downgraded products (quantity and quality), spillage losses, evaporation losses, reusable wastes.
- Wastewater sources, the units that they come from, their volume and concentration. Examples include dyebaths, washes and rinses within the processes, boiler blowdown, floor washing. Combined wastewater flows should also be clearly identified in terms of their origin, where in the factory this takes place and how they are combined (e.g. into a balancing tank, combined in main drain, etc.).
- Solid wastes, including information on where they come from, what they consist of, their volume and their eventual disposal route (e.g. segregated and sold, recycled, disposed as a waste off-site).
- Gaseous emissions, including in-process sources, vents and chimneys.

Note: A checklist can be used as an aide memoire in collecting the information described in steps 3-6. The checklist used in the SEAM Project is given as Appendix 6.

Step 7 Prepare Material and Energy Balances

Material and energy balances give a detailed account of all inputs and outputs, so that problem areas can be identified and losses quantified. They will also clearly identify and quantify previously unknown losses or emissions.

> **Sources of Information for Material/ Energy Balances**
> *The majority of this will already have been collected during Steps 3-6*
> - Sample analyses and measurement of raw materials, products and wastes.
> - Raw materials purchase records and inventories.
> - Emission inventories.
> - Equipment cleaning procedures.
> - Processing recipes.
> - Product specifications.
> - Operating logs.
> - Standard operating procedures and operating manuals.

1. ***Prepare Material and Energy Balances for each Process Unit***. These are normally presented as flow diagrams, which simply show the nature and volume of total inputs against the outputs. These can be prepared for:
   - Process units, to quantify consumption and losses for each process and
   - Important and/or expensive resources, such as sizing agents and printing pastes.
2. ***Identify Discrepancies***. When a material balance is first attempted, inputs usually exceed outputs, indicating that data are either incomplete or missing. The source(s) of these discrepancies must be identified and where possible, quantified. Common causes of discrepancies include inaccurate data, different units of measurement being compared, missed discharges or waste streams and missed recycling steps.
3. ***Refine Material Balance to a satisfactory Level of Accuracy***. High levels of accuracy in material balances are usually difficult to achieve - an accuracy of ±10% should generally be acceptable. However, if hazardous and/or expensive substances are involved, a higher level of accuracy should be targeted. Once the material balance has been satisfactorily completed, this information can be used to calculate:
   - The value of the losses incurred. This can be calculated using the cost of the raw material and the corresponding volume and value of the lost product.
   - The amount of resources consumed in the production of 1 ton of fibre or fabric.
   - The volume of waste generated in the production of 1 ton of fibre or fabric.

Step 8 Benchmarks and Standards

The values derived for resource consumption and wastes generation can then be compared to national (where they exist) and international averages, known as benchmarks, to show how well the factory is performing. These benchmarks can also be used to set targets for the factory to achieve in order to reduce wastage and optimise production. Some examples of international benchmarks and standards follow:

World Bank:

- Air emissions - less than 1 kg/ton of fabric produced.
- Wastewater volume - Preferred: $100m^3$/ton fabric.
  Acceptable: $150m^3$/ton fabric.

World Bank Draft PARCOM Regulations for Wet Textile Processing:

(i) ***Quality of Raw Materials*** - the following concentrations in untreated wastewater from the pre-treatment step can be used to indicate if raw materials are of an acceptable quality or not. If these limits are exceeded, alternative sources of raw materials should be considered:

- DDT: 1 µgDDT/l
- Pentachlorophenol: 20 µgPCP/l
- Arsenic: 200 µgAs/l

- Lead: 50 µgPb/l
- Cadmium: 5 µgCd/l
- Mercury: 1 µgHg/l
- Zinc: 3 mgZn/l (viscose or recuperated proteinous fibres)
- Total Chromium: 0.5 mgCr/l (recuperated proteinous fibres)

(ii) Metal content of dyes - dyes with low metal content are preferred and their replacement should be considered if the following concentrations in untreated dyehouse effluent are exceeded:

- Chromium: 4.0 mg Kr/l and 1.0 kg Kr/day.
- Copper: 0.5 mg Cu/l and 0.5kg Cu/day.

At present, no benchmarks have been developed specifically for Egypt.

Step 9 Identification of Potential Cleaner Production Options

Using the previously gathered information, the Team are now in a position to identify a large number of potential improvements. Specific actions that have been carried out in Egyptian factories are described in Section 6.0.

1. ***Identify Obvious Improvement Measures***. Most of these will have been identified during the factory walk through. Examples of such measures include:

- Stopping leakages and spillages.
- Eliminating unnecessary water usage.
- Recycling of slightly contaminated washwaters.
- Improving existing storage facilities to minimise damage to raw materials and processed fabric.
- Segregation of wastes for recovery, recycling or sale.

These measures are generally easy to implement, with little or no capital investment.

2. ***Identify Particularly Hazardous or Polluting Wastes***. Pollution in wastewater is an indicator that valuable raw materials, products or potential by-products are being wasted. Highly polluted wastewaters may also be toxic and hazardous, difficult to treat and its discharge into the environment can cause significant damage, as well as exceeding legislative discharge standards.

3. ***Develop Other Improvement Measures***. These can include:

- Substitution of raw materials which have been identified as toxic, hazardous or otherwise unsuitable.
- Modification of existing processes to optimise the amount of processing carried out or to improve the processing method.
- Changing operating practices to ensure that wastage is minimised.
- Recovering and recycling expensive process chemicals (e.g. NaOH, non-starch sizes).
- Recovering previously wasted by products (e.g. wool grease from wool washing).
- Installation of more efficient machinery, new processes, new technology.

Step 10 Assess Costs and Benefits of Cleaner Production Options

At this stage, a large number of Cleaner Production options will have been identified. The next step is to identify those options which will be of most benefit to the factory, both financially and environmentally. Following is a description of the sort of information that needs to be considered - the amount of detail required will vary on the overall size and complexity of the proposed action.

1. ***Technical Feasibility***. This describes the proposed intervention in detail and evaluates how the proposed measure will affect the process, product, production rate, etc. For each option proposed, the technical benefits that will result should be clearly identified (e.g. improved fabric quality, reduced energy consumption, improved productivity). These can then be quantified in the assessment of financial viability.

2. ***Financial Viability***. This step establishes the costs and benefits of implementation. The information required includes present production costs, capital and operating costs associated with each intervention and value of any savings made. Priority should be given to the evaluation of low-cost/no-cost options, which may only require the calculation of a payback period. Higher cost options may need a more detailed assessment to evaluate economic feasibility.

3. ***Environmental Benefits***. Where possible, an environmental assessment of the selected options should be carried out, even if some of the benefits cannot be quantified. This should include effect on wastewater volume and toxicity (and hence reduced treatment costs and movement towards legislative compliance), reduced generation of solid wastes (improved site appearance, reduced disposal requirements) and improved working conditions.

Note: In the SEAM Project, this was presented in the form of Project Concept Notes (see Section 7.4.6).

Step 11 Prioritising Cleaner Production Options

It is unlikely that all of the options identified can be implemented immediately. Therefore, once all of the realistic opportunities have been identified, the next step is to prioritise them. A suggested method of prioritisation follows:

Priority 1: Factors where there are significant polluting effects or a strong probability of an incident which will require urgent and effective action OR where the company is acting illegally OR significant benefit to the company will result through reduced costs or improved efficiency. This group will include most of the Obvious Improvement Measures described in Step 9, which will be very easy and cheap to implement. ***The financial benefit to the company will exceed the cost of implementation within a short time (less than 1 year).***

Priority 2: Factors where there are apparent polluting effects or a probability of an incident which will damage the environment OR is a significant risk to the health and safety of staff OR the ***benefits to the company will result through investment in the medium term (1-3 years).***

Priority 3: Factors which will not have immediate adverse consequences but where the company can expect benefits in the longer term through reduced costs or better employee, customer or public relations.

Step 12 Developing Cleaner Production Action Plans

The Action Plan should describe when and how the prioritised actions should be implemented. This will allow the factory to match the proposed actions to any budget constraints that exist, as well as identifying critical actions, such as eliminating the use of banned chemicals. This should be supported by a monitoring programme which will record the actual benefits made.

The Action Plan should also identify when the next Cleaner Production Audit is to be carried out and how often this should be done.

Step 13 Implementation of Proposed Cleaner Production Options

Once the options have been assessed and prioritised, implementation can commence. Most Priority 1 options can be implemented immediately - of these, the lowest cost options should be completed first. The remaining options may require some planning if implementation is to be successful. Again, the amount of detail required will vary on the overall size and complexity of the proposed action.

1. ***Preparation*** - This will require:

   - A Team to be set up which will be responsible for implementation and a Team Leader, who will co-ordinate the tasks and monitor progress.
   - The preparation of technical documents that describe what the project is, where it is located and what work needs to be carried out. This may include a Bill of Quantities, which itemises equipment which has to be purchased.
   - A workplan which describes all the tasks that need to be carried out and an estimate of how long each task will take to complete. This will also allow work to be scheduled to minimise disruption to the normal working day.

   In order to achieve the best results, it is important that staff are kept informed of the changes going on and provided with training if required.

2. ***Implementation*** - the workplan developed in the planning stage should be used as a guide for implementation. Each task in this should be assigned to the most appropriate member of the Team, with individual tasks being co-ordinated by the Team Leader. If any significant delays occur, the workplan should be modified, so that tasks can be rescheduled. Progress reports can also be provided to senior management and other Team members to keep them informed of project developments.

   Once implementation has been completed, the new work procedures should be documented in the form of revised work instructions. Staff training may be required to ensure that these are understood and can be easily followed. Revised instructions to other departments may also be necessary. For example, if one chemical has been substituted by another, revised instructions to the purchasing department will be required.

3. ***Monitoring and Evaluation*** - this will need to be carried out once implementation has been completed to ensure that the project is performing normally and that the expected benefits are being realised. This will help identify - and solve - any unforeseen problems at an early stage, as well as informing management of progress.

5.3 Sampling and Analytical Requirements

(i) Water and Wastewater Flow Measurements

Ideally, continuous measurement of liquid flow rates should be carried out with fixed equipment. If this does not exist, then estimates of flow have to be made by simple methods by using, for example, a calibrated collecting vessel and stopwatch. Crude estimates can be made from pipe dimensions, judgements of flow rates, etc.

(ii) Wastewater Sampling

In most factories there will be considerable variability in wastewater quality over time; sampling therefore needs to be carried out to minimise this:

- A series of single grab samples can be manually collected. These can either be tested independently or combined to give a composite, time-averaged sample. Automatic time-average samplers for wastewaters are available commercially.
- Flow proportioned samples are desirable but in practice are difficult to take.

Samples should be taken from the end of discharge pipes where possible.

Certain chemical parameters require the sample to be stabilised, for example, by the addition of acid for heavy metal analyses. In some cases the sample has to be taken into glass containers rather than plastic.

Before any sampling is carried out, it is advisable to discuss and finalise what is required with the laboratory which will be carrying out the analyses.

(iii) Sample Storage and Transportation

Once taken, the samples should be delivered to the testing laboratory as soon as possible after sampling, preferably within the same working day and always within 24 hours. If there is any delay, samples should be kept cool by storing them in insulated boxes with freezer packs.

(iv) Wastewater Analyses - Laboratory Analyses

Wastewater may need to be tested for one or more of the following parameters:

- Biological Oxygen Demand (BOD_5), Chemical Oxygen Demand (COD), Suspended Solids and Total Solids.
- Heavy metals. Analyses would only be required for specific metals based on the chemical substances used in the factory.
- Organics such as pesticides, hydrocarbons, oil & grease.

The need for chemical analyses should be carefully assessed, as it is usually complex and expensive.

(v) Wastewater Analyses - in situ Measurements

The following parameters can be measured at the discharge point itself, using portable meters:

- Temperature.
- Conductivity.
- Turbidity.
- pH.

(vi) Measurement of Gas/Vapour Flow Rates

Gas/vapour flow rate measurements may be necessary at vent entries and exits or within ducts, although the latter may be problematic because of access difficulties. Where access is possible hot wire anemometers can be used for flow rate measurements.

Flow rate should be measured where it is least affected by bends, etc. and a number of measurements taken in the centre and towards the sides of the duct. Before ducts are breached, consideration must be given to the potential release of hazardous materials and the way in which the duct can be effectively sealed after measurements have been made.

(vii) Air and Flue Gas Composition

In the absence of suitable electronic equipment, boiler efficiency can be assessed based on such factors as plume colour (e.g. Ringelmann chart shade), fuel usage and length of time since previous checks. The concentration of many gases can also be estimated using Draeger tubes.

(viii) Noise

Noise needs to be considered in relation to environmental nuisance or as an occupational hazard. The maximum allowable sound level (Law 4) is 90 decibels. Prolonged exposure to noise above 80 decibels can result in permanent damage to hearing.

5.4 Sustaining and Developing Cleaner Production

The advantages gained by the implementation of CP options need to be monitored to ensure that the new practices are followed by factory staff. This could be encouraged by the establishment of reward and recognition schemes to ensure that employee interest and motivation is maintained.

In order to identify new CP options, this audit process should be carried out again after 1 year or so. If possible, the original Audit Team should be used, in order to take advantage of their newly acquired knowledge and skills in the identification and implementation of CP options.

6.0 Cleaner Production Options Identified through SEAM

The hierarchy of CP options ranges from simple housekeeping measures at the first level, followed by recycle - reuse of water and recovery of energy and chemicals, eventually leading to process modifications entailing chemical substitutions, equipment modifications and changes in the technology.

Examples of specific actions identified by the industrial audits under the SEAM Project, as well as other interventions that could be implemented are described in the following sections.

6.1 Good Housekeeping Measures

Good housekeeping measures can result in high savings of water, energy, raw materials and finished products. These measures usually consist of extremely simple actions, which can be implemented with little or no capital expenditure. They can be implemented immediately and reviewed as a part of a regular maintenance programme.

During the industrial audits, a number of issues were commonly observed. These included:

(i) Storage of Raw Fibres and Finished Fabrics

- Poor storage of raw fibres, resulted in soiling and the generation of a serious fire hazard. This can be avoided by ensuring that all raw fibres that are delivered have been properly wrapped and that these are kept intact until the fibre is processed.
- Intermediate and finished products left uncovered and touching the floor, resulting in physical damage and soiling. These losses could be eliminated by storing this fabric in high sided containers and covering with plastic sheeting.

(ii) Storage of Process Chemicals and Dyestuffs

- Dye transfer and mixing in the colour kitchen should be carried out carefully to minimise spillage and loss. This will also reduce cross-contamination of made-up recipes occurring and improve working conditions.
- The containers of reactive dyestuffs were often left open, allowing dye hydrolysis to occur. The average annual value of these losses was calculated as LE17,500. The only action required to prevent this loss is for the workers to firmly replace the lids immediately after use.
- Hydrogen peroxide should be stored in cool, dry conditions, to prevent it from decomposing. Use of this can produce a fabric with unsatisfactory fabric whiteness, as well as being a potential explosion hazard.
- Acid, direct and chrome dyes started to agglomerate, as a result of being left in humid conditions, resulting in average annual losses of LE1,700. Indirect losses from a reduced fabric quality and increased wastewater treatment costs will also occur. Ensuring that these are stored in dry conditions, in sealed containers will reduce these losses to near zero.
- mercerizing range of one factory, it was found that the annual loss of NaOH reached about LE69,000 due to defects in the collection and pumping system. An investment of LE2,000 would avoid these losses.

(iii) Handling and Use of Process Chemicals and Dyestuffs

- In the process areas, chemicals should be carefully handled so as to minimise waste.
- In the mercerisation range, the rollers used in NaOH impregnation of fabric should be periodically cleaned of fibres and yarns, etc., to ensure that mercerisation is homogeneous and that dyeing and printing is even.

- Maintain close control over the mill operations to avoid accidental spillages of process chemical baths.
- In the dyeing and printing processes, the amount of fabric to be processed should be used to calculate exactly how much dye liquor or printing paste is required, to avoid wastage.
- Printing paste remnants should be recovered and reused.
- Any accidental spillages of hazardous chemicals must be immediately contained (by absorption and/or by dilution) to prevent shock loads reaching the wastewater treatment facility. Ideally, as much of the spillage as possible should be collected by absorption (e.g. soaking up the spillage with sawdust, which can then be separately disposed), before the remainder is washed into the drain.
- Cleaning the floors and machines of dirt, grease rust, etc., will reduce the possibility of their accidentally soiling the fabric, which eliminates the need for extra washing.

(iv) General Issues

- Avoid wasting packaging materials.
- Recycle or reuse empty containers (to prevent the generation of solid wastes).
- In the majority of the factories audited, significant spillages had occurred in the mazot delivery and storage area. Supervision of delivery to reduce these spillages would have little or no capital cost; in one factory, annual savings of LE11,400 could be made.

Raw materials can also be conserved by:

- Identifying how they interact with processes, substrates, and other chemicals.
- Determining their environmental effects, proper handling and emergency procedures.
- Adopting a system that allows mislabelled drums to be quickly identified, to reduce the likelihood of the wrong chemicals being used.

