Part B

CLEANER PRODUCTION AND THE SEAM PROJECT:
Implementation in the Egyptian Oil & Soap 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 4.).
- 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 payback periods.
- Incorporate an Action Plan which will describe how the Cleaner Production measures can be best implemented at the factory.

The basic theory behind a Cleaner Production audit is that whatever goes into a unit operation eventually comes out in one form or another.

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>⇒ Seed receipt and storage.</td>
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<tr>
<td>⇒ Oil extraction.</td>
<td></td>
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<tr>
<td>⇒ Oil Refining.</td>
<td></td>
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<tr>
<td>⇒ Hydrogenation and shortening.</td>
<td></td>
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<tr>
<td>⇒ Soap production.</td>
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<tr>
<td>⇒ Glycerine production.</td>
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<tr>
<td>⇒ Animal feed.</td>
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<tr>
<td>⇒ Product dispatch.</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 (including a representative from the laboratory).</td>
<td>Quality control procedures fabric and process chemical information analytical capabilities.</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 (seeds crude oils process 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 about 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 minimize 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 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 incoming seeds (e.g. acidity) and wastewater quality (e.g. pH, BOD, COD).

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 (Alkali Refining of Crude Oil)

**INPUTS**

- Steam
- Crude oil

- Phosphoric acid
- Sodium hydroxide
- Water
- Gummy substances

**OUTPUTS**

- Condensate (recycled to boiler)
- Gummy substances
- Muclage (sent to soap plant)

**Process Steps**

1. Heating
   - Inputs: Steam, Crude oil
   - Outputs: Condensate (recycled to boiler)

2. Degumming (mixer 1)
   - Inputs: Phosphoric acid, Gummy substances
   - Outputs: Gummy substances

3. Neutralisation (mixer 2)
   - Inputs: Sodium hydroxide, None
   - Outputs: None

4. Separator (number 1)
   - Inputs: Water
   - Outputs: Muclage (sent to soap plant)

5. Heating
   - Inputs: Steam
   - Outputs: None

6. Washing (mixer 3)
   - Inputs: Hot water
   - Outputs: None

7. Separator (number 2)
   - Inputs: None
   - Outputs: Hot wastewater

8. Washing (mixer 4)
   - Inputs: Hot water
   - Outputs: None

9. Separator (number 3)
   - Inputs: None
   - Outputs: Hot wastewater

10. Drying
    - Inputs: None
    - Outputs: None

11. Third Grade Oil
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 will probably be the boiler house);
- the volume of steam consumed (steams of different pressures should be accounted for separately);
- the amount of process 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 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 5.

Step 7 Prepare Material and Energy Balances

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

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.

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 product.
⇒ the volume of waste generated in the production of 1 ton of product.

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.

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 final products.
⇒ Segregation of wastes for recovery recycling or sale.
2. These measures are generally easy to implement with little or no capital investment.

3. **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.

4. 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. hexane nickel catalyst).
   - Recovering previously wasted by-products (e.g. aluminium soap).
   - 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. 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 effects 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 7.6).

**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 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. Following are some of the recommended CP interventions made for the factories audited during the SEAM Project.

- The existing environmental management practices in several oil and soap factories are given in Appendix 6.

6.1 Good Housekeeping Measures

There are numerous simple internal measures that can be taken in every plant to reduce its wastage. All of these may be described as common sense practices; they are commonly referred to as good housekeeping. Many of them involve the elimination of accidental spills and major losses of costly raw materials. These can cause heavy pollution loads upset in the treatment system and significantly degrade the appearance of the factory. For example batch tanks that are filled manually can be equipped with a high-level alarm or more positive control to prevent over-topping. Material losses resulting from filling mixing boiling or aerating of tanks can be prevented by increasing the free board or adding splash plates at strategic points.

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.

In many industries significant in-plant reduction of wastes can be accomplished by improvement of clean-up techniques. The cleaning of equipment and work areas may be carried out in continuous operation or it may be conducted batch wise on non-production shift. Some units require cleaning very frequently or once per year. Whatever the cleaning schedule and frequency the resulting wastes differ from the normal production wastes and place an additional and different load on the discharge facilities.

Proper maintenance and repair of leaks whether occasional or regular (such as a leaking pump gland) are obvious and can be important in combating both material losses and excessive pollution loads. Other simple housekeeping programs can be devised by alert operators. Increasing the drainage time of wet materials before moving the material to the next step will prevent the transfer of liquids and spread of pollution problem.

