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# Industrial Pollution Prevention

# Case Study: Oil & Soap Sector

## Waste Minimisation at:
## Sila Edible Oil Company, Fayoum, Egypt

### INTRODUCTION

A range of waste minimisation opportunities have been identified and are currently being implemented by Sila Edible Oil Company, in Fayoum, Egypt. To date, this has involved a total investment of LE621,300 and resulting in annual savings of LE1,557,110. Proposed expenditure on the wastewater treatment plant has also been reduced from LE1.5 million to LE549,800.

*Insulation of steam pipes and steam network upgrading reduced energy costs by 48%*

### THE FACTORY

This factory is an edible oil manufacturing plant located in the Kom Osheem desert area, 68km south of Cairo and 30 km north of Fayoum. Privately established, it began operations in 1993, with a workforce of 200 employees. The factory covers an area of 34 feddans.

The factory processes an average of 68,000 tons of seeds per year, mainly sunflower, corn, soybean and cotton, producing up to 24,000 tons of first grade edible oil per year. The main by-products include around 40,000 ton/year of dried meal (packaged in sacks and sold as animal feed) and approximately 1,800 ton/year of soapstock and gums (separated by high-speed centrifuge).

**Process Description**

Oil processing consists of five main steps, as follows::

***Seed Receiving and Storage*** - seeds are received and transferred to a screening unit to remove impurities (4%), followed by fine sieving to separate broken seeds and hulls (5-10%)

***Seed Preparation*** - clean seeds are weighed and passed to a destoner to remove stones and metals, then prepared for oil extraction and cooking. 50% of the crude oil content is extracted using expellers, while the seed cake (containing around 30% oil) is sent to the solvent extraction unit.

***Solvent Extraction Unit*** - the seed cake is fed into this unit and mixed with the hexane. This produces a solvent-oil mixture (miscella) and an extracted meal (2% oil content) which is sent to DTDC (desolventising, toasting, drying and cooling). Crude oil is extracted from miscella by a 3-stage evaporation system. The evaporated hexane is recovered within the system and reused.

***Refining of Crude Oil*** - This takes place in the following stages:

- Degumming, removing about 0.15% gums.
- Neutralisation (caustic soda) to remove fatty acids to generate soap stock (5%),
- Washing and separation (by centrifuge).
- Drying and bleaching, to remove the colour.
- Deodorisation of the bleached oil by vacuum distillation.

***Packaging of Primary Oil*** - A brine chiller is used to cool the RBD (Refined-Bleached-Deodorised) oil in a buffer tank. This is then transferred to 0.75L or 2.0L bottles, capped, labelled and cased.

**Service Units**

Service units include boilers, cooling towers, quality control laboratory, warehouse and maintenance facilities.

**Energy Consumption**

The two main sources of energy used within the factory are electricity and mazout.

- Mazout is used to run the boilers, with an annual consumption of around 36,000 tons.
- Approximately 6 million kWh of electricity is consumed annually.

**Water Consumption**

The factory uses 270 m3/day of water, of which:

- 190$m^3$/day is softened for use as boiler feed water and as process water in the refining unit.
- 80$m^3$/day is used without treatment in other factory units. This water is taken entirely from the Edwa Canal, a branch of the Nile. This is characterised by values of TDS reaching 700ppm and hardness reaching 200ppm.

**Wastewater Generation**

The factory generates 180 $m^3$/day of industrial wastewater from different factory streams, including process effluents, domestic sewage, boiler blowdown, cooling tower blowdown and steam condensate. All of these are collected and stored in a central holding tank. This is then trucked out four times a day and dumped in disposal site 9 km from the plant.

## POLLUTION PREVENTION OPPORTUNITIES

Pollution prevention opportunities were initially identified through an industrial audit of the factory, carried out by the SEAM Project. The most significant follow:

1. Throughout the factory, steam losses were very high, as a result of damaged lines, damaged or open valves and inadequate insulation. These losses were estimated as being up to 34 ton/day.
2. In the seed receiving unit, broken seeds and hulls are treated as waste, rather than being reused in the oil extraction process.
3. Mazout leaks and spills occurring during delivery and transfer in the receiving area account for 2-5% of total fuel consumption.
4. Wastewater from the refinery has the highest organic load (BOD 3,420 ppm, total oil and grease 100,200 ppm), and is the main contributor to the pollution load of the final effluent.
5. High losses (1-2%) due to the spillage of process chemicals in the refinery unit.
6. Oil losses in the refinery (0.5 tons/day) occurred as a result of leakages in storage units and during handling/transfer.
7. Spillages in the packaging area (0.05 tons/day).
8. The high levels of organic pollution present in the final industrial effluent are in violation of the land disposal regulations.