Staff training concerning the causes and effects of pollution, along with how it can be effectively eliminated will increase awareness and help to eliminate a significant number of these problems.

6.2 Energy Conservation Measures

Energy use in the textile industry varies from process to process in both amount and the sources of energy used. Electricity is used for motors and pumps to drive machinery and pump liquids whilst gas and fuel oils are used to generate steam to heat process vats. The SEAM Project identified interventions whose average savings per factory were LE57,200, for a capital investment of LE5,600. In all factories, whatever the value of the capital investment, the payback period was always immediate. Actions included:

- Implementation of suitable preventative maintenance programmes.
- Regular boiler tuning.
- Proper insulation of steam pipes.
- Repair of broken and steam pipes and connections.
- Heat recovery from boiler blowdown water.
- Installation of steam flow meters for each processing department.

One or more of these interventions were required in every factory participating in the SEAM Project. Other actions, including some equipment modifications are also recommended. Typical modifications for energy conservation include:

- Fluidised bed boilers, three pass package boilers and thermic fluid heaters.
- Water treatment to control the TDS.

- Effluent heat recovery from process water (especially hot water washes) through installation of heat exchangers.
- Optimising boiler efficiency by controlling draft (implementation of damper and fuel firing practices).
- Optimisation of the burner.
- Avoidance of space heating.

6.3 Water Conservation Measures

Water is widely used in the textile industry for processes ranging from preparation, to dyeing and finishing. The largest sources of wastage are from excess use of water within these processes and disposal of relatively clean water without reuse. This section describes water conservation opportunities that were identified in 10 Egyptian textile factories and suggests where further savings could be made.

A case study describing a number of water and energy conservation measures carried out at El-Nasr Company for Spinning and Weaving, Mahalla El-Kobra is given in Appendix 8.

6.3.1 Flow Reduction

Flow reduction aims to optimise the volume of water used in production processes, to minimise wastewater effluent volume. The industrial audits identified numerous opportunities for flow reduction in all factories:

- Unnecessarily high levels of water consumption resulting from leaks, broken or missing valves, hoses left running. Rectifying these can make savings of up to 15%.
- Provide water to the equipment only when required (i.e. do not allow water to flow continuously to equipment, whether or not it is being used).
- Assessment of the processing sequence showed that some of the washing stages carried out were unnecessary. This was studied in 3 factories and the annual water and energy savings that could be made ranged from LE 4,300 to LE 56,100 and required no capital investment. Processing time was also reduced.
- Use automatic shutoffs/flow limits where possible. In the factories audited, average annual savings of LE 325,000 could be made for an initial investment of LE 50,000 (water and energy savings). Highest priority should be given to those units where hot and/or chemically treated water is being lost.
- Adopt the counter flow of wash water in finishing plants, i.e. scouring, mercerising or dyeing in continuous ranges. In the factories audited, it was shown that by implementing this measure, average annual savings of LE 137,000 could be made for a capital investment of LE 22,000.

Other interventions that can be implemented include:

- Identify the amount of water required for processing based on fabric width.
- Decrease the amount of wash water required by using high efficiency washers.
- Use low wet pick-up technology whenever possible in textile wet processing. Examples include low add-on technique, foam technique.
- Install water flow meters. This will allow the identification of departments which have excessively high water consumption levels. These can then be individually investigated to see what specific actions are required to reduce consumption.

The majority of these improvements can be made for little or no capital investment and as such, payback will be immediate. A regular maintenance programme which identifies and actions such losses will ensure that these losses do not develop in the future.

6.3.2 Water Reuse

In many factories, water is used once and then disposed, even when little or no contamination has occurred. Water that is particularly suitable for reuse includes that which has been used for washing, cooling water and condensate.

(i) Reuse of Slightly Contaminated Process Water

Significant savings can be made by recovering and reusing water which is only slightly contaminated, particularly if it is hot and/or chemically treated (e.g. softened). Numerous opportunities of water reuse and recycle were identified during the industrial audits. The average capital investment required for each intervention was LE 6,000, with the lowest being LE 1,000. Average annual savings were LE 40,100. Examples of where recycle and reuse of water could be carried out include:

- Recycling of the final washwater after hydrogen peroxide bleaching as a washwater for second scouring step or for earlier bleaching steps.
- Reuse of bleaching washwater to start another bleaching batch.
- Reuse of hot washwater from bleaching to start the optical brightening bath.
- Reuse of optical brightening washwater to start another optical brightening batch.
- Final washwater after cone scouring and bleaching can be used as a washwater earlier in the scouring and bleaching process.
- Recovery of cold rinse water after the scouring and bleaching step to prepare new scouring and bleaching baths.
- Cold rinse water used after the scouring step in sulphur black dyeing can be used for the reduction step. If this is being done in a jet machine, this can be done directly, without any change of water being required.
- Reuse of hydrosulphite washwater to start another hydrosulphite batch.
- Reuse of water from the pressing and repressing of surgical cotton.
- Reuse of final washing and souring water after rope souring and crabbing of wool.
- Reuse of clarified print-wastewater in washing the blankets and screens of the print machines.

(ii) Reuse of Condensate

Condensate can be recovered and sent back to the boiler, used either within the process as a washwater or, if it is contaminated with iron (which can cause pinholes to develop in the fabric) or other solids, for floor washing, etc. The average capital cost involved with implementing these interventions was LE 12,200, with a corresponding annual benefit of LE 25,300. Payback periods ranged from zero to 3 months. Examples include:

- Recovery of condensate from pre-treatment ranges as final rinse water.
- Recovery of condensate from calendering process for use as boiler feed water.
- Condensate from around the plant can be recycled to boiler.
- Cooling water and condensate in wool tops dyeing department can be reused as a washing water after dyeing.
- Reuse of condensate (and cooling water) from yarn dyeing plant for scouring, soaping (in reactive dyeing), hot wash water.
- Reuse of condensate from cone dryer in other processes e.g. washing or preparation.

(iii) Reuse of Cooling Water

Depending on its cleanliness, this can be used either within the process as a washwater or for floor washing, etc., within the factory. Examples identified by the industrial audits included:

- Cooling water from pre-treatment ranges used as a final washwater before bleaching.
- Cooling water from yarn dyeing used in washing half-bleached fabric.
- Cooling water from drying units used in the final cold water wash after mercerisation.
- Cooling water used in wet processing (pre-treatment and dyeing) can be used in-process or as a wash water.

The average cost of implementing these measures was LE 7,800, with associated annual savings of LE 4,700.

6.3.3 Improved Washing Technologies

One of the most water intensive processes in textile wet processing is washing. Improved washing technologies for water conservation include:

- Countercurrent washing.
- Low wash methods.
- Vacuum extraction and
- Rinse bath reuse.

6.4 Process Specific Options

Process specific CP options can be broadly categorised into in-plant measures and prevention measures. In-plant measures include optimisation of processes to save energy, water and chemicals; recovery of chemicals and energy and reuse of water. Prevention measures involve the selection of raw materials and chemicals by considering their utility and environmental impact (quality requirements); limiting the use of a substance when there is no alternative readily available or is economically not feasible and phasing out the use of hazardous or dangerous substances.

Optimising the use of all process chemicals, so that the fibres are not treated beyond the quality required should also be considered.

6.4.1 Raw Wool Processing

If possible, wool washing stages should be kept separate to prevent dilution of pollutants and to allow separate recovery of by-products. Wool grease for example, can be recovered by the acid cracking process, centrifuging or by solvent extraction of the wool scouring liquor.

6.4.2 Spinning and Weaving

This is a predominantly dry process, the only major wet process being sizing, although spin finishing substances may also need to be considered. In all factories audited, natural starch was the most commonly used sizing agent. This is a very polluting substance in terms of increasing the organic load (e.g. BOD) and therefore spillages must be minimised. The following preventative measures were recommended for each factory.

In the sizing (slashing) department the following procedures should be followed:

- Avoid damaging starch bags.
- Avoid washing spilled sizing materials down the drains.
- Avoid disposal of unused sizing baths in the drains.
- Collect spillages for use in the process if possible.

Spin finishing substances such as oils, anti-static agents and emulsifiers should be biodegradable wherever possible. For example, mineral oils and mineral oils containing significant amounts of aromatics should be substituted with degradable synthetic oils or vegetable oils which do not contain hazardous preservatives.

The use of spin finishing substances and sizes should be optimised, to reduce the total organic load and total nitrogen load of the final effluent.

6.4.3 Desizing

Desizing operations are typically large contributors to pollution, typically accounting for 40-50% of the total pollution load from preparatory processing. The industrial audits identified a number of CP opportunities in this department which were commonly encountered.

In addition to basic size materials, commonly used assistants in size mix are glycerine, waxes, urea and surfactants, each of which contributes to BOD. Thus, reduction strategies for BOD in desizing would mainly depend on selection of size material, work practices, size recovery and reuse. It is essential to ensure that unused portions of size mixes containing starches are not disposed directly into the drain.

Size represents the largest single group of chemicals used in textile mills, which in most cases does not become a permanent part of the product. Therefore, size recovery represents perhaps the greatest opportunity for recovery.

The choice of sizes used within the weaving mill(s) should be examined. Degradable, recoverable, water soluble (for staple fibres), universally applicable, efficient sizes should be promoted. Starches that have high BOD should be replaced by other sizes such as acrylates or partially substituted by polyvinyl alcohol. These are recoverable and can reduce the BOD load from the unit by 90%. Up to 50% of low viscosity sizes (PVA, CMC) can be recovered by using high pressure or vacuum technology in a pre-wash stage and can then be reused following sterilisation (>80 up to 90% is possible by partial recycling of the prewash and ultrafiltration of diluted washwater (size concentration <1%).

However, recoverable sizes are more expensive than starch. Thus it is difficult for a non-vertical textile mill to use these more expensive sizes so that another independent processor can recover them at a later stage. Moreover, it is difficult for a non-vertical wet processor to buy expensive recovery equipment anticipating the use of a recoverable size by the weaver. Therefore size recovery systems are found typically in vertical operations. Presently in Egypt, the number of vertical operations are decreasing.

Some initiatives have been taken towards development of recoverable starch sizes based on rice and maize starch in Egypt and a pilot plant has been set up at one of the largest textile mills in the country to test the product and its recovery by ultrafiltration.[1]

(a) *Oxidative Desizing:* When the starch is degraded by oxidation using hydrogen peroxide, the BOD is much lower in the effluent as the starch is degraded to carbon dioxide and water. In future it is expected that processors, especially with smaller capacities may begin to use this oxidative desizing technology. Oxidative desizing is not a new technology; however it is not widely practised due to the problems that can arise from oxidation damage of the cotton itself, producing oxycellulose. To carry out oxidative desizing successfully, it is necessary to have extremely careful control of temperatures, residence time and chemical concentrations. This has not been practical in the past, but

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[1] This was done based on research at the National Research Centre, Cairo and with the assistance of the Institute of Textile Research and Chemical Engineering, Germany.

with microprocessor-controlled chemical feeds and temperature sensing equipment, the necessary degree of control can be accomplished.

(b) *Use of newer enzymes:* Another innovative desizing method is the use of newer enzymes, some of which degrade the starch size to ethanol instead of anhydroglucose. The ethanol can then be recovered by distillation for use as a solvent or fuel, thereby reducing the BOD load in the desized effluent considerably.

6.4.4 Scouring

- The following are low cost options, which can be easily implemented:
  1. No more than optimum amounts of alkaline recipes should be prepared;
  2. Alkalis should be recycled and reused as much as possible; rinsing water should be reused for preparing the scouring bath. This can reduce carry-over of the alkali.
- Combining the desizing and scouring processes can save water and energy and also reduce processing time. This option was investigated for several of the factories audited - for little or no capital investment, average annual savings of LE 220,000 could be made.
- Commercial desizing agents used in the desizing and scouring of cotton and polyester/cotton fabrics can be replaced by ammonium persulphate. In one of the factories audited, this resulted in annual savings of LE 39,600 being made, at a cost of LE 4,200.

Other actions that can be taken include:

- Tri-sodium phosphate (TSP) should be substituted with sodium carbonate. This is a low cost option, which can be easily adopted.
- A 25% reduction in sodium hydroxide can be obtained by substitution with sodium carbonate.
- Use of sodium acetate is recommended for neutralising scoured goods so as to convert mineral acidity into volatile organic acidity.

6.4.5 Bleaching

The following changes are recommended:

- If there is a problem with pinholes, oxalic acid is often used as a remedy.
- Textiles that need to be coloured in deep shades should not be bleached excessively. In several of the factories audited, overbleaching had been carried out, resulting in excess consumption of bleach and increased pollution load.
- As an alternative to combining the desizing and scouring steps, scouring and bleaching processes can save water and energy and also reduce processing time. The costs and benefits of implementing this action in a range of factories were investigated and showed that with little or no capital investment average annual savings of LE 99,100 could be achieved.

Note: The desizing, scouring and bleaching steps are very difficult to combine successfully - this is still the subject of several different pilot trials.

- Peroxide bleaches should be used instead of reductive sulphur-containing bleaches.
- Hydrogen peroxide (H_2O_2) should be used as the bleaching agent in preference chlorine-containing compounds, such as hypochlorite. This will:
  a) produce a fabric which is not prone to yellowing;
  b) take the factory one step closer to obtaining an ecolabel, (the use of hypochlorite is banned by many certifying agencies) which is becoming increasingly important in maintaining and developing European markets;

c) minimise the content of hazardous organohalogen substances in the final effluent;
d) eliminate a toxic and hazardous chemical from the workplace and improve working conditions.

Although hydrogen peroxide is more expensive than hypochlorite, the cost may be offset by a reduction in dye consumption due to improved whiteness of the fabric. In the textile sector case study Combining Preparatory Processes: A Low Cost, High Productivity Solution (Appendix 8), implementation of the combined scour bleach process in full bleaching saved LE30/ton, corresponding to annual savings of LE 8,640 (including benefits resulting from increased production capacity).

- Hydrogen peroxide bleaching may also be combined with optical brightening. This was assessed at 2 factories - no capital investment was required and average annual savings totalled LE 8,200.
- The use of the enzyme *Terminox Ultra* (of Novo) in the textile finishing industry to neutralise the fabric after bleaching and before dyeing. This was implemented in 2 factories - no capital investment was required and any increase in chemical costs were completely offset by water and energy savings. Total annual savings for both factories was LE149,330. This is described in more detail in the case study Bleach Clean-Up in Cotton Textile Processing using Enzymes (Appendix 8).

  These enzymes can also be used in place of a reducing agent such as thiosulphate and can reduce the processing time by half, Again, there is also considerable reduction in water and energy consumption.

Other actions that can be taken include:

- Wetting agents, emulsifiers, surfactants and all other organic chemicals should be readily biodegradable (OECD-Test 301) without producing metabolites which are toxic to aquatic species.
- The installation of holding tanks for bleach bath reuse, where the bath was reconstituted to correct strength after analysis by titration. BOD decreased over 50% - from 842mg/l to 400mg/l, water use decreased and the mill came into compliance with permits and economic benefits were realised. This has been carried out in some mills in the US.

6.4.6 Mercerising

- When narrow fabric is being mercerised, double beam fabric should be used rather than single beam. This intervention requires no capital investment and in one factory resulted in annual savings of LE 56,100. Product quality will not be affected by this modification.
- Dilute alkali from mercerising should be reused in scouring, bleaching or dyeing operations. This is a low cost option that can be readily implemented. Processes should be optimised so that discharges from alkaline treatment (mercerising) can be minimised.
- Steam condensate from caustic soda recovery plant can be reused in washing of mercerising goods.

Other actions that can be taken include:

- Alkali should be recovered and recycled or reused after regenerative treatment (coagulation, flotation, micro-filtration, nano-filtration) to remove dirt and after concentration of NaOH by electrochemical membrane cell technology or distillation. This is a high capital cost option, but there would be savings due to savings of caustic soda, and improved fabric quality.
- Ammonia mercerisation utilises the rapid swelling and plasticising effects of liquid ammonia on cotton. This is called the Prograde Process for treating sewing threads. Improved lustre, dye affinity, strength, and dimensional stability can be obtained by caustic mercerisation. In

addition, ammonia produces a fabric with a softer feel, improved resistance to wear and crease shedding compared to that of caustic soda.

- Significant increases in strength of cotton print cloth is observed with ammonia mercerisation compared to conventionally mercerised fabric. Another possible application of liquid ammonia is as a low pollution substitution for conventional mercerisation.
- Heavy cotton treated with liquid ammonia is capable of giving better form and dimensional stability, less shrinkage during laundering, requires less dye for a given depth of shade, and could be made shrinkfast on a mercerising machine.

6.4.7 Dyeing

(i) Salt Management

Salt is cheap, effective and has very low toxicity. Moreover, it is difficult to find another chemical which could perform all of the functions of salt at a comparable cost and with lower toxicity. Consequently, textile mills often misuse or overuse salt. There are a few general approaches to the reduction or elimination of salt, as follows. Before these are implemented though, trials will need to be carried out to identify where process modifications and recipe changes might be required.