6.1.1 Storage of Raw Materials

Incoming seeds should be stored out of the sun in a secure clean area preferably off the ground as seeds left in the sun will heat up rapidly increasing the levels of fatty acids which will in turn increase the acidity of the extracted crude oil. The heat will also convert proteins and carbohydrates into fat soluble compounds resulting in a strong colour in the crude oil which is difficult to eliminate. Specific recommendations for seed and raw materials storage include:

- Seeds and other raw materials should be delivered in suitable sacks and stored out of the sun. In several factories seeds were often delivered in plastic bags which weakened and then ruptured when left in direct sunlight for too long. This then resulted in seeds spilling out of the sacks and across the storage area. Windblown materials also increased the dustiness in the immediate area covering buildings clogging machinery and making working conditions uncomfortable. In one factory poor storage of incoming seeds resulted in losses of 3% corresponding to annual seed losses of over LE1000000. In this factory,
it was calculated that these losses could be eliminated by an investment of LE200000 in a simple storage shed.

- Seeds should be stored off the ground preferably on palettes. Seeds stored on the ground and in the open are susceptible to physical damage by passing vehicles and personnel. They can become easily contaminated by dirt stones solid and liquid wastes. They are also vulnerable to infestation and consumption by insects rodents and other animals. In one factory physical damage by careless storage and transfer to process units caused annual losses valued at LE250000.

6.1.2 Material Handling and Usage

- Crude oil delivery to the factory should be carefully monitored and controlled to ensure that unloading is complete and spillages kept to a minimum. This would require little or no capital investment. In one of the audited factories annual losses of crude oil during delivery were calculated as being LE300000. These generally occurred once the oil had been delivered; the emptied vehicles would move around the delivery area with their discharge valves open allowing the residual oil to escape.

- Prevent spillage of oils and fats by improving procedural instructions. In one factory oil losses during loading and unloading of batch reactors totalled 1% corresponding to approximately 100 tons per year. The recommendation made was to better control loading and unloading operations by improving operational instructions and by training the operators. This required no capital investment and resulted in annual savings of around LE200000 (assuming 100% efficiency).

- Most of the factories audited had soap processing units. In all of these it is possible to reduce the soap dust losses to a minimum by applying the following actions:
  1. Periodical discharge of the powder precipitator after each shift.
  2. Changing the rubber gasket in the powder precipitator regularly to reduce the leakage.
  3. Recovery of soap dust from the floor using a vacuum cleaner.
  4. Discharge the contents of the powder precipitator directly to the powder soap unit by mechanical rather than manual means.

6.1.3 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 more than LE 23000 could be made.
- Install bunds around all storage tanks. If any leakage occurs the material can be recovered and will be prevented from either entering the sewer which will increase the organic load of the effluent; or fouling the surrounding area.
- Clean the floors regularly especially in areas where slippery surfaces can develop (e.g. soap production unit and oil refining unit). In one of the factories audited this was the cause of the majority of accidents three of which were very serious. In another of the factories non-slip tiles were installed as a part of routine maintenance to further minimise the risk of slips.
- Regularly inspect all storage tank pipes and connections to identify leaks as soon as possible. This can be formally carried out as a part of a routine inspection and maintenance schedule.
- Regular cleaning of grease traps should be carried out to ensure that they are operating efficiently.
Wherever possible dry cleaning and removal of solids should be carried out before wet cleaning. This will allow spilt products (e.g. soap) to be recovered and will also minimise the strength of the final effluent.

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 oil and soap 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. Actions that can be taken include:

- Implementation of suitable preventative maintenance programmes.
- Regular boiler tuning and maintenance should be carried out to remove scale and any unburned materials. This will improve combustion efficiency and consequently reduce fuel consumption. In one of the audited factories an initial investment of LE20000 gave annual savings of LE 225000. FEI data indicates that as scale increases fuel consumption also increases:

<table>
<thead>
<tr>
<th>Thickness of scale (mm)</th>
<th>Increase in mazot consumption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5</td>
<td>15</td>
</tr>
<tr>
<td>3.0</td>
<td>20</td>
</tr>
<tr>
<td>6.0</td>
<td>39</td>
</tr>
</tbody>
</table>

- Proper insulation of steam pipes.
- Repair of broken and steam pipes and connections. In one factory losses of around 10% were observed. Elimination of these resulted in annual savings of LE222000 for little or no capital investment.
- Heat recovery from boiler blowdown water.
- Installation of steam flow meters for each processing department.

At another factory upgrading of the existing steam network was carried out. This included rehabilitation of steam lines boiler tuning and improved treatment of boiler feedwater recycling of steam condensate replacement of faulty/broken valves replacement or repair of steam traps and pipes and the insulation of hot water and steam pipes. As a result of these actions steam consumption has been reduced by 1800 tons of steam per month and one boiler was taken off line. This resulted in annual savings of over LE550000 for a capital investment of LE30000 (see Waste Minimisation at Sila Edible Oil Co. Fayoum Appendix 7). Other actions including some equipment modifications are also recommended. Typical modifications for energy conservation include:
Water treatment to control the Total Dissolved Solids (TDS).

Optimising boiler efficiency by controlling draft (implementation of damper and fuel firing practices).

Optimisation of the burner.

Avoidance of space heating.

Where practicable substitute natural gas for solar and mazot.