## Cleaner Production Applications

The measures which have been identified for implementation by the SEAM Project are briefly outlined below. During the audit stage, particular attention was paid to those improvements which could be carried out at low or no cost to the factory. These are easy to implement and often yield significant savings as well as reducing final effluent strength and volume. The size of the wastewater treatment plant can then be correspondingly reduced.

**Low Cost Housekeeping Improvements**

***Preventative Maintenance Programme***

This has included in-factory servicing of the expeller and modification of the packing of the cooling towers, which has resulted in annual savings of LE25,000 and LE5,000 respectively.

Other measures undertaken (which have not yet been quantified include):

- Steam trap modifications.
- Repair of leaking or broken valves.
- Repair of damaged water pipes.
- Repair of damaged steam pipes.

*Implementation Cost:* LE15,000
*Annual Savings:* LE30,000

***Packaging Unit: Collection & Recycling of Spilt Oil***

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 the drain. These are now immediately collected in troughs and pumped to a collection tank, where the oil is recycled to the refinery for reprocessing. Approximately 1.16 tons of edible oil are recovered on a monthly basis.

*Implementation Cost*: LE2,500
*Annual Savings*: LE35,000 (recovered oil only)

**Process Modification**

***Reuse of Fines from Preparation Unit***

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.

Consequently, the crushing capacity has been increased by 40 ton of sunflower seeds per day. The crush margin is considered by the factory to be 40LE/ton. Sunflower seeds are available for 3 months of the year, and hence the additional yearly income is equivalent to LE120,000.

*Implementation Cost:* LE10,000
*Annual Savings:* LE120,000

**Material Substitution**

***Use of Caustic Soda Solution***

Originally, solid caustic soda was used for the neutralisation proces. This has now been substituted by a caustic soda solution, at a much lower cost: LE2,100/ton as against LE1,000/ton. As a result, daily neutralisation costs dropped by 47%, equivalent to savings of 6.5 LE/ton of crude oil.

Other benefits of this intervention include:

- reduced losses of caustic soda during transfer to the neutralisation process,
- reduced levels of corrosion,
- improved soapstock quality and
- better working conditions.

*Implementation Cost*: none (to the extent that all necessary modifications were made using available equipment).

*Annual Savings:* LE250,000

**Water and Energy Conservation**

***Upgrade Steam Network***

This involved a detailed inspection and overhaul of the steam production system. Work carried out 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,
- insulation of hot water and steam pipes.

As a result, steam consumption has been reduced by 1,800 tons of steam per month and one boiler has been taken off line.

The savings associated with this include:

- mazout usage has been reduced by 144 ton/month, saving LE38,880/month,
- water consumption was reduced by 2,400 ton/month, saving a total of LE6,200/month (consisting of savings in raw water abstraction, reticulation and softening),
- maintenance costs have been reduced by LE12,000/month.

*Implementation Cost*: LE30,000
*Annual Savings:* LE552,960

**Reuse and Recycling**

***Recovery of Broken Seeds***

Seeds delivered to the factory 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. Originally, these were collected and sold for LE100 as animal feed.

The process has now been modified so that they are collected using a screw conveyor and transferred to the preparation unit, where they are further processed. As a result, an extra 78 tons of oil and 595 tons of meal are produced annually, valued at LE463,250.

*Implementation Cost: LE*9,000
*Annual Savings:* LE463,250

***Recovery of 10% Fatty Matter from Final Effluent***

Fat is manually collected from the refinery effluent by scraper, acidulated and then split. The wastewater is disposed and the fatty matter transferred to soapstock storage tanks. Benefits of this measure are the recovery of product and reduced strength of wastewater. An additional 29 tons/year of soapstock is recovered, valued at LE500/ton.

*Implementation Cost: LE*5,000
*Annual Savings*: LE14,400

**Wastewater Segregation and Treatment**

***Wastewater Segregation***

Wastewater produced by the factory 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 a BOD of 3,420 mg/l. On segregating the remaining effluent is of good enough to use for land reclamation activities within the factory, such as watering lawns and trees.

The amount of effluent to be disposed off-site was reduced such that disposal costs were reduced by LE18,000/year.

*Implementation Cost*: none (existing structures used)
*Annual Savings*: LE18,000

***Minimising Wastewater Treatment Costs***

Prior to the audit carried out by SEAM Project, the factory had intended to install a wastewater treatment plant with a design capacity of 15$m^3$/hour. Received tenders ranged from LE1.53million to LE0.98million, with an median value of LE1.5million.

By introducing in-plant waste minimisation measures, water consumption was reduced by 2,400$m^3$/month with a 3,420kg BOD/day organic load. As a result, a treatment plant with a design capacity of only 5$m^3$/hour is required to treat the effluent. This is being installed at a capital cost of LE549,800, with a saving of LE950,200 against the previous investment cost. Additional savings will also result from reduced operating and maintenance costs.