- Optimise salt dosage for each individual for each dyeing.
- Consider continuous or pad/batch dyeing as a process alternative to exhaust dyeing.
- Select dyes which exhaust with minimum salt e.g., Cibachrone LS dye.
- Optimise dyeing temperature for each individual recipe.
- Use low liquor ratio dyeing machines.
- Machine manufacturers have tended toward lower bath ratio dyeing systems, for energy conservation as well as chemical savings.

(ii) Dye Management

- Dyebath temperatures should be assessed to ensure that overheating is not being carried out. In one of the audited factories, a reduction in dyebath temperature resulted in annual savings of LE 35,000. This also resulted in a better quality of dyed fabric and reduced dye consumption.
- Dyebaths heated with direct steam should be heated gently, to avoid overflowing and subsequent loss of dyebath solution. All that this requires is for the operator to be instructed to heat the bath slowly, or in the case of automated controls, for settings to be correctly adjusted. Average annual savings of LE 12,800 resulting from this intervention were calculated.
- If possible, dyes should be recycled by the standing bath technique, going from lighter to darker shades.
- In Egypt, sulphur black dyeing is often carried out using sodium sulphide (the reducing agent) and dichromate (the oxidising agent). Their use should be discontinued, as:

  a) both are toxic and hazardous to handle;

  b) their usage may leave harmful residues in the finished fabric;

  c) they generate effluents that are difficult to treat and damaging to the environment;

  d) their discharge into the environment is also strictly controlled.

  Possible substitutes for this are:

  a) glucose for reduction;

  b) sodium perborate (for woven fabrics) and hydrogen peroxide (for knitted fabrics) for oxidation.

These substitutions were successfully made at 3 Egyptian factories and resulted in average savings of LE195/ton. This is described in more detail in Section 7.1.5 and in the case study Sulphur Black Dyeing: A Cleaner Production Approach, given in Appendix 8.

- Aniline black dyes, which require large quantities of potassium dichromate and sodium chlorate can be replaced by sulphur dyes (using glucose as a reducing agent and either sodium perborate or hydrogen peroxide as the oxidising agent).
- Acetic acid should be replaced with formic acid, as it has a lower BOD value.

Other actions that can be taken include:

- The use of liquid dyes (with minimal amounts of solvents or organic solubilising agents) or low dusting granules suitable for automated dispensing, particularly for continuous dyeing and printing, is preferred, to reduce wastage.
- Some vat dyes can be recovered by ultrafiltration and reused.
- In vat dyeing, potassium dichromate (which is toxic and hazardous) can be satisfactorily replaced by peroxides or periodates.

Current research trends in dyeing are in combining the dyeing and finishing steps, particularly with soluble vat dyes, reactive, acid and basic dyestuffs.

(iii) Identification and Substitution of Harmful Dyestuffs

A number of dyes have been banned from use due to their potentially toxic, mutagenic or carcinogenic properties. Some of the dyes are known to release amines during processing. Due to the carcinogenic potential of these amines, dyes releasing them are banned in a number of countries. Table 6.1 provides a list of the banned amines.

Table 6.1 List of Banned Amines

Sr. No.	Banned Amine	Sr. No.	Banned Amine
1	4-Aminodiphenyl	11	3,3 Dimethoxybenzidine
2	Benzidine	12	3,3 Dimethylbenzidine
3	4-Chloro-o-toluidine	13	3,3 Dimethyl 1-4, 4 diaminodiphenylmethane
4	2-Naphthylamine	14	p-Kresidin
5	o-Aminoazotoluidine	15	4,4 Methyene-bis-(2-Chloraniline)
6	2-amino-4-nitrotoluene	16	4,4 Oxydianiline
7	p-Chloraniline	17	4,4 Thiodianiline
8	2,4-Diamonoanisol	18	o-Toluidine
9	4,4 Diaminodiphenylmethane	19	2,4 - Toluylendiamine
10	3,3- Dichlorobenzidine	20	2,4,5-Trimethylaniline

Source: United Nations Environment Program Cleaner Production in Textile Wet Processing , A Workbook of Trainers, 1996

A list of the safer alternatives for these banned dyes and are provided in Tables 2.2(a), (b) and (c).

Table 6.2(a) Safer Alternatives for Banned Acid Dyes

Banned acid dye	CI number	Alternative	CI number
Acid Orange 45	22195	Acid Orange	1914690
Acid Red 4	14710	Acid Red 157	17990
Acid Red 150			
Acid Red 114			
Acid Red 5	14905	Acid Red 191	14730
Acid Red 158	20530		
Acid Red 24	16140		17900
Acid Red 73	27290		
Acid Red 128	24125		
Acid Red 85	22245		
Acid Red 26	16150	Acid Red	24785
Acid Red 115	27200	Acid Red 37	17045
Acid Red 148	26665		
Acid Violet 49	42640	Acid Violet 72	42665
Acid Violet 12	18075	Acid Violet 13	16640
Acid Black 94	30336	Acid Black 24	26370

Source: Environmental Quick Scan Textiles, compiled for CBI and SIDA by Consultancy and Research for Environmental Management, Published by CBI, SIDA, VIVO, 1996

Table 6.2(b) Safer Alternatives for Banned Direct Dyes

Banned Direct dye	CI number	Alternative	CI number
Direct Yellow 48	23660	Direct Yellow 15	
Direct Orange 8	22130	Direct Orange 102	29156
Direct Red 2	23900	Direct Red 81	28160
Direct Red 72	29200		
Direct Red 10	22145	Direct Red 120	25275
Direct Red 13	22155		
Direct Red 24	29185	Direct Red 23	9160
Direct Red 37	22240		
Direct Red 46	23050	Direct Red 31	29100
Direct Red 62	29175	Direct Red 4	29165
Direct Violet 1	22570	Direct Violet 66	29120
Direct Brown 2	22311	Direct Brown 112	29166
Direct Brown 31	35660		
Direct Brown 95	30145		
Direct Black 29	22580	Direct Black 51	27720

Source: Environmental Quick Scan Textiles, compiled for CBI and SIDA by Consultancy and Research for Environmental Management, Published by CBI, SIDA, VIVO, 1996

Table 6.2(c) Safer Alternatives for Banned Disperse Dyes

Banned Disperse dye	CI number	Alternative	CI number
Disperse Yellow 7	23660	Disperse Yellow 15	
Disperse Yellow 23	22130	Disperse Orange 102	29156
Disperse Blue 12	3900	Disperse Red 81	28160
Disperse Red 151	29200		
Disperse Orange 50	22145	Disperse Red 120	25275
Disperse Yellow 13	22155		
Disperse Yellow 24	29185	Disperse Yellow 23	29160
Disperse Yellow 37	22240		
Disperse Yellow 46	23050	Disperse Yellow 31	29100
Disperse Yellow 62	29175	Disperse Yellow 4	29165
Disperse Yellow 1	22570	Disperse Violet 66	29120
Disperse Yellow 2	22311	Disperse Yellow 112	29166
Disperse Yellow 31	35660		
Disperse Yellow 95	30145		
Disperse Yellow 29	22580	Disperse Yellow 51	27720

Source: Environmental Quick Scan Textiles, compiled for CBI and SIDA by Consultancy and Research for Environmental Management, Published by CBI, SIDA, VIVO, 1996

6.4.8 Printing

- Excess printing pastes can be recovered through optimised paste preparation and supplying systems; they should be recycled and reused.
- The use of urea in printing with reactive dyes should be reduced by (or in combination with) other techniques (e.g., pre-wetting of fabric) so that the nitrogen emissions do not increase. The printing paste should contain not more than 30g of urea/kg of textile. Some approaches to eliminate or replace urea in cellulose printing are:
  1. Adoption of two-phase flash printing;
  2. Complete or partial substitution of urea with an alternative chemical Metaxyl FN-T;
  3. Mechanical application of moisture to printed fabric prior to entering the steamer.

The following preventive measures involve chemical substitutions:

- Full or partial substitution of gum thickening by emulsion thickening in textile printing.
- Replacement of the use of white spirit or kerosene by water-based systems.
- Use biodegradable natural thickening auxiliaries or highly degradable synthetic thickeners.
- Minimising the use of copper and chrome salts to the extent possible.
- Avoid usage of solvent-based printing pastes in pigment printing.
- Recovery of acetic acid, which is used to bond the two components of azoic dyes.
- Use of pigments which give improved absorption and lower effluents for reducing COD.

All these options for the finishing process are extremely relevant for the Egyptian textile industry and have been considered as demonstration projects under the SEAM project.

Some of the pigments which were suspected to have toxic/carcinogenic properties are listed in Table 6.3. Safer alternatives by which they can be substituted are also provided in the Table.

Table 6.3 Safer Alternatives for Suspected Pigments

Suspected Pigment	CI number	Alternative	CI number
Pigment Orange 50	20170	Pigment Orange 38	
Pigment Yellow 12	21090	Pigment Yellow 147	12367
Pigment Yellow 13	21100		60645
Pigment Yellow 14	21095		
Pigment Yellow 124	21107		
Pigment Yellow 63	21091	Pigment Yellow 148	50600
Pigment Yellow 126	21101	Pigment Yellow 5	11660
Pigment Yellow 127	21102		
Pigment Yellow 17	21105		
Pigment Red 39	21080	Pigment Red 87	73310
Pigment Yellow 176	21103	Pigment Yellow 101	48052
Pigment Yellow 171	21106		
Pigment Yellow 114	21092	Pigment Yellow 10	12710
Pigment Yellow 170	21104		

Source: Environmental Quick Scan Textiles, compiled for CBI and SIDA by Consultancy and Research for Environmental Management, Published by CBI, SIDA, VIVO, 1996

6.4.9 Finishing

- Hot catalysts should be used in resin finishing, to reduce energy consumption in the thermofixation step and decrease fabric tendering. In one of the factories audited, implementation of this action would result in annual savings of LE 13, 500.
- Whenever feasible, building finishing chemicals into the fibre during production (co-polymerisation, extrusion) or during spinning is preferred over applying the finish at a later stage.
- Finishing chemicals should be reused whenever possible.
- Reduce the use of formaldehyde releasing products as much as possible. Formaldehyde should be replaced with polycarboxylic acid. Alkylphenol should be replaced with fatty alcoholethoxylates.
- Replacement of acetic acid (used for pH adjustment in resin finishing baths) with formic or mineral acids to reduce BOD load.
- Develop and use formaldehyde-free cross-linking agents for cellulose textiles and formaldehyde-free dye-fixing agents.
- Use formaldehyde scavengers during application and storage of resin finished goods.
- Dimethylol or dihydroxyethyelene urea should be used in anti-wrinkle finishing should be substituted by polycarboxylic acids, mainly 1,2 3,4-butanetetracarboxylic acid or glyoxales.
- MAC complexing agents like DTDMAC, DSDMAC, DHTDMAC used in softening finishing should be replaced with cellulase enzymes.
- Asbestos, halogenated compounds like bromated diphenylethers (PBDEs) and heavy metal containing compounds used in flame retardant finishing should be replaced by inorganic salts and phosphonates.
- Biocides such as chlorinated phenols (PCP), metallic salts (As, Zn, Cu, or Hg), DDE, DDT, and benzothiazole used in preservation finishing should be substituted by UV treatment and or mechanical processes or by enzymatic finishing.

Other interventions that can be implemented include:

- The use of hazardous chemicals for the preservation of textiles should be minimised, either through substitution or through tailor-made selective use to only those textiles, which are exposed to possible environmental degradation.
- Application of fireproofing chemicals is best done using techniques which consume minimal amounts of water (e.g. vacuum, back coating, foam or lead to minimal amounts of residues, particularly (e.g., foam).

6.5 Optimising Process Chemical Use

In preparing chemical formulations, a large margin of safety is adopted in order to avoid having to repeat the treatment. This results in an unnecessarily high level of chemicals consumption. A careful evaluation of the various textile processing steps should be carried out to identify where recipes can be optimised, to decrease the amount chemicals to a minimum without affecting the product quality. It is possible to reduce chemical consumption in textile wet processing by 20-40%, resulting in an estimated 30% decrease in the pollution load.

6.6 Chemical Substitution

In addition to dyes which are banned and pigments which are suspected to be toxic, some of the other chemicals used in textile processing which can be substituted with safer alternatives are presented in Table 2.4.

Table 2.4 Chemical Substitutions Possible in Textile Processing

Process	Chemical	Substituted by
Sizing	Starch based warp sizes by PVA	Acrylates or partial substitution
Desizing Scouring	Acid	Hydrogen peroxide and enzymes
Aqueous Scouring	alkylphenol ethoxylates TSP, NaOH	Fatty alcohol ethoxylates Sodium Carbonate
Detergent Scouring	Alkyl benzene sulphonates	Fatty alkyl sulphates Polyglycolether
Light Scouring	NTA, EDTA	Zeolites (sodium aluminium Silicate)
Bleaching	Reductive sulphur bleaches	Peroxide bleaches
	Chlorine compounds	Peroxide Bleaches
Dyeing	Benzidine based dyestuffs and other amine releasing dyes	Mineral/pigment dyes single class dyes like indigsol, pigments, reactives
	Dichromate used for oxidation in vat and sulphur dyes	Peroxide, air oxygen, metal free agents
	Acetic acid in the dyeing bath	Formic acid
	Dispersants for dyes and chemicals	Water based system
	Copper sulphate used to treat direct dyes	Polymeric compounds
	Dye Powder in automatic injection	Liquid dyes
	Sodium hydrosulphite	Stabilised Sodium hydrosulphite
	Aldehyde and toxic metallic salts used as auxiliaries	High molecular weight polymeric auxiliaries
	Sodium sulphide	Glucose based reducing agents
Printing	Kerosene or white spirit	Water based systems
Finishing	Formaldehyde	Polycarboxylic acid
	Alkylphenol	Fatty alcoholethyoxylates

Process	Chemical	Substituted by
Anti-wrinkle finishing	dimethylol dihydroxyethylene urea	Polycarboxylic acids mainly1,2,3,4 butanetetracarboxylic acid) Glyoxales
Softening finishing	MAC complexing agents like DTDMAC, DSDMAC, DHTDMAC	Cellulase enzymes
Flame retardant finishing	Asbestos, Halogenated compounds like, bromated diphenylethers (PBDEs) and heavy metal containing compounds	Inorganic salts and phosphonates
Preservation finishing	Biocides such as chlorinated phenols (PCP), metallic salts (As, Zn, Cu or Hg), DDE, DDT, Benzothiazole	UV treatment, mechanical or enzymatic finishing

To enable implementation of chemical substitution, an inventory and quality control of the chemicals being procured is necessary. The protocol for incoming chemical quality control may consist of the following steps:

- Marking the date the container was opened;
- Checking pH, viscosity, density, conductivity, and colour;
- Comparing data with previous history and vendors standard values;
- Entering data on a control chart for display;
- Maintaining records;
- Reviewing data with the vendor;.
- Checking whether the chemicals are listed as priority pollutants;
- Import of raw materials (fibres, textiles, and chemicals) should be investigated for their potential contribution to aquatic emissions of blacklist pollutants. When assessing this issue, the following concentrations in untreated waste water from any pre-treatment step can be used as an indication when preventive action may be warranted:
  a) DDT: 1 mg DDT/L
  b) pentachlorophenol (PCP): 20 mg PCP/L
  c) arsenic: 200 mg As/L
  d) lead: 50 mg Pb/L
  e) cadmium: 5 mg Cd/L
  f) mercury: 1 mg Hg/L
  g) zinc: 3 mg Zn/L (viscose or recuperated proteinous fibres)
  h) total chromium: 0.5 mg Cr/L (recuperated proteinous fibres)

  If these threshold levels are exceeded, preventive or remedial measures should be considered, such as:

  a) Substitution of the pollution-carrying imported material.
  b) Installation of an adequate water treatment system, which can remove these persistent compounds from the effluent.
  c) Substances that contain PCP or p-chlorophenol (a precursor of PCP) should be avoided.
  d) Chemicals containing hazardous substances should be investigated for their substitution.
  e) Good inventory management can reduce waste by using all materials efficiently and reducing the likelihood of accidental releases of stored material.

- Designating a materials storage area, limiting traffic through the area, and giving one person the responsibility to maintain and distribute materials can also reduce materials use and contamination and dispersal of materials.
- Purchase raw materials in returnable containers.

6.7 Technology Change and Modification

Modification of existing processes/equipment or the purchase and installation of new equipment may be considered to reduce the consumption of process chemicals, energy and water. As a result of work carried out in the SEAM Project, the options outlined in the following sections are particularly suitable for Egyptian textile mills.

6.7.1 Shortening the Processing Time

- Replacement of conventional jigger dyeing by pad-develop process for dyeing, whenever possible.
- Elimination of intermediate drying (e.g. after dyeing of synthetic component) in dyeing of polyester/cellulose blend fabric.
- Carbonisation of disperse-printed and fixed goods directly without intermediate washing and drying.
- Use of one class of dyestuff for coloration of both components of p/c blend fabrics.