6.3 Water Conservation Measures

Water is widely used in the oil and soap industry for processes ranging from generating steam to the washing of oil. 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 11 Egyptian oil and soap factories and suggests where further savings could be made.

6.3.1 Flow Reduction

Consideration should be given to reduce the total flow. This can be accomplished by the use of high-pressure low-volume jet or spray streams for washing. The amount of pollution in the waterborne waste can be reduced by preliminary dry cleaning operations. Moreover the characteristics of the waste can be improved by changing the cleaning agents used.

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:

- Install self-closing taps and water meters to control water consumption. In one of the factories audited this reduced the capacity of the required wastewater treatment plant from 600m$^3$/hour to 30m$^3$/hour. This was achieved at a cost of LE40000 for 10 water meters (various diameters) and 20 self-closing taps. Other benefits included a reduction in water consumption of 1200m$^3$ per day resulting in annual savings of LE36000 (based on the costs of pumping and treating groundwater) and a reduction in the capital costs required for constructing the wastewater treatment plant.

- Unnecessarily high levels of water consumption resulting from leaks broken or missing valves hoses left running.

- 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).

- Use automatic shutoffs / flow limits where possible. Highest priority should be given to those units where hot and/or chemically treated water is being lost.

The installation of water flow meters will also allow of departments which have excessively high water consumption levels to be identified. These can then be individually investigated to see what specific actions are required to reduce consumption.

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 Recovery and 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 cooling water and condensate.

- Cooling water should be recycled rather than disposed. At one factory four cooling towers were already in place and only needed some new packing materials for them to be operational. For an initial investment of LE10000 in each cooling tower annual savings of
LE13000 in terms of reduced water consumption alone were calculated. In another factory recycling the cooling water from the soap plant to a chiller rather than disposing of it to the sewer would save around 1975m³ per day. Initial calculations showed that for a capital investment of LE10000 annual savings of around LE135000 could be achieved.

- In the oil refining process washwater from the second stage can be recycled and reused in the first washing step. It can also be used to prepare the caustic soda solution required for neutralisation.
- An evaporative cooling system is preferable to open cooling circuits. This can reduce water consumption by 85% as well as reducing the volume of the final effluent.
- Steam condensate can be recycled to save both energy and minimise the consumption of demineralised water. An assessment of one factory showed that for an initial investment of LE96000 annual savings totalling LE425000 could be realised. Actions required included repairing and upgrading the existing system requiring the insulating of the condensate return pipes as well as installing and insulating components such as steam traps and water buckets.

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.

- Optimise feeding rate of flaked seeds to the extractor. This will result in an increased extraction efficiency reduce spillages and hexane losses. However this will need a skilled operator to ensure that optimum conditions are maintained.
- Reuse of Fines from Preparation Unit. In one of the factories audited it was noted that the plant was originally designed to recycle sunflower seed fines totalling approximately 40 ton/day back to the expeller (in the seed preparation stage). This step was modified to direct these fines immediately to the extraction plant therefore allowing a higher throughput of fresh seed in the expeller. As a result of applying this modification the crushing capacity was increased by 40 ton of sunflower seeds per day the crush margin considered to be 40LE/ton. Sunflower seeds are available for 3 months of the year and hence the additional yearly income is equivalent to LE120000 with an implementation cost of LE10000.
- Proper maintenance of hexane sensor. This will allow the extraction process to be carefully controlled and to reduce hexane losses through over consumption.
- Modification of solvent spray nozzles (fan flat type). This will improve extraction and optimise hexane consumption. At one factory it was calculated that this would cost LE10000 to implement generating annual savings of LE10000.
- Use of Caustic Soda Solution. In most of the factories audited solid caustic soda was usually used for neutralisation. In one factory this was substituted with a caustic soda solution at a much lower cost: LE2100/ton as against LE1000/ton. As a result daily neutralisation costs dropped by 47% equivalent to savings of 6.5 LE/ton of crude oil. This improvement was achieved at no cost (to the extent that all necessary modifications were made using available equipment) and resulted in annual savings of LE250000. Other benefits of this intervention included reduced losses of caustic soda during transfer to the neutralisation process; reduced levels of corrosion; improved soapstock quality and better working conditions.
Installation of a mechanical skimmer on hot wells to recover short-chain fatty acids. Demulsifying chemicals may also be added to achieve a pH of 8-9 so that oil droplets will not be deposited in the water nozzles of the cooling towers. The estimated initial cost of skimmer installation is LE2000. Thus the benefits of this action include the recovery of fatty acids and an overall improvement of cooling towers performance and reduced maintenance needs.

Upgrading oil refining by introducing centrifuges for efficient gum separation. This recommendation is particularly suitable for old factories that suffer from inefficient or non-existent degumming facilities. Poor degumming can increase the amount of oil lost in mucilage which reached about 0.2% of total produced oil in some cases. The capital cost of implementing this action is relatively low as it only involves installation of a centrifuge pumps and piping network. The financial benefits are usually high and pay back period in the order of a few months.

