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:

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

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)

- **INPUTS**
  - Water
  - Steam
  - Grey fabric
  - Process chemicals:
    - Nonil N
    - NaOH
    - H₂O₂
    - Organic stabiliser
  - Water
  - Steam
  - Grey fabric
  - Process chemicals:
    - NaOH
    - H₂O₂
    - Organic stabiliser
- **OUTPUTS**
  - Condensate (recycled to boiler)
  - Wastewater
  - Condensate (recycled to boiler)
  - Condensate (recycled to boiler)
  - Wastewater
  - Condensate (recycled to boiler)
  - Condensate (recycled to boiler)
  - Condensate (recycled to boiler)

- **Process Steps**
  - Scouring and Half Bleaching (Combined Process)
  - Flotation
  - Hot Water Wash
  - Full Bleaching and Optical Brightening
  - Hot Water Wash
  - Softening
  - Full Bleached Finished Fabric to Drying

- **Half Bleached Fabric to Dyeing Department**
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.
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: 100 m$^3$/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 (BOD₅), 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 LE 17,500. 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 LE 1,700. 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 LE 69,000 due to defects in the collection and pumping system. An investment of LE 2,000 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

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 \( (\text{H}_2\text{O}_2) \) 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., Cibachrome 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>
<thead>
<tr>
<th>Sr. No.</th>
<th>Banned Amine</th>
<th>Sr. No.</th>
<th>Banned Amine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-Aminodiphenyl</td>
<td>11</td>
<td>3,3 Dimethoxybenzidine</td>
</tr>
<tr>
<td>2</td>
<td>Benzidine</td>
<td>12</td>
<td>3,3 Dimethylbenzidine</td>
</tr>
<tr>
<td>3</td>
<td>4-Chloro-o-toluidine</td>
<td>13</td>
<td>3,3 Dimethyl 1,4, 4 dianodophenylmethane</td>
</tr>
<tr>
<td>4</td>
<td>2-Naphthylamine</td>
<td>14</td>
<td>p-Kresidin</td>
</tr>
<tr>
<td>5</td>
<td>o-Aminoazotoluidine</td>
<td>15</td>
<td>4,4 Methylene-bis-(2-Chloraniline)</td>
</tr>
<tr>
<td>6</td>
<td>2- amino-4-nitrotoluene</td>
<td>16</td>
<td>4,4 Oxydianiline</td>
</tr>
<tr>
<td>7</td>
<td>p-Chloranilite</td>
<td>17</td>
<td>4,4 Thiodianiline</td>
</tr>
<tr>
<td>8</td>
<td>2,4-Diamanoanisol</td>
<td>18</td>
<td>o-Toluidine</td>
</tr>
<tr>
<td>9</td>
<td>4,4 Dianodophenylmethane</td>
<td>19</td>
<td>2,4 - Toluylendiamine</td>
</tr>
<tr>
<td>10</td>
<td>3,3 - Dichlorobenzidine</td>
<td>20</td>
<td>2,4,5-Trimethylaniline</td>
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</tbody>
</table>


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

<table>
<thead>
<tr>
<th>Banned acid dye</th>
<th>CI number</th>
<th>Alternative</th>
<th>CI number</th>
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<tbody>
<tr>
<td>Acid Orange 45</td>
<td>22195</td>
<td>Acid Orange</td>
<td>1914690</td>
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<tr>
<td>Acid Red 4</td>
<td>14710</td>
<td>Acid Red 157</td>
<td>17990</td>
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<td>Acid Red 150</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Acid Red 114</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acid Red 5</td>
<td>14905</td>
<td>Acid Red 191</td>
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</tr>
<tr>
<td>Acid Red 158</td>
<td>20530</td>
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<td></td>
</tr>
<tr>
<td>Acid Red 24</td>
<td>16140</td>
<td></td>
<td>17900</td>
</tr>
<tr>
<td>Acid Red 73</td>
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<td></td>
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<td>Acid Red 128</td>
<td>24125</td>
<td></td>
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<td>Acid Red 85</td>
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<td>Acid Red 115</td>
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<td>Acid Red 37</td>
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<td>Acid Red 148</td>
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<td></td>
<td></td>
</tr>
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<td>Acid Black 94</td>
<td>30336</td>
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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

<table>
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<td>Direct Yellow 48</td>
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<tr>
<td>Direct Orange 8</td>
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<td>Direct Orange 102</td>
<td>29156</td>
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<tr>
<td>Direct Red 2</td>
<td>23900</td>
<td>Direct Red 81</td>
<td>28160</td>
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<td>Direct Red 72</td>
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<td>Direct Red 10</td>
<td>22145</td>
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<td>Direct Red 13</td>
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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

<table>
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</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Suspected Pigment</th>
<th>CI number</th>
<th>Alternative</th>
<th>CI number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment Orange 50</td>
<td>21070</td>
<td>Pigment Orange 38</td>
<td></td>
</tr>
<tr>
<td>Pigment Yellow 12</td>
<td>21090</td>
<td>Pigment Yellow 147</td>
<td>12367</td>
</tr>
<tr>
<td>Pigment Yellow 13</td>
<td>21100</td>
<td></td>
<td>60645</td>
</tr>
<tr>
<td>Pigment Yellow 14</td>
<td>21095</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Yellow 124</td>
<td>21107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Yellow 63</td>
<td>21091</td>
<td>Pigment Yellow 148</td>
<td>50600</td>
</tr>
<tr>
<td>Pigment Yellow 126</td>
<td>21101</td>
<td>Pigment Yellow 5</td>
<td>11660</td>
</tr>
<tr>
<td>Pigment Yellow 127</td>
<td>21102</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Yellow 17</td>
<td>21105</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Red 39</td>
<td>21080</td>
<td>Pigment Red 87</td>
<td>73310</td>
</tr>
<tr>
<td>Pigment Yellow 176</td>
<td>21103</td>
<td>Pigment Yellow 101</td>
<td>48052</td>
</tr>
<tr>
<td>Pigment Yellow 171</td>
<td>21106</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pigment Yellow 114</td>
<td>21092</td>
<td>Pigment Yellow 10</td>
<td>12710</td>
</tr>
<tr>
<td>Pigment Yellow 170</td>
<td>21104</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

- Substitution of the pollution-carrying imported material.
- Installation of an adequate water treatment system, which can remove these persistent compounds from the effluent.
- Substances that contain PCP or p-chlorophenol (a precursor of PCP) should be avoided.
- Chemicals containing hazardous substances should be investigated for their substitution.
- 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 H₂O₂ 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°-115°C against 140°-150°C for conventional printing.
- Use of highly active catalyst systems (such as MgCl₂·6H₂O / 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, stabilizer 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

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

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Technical</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the Project be implemented without significant interruption to process schedules?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the Project be implemented without training of operators or maintenance personnel?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Managerial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the management effectively communicate policy changes within the company?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Replicability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Can the equipment be obtained/manufactured locally?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will the health and safety of the workers be improved?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Does the project avoid negative effects on the community?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Priority</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will on-site improvements lead to an improvement in the external environment*?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Will the project result in a variety of internal environmental improvements?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Such as water quality, air quality, health, noise transmission, land contamination, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### 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](image)

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>
<thead>
<tr>
<th>No.</th>
<th>Demonstration project</th>
<th>Location</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| 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)  
All three companies had different product ranges and different processing machinery. |
| 5   | Bleach Clean-Up using Enzymes                             | Lead Site: Dakahleya Spinning and Weaving Co., Mansoura  

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 into 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.