6.7.2 Combination of Separate Processes

- Single-stage bleaching: when conventional pre-treatment processes (e.g. desizing, scouring and bleaching) are combined together to save energy (about 60%), chemicals, water and time, as described in Sections 6.4.4 and 6.4.5.
- Hot mercerisation: which involves the impregnation of the fabric with caustic soda of the mercerising strength at elevated temperature to obtain mercerising and scouring effect in a single unit operation, followed by cooling the hot saturated fabric and washing out of the alkali while maintaining predetermined tension conditions at appropriate stage. This process results in reduction in water, energy and chemicals.
- Combination of optical brightness and heat setting operation for synthetic fibre-fabrics.
- Combination of dyeing and finishing in one step, where the finishing bath comprises both the finishing agent (e.g. reactant resins), certain types of dyestuffs (soluble vat, direct, reactive, pigment), additives (wetting agent and softener) along with a proper catalyst. This combination enables dyeing and resin finishing of cellulose based textiles and their blends with minimum energy consumption and water reduction as well reduce the process chemicals. This in turn is reflected on decreasing the pollution load as well as total production cost.
- Combination of finishing and transfer printing in one step for cotton/polyester blends: when the dry heat of printing is utilised in curing the resin. This brings about good energy saving.

6.7.3 Cold-Pad Batch Techniques

These main advantage of techniques is that they save significant amounts of energy, which in turn reduces both the production cost and thermal pollution. New trends aim not only at energy reduction and ease of application, but also at lowering chemical usage and effluent strength, high productivity and less damage to knitted goods.

The main disadvantage of these techniques though is that storage space is required for treated batches.

- Cold pad batch bleaching of cotton fabric can be performed by using H_2O_2 in presence of silicate stabiliser and peroxydisulphate.
- Cold pad-batch dyeing can also be performed by careful selection of dyestuff and dyeing formulations.

6.7.4 Lower Temperature Dyeing, Printing or Finishing

Some of the textile processes can be carried out at lower temperatures than are conventionally used, with effective usage of the process chemicals. This results in reducing usage of both the energy and process chemicals, thereby lowering the pollution load. For example, the following techniques can be performed:

- Use of redox system (e.g. hydrogen peroxide/glucose, ammonium persulphate/glucose) in conjunction with some dyes (e.g. acid, direct, basic) can effect dyeing of certain substrates, such as wool, viscose, nylon, cotton, silk, etc. at lower temperature than conventional dyeing.
- Use of fast acting catalysts enables the fixation of pigment prints at lower temperature, around 110^{o}-$115^{o}C$ against 140^{o}-$150^{o}C$ for conventional printing).
- Use of highly active catalyst systems (such as $MgCl_2.6H_2O$ / citric acid) have a considerable economy in operational and energy costs of resin finishing.

6.7.5 Low Wet Pick-up Technology

Low wet pick-up techniques are attractive alternatives to conventional processing methods in textile wet processing due to the high potential savings in both energy and water. Many approaches are suggested for low wet pick-up techniques; a selection of which follow:

- Foam technology: where water is replaced by air in the form of foam in chemical recipes and formulations. This helps to save energy, decrease chemical costs, increase production and minimise effluents and pollution. Foam technology can be applied in sizing, dyeing, printing and finishing processes. By suitable combination of foaming agents, stabiliser and process chemicals the treatment process can be easily achieved.
- Spray technique: where sprays of concentrated solutions are applied to the goods to achieve treatments such as dyeing and finishing. The use of electrostatic systems was introduced by Sandoz to improve uniformity and distribution. This technique ensures the use of minimum amount of water to perform treating of textiles, which leads to very high decrease in both energy and wastewater volume.
- Use of high performance squeezers: to lower the wet-pick-up on the fabric or yarns. These squeezers can be applied in sizing, dyeing and finishing.
- Vacuum extractors can also be used to lower the moisture content of a textile material before it enters the dryer. These are most effective on fairly porous, synthetic materials.

6.7.6 Use of Heat Exchangers

Heat exchangers should be used, particularly since reduction in water use means an increase in effluent temperature. The textile industry also needs to practice heat recovery to avoid thermal shock to treatment plants caused by hot wastewater effluent.

6.7.7 Radio Frequency Technique

In this technique radio-frequency (RF), e.g. micro-wave and Infra Red are used for drying loose stock, packages and hanks that have been given finishing or dyeing treatments. This technique is a commercial reality with demonstrable cost, energy and time savings.

6.7.8 Computer Technology

Computer control and other forms of automation can be introduced to dyeing processes in order to allow greater reproducibility and optimised use of dyes and additives in dyeing formulations. The development of the necessary computerised control systems will be expensive, but it has been reported that it can be profitable within a reasonable time provided that the staff are well trained and capable of developing the systems.

6.7.9 Solar Energy

Use of solar energy as an alternative for the conventional energy is a promising approach for reducing energy consumption needed for heating at process water.

6.8 Adoption of Worker Training Programs

Companies should establish safety procedures for receiving, storing, and mixing chemicals, and implement worker-training programs. These programs should inform workers of the environmental impacts of chemicals and identify those most harmful to the environment. Workers should be trained in proper procedures for handling these chemicals. Training should also include the correct procedures for pasting, dissolving, and emulsifying of chemicals. These procedures should be subject to auditing and record keeping. In addition, policies regarding receipt, storage, and mixing should be established.

This will help ensure that:

- Wastage within the factory is kept to a minimum.
- Any measures that are implemented can be sustained and possibly improved.
- The workers themselves will be able to suggest other improvements which can save money, time and reduce wastage.

7.0 Cleaner Production Demonstration Projects

7.1 The SEAM Project Approach

The approach for the SEAM Project was evolved based on an analysis of the textile sector in Egypt, which showed that:

- The sector is characterised by absence of modern process technology;
- There is a lack of technical skills in textile processing, specific to CP;
- There is no local expertise for CP promotion as well as to provide CP solutions;
- Technical support in the form of guidance manuals is not available.

7.2 The Aim of Implementing Demonstration Projects

The main goal of the Cleaner Production demonstration projects is to show that significant financial savings and environmental improvements can be made by relatively low-cost and straightforward interventions. These consist of pollution prevention through good housekeeping, waste minimisation, process modification and technology changes. This approach has two benefits - valuable materials are recovered rather than being wasted and factories are moved towards legislative compliance.

As these interventions will reduce both the volume and the strength of the final effluent, the size and capacity of a new wastewater treatment plant will be minimised. This will result in reduced capital, operating and maintenance costs.

In the SEAM project, a structured methodology was adopted in co-operation with the EEAA. Such a structured approach resulted in a success both in terms of results as well as cost-effective utilisation of the resources. Demonstration projects in many ways help in providing ideas for further innovations, confidence to replicate and when promoted can cast a considerable impact in the sector. The demonstration projects completed in the SEAM project, are expected to lead to such multiplier factor. In many ways therefore SEAM can become a model for the promotion of the demonstration projects under the National Industrial Pollution Prevention Programme.

7.3 Identification of Demonstration Projects

It was important that the demonstration projects implemented addressed commonly occurring problems in Egyptian mills. This was achieved as follows:

- **Selection of factories** - A sample of 10 factories were identified that represented the range of wet processing textile mills present in Egypt.
- **Industrial audits** were carried out in each of these factories (the methodology developed for this is described in Chapter 5.0 Identifying Cleaner Production Opportunities) and an industrial audit report produced. This reviewed the manufacturing process with respect to optimal use (and reuse) of resources, improved housekeeping, more optimal process operation, etc. In some cases, particularly in the old textile mills in Egypt, even the basic manufacturing process had to be examined in terms of possible substitution of raw materials, equipment redesign or by identifying entirely different new manufacturing processes.
- **Longlisting Potential Demonstration Projects** - Each audit report was reviewed to identify those problems which were common throughout the sector. At this stage, some of the options which were not true CP options, were discarded.

- **Shortlisting Potential Demonstration Projects -** The longlist of projects identified through the industrial audited were then short-listed using the criteria shown in Table 7.1. These criteria reviewed each option in more detail, to see which met SEAM Project objectives, particularly with regard to compliance with existing laws, replicability and sustainability. Factory commitment to the CP approach was also required and was assessed in terms of how many of the no cost options had been implemented by the factory.

The short-listed options that emerged as demonstration projects were largely process related (15 projects), housekeeping measures (7 projects), recycle and reuse of water (8 projects) and chemical recovery (4 projects). Appendix 7 provides the list of these shortlisted demonstration projects.

Table 7.1 Criteria used to Shortlist the Demonstration Projects

Criterion	Yes	No
Does the project comply with Egyptian laws (i.e. not in known violation of existing laws)?		
Does the project comply with the DFID (ODA)/SEAM funding policy?		
Does the project result in economic benefits with a relatively short payback period?		
Does the Project demonstrate the benefits of waste minimisation and/or CP principles?		
Have any low cost measures identified in the audit been implemented?		
High Priority		
Financial		
Is internal or external parallel funding (possibly in kind) available?		
Does the Project involve relatively low initial capital expenditure?		
Environmental		
Is the Project consistent with the priorities set by the NEAP/GEAP/NIPPP?		
Does the Project assure/assist in compliance with the Environmental Laws?		
Technical		
Is the technology appropriate to local conditions?		
Does the Company possess appropriate levels of technical skills and resources to implement and maintain improvements?		
Managerial		
Does the management show good awareness of environmental issues and willingness to implement good environmental practices, including pollution control at source?		
Are managerial and structural barriers to change absent or removable?		
Sustainability		
Is management willing to commit staff resources to the on-going process of internal auditing and improvements for pollution control?		
Is environmental management likely to be integrated in the existing structure?		
Replicability		
Are there significant opportunities to replicate the Project?		
Project Design and Implementation		
Can the Project be completed and evaluated in less than 12 months?		
Can any necessary approvals/licenses be obtained within 2 months?		
Medium Priority		
Environmental		
Will organic loads, chemical or toxic components be reduced/ eliminated?		

Criterion	Yes	No
Technical		
Can the Project be implemented without significant interruption to process schedules?		
Can the Project be implemented without training of operators or maintenance personnel?		
Managerial		
Does the management effectively communicate policy changes within the company?		
Replicability		
Can the equipment be obtained/manufactured locally?		
Social		
Will the health and safety of the workers be improved?		
Does the project avoid negative effects on the community?		
Low Priority		
Environmental		
Will on-site improvements lead to an improvement in the external environment* ?		
Will the project result in a variety of internal environmental improvements?		

* Such as water quality, air quality, health, noise transmission, land contamination, etc.

7.4 Demonstration Project Implementation Strategy

The shortlisted projects were classified into 3 basic groups:

1. Housekeeping initiatives
2. Process-based initiatives
3. Product-based initiatives

7.4.1 Housekeeping Initiatives

These consist of low cost, low skill and high return options. Many of the textile industries in Egypt do not practice housekeeping due to lack of awareness. In general, there is little awareness of how attractive, low cost or low investment measures such as housekeeping are in enabling significant savings and thereby improving the profitability. The demonstration projects centred around housekeeping measures were thus expected to show the industry that housekeeping is the easy way to be more competitive.

The housekeeping based demonstration projects were provided a *theme* to lay down a framework such as water and energy conservation. This allowed greater focusing of the scope of the activities or sub-projects and contracting of project specific consultants. In many ways, the housekeeping based demonstration projects were *umbrella* projects, consisting of several CP options as identified from the CP audits. These can be applied to large Egyptian textile plants dealing with wet processing.

7.4.2 Process-based Initiatives

These are aimed at introducing low cost, moderate to high return but high skill options. These interventions were specific to a process, e.g. dyeing or scouring or bleaching, in order to make them more environmental friendly or increase its eco-efficiency.

This type of project can be implemented in most private sector companies and in some public sector companies where, different types of raw materials (fibres, yarns and fabric) are processed through different operations and formulations, wherein large quantities of chemicals are used. This necessitates the optimisation of the used formulations.

7.4.3 Product-based Initiatives

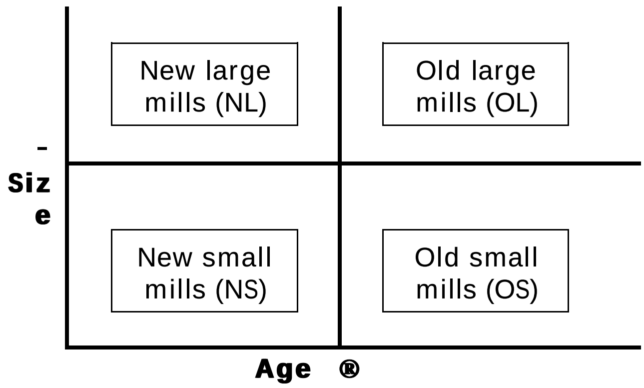
These are basically low cost and high skill options having a significant process-product-market interface. These demonstration projects took account of some of the frontier problems faced by the export-oriented textile processing industries in Egypt. The eco-friendly processing projects, that were again of the *umbrella* category, focused on securing eco-labels needed for export of textiles to the European market.

7.4.4 Selection of Factories for Demonstration Project Implementation

Demonstration projects had been carefully selected to address problems that were common throughout the Egyptian textile sector. The selection of mills as demonstration project hosts had to be carried out with equal care, to prove that the projects were widely applicable throughout the sector, regardless of factory age, size or whether they were publicly or privately owned.

The distribution of textile mills based on size and age of the mills is schematically presented in Figure 7.1.

Figure 7.1 Conceptual Diagram of the Segments of the Textile Industry in Egypt



When applied to sector profile data, the following conclusions can be made:

- The large mills (primarily OL type) constitute about 1% (31 nos.) of the total number of textile mills in Egypt as against the small units which are around 2,400 in number.
- Most of the large mills (primarily OL type) are public sector ownership by the Government of Egypt.
- The large mills' share of the total textile production is much larger than that of the smaller mills.
- Most of the large mills in Egypt belong to the OL category which means that they use traditional processing methods and are one of the major contributors to pollution.
- The smaller mills (primarily NS type) are private ownership units.
- There is not much information available about the NL and OS categories.

The strategy for implementation of CP options as demonstration projects therefore was to first apply housekeeping measures in the OL mills and minimise the pollution load as much as possible. This would then have to be followed by a thorough examination and review of their processes for a complete change so that they can be equipped to gradually adopt the process related options and eventually move to product related options.

In the case of the private mills of the NS category product and process related options were applied since they were equipped to implement these options.

It was believed that the examples of the demonstration projects at OL and NS would serve as models for the other categories of mills to follow and implement CP options.

The diversity of the sector also indicated that there should be at least two sites for demonstration project implementation. Therefore, each demonstration project was assigned 1 *Lead* and 1 or 2 *Shadow* sites. Implementation commenced at the Lead sites and when an agreed milestone was reached, work started at the Shadow site(s). In this way, the shadow sites would get the benefit of the experience already gained at the lead sites and show how implementation time decreased with experience.

7.4.5 Plants selected for Implementation

The demonstration projects identified and the factories where these were implemented are shown in Table 7.2.

Table 7.2 Summary of Demonstration Project Implementation

No.	Demonstration project	Location	Remarks
1	Achieving Eco-Friendly Processing for Export Markets	Lead Site: Misr Spinning and Weaving, Mahalla El Kobra, Gharbia Governorate Shadow Site: Giza Spinning, Weaving, Dyeing and Garment Co., Giza Governorate	A product based initiative umbrella project.
2	Water and Energy Conservation	Lead Site: El-Nasr Company of Spinning and Weaving (Mahalla El Kobra) Shadow Site: Misr Beida Dyers, Kafr El Dawar (Alexandria).	A housekeeping based initiative umbrella project.
3	Sulphur Black Dyeing	Lead Site Dakahleya Spinning and Weaving Co., Mansoura Shadow Site 1: El-Nasr Company of Spinning and Weaving (Mahalla El Kobra) Shadow Site 2: AmirTex Weaving, Dyeing, Printing and Finishing Co., Sadat City.	A process oriented demonstration project. All three companies had different product ranges and different processing machinery.
4	Combined Scour-Bleach Process	Lead Site Giza Spinning, Weaving, Dyeing and Garment Co., Giza Governorate. Shadow Site: Misr Beida Dyers, Kafr El Dawar (Alexandria).	A process oriented demonstration project.
5	Bleach Clean-Up using Enzymes	Lead Site Dakahleya Spinning and Weaving Co., Mansoura Shadow Site: AmirTex Weaving, Dyeing, Printing and Finishing Co., Sadat City.	A process oriented demonstration project.

Based on the discussions in the preceding chapters, the main elements of the demonstration projects address the following issues:

- Phased transfer (shift) from or hazardous raw material to safe biodegradable chemicals.
- Minimisation of heavy organic loads via recovery of sizing materials.
- Increasing dye uptake and recycling via appropriate control schemes.
- Water reuse through separation of cooling systems and appropriate physical separation.
- Proposing resource management scheme to improve use of unemployed facilities.

7.4.6 Project Concept Notes (PCNs)

Project Concept Notes (PCNs) were developed for each of the demonstration projects, which described:

- The rationale and justification for carrying out the project.

- The purpose, outputs and replicability of each project and the various activities that would be carried out to achieve these. This also incorporated an outline timebound workplan, which described how long each activity should take to complete.
- An assessment of the costs associated with implementation, including consultancy costs, equipment purchase and analytical expenses.