A cleaner technology for oil refining by chemical methods is the miscella refining technique. In this technology the crude oil is mixed with hexane (50% concentration) and then the caustic soda is added as usual. The separation of the mucilage from the refined oil in solvent occurs much more efficiently as the viscosity and specific gravity of the mixture is lower than the crude oil and also lower than the mucilage. The oil losses during chemical refining are therefore lower and the power consumed in mixing and pumping the oil-solvent mixture is less. Besides the advantage of lower oil losses during the caustic refining and less power consumed in mixing and pumping the technology of miscella refining has also the advantage of producing an oil of superior bleach colour than that is obtained by conventional refining techniques. However this technology has the following disadvantages:

⇒ All equipment has to be tightly closed and explosion proof which adds to the cost.
⇒ High maintenance levels of equipment are required to avoid solvent losses.
⇒ Refining has to be carried out in the solvent mill.
⇒ Miscella has to be concentrated to about 50% oil before being refined which requires a two stage solvent removal process.

Collection and recycling of oil spilt in the packaging unit. In most of the factories visited spillage and consequent loss of the edible oil was common. In one of these factories a system was installed to recover edible oil from accidental spillages in the bottling department. Originally the oil fell directly to the floor where it was washed to drain. The system was modified so that the oil was immediately collected in troughs and then pumped to a collection tank where the oil was recycled to the refinery for reprocessing. Approximately 1.16 tons of edible oil are recovered on a monthly basis. This was achieved for a capital Cost of LE2500 generating annual savings of LE35000 (recovered oil only).

Accurate adjustment of temperature and pressure in the glycerine distillation unit to prevent polymer formation. Distillation of crude glycerine should take place under reduced pressure (6-12 mm Hg absolute) in a current of steam at a temperature ranging between 157 to 160 °C. If these conditions are not maintained accurately the temperature of thermal decomposition at this pressure could be less than the boiling of the solution in the distillation unit. The result of such bad operating conditions is production of a polymeric residue that if discharged to wastewater streams represents a shock pollution load. Therefore accurate adjustment of distillation conditions is a very important pollution prevention measure.

Feeding hot spent lye to a saponification unit (resaponification of hot spent lye). Inefficient separation of soap from the spent lye discharged from saponification kettles (batch
saponification process) results in high soap content in the spent lye. This usually causes overflow of foam to the floor of the unit which is usually washed down causing foaming problems in wastewater. The recommended solution is feeding hot spent lye (at 105°C) to a saponification unit. A determined amount of free fatty acids based on the residual caustic soda in the spent lye can be added. The remaining glycerine water mixture will then be almost free from foams.

Any wasted soap should be recovered and recirculated to the saponification unit through a closed loop operation system.

A direct pipeline between a batch saponification unit and glycerine production unit should be installed. This will prevent significant spills and loss of material.

In the soap production plant pipelines carrying molten soap should be steam jacketed. If pipelines are not adequately protected and a power cut occurs the soap will cool rapidly solidifying and clogging the whole system. The plant will then be unable to operate until the system is cleaned out. In one of the factories audited a capital investment of LE600 was all that was required to insulate the pipeline which would keep the soap hot for long enough to allow it to be completely pumped out. This resulted in annual savings of LE2400 in terms of soap alone - lost revenue due to down time will significantly increase this value. Some manufacturers tackle this problem by blowing steam to soap deposits and collecting these deposits in a simple tank although the soap quality will be poor. To avoid soap deposits building up in this collection tank thus reducing its capacity a steam-jacketed tank should be used.

High levels of soap dust were commonly observed in soap preparation units. This results in a thick coating of dust on all surfaces clogging of moving parts and unpleasant working conditions. In one factory the soap powder recovered from the cyclone was dumped on the floor and manually transferred back to the main process rather than being recycled in a closed mechanical system.

Reduction of pollution load discharged from a saponification unit. In an attempt to reduce the organic load discharged from the saponification process wash water discharged after completion of the saponification process was collected in an empty pan. Sufficient fats were added to the pan in order to neutralise the caustic soda. The residue was then boiled using steam and allowed to settle. The incompletely saponified product was then returned to the first pan to complete saponification. This allowed recovery of fats and caustic soda and decreased the strength of wastewater significantly.

Recovery of Fodder Ingredients. Animal fodder production unit tend to be characterised by heavy dust emissions caused during the loading and unloading of the raw materials. This results in the loss of valuable raw materials as well as clogging machinery and generating unpleasant working conditions. In one factory LE127600 was invested in the installation of a cyclone vacuum system which recovered the ingredients and transferred them directly to the raw material intake system. Annual savings of LE107520 were achieved.

Injection of a neutralising amine at high pressure into the steam pipeline just after the boiler. This avoids pipe corrosion by condensate which may become acidic by absorbing atmospheric carbon dioxide.