***Industrial Wastewater Treatment Plant (IWWTP) - underway***

The heavily polluted refinery wastewater will be treated in three steps:

- *pre-treatment*, consisting of sand traps, equalisation tank, and gravity oil separator, supplemented by liquid waste traps, submersible pumps, dosing pumps and controls.
- oil and fat separation will be achieved using a Dissolved Air Flotation (DAF) unit. This breaks down the fats held as an emulsion and then separates the fats by flotation. It is estimated that 0.4 ton/day of soapstock can be recovered and sold for LE500/ton.
- biological treatment, using an activated sludge aeration process. The effluent from this can be used for irrigation and floor washing.

*Implementation Cost: LE*549,800
*Annual Savings*: LE73,500

## ECONOMICS

Throughout industry, pollution prevention and environmental protection measures can offer real financial benefits in terms of:

- Reduced raw materials consumption.
- Waste minimisation.
- Reuse or recycling of in-plant materials.
- Reduced capacity of the IWWTP.

Implementing these measures will also reduce environmental pollution and permit adherence to discharge consent limits.

The total capital and operation costs invested in the cleaner production measures at Sila Edible Oil factory amounts to LE621,300. This has produced total savings of around LE1,557,110, with an average payback period of less than 5 months.

| Cost Benefit Summary of Integrated Water Management Project | | | | |
|---|---|---|---|---|
| **Factory Unit** | **Action** | **Capital / Operating Costs (LE)** | **Yearly Savings (LE)** | **Payback Period (month)** |
| **All** | Preventive Maintenance Program | 15,000 | 30,000 | 6 |
| **Steam** | Upgrade Steam Network | 30,000 | 552,960 | < 1 |
| **Receiving** | Recovery of Broken Seeds | 9,000 | 463,250 | < 1 |
| **Preparation** | Reuse of Fines | 10,000 | 120,000 | 1 |
| **Refinery** | Use of liquid Caustic Soda | None | 250,000 | Immediate |
| **Packaging** | Oil Recycling | 2,500 | 35,000 | < 1 |
| **Effluent** | Wastewater Segregation | None | 18,000 | Immediate |
| **Effluent** | Fat Recovery | 5,000 | 14,400 | < 5 |
| **Industrial Wastewater Treatment Plant (IWWTP) - after implementing waste minimisation measures.** | | 549,800 | 73,500 | 6 years |
| | **TOTAL** | **621,300** | **1,557,110** | **< 5** |
| **Capital investment savings on Industrial Wastewater Treatment Plant (IWWTP).** | | - | 950,200 | - |

## BENEFITS AND ACHIEVEMENTS

- Maintenance costs have been reduced by 10%.
- Water consumption has been reduced by 46%.
- Wastewater treatment requirements have been reduced by 66%.
- Boiler fuel consumption has been reduced by 48%.
- Annual recovery of oil, soapstock and meal, valued at LE692,650.
- Discharge compliance achieved (Law 93).

*Recovery of edible oil from accidental spillages saved LE35,000 per year*

*Substituting liquid for solid caustic soda saved LE250,000 per year*

## CONTACTS

More information on this project and the SEAM Project, are available from:


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## The SEAM Project

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

## SEAM: Pollution Prevention

This is being implemented under the National Industrial Pollution Prevention Programme (NIPPP). NIPPP focuses on the introduction and promotion of low-cost improvement measures, which can be easily and quickly implemented by factories. It also emphasises the importance of economic benefits of any such intervention, particularly those with short pay-back periods.

## Methodology - A Description

Pollution prevention opportunities can be identified through an industrial audit[1]. This systematically reviews the factorys operations and processes, focusing on reducing waste, improving efficiency and alleviating pollution. This aims to identify and prevent losses from occurring in the first place, rather than resorting immediately to a treatment facility.

The SEAM Project has carried out audits in 32 factories in the food, textile and oil and soap sectors, which identified a wide range of low-cost pollution prevention opportunities, including water and energy conservation, the importance of good housekeeping, in-process modification and hazardous materials substitution. The SEAM Project is presently implementing 23 of these opportunities as demonstration projects.

## Benefits of Pollution Prevention

It can ***REDUCE :***

- production costs;
- losses of valuable raw materials;
- on site treatment costs;
- energy and water costs;
- the volume of solid and liquid wastes generated;
- the risk of spills and accidents.

. . . and ***IMPROVE :***

- overall operating efficiency;
- generation of income through reuse and recycling of wastes;
- this approach can be easily replicated in sister factories to achieve similar savings;
- safety of employees;
- legislative compliance;
- company image.

1 Guidelines for Industrial Audits have been prepared by the SEAM Project.