Each PCN was then discussed and finalised with senior management and technical staff. This then formed the basis for a formal Agreement (including a detailed Bill of Quantities) between the SEAM Project and each of the factories, which described the responsibilities and financial contributions of each party.

7.5 Overview of Demonstration Projects

Case studies describing these projects in more detail are included in Appendix 8.

(i) Ecofriendly Processing and Obtaining Ecolabels

This demonstrated how 2 Egyptian factories improved their processing such that they could obtain an internationally acceptable ecolabel. As a result, pollutants from the textile wet processing operations were efficiently and cost effectively reduced, including discharges/emissions from the factory in to the environment as well as those which remain in the fabric. Other benefits have included:

- Enhanced export opportunities.
- Opportunities to conserve resources such as process chemicals and dyes, electricity, steam and water, with corresponding financial savings.
- A reduction in the strength and volume of wastes, bringing the factory closer to legislative compliance and reducing wastewater treatment and disposal costs.
- Improved levels of Right First Time (RFT) in the dyeing process after bleaching.
- Increased capacity utilisation of the production equipment.
- In addition, eco-labelling and ISO 14000 have many elements in common. Therefore, achieving an eco-label provides a good start for those companies wishing to obtain ISO14000 certification.

(ii) Water and Energy Conservation

A range of opportunities relating to water and energy conservation were identified and implemented by El-Nasr Company for Spinning and Weaving, in Mahalla El-Kobra, Egypt. This involved a total investment of LE246,810 and result in annual savings of LE753,420.

General housekeeping improvements implemented included:

- Improving dye storage facilities.
- Optimising chemical usage.
- Recovering steam condensate.
- Upgrading the insulation of the steam and hot water network and in the pre-treatment section.
- Installing a counter current flow system in the Kyoto range.

(iii) Substitution of Hazardous Chemicals in Sulphur Black Dyeing

The traditionally used reducing agent, sodium sulphide and oxidising agents, sodium and potassium dichromate are toxic and hazardous to handle, may leave harmful residues in the finished fabric and generate effluents that are difficult to treat and damaging to the environment.

The measures implemented by the SEAM project demonstrate how these can be safely substituted without a decline in fabric quality. As a result the advantages of sulphur black dyeing can be retained, whilst eliminating the adverse environmental and health impacts.

No capital spending was required to implement this project - savings made from reduced steam, water and energy consumption ranged from LE 9,312 to LE 2,386. Annual benefits from increased production capacity at Dakahleya factory totalled LE 21,000 and in AmirTex, the annual savings made by reduced use of reactive dyes totalled LE 23,716. Other benefits included improved fabric quality (due to a reduction in fabric tendering); improved Right First Time, reduced processing time, increased productivity and improved effluent quality.

Implementation of this Project has permitted sulphur black dyeing to continue, retaining all of the advantages - low cost, excellent washing and light fastness properties - and none of the disadvantages.

(iv) Combining the Desize/Scour and Scour/Bleach Processes

Desizing, scouring and bleaching are normally carried out as three separate steps. The demonstration project was implemented at two factories - at Misr Beida Dyers, the desize and scour steps were combined and at Giza Spinning, Weaving, Dyeing and Garments Company, the scour and bleach steps were combined.

These modifications were implemented at no capital cost and resulted in cost savings of up to 25% on consumable materials. Other benefits included the elimination of toxic and hazardous materials from the workplace and environment, improved fabric quality and increased productivity.

Demonstration project implementation resulted in reduced steam, electricity, labour and water consumption at both factories. In Misr Beida Dyers, this resulted in savings of LE107/ton of fabric, corresponding to annual savings of LE 63,237. In Giza Spinning, Weaving, Dyeing and Garments Company, this resulted in savings of LE 55.5/ton of half bleached fabric and LE30/ton of full bleached fabric, corresponding to annual savings of LE 66,600 and LE 8,640 respectively. The reduced processing time also allowed the factory to increase their production capacity by 480 tons (half bleached fabric) and 48 tons (full bleached fabric), giving additional annual revenue of LE 90,480.

(v) Use of Enzymes in Bleach Clean-Up

Catalase enzymes can be used in bleach clean-up as an alternative to multiple rinses or chemical reducing agents. Under industrial conditions, the enzymes take 10-20 minutes to completely break down residual hydrogen peroxide and have no adverse effect on either the fibres or the subsequent dyeing process. Once bleach removal is completed, dyeing can be carried out in the same liquor, without any need for further heating.

In Dakahleya Spinning and Weaving, implementation was completed with no increase in costs. As a result, steam, water and electricity costs were reduced by 24-48%. For half bleached and dyed fabric, this gave savings of LE213/ton, corresponding to annual savings on current production of LE 26,412. For full bleached fabric, savings of LE183/ton were made, corresponding to annual savings on current production of LE 86,559. The biggest savings at AmirTex were made with regard to energy consumption, mainly resulting from the phasing out of the hot water wash. This generated savings of LE103/ton of half bleached fabric, with corresponding annual savings on existing production of LE 50,450.

Additional benefits resulting from implementation of this demonstration project included:

- Effluent volume at both factories reduced, due to the elimination of unnecessary washing steps.

- A decrease in concentration of Total Dissolved Solids (TDS) in the effluent.
- Enzymes are safe to handle and completely biodegradable.
- Improved productivity.
- Improved working conditions.

7.6 Outputs from the Demonstration Projects

For each demonstration project, one national and one international consultant were appointed. Detailed technical reports were prepared as support for the demonstration projects by the national consultants and were reviewed by the international consultants. Case Studies (reproduced in Appendix 8) and Guidance Manuals were also prepared for the sector for each project, so that companies not involved in the SEAM Project could benefit from the experience gained. This will help ensure that the projects are replicated throughout the sector by demonstrating the credibility and feasibility of the CP measures to other units so that they can design and implement similar projects at their facilities.

Guidance manuals prepared for the textile sector include:

- Cleaner Production for Textiles: Ecofriendly Wet Processing of Textiles.
- Cleaner Production for Textiles: Water and Energy Conservation.
- Cleaner Production for Textiles: Sulphur Black Dyeing.
- Cleaner Production for Textiles: Combining Preparatory Processes.

Dissemination workshops to share the experiences of the demonstration projects were organised at the management and senior management levels.

The actual implementation of the demonstration projects and the lessons learnt from the implementation are presented and discussed in the next part of this report.

Part C

SUSTAINING CLEANER PRODUCTION

8.0 Cleaner Production Issues in Egypt

The textile mills in Egypt may be categorised into:

- Large, old, government owned mills which use traditional processing methods (these are among the largest contributors to pollution but are also the main producers of textiles).
- Newer units which tend to be smaller and adopt newer technologies.
- Medium sized mills moving towards adoption of newer production technologies.

Among the older mills, most use heavily polluting processes such as hypochlorite bleaching, aniline dyeing and pigment printing using kerosene. Equipment varies from the very old and obsolete to modern equipment in the newer mills. Fully automated equipment is used to some extent in the spinning and weaving sub-sectors but are not widely used in wet processing, even in newer mills.

The chemicals used in the Egyptian textile industry should be screened to exclude those which are severely polluting and/or banned and substituted with safer alternatives. For example, Benzidine-containing dyestuffs, bleaching agents liberating chlorine or chlorine dioxide, materials containing heavy metals (e.g. metal complexes dyestuffs, finishing catalysts, salts), formaldehyde or ammonia releasing agents are commonly used and need to be regulated. In addition, starch based materials (e.g. sizing agents) must be partially or fully replaced by reclaimable/low BOD materials.

It is thus clear that control of the processes and the products towards ensuring a cleaner industry is essential if the textile market has to compete in the international market.

8.1 Barriers to CP Adoption in Egypt

Even though some initiatives have been adopted by the textile sector towards adoption of CP, there still are a number of barriers to its adoption in Egyptian factories. These barriers relate to:

- Economic concerns.
- Technology and technical skills.
- Cultural concerns.
- Quality considerations.
- Information dissemination.

Examples of Barriers to CP Adoption in Factories:

☹ Lets think about this later.
☹ Its good to talk about but will not work in practice.
☹ It just will not work.
☹ We do not have the time for this.
☹ Has anyone done this before?
☹ What is wrong with the present system?
☹ We are already doing this!
☹ You do not understand the problem.
☹ Talk to someone else. This is not my field.
☹ We are too big/too small for this.

Implementation of a CP programme will involve the assessment and quantification of emissions, economies and efficiency. In Egypt, emissions (mainly liquid discharges) have received the most attention but in future, greater emphasis must be placed on seeking economies to:

- Minimise the use of energy, water and raw materials.
- Improve the efficiency of operating practices to ensure the best use of materials.
- Reduce the volume of waste being generated.

In this way, the profitability of a business will increase whilst its adverse impact upon the environment will diminish.

8.1.1 Economic Barriers

Economic barriers can occur when a company believes it does not have the financial ability or sufficient incentive to implement waste minimisation.

Similarly, the low costs associated with the abstraction of water and the disposal of wastes means that there is little incentive for companies to make savings in these areas.

8.1.2 Technical Barriers

Experience in Egypt has shown that many companies are well aware of local pollution problems but have little appreciation of the wider environmental issues. However, the level of knowledge is limited so that there may be a belief that a subject is well understood but in practice is poorly applied. This problem is compounded by a generally poor quality and low availability of up-to-date technical information.

Changes in the a way in which a company operates will frequently present technical difficulties such as:

- Lack of suitable information.
- Concern about changes to product quality and customer acceptance.
- Retrofitting of processes causes shutdown of existing operations.
- New operations may not work.
- There is insufficient space to easily accommodate any additional equipment.
- Adverse employee reactions.

Unlike other countries, there are very few textile experts who could provide objective technical assistance to the industry on, for example, eco-friendly processing. The chemical suppliers dictate the market and the production trends. Awareness of CP is very low among a number of these chemical suppliers except for large multinational chemical companies. Thus between the textile industry and the chemical and equipment suppliers there is no middle level interface of technical experts who could advice industry on the choice of technology, raw materials, chemicals, environmental management etc. that would ensure eco-friendly processing.

Textile machinery is not produced locally and there are no technical skills for local manufacture of such equipment. Hence the industry has to depend on used and at times obsolete equipment from other countries.

Most of the textile mills in Egypt do not have effluent treatment plants. Water and energy are subsidised and hence there is no pressure on the textile mills to practice conservation of these resources. Groundwater is being extensively exploited, as this is the main source of water for the textile industry. The lack of effluent treatment plants will also result in disposal of effluent to receiving water bodies or on land. This could lead to widespread contamination of the groundwater.

Other infrastructure related issues are the inadequacy of testing facilities for purity testing of dyes, chemicals and fabric testing. There are also no testing facilities for quality assurance and verifications, which are essential requirements for the process of achieving eco-labels.

8.1.3 Cultural Barriers

Many companies are over-manned in comparison to international norms. This may lead to a lack of individual responsibility and a perception that no individual can achieve change. In many factories, this is compounded by an autocratic management structure with all instructions coming from the top so that workers do not accept personal responsibility for change.

Resistance to change and friction between personnel may introduce barriers and can be caused by:

- Lack of senior management commitment.
- Lack of awareness of corporate goals and objectives.
- Poor internal communication.
- Restrictive employment practices.
- Inflexible organisational structure.
- Bureaucracy inhibiting change.

8.1.4 Quality Considerations

The lack of quality (defined in this context as fitness for the purpose) of many products is common and consistency is poor. Down-graded products are common but still finds market outlets in Egypt. Where companies have export markets, customer demands often ensure that production methods are better controlled.

There is a need to establish a quality culture within companies and whilst ISO 9000 is widely recognised it is poorly understood. Too often it is regarded as a marketing aid and not as a management tool for maintaining quality, improving efficiency and reducing wastage. However, where a company is considering ISO 9000 it can be used as a vehicle to assist in implementing change within an organisation.

8.1.5 Information Dissemination

To date, information concerning CP opportunities has not been readily available. There are no independant associations dedicated to providing technical assistance and information to industry, government departments and others involved in the industry. No formal centre exists which could serve as a clearinghouse of information and as a counselling centre for the promotion of CP in the country.

In the dissemination of information, language can be a barrier as all documents, manuals etc. have to be translated into Arabic to ensure that the information is available to the widest possible audience.

8.2 Overcoming Barriers to Cleaner Production Implementation

8.2.1 Economic Factors

Economic arguments are all too often the only justification given for a change within an organisation. There is little doubt that in a business sense, profitability is the most significant factor but company profits have little short term effect on the way in which individuals respond within a company.

If individuals perceive a threat to their livelihood, and there is a chance that they may lose their jobs, this will be a strong motivator as it has a direct bearing on their ability to satisfy their physiological needs for water food and shelter. But making more money for their employers and shareholders is rarely a strong motivator and other more intangible factor such as pride, status, achievement etc. are more significant. Once people feel personally secure and safe they become more concerned with the wider environmental issues such as global warming and damage to the ozone layer. The quality of life is as important, if not more so, than the economics alone.

However, any recommendations made have to be financially sound and will include:

- Monitoring to determine the full cost of pollution control, waste management, etc.
- Cost/benefit calculations and pay back periods for investments.
- Target setting, based on true data, to achieve reductions in usage of materials.
- Identification of potential liabilities through a failure to control an environmentally damaging activity.
- Details of environmental funds, customs and tax credits, fixed interest loans to encourage cleaner technologies, etc., if/when these are available.
- Identification of cost savings.

⇨ **Action:** Reduce wastage of raw materials.
Effect: Raw materials costs decrease.

⇨ **Action**: Reduce the volumes of waste generated.
Effect: Waste treatment, transportation and disposal costs decrease.

⇨ **Action**: Reduce labour time spent monitoring and handling waste.
Effect: Valuable labour time can be channelled elsewhere.

⇨ **Action**: More efficient use of energy.
Effect: Reduced electricity, oil and/or gas bills.

⇨ **Action**: More efficient use of water.
Effect: Reduced water bills where relevant and potential knock-on effect regarding effluent volumes and associated costs.

Taking these actions will also reduce long-term environmental liability and insurance costs.

There are other, wider environmental benefits such as less fossil fuel being burnt at power stations, less need for landfill for solid wastes, etc.

8.2.2 Technical Factors

This is the area in which the company personnel will feel most at home since they know their business well. It is also the area in which they can be highly conservative. To overcome initial reservations, personnel will need to be shown that CP can be very successful. This can be achieved through:

- Source of up-to-date information from within the company and outside.
- Identification of training opportunities.
- Pilot scale projects prior to major change.
- Reviews of customer requirements.
- Involvement of all relevant departments in the planning process.
- Use of well-tried technology wherever appropriate.
- Examples of successful applications in other businesses.
- Provision of work instructions, safety data sheets, duty of care for hazardous wastes.

8.2.3 Cultural Factors

A large number of surveys have been conducted in a variety of countries as to the factors which contribute to the quality of life of an individual. Invariably the list includes a number of essential factors which are in order:

- Good education.
- Clean/healthy environment.

- Personal/family health.
- Good social relationships.
- Money.
- Employment.

Individuals will also describe a wide range of other factors including moral and spiritual values, freedom, peace of mind, stable government, etc. The significant factor is that money, in itself, is not a prime motivator and companies can encourage change through a wide variety of techniques.

Recommendations to overcome cultural barriers will include:

- Company policy and management changes.
- Identification of training needs.
- Identification of incentive schemes which can include financial bonuses, recognition of achievements, employee of the month, issue of certificates.
- Allocation of responsibilities to individuals, goal setting, timescales for change, use of staff suggestion boxes.
- Company news letters, publicity for achievements, involvement of local community.
- Education in wider environmental issues and protection of the global and local environment.
- The use of the company as an environmental (champion) to stimulate other similar companies; the formation of waste minimisation (clubs) within a geographical area or industrial sector to pool ideas and share experiences.
- Religious beliefs of relevance to the protection of the environment.

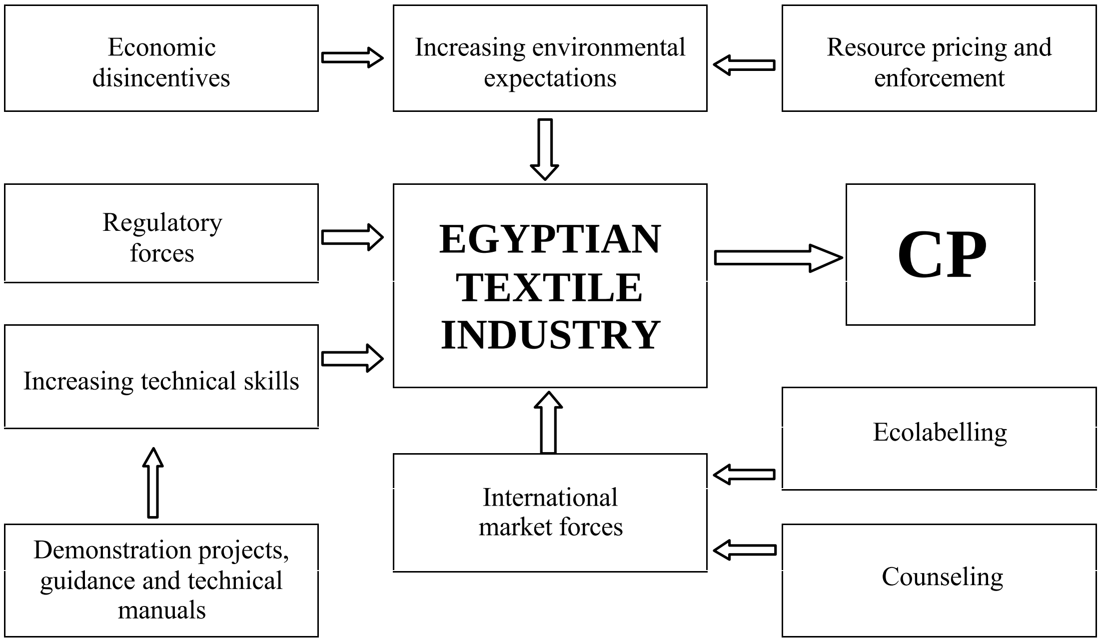
Change in Egypt, as with anywhere else in the world, will occur slowly and by a multiplicity of influences. Motivation is complex and frequently difficult to predict. It is important that any recommendations made are realistic and also consider how the changes can be achieved.