In addition to process optimisation the assessment of the performance of existing equipment and possible modifications to improve efficiency will need to be considered. These following modifications are most likely to be required:

⇒ Installation of varying speed mixer in batch neutraliser to avoid excessive insulation.
To replace solvent spray shower (perforated) by fishtail fan flat type to get uniform and effective extraction.

6.5 Optimising Process Chemical Use

- By careful control of the use of bleaching earth one factory reduced consumption from 8kg per ton to 5kg per ton. This generated annual savings of over LE81000.
- Refined bleached and deodorised (RBD) palm oil used to produce shortening should be physically rather than chemically refined. In several factories the fatty acids were removed chemically (through alkali neutralisation). As RBD palm oil usually has a very low acidity this step is unnecessary - any excess acidity which develops during storage can be efficiently removed by deodorisation alone. In this way palm oil losses will be minimised the organic load of the final effluent reduced caustic soda and bleaching earth consumption minimised. This action can be implemented at no cost with annual savings at one factory totalling LE460000.
- Hexane consumption can be optimised by ensuring that cotton seeds are properly delinted. In a well-operated unit 8kg hexane can be used to process 1 ton of cotton seeds. The volume of hexane required will increase as the amount of lint present increases. In one factory hexane loss in cotton seed oil extraction was around 16kg per ton of seed. Although the plant was quite old (around 15 years) it was calculated that of this the lack of a delinting stage was accounting for 5kg of the additional hexane requirements. This corresponded to an annual increase in costs of LE76000.
- The optimum amount of sodium hydroxide should be determined in the removal of fatty acids from the crude oil. Too much sodium hydroxide makes the oil start to migrate to the soap fraction giving them an undesirable fatty texture as well as losing the more valuable oil. In a number of the factories audited overdosing with sodium hydroxide was common.

6.6 Materials Substitution

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 container with the date it was opened;
- 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;
- 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 Recovery of By-Products and Wastes

6.7.1 Process Units

- In the seed cleaning unit lint can be collected from the cyclones and sold as a low grade lint for LE200/ton.
- Lint can also be collected from the delinting unit itself pressed packed and sold for LE350/ton. In one of the factories audited this generated an annual income of LE6000.
Recovery of Broken Seeds. Seeds delivered to oil and soap factories are sieved to remove stones and gravel (which are disposed as waste) and hulls and broken seeds (constituting around 1% by volume and containing 25% oil). In most factories audited these were collected and sold for LE100 as animal feed. Alternatively the process can be modified so that these are collected and transferred to the preparation unit where they are further processed. In one factory all that was required was the installation of a screw conveyor from the sieving and screening area to the seed preparation unit. As a result an extra 78 tons of oil and 595 tons of meal are produced annually valued at LE463250 for a capital investment of LE9000.

Lecithin can be recovered from gums produced in the degumming unit and sold to the food industry as an emulsifier for LE3800. In one factory 100 tons of gum was produced annually from which about 80 tons of lecithin could be recovered generating a revenue of around LE304000. In a second factory 22.3 tons of lecithin was produced annually generating an annual income of LE84700. In one factory which did not have a lecithin recovery unit gums from soybean processing were sold for lecithin recovery for LE700/ton generating an annual revenue of LE175000.

Utilisation of spent earth as a fuel (having a calorific value of around 14MJ/kg). In one factory the spent earth is supplied free of charge to nearby homes use in for domestic ovens.

Utilisation of spent earth as soil conditioner. This use is still being researched the feasibility of utilising spent earth to improve sandy soils for agricultural use will be investigated. Physical and chemical properties of spent earth need to be analysed and its effect on sandy soil will be investigated after biological composting. If proven feasible using spent earth in soil conditioning can significantly reduce solid waste problems in the industry and reduce environmental risks of spent earth storage and disposal.

Volatile Fatty Acids (VFA) escaping from the deodorisation columns will accumulate on the surface of the hot well. This can be skimmed off manually and used as an animal fodder constituent.

Deodorisation distillate (fatty acids) can be collected and sold to soap factories for manufacturing third grade soap. In one factory distillate from the oil deodorisation process was sold for LE900/ton giving an annual revenue of LE135000. The same factory also sold deodorisation distillate from the shortening unit for LE1200/ton generating an annual income of LE126000.

The deodorisation distillate is usually considered to be a waste. It contains odoriferous volatile substances tocopherol and free acids (it is especially rich in free acids when the deodoriser is used as a physical refining unit as well as a deodorisation unit as is the case with palm oil processing). This waste can be utilised to obtain two components which are economically valuable:

⇒ Tocopherol (vitamin E) is used as a natural antioxidant for edible oils and their products

⇒ Distilled free acids are used in the soap and food industries. Processing of this waste to recover utilisable products also reduces the final pollution load.

During the hydrogen production process (hydrogen being used in the hydrogenation of oils) oxygen is generated as a by-product. If generated in sufficient quantities this can be recovered and compressed for use in the medical sector where it is valued at LE1.7/m³.

The semi-solid waste generated in the distillation tower in the fatty acid splitting unit and in the glycerine concentration plant may be suitable for use as a waterproofing or paving material. At one of the factories audited this pitch-like material is collected from the glycerine concentration plant stored in barrels and sold annually for LE1000 rather than being disposed as a solid waste.
- In the glycerine concentration unit the salt that is generated by the process can be recovered and reused in the soap plant. In one factory 600kg of salt were generated daily - if managed correctly this would fulfil all the salt needs of the soap plant and no additional purchases would be required. This would generate annual savings of LE10000.
- In one of the factories audited glycerine residues from the glycerine concentration plant are recycled to the soap plant rather than being lost to the wastewater during cleaning.
- Solid aluminium soap is formed in the glycerine unit as a result of treating the glycerine water with aluminium sulphate. This is usually treated as a solid waste and disposed off-site. However this can be recovered and sold as a metallic soap. The aluminium soap could also be treated with caustic soda to produce aluminium hydroxide.
- Improving handling of deoiled seeds by minimising losses. Deoiled seed cake has an estimated price of LE250/ton as it is an important ingredient in animal fodder production. Estimated annual seed losses due to bad control of handling and feeding systems have reached 1000 tonnes in some cases. In one factory the provision of forklift truck equipped with suitable platform for proper handling of seed bags was recommended to overcome this. It was estimated that this would cost LE200000 ultimately saving LE250000 L.E per year (assuming 100% efficiency of the system) and reducing many wastage problems.
- Recovery of soap stock from wastewater. Although such wastewater may be low in volume its organic strength is usually significantly high. By segregating this wastewater stream and then filtering it a BOD load of 73000 mg/l can been reduced by 50%. The semi-solid filtrate (fatty matter) is then collected and reused in the process.

6.7.2 Packaging Wastes
- Offcuts and scraps from the manufacture of cans can be pressed and sold to a metal processing factory. Scrap steel is valued at around LE2000 per ton and tin LE400 per ton. At one factory 10 tons of scrap tin was generated and sold for LE4000.
- Damaged plastic bottles and cartons can be collected and sold for recycling. In one factory 1500 tons of polyethylene (PE) are collected and sold for LE400 per ton generating an annual revenue of LE600000.

6.7.3 General
- Construction of oil and grease traps at the outlet of each process unit to recover fats and minimise the strength of the final effluent. This should be collected on a regular basis and either processed on site or sold to soap producing factories. The amount of oil and fatty matter that was wasted in wastewater and which could be recovered by simple gravity means reached 600 tons/year in some cases. The capital cost involved in fitting efficient gravity oil separators is relatively high (about LE100000 per separator) but the benefits are usually high with a pay back period of less than a year.
- Recovery of fatty matter from the refinery effluent. Fat can be manually collected from the refinery effluent by scraper acidulated and then split. The wastewater can then be treated or disposed and the fatty matter transferred to soapstock storage tanks. The benefits of this intervention are the recovery of product and reduced strength of wastewater. In one of the factories where this was implemented an additional 29 tons/year of soapstock was recovered valued at LE500/ton. For a capital investment of LE 5000 annual savings of LE 14500 were achieved.
- Copper welding electrode residues and copper wires can be collected and sold to copper processing factories for LE8000 per ton.
- Wastewater Segregation. Wastewater produced by oil and soap factories includes process effluents domestic sewage boiler blowdown cooling tower blowdown and steam condensate. Of these process effluents have the highest organic loads the effluent coming from the refinery being particularly strong; with typical BOD values exceeding 3000 mg/l.
The blowdown and condensate are usually low in terms of organic pollution but high in volume. In general process effluents blowdown and condensate are combined and disposed generating a high volume organically polluted wastewater. An alternative to combining these wastewater streams is to segregate them. The cooling and condensate water is of a suitably high quality to use for land reclamation activities within the factory such as watering lawns and trees. The heavily contaminated process effluents alone can then be sent straight to the wastewater treatment plant (WWTP) thus reducing the required capacity of the WWTP (see section 6.10).

In one factory the effluent disposal costs were reduced by LE18000/year for no additional cost (existing structures used). This was also recorded in another factory where the combined effluent was 420-650m$^3$/hour of which process effluent was only 20-30m$^3$/hour. Segregation of the heavily polluted wastewater from this reduced the required WWTP capacity resulting in capital expenditure savings of LE680000.

6.8 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 oil and soap factories.

6.8.1 Use of Heat Exchangers

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

6.8.2 Solar Energy

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

6.9 Adoption of Worker Training Programmes

As an essential part of any Cleaner Production programme at any level for any firm a worker training and awareness programme is essential. Although management commitment is equally important without staff involvement and their sense of need then the gains made by Cleaner Production will be minimised. Without worker training involvement and a sense of ownership the Cleaner Production programme will be difficult to sustain in the longer term.