8.3 Promotional Strategies for Adopting CP in Egypt

Development of a strategy for cleaner production entails identification of the (approach) to be adopted (whether product, process, technology or operation related), the (options) available, the (pollution prevention practice) to be adopted (for the sector, specific to Egypt) and finally the (measures) (i.e., the specific demonstration projects for each mill) that should be taken to implement CP.

Given the barriers identified in the previous section, the shift from end of pipe approach to CP in the Egyptian textile industry take a long time to implement, adversely affecting company productivity, causing environmental degradation and a threat to self - reliance. However, as shown in Figure 8.1, a number of factors may help accelerate the (push) of the textile industry towards adopting CP.

Figure 8.1 Push Factors on the Egyptian Textile Industry to Move Towards CP



8.3.1 Policy Options

The policy options need to consider infrastructure issues such as water and energy resources - excessive subsidies on water and energy need to be eliminated and realistic pricing structures developed so that they serve as (push factors) for industry to practice water and energy conservation, thereby facilitating promotion of CP.

In addition to the pricing structure, suitable fiscal incentives also require to be developed by the GOE to promote and encourage adoption of CP methods.

Policy options should target provision of subsidy schemes for Small and Medium-sized Enterprises (SMEs) for the implementation of CP options and establish a system for banning of (dirty technologies) and phasing out banned chemicals.

8.3.2 Capacity Building and Technical Assistance

The experiences from the various SEAM demonstration projects need to be disseminated across the sector. The Guidance Manuals and technical reports and resource materials prepared under the project need to be disseminated to enable other textile mills to implement the CP options. This will bring about a multiplier effect of the demonstration projects.

Awareness workshops and training programmes need to be organised for industry, government officials, industry associations in the textile sector. The training programmes should be structured to target the following groups:

- **Senior management** of industry and policy makers and decision makers in government on the economic and environmental benefits of CP;
- **Middle level technical and managerial personnel** in industry on production technologies, health and safety aspects;
- **Textile workers** particularly on health and safety aspects.

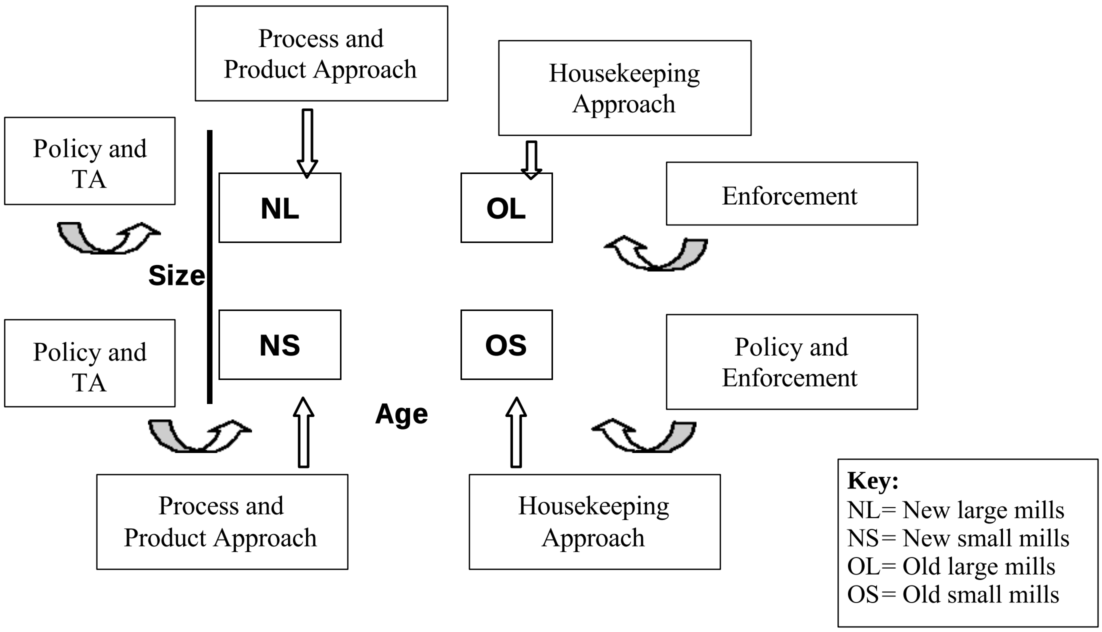
The GOE also needs to support development of counselling centres for CP options targeted primarily at the SMEs.

There is a large deficit in terms of independent technical skills in the textile sector. Consultants or experts who can provide an objective technical viewpoint to industries on choice of processes, technologies and chemicals are limited. As a result of this, chemical and equipment suppliers command the textile processing market in Egypt. Capacity building to create a middle level of such experts is essential. Senior technical personnel from the textile sector who have extensive experience in the industry and who have retired from active service should be targeted for development of such a technical corps.

Capacity building for the sector should also commence at the educational institution level where textile chemistry, textile engineering, cleaner production etc. should be integrated into the curricula so as to build local technical capacity in the sector.

Figure 8.2 presents a strategy that may be applied to the various segments of the textile sector for the promotion of CP. The figure has been developed using the categorisation developed in Figure 7.1. This incorporates the various tools that have been discussed above and the suggested CP approaches that should be applied to the industries in the sector.

Figure 8.2 Suggested Strategy for Promotion of CP



8.3.3 Impact of the SEAM Demonstration Projects

The SEAM project has, through the implementation of the demonstration projects, facilitated the introduction of the technology component of CP into the Egyptian textile industry. This has resulted in demonstrating that the CP options are credible, feasible, economical while enabling pollution abatement.

Some of the achievements of this project have been; award of the ko-Tex eco-label to two textile mills (Misr for Spinning and Weaving, Mahalla El-Kobra, a large, public factory and Giza Spinning, Weaving Co., (a small private sector unit) and successful implementation of process modification involving chemical substitution of sulphide and dichromate in the sulphur black dyeing process at El-Nasr, Dakahleya and AmirTex mills.

This however, is the first step in the promotion of CP in the Egyptian textile industry. From this point on the onus is on the Government of Egypt to initiate aggressive promotion of CP. The experience from the demonstration projects has to be scaled and multiplied across the sector.

The Government of Egypt therefore needs to play a major role in providing the necessary push factors to enable Egypt's textile sector to compete in the global market. These factors include:

- Developing suitable policy options.
- Strengthening enforcement strategies.
- Providing support for technical assistance in technology transfer, training and awareness, developing innovative CP options locally for the sector and disseminating the experiences from the project across the sector.

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Appendices

Appendix 1:	**Statistics on the Main Resources of a Large Sample of Textile Companies**
Appendix 2:	**Major Export Companies and their Main Products**
Appendix 3:	**Process Flow Diagrams for Wool Processing**
Appendix 4:	**Process Effluents: Impacts of Hazardous Substances used in Textile Production**
Appendix 5:	**Summary of Relevant Environmental Legislation**
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Appendix 1

Statistics on the Main Resources of a Large Sample of Textile Companies

Statistics on the Main Resources of a Large Sample of Textile Companies

Table 1 Textile Mills Exporting Goods - Public Sector

No.	Company	Address	No. of Spindles	No. of Looms	No. of Employees	Main Product
1	Misr Spinning & Weaving Co.	El Mahalla El Kobra	350,000	5,600	34,000	Yarn, fabrics (grey & finished), terry towelling, bed sheets, pillow cases, ready made garments, cotton wool, gauze bandages
2	Misr Fine Spinning & Weaving Co.	Kafr El Dawar	396,548	3,672	30,109	Loomstate, finished cotton, blend cloth, cotton yarns, blend poly/cotton, knitting and weaving, sewing threads, waste cotton
3	Misr-Helwan Spinning & Weaving Co.	Kafr El Elou - Helwan	119,392	2,812	18,500	Cotton yarns, cotton and blended textiles (grey, bleached) (dyed & printed), corduroy & velvet plain & printed upholstery fabrics, ready made garments, guipure embroidered textiles, jersey & natural silk
4	Establisements Industriels Pour la Soie et le Cotton S.A.A. (ESCO)	15 Gawad Hosni St. P.O. Box - Cairo	215,336 cotton, staple yarn, 3,744 rayon, continuous filament	2,880 worsted, 2,409 cotton fabrics, 34 terry towels, 56 blended worsted	22,002	Yarns: combed & carded cotton, blended worsted yarns & viscose, rayon yarns, grey & finished fabrics & terry towels
5	El Nasr Spinning & Weaving & dyeing Co.	El Mahalla El Kobra P.O. Box 95	52,000	1,500	13,000	Cotton terry towels, jacquard & plain dyed kitchen towel & table cloth, bed covers, bed sheets, printed & dyed, cotton textile creton, poplin, ticking sheeting, grey cloth, cotton yarn no. from 20 to 40, ready made garments
6	The Arab & United Spinning & Weaving Co.	Siouf, Alexandria	170,000 spindles & 2,700 rators	1,218	8,000 workers	Spinning, weaving, processing of 100% cotton & blended yarns & fabrics for the local market & for the export
7	Misr-Shebin El Kome SPG & Weaving Co.	Shebin El Kome - Monofeya	167,000	200	10,000	Cotton yarn
8	El Nasr Wool & Selected Textile Co. (STIA)	El Nozha - Alexandria	--	--	--	Cotton yarns, cotton underwear, worsted & woolen fabrics
9	National Spinning & Weaving Co.	132 Canal El Mahmoudeya St., Alexandria	--	--	--	Cotton piece goods, cotton perle, coarse & fine yarns, cotton tricot, terry towels, terry cloth, sewing threads, ready made garments
10	Misr Beida Dyers S.A.E	P.O. Box Alexandria	--	--	7,273	Finishing, dyeing & printing, cotton piece goods, white and/or dyed wool tops, yarns of different counts made out of 100% wool or acrylic, wool noils & carbonised wool wastes
11	El Nasr for Spinning, Weaving & Tricot	Embaba P.O. Box 1890 - Cairo	39,420 marden	383 nol	5,818	Spinning, weaving and tricot

No.	Company	Address	No. of Spindles	No. of Looms	No. of Employees	Main Product
12	Societe Misr Pour la Rayonne	Kafr El Dawar	--	--	--	Rayon filaments, viscose staple fibre, polyester fibres, nylon filaments, nylon staple fibre, spun yarns
13	Upper Egypt Spinning & Weaving Co.	50 El Gomhoureya St. Cairo	149,220	--	9,273	Cotton yarn, wooden yarn, carpets
14	The Middle Egypt Spinning & Weaving Co.	50 El Gomhoureya St. Cairo	120,000	1200	13,000	Cotton yarn & cotton clothes & terry towels
15	Orient Linen & Cotton Co.	Tarik Mostafa Kamel, Ras El Soda, Alexandria	68,748	644	7,000	House holds products bed sheeting, terry, towels, curtains, table cloth, bed cover, cotton yarn, flax yarn
16	Damietta Spinning & Weaving Co.	3 Saad Zaghloul St. Damietta	114,592	828	6,785	Cotton yarns, cotton textiles, embroideries sets, ready made clothes
17	El Nasr Spinning & Weaving Co. (Port Said & Zakazik)	83 El Azhar St., Cairo	--	--	--	Cotton duck
18	Arab Carpet Upholstery	Damanhour, Nasr St. P.O. BOX 8	1,572	18	2,958	Machine-made carpets (wool & acrylic), blankets (acrylic)
19	El Siouf Spinning & Weaving Co.	Elmassanaa St., El Siouf, Alexandria	155,528	1,554	10,973	Cotton yarns & textiles (grey-dyed-printed)
20	The Alexandria Spinning & Weaving Co.	Nozha - Alexandria	140,000	--	6,000	Cotton yarn ranging count Ne 12 up to Ne 80 single & PLY, carded & combed, on cones or hanks, sewing thread Ne 40/3
21	Dakahleya Spinning & Weaving Co.	Mansoura P.O. Box	181,584	240 looms sulzer PU	8,200	Cotton yarns of all counts & blended yarns (polyester/ cotton), all sorts of textile, cotton & blended ready made garments
22	Delta Spinning & Weaving Co.	6 El Galaa St. Tanta	55,012	787	7,967	1. Combed & carded yarn, gassed & mercerised single & double grey, white, dyed sewing, weaving & knitting production of fine yarn: from 20/1 till 80/1. 2. Woven products: grey, white, dyed sets of bed-sheets, table covertura, terry towels, kitchen towels, draw sheets, baby sets, table, covers, blanket covers, herring bone.
23	Cairo Dyeing & Finishing Co. S.A.A.	15 May Road- Shoubra El Kheima (Head Office)	--	Machines specialised in bleaching, mercerising, dyeing, printing & finishing not less than 72 million meter/ year	3,086	Cretonne,bed sheeting , gabardine printed & coloured , pique poplin , batiste , sheeting , fancy shirting cloth , hank dyeing & all kinds of converted fabrics with width not more than (140 CM) finishing
24	Modern Textile Co.	6 Peres Jesuites St. - Alexandria	--	--	--	Textile fabrics made of silk - viscose rayon - blends of rayon & cotton

Statistics on the Main Resources of a Large Sample of Textile Companies

Table 2 Textile Mills Exporting Goods - Joint Ventures

No.	Company	Address	No. of spindles	No. of looms	No. of employees	Main Product
1	Misr Iran Textile Co. (Miratex)	28 Talaat Harb St., Cairo P.O. Box 1461 Cairo	--	--	--	Cotton and cotton blended yarns Ne 4 up to Ne 100 single, plied, carded, combed grey. Singed and mercerised on cones and hanks
2	Moselay Weaving Mill	164 El Tahrir St., Cairo	--	128	250	Satin and grey cloth - velvet, jeans, very fine coil for shirts
3	Modern Canava Industries (M.C.I)	15a Radwan Ibn Tabib P.O. Box 158, Orman, Giza	540	50	300	Cotton duck, cotton canvas, tarpaulins & tents
4	Misr El Amreya Spinning & Weaving	13 Salah Salem St., Alexandria	--	--	--	Cotton yarn, blended yarns (polyester-cotton) grey fabrics

Statistics on the Main Resources of a Large Sample of Textile Companies

Table 3 Main Producers of Knitted Goods and Ready-Made Garments - Public and Private Sectors

No.	Company	Address	No. of Spindles	No. of Looms	No. of employees	Main Product
1	El Nasr Clothing & Textile Co. (KABO)	407 Rue Canal Mahmoudeya, El Hadra, Alexandria	--	--	6,857	Knitted under and outer garments for children, ladies and men made of 100% Egyptian cotton, T-shirts, polo shirts, sweat shirts, turtle neck singlet, slip, pants, training suit
2	Cairo Clothing & Hosiery S.A.	6 El Madares St. Hadayek El Kobba, Cairo	6,264	--	4,174	Underwear, outer garments, ready made garments, T shirts, sports garments, socks for men, children braiding, elastic bands and ribbons
3	DIEA Co. for Knitting & Fashion	15 Ahmed Zaki St. Hadayek El Kobba, Cairo	54 (sewing machines)	12 (knitting machines)	140	Underwear, T shirts (for men, ladies & children)
4	Giza Textiles & Clothing Co.	162 Gohar Al Kaid St., Darrassa, Cairo	20 knitting machines and sewing	Dyeing, cutting	450	Men, ladies and children underwear, T shirts, sweat shirts
5	Societe Egyptienne Pour La Fabrication des Tissus Indemaillable (MATAR & Co.)	26 Rue Zeitoun, Hadayek El Zeitoun, Cairo	200	25 fully automatic round electric machines	60	Children, men & ladies underwear
6	Koujoutex Co. for Textile Industries	15 Souk El Nokalia St., El Nasr Square, Alexandria	19 (sewing machines)	8 circular - 8 flat - 14 socks machines	67	Underwear, outer garments, socks (men/children), knitting cloth (rib, interlock, push, net, jaquard double jersey)
7	Eva Factory, Aida Riad & Co.	7 Yehia Tawfik St. Gisr El Suez, Cairo	65 (sewing machines)	7 (knitting machines)	120	Men, ladies & children T shirts, underwear, pyjamas for men, ladies & children
8	The Egyptian Company for Trading & Industry (Arafa & Co.)	Rue Canal El Suez, El Mansheya El gedida	102 (sewing machines)	13 (knitting machines)	190	Underwear & outer garments from knitted fabrics
9	Sphinx Ready Wear MFG Co.	24 Mansheya St., Sharabeya, Cairo	35 (sewing machines)	5 (knitting machines)	80	T shirts, underwear & night gowns
10	Palmtex ,EX, Pamgrove Weaving & Dyeing Factory	10 Bibars St., Hamzaowi, Cairo	50 (sewing machines)	9 (knitting machines)	400	