There are many different types of worker training programmes available. These depend heavily on the needs of the organisation its size and management structure. When Cleaner Production awareness does not exist or is relatively low a programme which introduces the general concepts would be most appropriate. Any such training should also assist factories to identify individuals and build up teams who would take the concept forward. Thus Cleaner Production can be used as a management tool for change as well as involving the workforce.

6.10 End of Pipe Treatment

This is not a Cleaner Production option but is often required to bring the final effluent up to a standard that complies with wastewater discharge legislation. Ideally this should only be considered once the volume and strength of the final effluent have been reduced as much as possible. In Sila Edible Oil Company in Fayoum a large number of low-cost interventions were implemented (see Appendix 7) which reduced wastewater volume and load such that the capacity of the wastewater treatment plant could be reduced by 66%. This resulted in capital savings of more than LE950200 as well as the annual savings of over LE1million that were made as a result of implementing the low-cost interventions.
Current research and experience suggests that one or more of the following steps will be needed to effectively treat from an oil and soap factory:

- Dissolved air floatation is an efficient method of oil and fat removal.
- Activated sludge process is efficient in reducing the organic load of effluent down to allowed levels.
- Activated sludge should be used after physico-chemical separation.
- Use of coagulants can improve the efficiency of dissolved air floatation process.
- In a study comparing plain floatation dissolved air floatation and dissolved air floatation aided by coagulants oil removal efficiencies was 50% 60% and 94% respectively.
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 oil and soap sector in Egypt which showed that:

- The sector is characterised by absence of modern process technology;
- There is a lack of technical skills in processing techniques specific to CP;
- There is limited 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 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 cooperation with the EEAA. Such a structured approach resulted in 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 factories. This was achieved as follows:

Selection of factories - A sample of 11 factories were identified that represented the range of oil and soap factories 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 factories 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
SEAM Project

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.

Table 7.1 Criteria used to Shortlist the Demonstration Projects

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Yes</th>
<th>No</th>
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<tbody>
<tr>
<td>Does the project comply with Egyptian laws (i.e. not in known violation of existing laws)?</td>
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<td>Does the project comply with the DFID (ODA)/SEAM funding policy?</td>
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<td>Does the project result in economic benefits with a relatively short payback period?</td>
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<td>Does the Project demonstrate the benefits of waste minimisation and/or CP principles?</td>
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<td>Have any low cost measures identified in the audit been implemented?</td>
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<td><strong>High Priority</strong></td>
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<td><strong>Financial</strong></td>
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<td>Is internal or external parallel funding (possibly in kind) available?</td>
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<td>Does the Project involve relatively low initial capital expenditure?</td>
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<tr>
<td><strong>Environmental</strong></td>
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<td>Is the Project consistent with the priorities set by the NEAP/GEAP/NIPPP?</td>
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<td>Does the Project assure/assist in compliance with the Environmental Laws?</td>
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<tr>
<td><strong>Technical</strong></td>
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<td>Is the technology appropriate to local conditions?</td>
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<td>Does the Company possess appropriate levels of technical skills and resources to implement and maintain improvements?</td>
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<td><strong>Managerial</strong></td>
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<td>Does the management show good awareness of environmental issues and willingness to implement good environmental practices including pollution control at source?</td>
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<td>Are managerial and structural barriers to change absent or removable?</td>
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<tr>
<td><strong>Sustainability</strong></td>
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<td>Is management willing to commit staff resources to the on-going process of internal auditing and improvements for pollution control?</td>
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<td>Is environmental management likely to be integrated in the existing structure?</td>
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<tr>
<td><strong>Replicability</strong></td>
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<tr>
<td>Are there significant opportunities to replicate the Project?</td>
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<td>Project Design and Implementation</td>
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<td>Can the Project be completed and evaluated in less than 12 months?</td>
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<td>Can any necessary approvals/licenses be obtained within 2 months?</td>
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<td><strong>Medium Priority</strong></td>
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<td><strong>Environmental</strong></td>
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<td>Will organic loads chemical or toxic components be reduced/eliminated?</td>
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<td><strong>Technical</strong></td>
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<td>Can the Project be implemented without significant interruption to process schedules?</td>
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<td>Can the Project be implemented without training of operators or maintenance personnel?</td>
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<td><strong>Managerial</strong></td>
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<td>Does the management effectively communicate policy changes within the company?</td>
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<td><strong>Replicability</strong></td>
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<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>
</tbody>
</table>

* Such as water quality air quality health noise transmission land contamination etc.
7.4 Selection of Factories for Demonstration Project Implementation

Demonstration projects had been carefully selected to address problems that were common throughout the Egyptian oil and soap sector. The selection of factories 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.