Appendix 2

Major Export Companies and their Main Products

Major Export Companies and their Main Products

No.	Company	Export Commodities
1	Misr Spinning & Weaving Company - El Mahalla El Kobra	Cotton & blended yarns, cotton & blended fabrics, hydrophile cotton wool, ready made garments, terry towels, bed sheets, gauze bandages
2	Misr Fine Spinning & Weaving Company - Kafr El Dawar	Cotton & blended yarns, cotton & blended fabrics, ready made garments
3	Misr/Helwan Spinning & Weaving Company	Cotton yarn, cotton & blended fabrics, furnishing fabrics
4	Etablissment Industriale Pour la Soie et le Cotton ESCO	Cotton & blended yarn, cotton & blended fabrics, viscose rayon filament
5	El Nasr Spinning, Weaving & dyeing Co., El Mahalla El Kobra	Cotton & blended fabrics, terry towels, bed-covers, ready made garments, bed sheets
6	Unirab Spinning & Weaving Co. Unirab	Cotton yarns, sewing threads, knit wear
7	Misr - Shebin El Kome Spinning & Weaving Shebintex	Cotton & blended yarns, polyacrylic yarns
8	El Nasr Woolen & Selected Textiles STIA	Cotton yarns, cotton & blended fabrics, knitted cotton underwear, wool blankets, bed sheets
9	National Spinning & Weaving Co.	Cotton yarn, cotton fabrics, bed sheets
10	Misr Beida Dyers Company	Wool tops, noils, lanoline, hydrophile cotton wool, acrylic yarns
11	El Nasr Spinning & Weaving & Knitting Co. Shorbagi	Cotton fabrics, knitted under wear
12	Societe Misr Pour La Rayonne Misrayon	Filaments & synthetic fibres
13	Upper Egypt Spinning & Weaving Co. Ascotex	Cotton & blended yarns
14	Middle Egypt Spinning & Weaving Co. Minatexco	Cotton yarns, cotton fabrics
15	OrientLinen & Cotton Co. Orlintex	Linen products, bed sheets, bed covers, terry towels, bathrobes
16	Damietta Spinning & Weaving Co. Damietex	Cotton yarns, cotton fabrics, bed covers
17	Port Said Spinning & Weaving Co. Portex	Cotton fabrics, canvas & tent fabrics
18	Arab Carpet & Upholstery Co. - Damanhour Damanhour Carpets	Wool & blended carpets
19	El Siouf Spinning & Weaving Co. Siouftex	Cotton yarns & fabrics
20	Alexandria Spinning & Weaving Co. Spinalex	Cotton yarns
21	Dakahleya Spinning & Weaving Co. Dakahletex	Cotton & blended yarns, ready made garments, knit wear
22	Delta Spinning & Weaving Co. Deltatex	Cotton yarns & fabrics, bed covers, terry towels
23	Cairo Dyeing & Finishing Co.	Cotton & blended fabrics
24	Misr Iran Spinning & Weaving Co. Miratex	Cotton & blended yarns
25	El Nasr Clothing & Textiles Co. Kabo	Knitted cotton under wear, knitted cotton garments
26	Cairo Clothing & Hosiery Co. Tricona	Knitted cotton underwear, knitted cotton garments, socks
27	El Sharkeya Spinning & Weaving Co. (Zakazik) Sharkatex	Canvas & heavy fabrics, cotton & blended yarns, cotton fabrics
28	Vesta Ready Made Garments Co. Vestiaco	
29	Societe Franco Egyptienne de Confection Sofeco	Ready made garments
30	Samanoud Weaving & Terry Co.	Cotton blended fabrics, denim fabrics, terry towels, ready made garments

Appendix 3

Process Flow Diagrams for Wool Processing

Figure A: Conversion of Raw Wool into Yarns

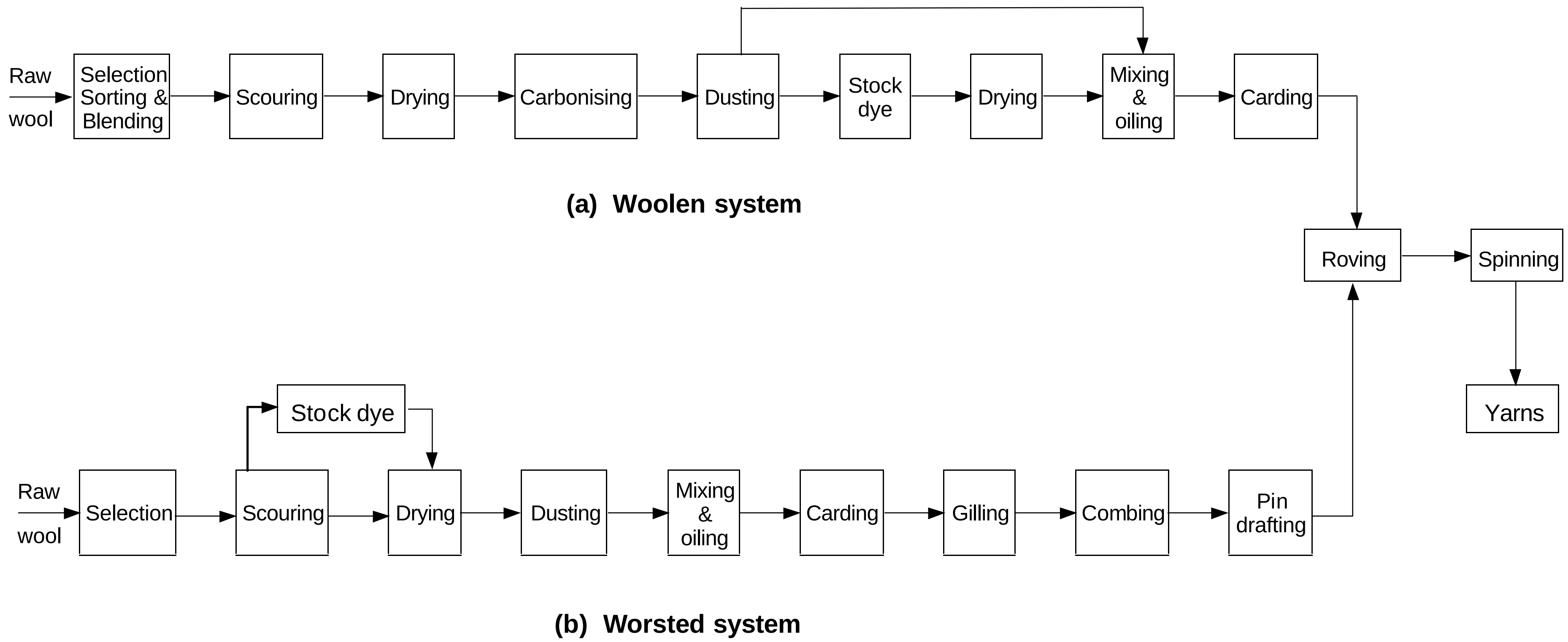


Figure B: Conversion of Wool Yarns into Fabrics

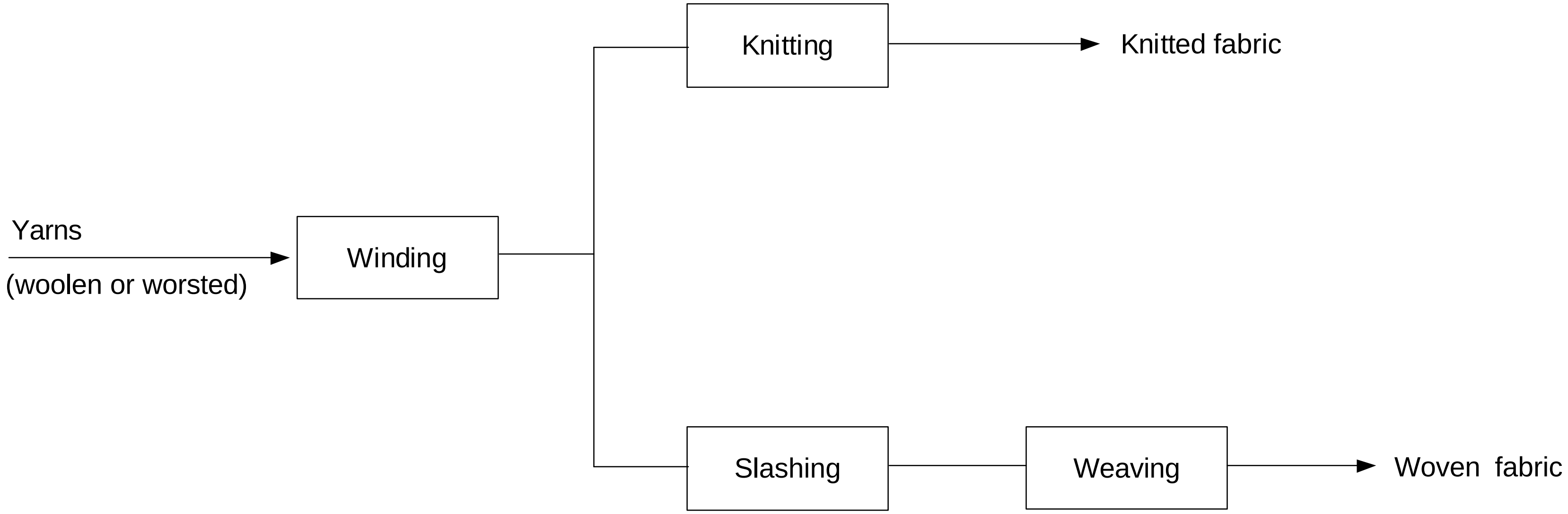
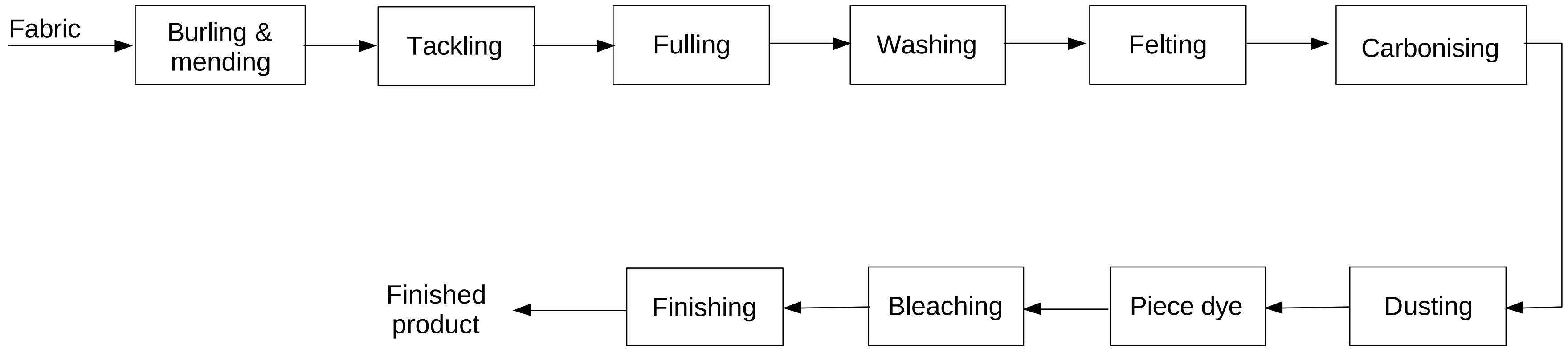


Figure C: Finishing of Woolen and Worsted Fabric



Appendix 4

Process Effluents: Impacts of Hazardous Substances used in Textile Production

Impacts of Hazardous Substances contained in Textile Production Process Effluents

Process	Effect/Purpose Description	Area of Application	Chemicals Employed	Possible Impacts on Health and Environment
Sizing	Strengthening of warps during weaving	All fibres	▪ Starch based sizes ▪ CMC, CMS ▪ PV OH ▪ Polyacrylate ▪ Polyester dispersion	▪ High BOD ▪ High COD ▪ Disturbance of aquatic life
Desizing	Removing of sizes	All fibres	▪ Enzymes ▪ Acids, e.g. H2SO$_4$, HCl ▪ Oxidising agents, e.g. persulphates, H_2O_2	▪ High BOD ▪ High COD
Scouring	Cleaning process	All fibres	▪ Alkalis ▪ Surfactants	▪ High BOD ▪ High pH ▪ Disturbance of aquatic life ▪ Not readily degradable
Bleaching	Whitening of textile materials	All fibres	▪ H_2O_2 ▪ NaOCl ▪ $NaClO_2$ ▪ Optical brightener	▪ AOX ▪ Toxic gases, e.g. ClO_2
Mercerisation	▪ Increased luster ▪ Improving dyeability	Fabrics containing cotton	▪ NaOH ▪ Surfactants ▪ Liquid ammonium	▪ High pH
Dyeing	Textile colouration	All fibres	▪ Dyestuffs ▪ Auxiliaries ▪ Reductants ▪ Oxidants	▪ Heavy metals, e.g. Cu, Cr ▪ Carcinogenic amines ▪ Toxic compounds, e.g. carriers ▪ H_2S ▪ Corrosion ▪ Irritant
Printing	Textile colouration	All fibres	▪ Dyestuffs ▪ Thickeners ▪ Binders (pigments) ▪ Kerosene (pigments) ▪ Other additives	▪ Heavy metals (toxic) ▪ Carcinogenic ▪ Irritants ▪ Fire-hazardous ▪ High BOD & COD depending on type of thickener ▪ Disturbance of aquatic life, e.g. ureas and phosphate
Chemical finishing	Functional finishes: ▪ Anticrease ▪ Flame-proofing ▪ Softening	All fibres	▪ Chemicals containing CH_2O ▪ Chemicals containing phosphorus ▪ Softeners ▪ Fluorinated chemicals ▪ Catalysts	▪ Carcinogenic ▪ Skin allergies ▪ Heavy metal toxicity
Water-proofing	Water repellence	All fibres	▪ Paraffin ▪ Aluminium salts ▪ Zircon salts ▪ Silicone ▪ Fluorocarbon resins	Fluorocarbon resins may cause disposal problems
Antistatic finish	Prevention of electrostatic charging	Synthetic fibres	Surface-active substances	Possibly skin allergies

Process	Effect/Purpose Description	Area of Application	Chemicals Employed	Possible Impacts on Health and Environment
Anti-felt finish	Prevention of felting	Wool	▪ Chlorine ▪ Polyamide ▪ Epichchlorohydrin resin	Large quantities of effluent
Moth & beetle protection	Indigestible fibres	Wool	▪ Chlorinated sulphonamide derivatives ▪ Biphenyl ether ▪ Urea derivatives ▪ Pyrethroids	Not strongly bound pyrethroids may cause neurotoxic effects
Weighting	Weight increase	Silk	▪ Stannic chloride ▪ Sodium phosphate ▪ Water glass	Large quantities of effluent
Hydrophilising	Faster spreading of water on the surface of fibres	Synthetic fibres	▪ Polyamide ▪ Polyacrylic ▪ Silicone	Large quantities of effluent
Delustering	Prevention of high-gloss finish	Synthetic fibres	▪ Phenol ▪ Turpentine ▪ Pine oil ▪ Glauber salt ▪ Barium chloride ▪ Alkali sulphide ▪ Chromium salts ▪ Resins containing ▪ Formaldehyde etc.	▪ Allergy inducing ▪ In some cases carcinogenic substances ▪ Environmental pollution (heavy metals)
Abrasion-resistant finish	Increased abrasion resistance	Cellulosic fibres	▪ Silica gel ▪ Plastic resins	Large quantities of effluent
Sanforising, Sanfor plus	Prevention of creasing and shrinking	▪ Cellulosic natural and man-made fibres ▪ Blends with synthetics	▪ Urea formaldehyde ▪ Melamine formaldehyde	▪ Skin allergies ▪ Strong suspicion of carcinogenic properties ▪ Environmental pollution

Appendix 5

Summary of Relevant Environmental Legislation

Summary of Relevant Environmental Legislation

Introduction

Industrial pollution control has been addressed in many Laws and regulations which has had implications on the level of enforcement scattered between many authorities. Therefore the need arose for a legal set-up that would co-ordinate all these regulations. The most recent of these is Law 4/1994 which designated the Egyptian Environment Affairs Agency (EEAA) as the highest national co-ordinating body for the environment in Egypt. As stated in the Law EEAA main responsibilities include:

- Establishing of norms and conditions to be complied with by owners of projects and establishments before the start of construction and during the operation of these projects.
- Carrying out field inspections of compliance with norms and conditions to be followed by agencies and establishments. Also it shall undertake the procedures stated in the Law against those who violate these norms and conditions.
- Establishing of necessary norms and standards to assure compliance with the permissible limits of pollutants and to ensure that these norms and standards are followed.
- Setting of principles and measures for environment impacts assessment of projects.