7.5 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>Demonstration Project</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Minimisation</td>
<td>Sila Edible Oil Company Fayoum</td>
</tr>
<tr>
<td>Oil and Fats Recovery</td>
<td>Tanta Oil and Soap Company Tanta</td>
</tr>
<tr>
<td>Reduced Wastage through Improving</td>
<td>Alexandria Oil and Soap Company Kafr El-Sheikh</td>
</tr>
<tr>
<td>Raw Water Quality</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.2 Summary of Demonstration Project Implementation

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

- Reuse and Recycling of in-plant materials.
- Water reuse through separation of cooling systems and appropriate physical separation.
- Optimisation of energy use through improved maintenance and process control.
- Minimisation of heavy organic loads via recovery of raw materials products and by-products.

7.6 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.

7.7 Overview of Demonstration Projects

7.7.1 Waste Minimisation Sila Edible Oil Company Fayoum

A range of low-cost pollution prevention actions were identified during the audit and have been implemented by the factory management. To date savings of LE1557110 have been made
for a capital investment of LE621300. A number of identified options were implemented quickly and efficiently:

**Good housekeeping measures:**
- Steam trap modifications.
- Repair of leaking or broken valves.
- Repair of damaged water pipes.
- Repair of damaged steam pipes.
- Collection and recycling of spilt oil from the packaging unit.

**Reduced water and energy consumption:**
- Rehabilitation of steam lines.
- Boiler tune-up and improved treatment of boiler feedwater.
- Recycling of steam condensate.
- Replacement of faulty/broken valves.
- Replacement or repair of steam traps or pipes.
- Insulation of hot water and steam pipes.
- Restoration of the softening unit to improve boiler performance and reduce blowdown.

**Product recovery:**
- Reuse of fines from the Preparation Unit.
- Recovery of broken seeds.
- Recovery of fatty matter from the final effluent.

**Material Substitution:**
- Use of liquid rather than solid caustic soda.

By introducing these waste minimisation measures water consumption and the organic load of the final wastewater was reduced such that the final wastewater treatment plant was downsized by 66%. This downsizing resulted in capital savings of over LE950000; additional savings will also result from reduced operating and maintenance costs.

The success of this project demonstrates the way barriers can be overcome by having a champion on site especially when it demonstrates the commitment of management. This project also shows that many aspects of management which are normally taken for granted such as controlling overflows and spills are often overlooked until solutions are pointed out. Management are then to eager to adopt necessary improvements.

**Oil and Fats Recovery Tanta Oil and Soap Company Tanta**

An industrial audit of the factory indicated that there were a number of low cost measures that could be implemented to reduce pollution and minimise losses. A number of these have been implemented by the factory - to date this has involved a total investment of LE621247 resulting in annual savings of LE637020. By implementing these actions the hydraulic load and organic load of the wastewater was reduced such that the required capital investment was reduced by LE500000.

The actions carried out included:

- **Upgrading of loading and unloading procedures.** During the transfer of oil ghee and fatty matter to and from the batch reactors and separators spillages often occurred. These losses were eliminated by improving the existing procedural instructions and by improving their supervision.
Recovery of oil ghee and fatty matter. Three gravity oil separators (GOS) units were installed in the continuous refining unit, the fatty acids splitting unit and the deodorisation unit. This has resulted in the recovery of large volumes of oil and ghee.

Recovery of animal fodder ingredients. The animal fodder unit used to generate large volumes of dust, particularly during the loading and unloading of the ingredients. This was recovered by installing a cyclone vacuum system with the recovered material being transferred directly to the intake system. As well as recovering valuable raw materials, working conditions were also improved.

Water conservation. Large volumes of water were being wasted as cooling water was being sent directly to the drain with the process effluents rather than being recycled and reused in a closed circuit system. This was addressed by segregating these from one another and sending the cooling water to the rehabilitated cooling towers. This also had the effect of reducing the hydraulic load of the final effluent.

Introduction of these waste minimisation measures significantly reduced both the water consumption and the organic load of the final wastewater. As a result, the capital investment required for the final wastewater treatment plant was reduced by LE 500,000. Additional savings will also result from reduced operating and maintenance costs.

7.7.3 Reduced Wastage through Improving Raw Water Quality Alexandria Oil and Soap Company Kafr El-Sheikh

Increasing salinity of the water abstracted from underground wells for use in processing and was identified from the Meet Yazid canal.

An inlet chamber water pumps before and after the treatment unit, sand filters, water pipes and fittings were installed at a cost of LE 275,000. Benefits that have resulted from the interventions include:

- Improved water quality for processing.
- Reduced boiler blowdown volumes.
- Reduced water treatment costs.
- Reduced maintenance costs for plant equipment.
- Reduced operating costs that had escalated to maintain water wells.

7.8 Outputs from the Demonstration Projects

Case studies were prepared for the following demonstration projects (reproduced in Appendix 7):

- Waste Minimisation at Sila Edible Oil Co. Fayoum.
- Oil and Fats Recovery Tanta Oil and Soap Co. Tanta.
- 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.