Relevant Environmental Laws and Regulations

The following are the laws and regulations concerning environmental protection. These concern the following:

A. Wastewater
B. Air pollution
C. Solid waste
D. Hazardous waste
E. Occupational health and safety
F Licenses

A. Wastewater

1. Law 48/1982 concerning protection of the River Nile and Egypt waterways from pollution:

Regulates the discharge of wastes to the River Nile its branches and the marine environment by a permit from the Ministry if Public Works and Irrigation after fulfilling certain criteria monitored by periodic analysis.

2. Minister of Irrigation Decree 8/1983 implementing Law 48/1982 (the Executive Regulations of Law 48/1982):

Section 6 sets regulations standards and specifications for treating wastewater before discharge to surface waters.

Article 60 indicates the quality of fresh water to which discharge of wastewater is allowed.

Articles 61 and 62 describe criteria of treated industrial wastewater to be discharged to fresh surface water and ground water.

Articles 66 67 68 and 69 set criteria for domestic and industrial wastewater before being discharged to non-fresh surface waters and the quality of the receiving water body.

This Decree was amended by the following Decrees:

- **Minister of Irrigation Decree 140/1984:**
  Amending some rules of the Minister Decree 8/1983 implementing Law 48/1982.
- **Minister of Irrigation Decree 225/1984:**
  Amending some rules of the Minister Decree 8/1983 implementing Law 48/1982.
- **Minister of Irrigation Decree 43/1985:**
  Amending some rules of the Minister Decree 8/1983 implementing Law 48/1982.
- **Minister of Housing and Utilities Decree 9/1988:**
  Amending some rules of the Minister Decree 8/1983 implementing Law 48/1982.
- **Minister of Housing and Utilities Decree 106/1991:**
  Amending some rules of the Minister Decree 8/1983 implementing Law 48/1982.

3. Law 93/1962 concerning sewage disposal:

Sewage disposal in public sewers is prohibited except by special permits and on condition of observing the specifications and standards decided by the Minister of Housing. Samples from commercial and industrial facilities are to be analysed in special laboratories designated by the Ministry of Housing to ensure fulfilment of the required criteria.

4. Minister of Housing and Utilities Decree 463/1962 implementing Law 93/1962:

Section 6 sets the specification and standards that must be fulfilled for wastewater discharge into public sewers.

Section 7 describes the methods and frequency of taking samples of wastewater for analysis.

B. Air Pollution

Presidential Decree 864/1969:
Establishes the Supreme Committee to Protect Air from Pollution chaired by the Minister of

a) studying sources of air pollution
b) formulating a general policy for preventing air pollution
c). Setting standards for air quality and
d) Preparing legislation for air quality.

Minister of Health Decree 470/1971:
Sets standards for permissible pollution loads for ambient and workplace air and was later amended by Decree 240 of 1979.

Minister of Housing Decree 380/1975:
Specifies the general conditions for public commercial and industrial buildings and comprises rules for ventilation and avoiding severe heat cold and humidity.

Minister of Housing Decree 600/1982 implementing Law number 3/1982 for Urban Planning:
Sets the specifications for establishing the new industrial areas.

Minister of Industry Decree 380/1982 implemented by Minister of Housing Decree 60 of 1982:
Necessitates the utilisation of air pollution abatement equipment in industry.

Decree 2/1996 which confined the location of heavy industries in specific locations nationwide.

Law 4/1994 for the environment and its Executive Regulations promulgated by the Prime Minister Decree 338/1995:

Article 34 prerequisites for granting a permit for the establishment of a project that the site chosen should be appropriate for its activity to ensure compliance with the accepted limits of air pollutants.

Article 35 the establishments should ensure that while practising their activities no leaked or emitted air pollutants shall exceed the maximum permissible levels specified in laws and decrees that are in force and stated in the executive regulations of this Law.

Article 36 prohibits the use of machines engines or vehicles that emit exhaust fumes exceeding limits set by the executive regulations of this Law.

Article 40 states that during burning of any fuel the resulting smoke gases and harmful vapours are within permissible levels. The executive regulations of this Law shall define these precautions and permissible limits as well as the specifications of chimneys and other means to control emissions.

Article 42 sets permissible limits of sound intensity and the permissible time limits for exposure to said noise.

Article 43 sets permissible limits of leakage or emission of air pollutants inside the work premises.

C. Solid Waste

Law 38/1967 amended by Law 31/1976:

Concerns public cleanliness regulates collection and disposal of solid waste from houses public places and commercial and industrial establishments.

Minister of Housing Decree 134/1968 implementing Law 38/1967:

Define garbage and solid waste including domestic and industrial waste.

Identifies garbage containers method of transport schedules for solid waste collection.

Sets specifications and locations of dumping places and methods of treatment (sanitary dumps composting incineration).

D. Hazardous Waste

Law 4/1994 for the environment and its Executive Regulations promulgated by the Prime Minister Decree 338/1995:

Articles 25-27 of the executive regulations: outline of regulations permitting authorities and procedures as well as permit cancelling/suspension conditions.

Article 28 sets regulations/guidelines procedures and policies controlling hazardous waste

Article 29 assigns specific responsibilities relevant to permitting hazardous waste treatment facilities.

Article 30 prohibits hazardous waste import and defines license procedures for trans-boundary movement of hazardous wastes.

Articles 31 and 32 outline general guidelines/precautions for those generating handling producing and importing hazardous materials (gases liquids solids) to ensure that no harm occurs to the environment.

Article 33 requires that owners of establishments whose activities result in the production of dangerous wastes must keep a register for these wastes and the methods of disposal and the quarters receiving these wastes.

E. Occupational Health and Safety

Law 137/1981 (Labour and Workplace Safety)

Requires industries to take special precautions for occupational safety and health in the work place and it deals with physical danger including noise. Section 5 presents the required standards of occupational health and safety.

Minister of Manpower Decree 55/1983

The Decree grants the industrial safety inspectors the right to check the types and composition of the chemicals used.

Article 6 of chapter 3 sets the precaution measures for exposure to chemicals used in the workplace. It also sets the standards for noise in working locations.

Minister of Industry Decree 91/1985 for implementing Law 21/1985

Regulates the production handling and importing of dangerous chemicals. It also regulates the conditions of the production and storage area.

Law 4/1994 for the environment and its Executive Regulations promulgated by the Prime Minister Decree 338/1995:

Article 43 sets permissible limits of leakage or emission of air pollutants inside the work premises.

F. Licenses

Law 453/1954 which gives relevant powers to local administration as the competent enforcement authorities.

Minister of Housing Decrees 380/1975 and 140/1976: implementing Law 453/1954.

Law 21/1956: deals with the industry organisation and the presidential Decree 449/1958 implementing Law 21/1958.

Appendix 6

Industrial Audit Checklist

Industrial Audit Checklist

This Checklist should be used as an aide memoire to assist the gathering of relevant information. Not all sections will be relevant to each site.

		Name	Action
SECTION A - COMPANY DETAILS			
1.0	**Site**		
1.1	Visual impact		
1.2	Previous land use		
1.3	Plans for expansion		
1.4	Geological / hydrogeological information		
1.5	Protection of sensitive environments on-site and adjacent to site		
1.6	Alternative sites considered		
1.7	Site security		
1.8	Location of any sites of special scientific or historical interest		
1.9	Surroundings including habitation, surface waters, neighbouring industries etc.		
1.10	On-site laboratories and capabilities, considering laboratory management and expertise, methods used, standards and calibration techniques, sampling methods.		
2.0	**General**		
2.1	Person(s) responsible for environmental issues		
2.2	Person(s) responsible for health and safety issues		
2.3	Person(s) responsible for product quality		
2.4	Pollution incidents in the last 5 years		
2.5	Major health and safety incidents in the last 5 years		
2.6	Government / local controls and checks - type and frequency		
2.7	Government permits and certificates held		
2.8	Complaints in the last 5 years		
2.9	Written procedures for dealing with incidents		
3.0	**Costs**		
3.1	Cost of water (Piasters [Pt] per cubic metre)		
3.2	Cost of energy: electricity (Pt per kilowatt), oil (Pt per kg), gas (Pt per m^3)		
3.3	Cost of discharge of waste to a public sewer (Pt per cubic metre)		
3.4	Cost of the disposal of other wastes including solids, process materials, etc.		
3.5	Cost of raw materials and process consumables		
3.6	Cost of manpower		

		Name	Action
SECTION B - ENVIRONMENTAL TOPICS - HIGH PRIORITY			
4.0	**Environmental Management and Housekeeping**		
4.1	General tidiness of site		
4.2	Losses through spillage, handling procedures etc.		
4.3	Spill and loss control procedures		
4.4	Presence of documented good housekeeping practices		
4.5	Other areas such as laboratories, maintenance shops, transportation etc.		
5.0	**Resource Usage**		
Resource usage associated with each process unit, factory unit and overall should be investigated.			
5.1	Raw materials:		
	Quantity and quality of raw materials used in process		
	Quantity and quality of cleaning materials		
	Quantity and quality of packaging material		
	Potential for reduction in wastage, reuse, rework or recycling		
5.2	Water:		
	Sources		
	Quantities used		
	Quality of public and private potable water supplies		
	Sufficiency of public and private potable water supplies		
	Results of laboratory analysis		
	Quality of process water		
	Sufficiency of process water		
	Abstraction licences		
	Treatment of water on site		
	Cost of on-site treatment		
	Potential for reuse of water (with or without treatment)		
5.3	Energy:		
	Quantity of oil used		
	Quantity of electricity		
	Quantity of natural gas		
	Potential for reduction		
	Potential for alternative energy sources		
	Checks on boiler efficiency		
	Frequency of power disruptions and effect on production, wastage, etc.		

		Name	Action
6.0	**Wastewaters**		
6.1	Details of effluent discharges (human and process waste)		
6.2	Details of surface water drainage		
6.3	Details of receiving water or sewerage system		
6.4	Typical effluent composition:		
	Volume		
	Analysis		
	Discharge conditions		
6.5	Details of wastewater treatment systems		
6.6	Costs associated with effluent discharge		
6.7	Potential for recycling or reuse of Wastewaters		
6.8	Potential for a reduction in wastewater volumes by:		
	Process changes		
	Segregation of effluent streams		
6.9	Details of any planned changes		
7.0	**Emissions to Air**		
Consideration should be given to point and fugitive (vapours and dusts from low level leakage, evaporation etc.) emissions.			
7.1	Types of gaseous emissions		
7.2	Consent conditions for discharges		
7.3	Sources of dust and whether a nuisance		
7.4	Sources of odour and whether a nuisance		
7.5	Potential for the reduction of emissions to air		
7.6	Details of emission control equipment (if any)		
8.0	**Solid and Hazardous Waste**		
8.1	Handling, storage and treatment of solid waste		
8.2	Details of hazardous and toxic wastes		
8.3	Waste minimisation studies		
8.4	Recycling and reuse of waste		
8.5	Details of landfill sites or other disposal routes		
9.0	**Hazardous Materials on Site**		
9.1	Details of hazardous chemicals used on site		
9.2	Availability of hazardous materials data sheets		
10.0	**Storage Tanks**		
Note should be made of operational and redundant storage tanks.			
10.1	Location and condition of above ground storage tanks and vessels		
10.2	Suitable bunding of storage vessels		
10.3	Location and condition of below ground storage tanks and vessels		
10.4	Frequency and method of checking tank integrity		
10.5	Presence of records of storage inventories		
10.6	Drum storage, condition and spill containment		

		Name	Action
11.0	**Fire Precautions and other Environmental Incident Emergency Procedures**		
11.1	Documented and suitable fire control procedures		
11.2	Availability and suitability of fire fighting equipment		
11.3	Availability and suitability of fire fighting personnel		
11.4	Evacuation procedures and fire drills		
11.5	Containment of water used in fire fighting if contaminated		
11.6	Fire certificates		
11.7	Correct storage of flammable materials		
11.8	Identification of other environmental risks and control procedures		
12.0	**Land Contamination**		
12.1	Evidence of contamination, visible pollution, vegetation die-back etc.		
12.2	Previous site history		
12.3	Presence of dumps, stockpiles, buried wastes etc.		
13.0	**Other Hazardous Materials on Site**		
13.1	PCBs		
13.2	CFCs		
13.3	Asbestos		
13.4	Pesticides		
13.5	Radioactive materials		
13.6	Laboratory wastes - chemical and microbiological		
14.0	**Noise**		
14.1	Assessment of noise levels and details of noise surveys		
14.2	Compliance with noise regulations		
14.3	Noise and vibration control measures		
15.0	**Other Considerations**		
15.1	Aesthetics of the plant, blending with surroundings		
15.2	Damage to the ecology of area		
15.3	Damage to historical sites		
SECTION D - HEALTH, SAFETY AND QUALITY FACTORS			
16.0	**Health and Safety**		
Obvious deviations from good working practices are to be recorded.			
16.1	Documentation of hazards and presence of safety data sheets		
16.2	Compliance with regulations		
16.3	Issue and use of personal protective equipment		
16.4	Safe place of work provisions		
16.5	Safe systems of work including guarding of equipment		
16.7	Ventilation and indoor air quality		
16.8	Exposure to heat		

		Name	Action
16.9	Sickness and accident records		
16.10	Health monitoring of employees		
16.11	Outstanding claims against the company		
16.12	Medical staff, first aid, emergency services		
16.13	Staff training		
16.14	Safety checks on boilers, pressure vessels, lifting equipment, etc.		
17.0	**Quality**		
Factors which affect the quality and safety of products should be noted. Particular care must be taken to ensure that changes to production practices do not compromise the quality and safety of products.			
17.1	Documented good manufacturing practices		
17.2	Quality management systems e.g ISO 9000		
17.3	Quality assurance system		
17.4	Effects of changing environmental practices on product quality		
SECTION E - OTHER FACTORS			
18.0	**Miscellaneous**		
18.1	Ways in which the facility is enhancing the environment or improving the local infrastructure		
18.2	Future plans		
18.3	Assistance required		
18.4	Information required		

Appendix 7

Shortlisted SEAM Demonstration Projects

Shortlisted SEAM Demonstration Projects

Process related

1. Combined scouring/bleaching of instead of separate scouring and bleaching.
2. Combined dyeing/finishing of polyester/cotton blends.
3. Chemical substitution:
   - Dichromate by H_2O_2 in Vat or sulphur dyeing.
   - Diammonium hydrogen phosphate with ammonium sulphate in pigment printing.
   - Kerosene by synthetic thickeners in pigment printing.
   - Diammonium hydrogen phosphate or sodium phosphate by ammonium chloride or soda ash.
   - Copper sulphate by resinous fixative in direct dyeing after treatment.
   - Kamilase by peroxy compounds in starch desizing.
   - High formaldehyde containing binders and fixers by low formaldehyde containing ones.
   - Heavy metal containing pigments by others, as per Eco- Standards.
   - Sodium sulphide during finishing by glucose based reducing agents.
4. Omitting the following hazardous processes:
   - Aniline Black Dyeing - this may be substituted by sulphur dyeing (i.e., substitution of Na_2S by hydrosulphite in reduction, and dichromate by H_2O_2 in oxidation) or reactive dyeing.
   - Benzidine containing Dyeing (azo dyeing).
   - Mordant Dyeing.
   - Hypochlorite Bleaching - This may be substituted by H_2O_2 bleaching.

Housekeeping

1. Tightening of dyestuff containers in the stores of production area.
2. Stopping of steam leaks due to holes, defective valves and faulty flanges.
3. Proper control of chemical stores in the production yard.
4. Preparing exact quantities of the required batches of chemical formulations so as to avoid wastage.
5. Covering the fabric during transportation or while storing for further processing.
6. Insulating steam pipes.
7. Installation of level controllers in the bleaching and dyeing ranges and the washing machines.

Recycle/Reuse and Recovery

Water Recycle/ Reuse and Recovery

1. Reuse of steam condensate from calendars as boiler feedwater.
2. Recycling of washing water after H_2O_2 bleaching as washing water after the second scouring.
3. Applying counter current flow technique in the washing machines.
4. Recycling final rinsing water for previous washing.

5. Reuse of pressing water for re-pressing of cotton.
6. Recycle softener and water in fabric softening.
7. Reusing the rinsing cold water (after scouring and bleaching) in the preparation of the new scouring and/or bleaching solutions.
8. Reuse of cooling water of yarn drying unit for washing purposes during mercerisation.

Chemical Recycle/ Reuse and Recovery

1. Recovery of caustic soda from mercerising process.
2. Size recovery.
3. Wool wax recovery.
4. Reuse of dyes and dye bath additives.

Appendix 8

Case Studies from the SEAM Project

(Ecofriendly Processing and Obtaining Ecolabels)

(Water and Energy Conservation)

(Sulphur Black Dyeing: A Cleaner Production Approach)

(Combining Preparatory Processes. A Low Cost, High Productivity Solution)

(Bleach Clean-Up in Cotton Textile Processing using Enzymes)