

Waste Minimization and Pollution Prevention in a Brewery & Beverage Industry: A Case Study

Dr. Samia Massoud Mohamed

EWATEC

ABSTRACT

Industrial pollution control measures used to concentrate on what is commonly referred to as “end of pipe” treatment, which focuses on what to do with the waste once it has been generated. Recently, pollution prevention directs attention towards the elimination or reduction of undesired by-products within *the* production process itself before treatment. On the long term, pollution prevention through waste minimization and cleaner production is more cost-effective and environmentally sound than traditional pollution control methods.

The objective of this work was to carry out a feasibility study to define and implement an integrated pollution prevention and control measure in order to minimize waste and therefore to achieve compliance with the Egyptian Environmental law.

In this case study, a new approach has been applied in a typical Brewery & Beverages plant in Egypt to minimize waste and save on materials, water, steam and energy. This integrated new techno-economic approach consists of the following:

- a. **In-Plant Modifications**, to reduce water & energy consumption and segregate highly polluted streams for point source treatment.
- b. **Improvement of housekeeping procedures.**
- c. **End of pipe treatment**, designed on the basis of the reduced pollution load obtained from the above a & b.

The main objectives of this project are

- Evaluation of magnitude and character of industrial waste streams and end-of-pipe effluent.
- Reducing pollution load through point source treatment and application of in-plant modifications.
- Reducing wastewater volume through the use of simple, low cost, in-plant modification measures (e.g. flow meters, spring valves.... etc.)
- To design an end-of-pipe treatment system to complement the in-plant modifications in order to comply with discharge regulations.
- Conduct a cost-benefit analysis to estimate the savings achieved from applying in-plant modifications.
- To suggest the most feasible alternative scheme for remedial measures combining in-plant and end-of-pipe treatment modules.
- To compare economically between two remedial schemes (with and without using in-plant modifications).

The proposed in-plant modifications will efficiently contribute in saving water and energy

consumption throughout the plant in addition to reducing hydraulic load on the wastewater treatment plant. An expected annual benefit of L.E. 1,413,069 can be achieved by conducting the proposed scheme.

1. INTRODUCTION

All initial efforts to control industrial pollution have concentrated on “End-of-pipe” treatment, which focuses on how to treat the waste once it has been discharged in order to comply with the Egyptian Environmental Law 48/1982.

Recently, pollution prevention focuses towards the elimination or reduction of undesired by-product within the production process itself before treatment.

In the long run pollution prevention through waste minimization and cleaner production is more cost-effective and environmentally sound than traditional pollution control methods.

A typical beverage industry is selected for this case study where a new integrated techno-economic approach including the optimum combination of in-plant modifications and end-of-pipe treatment modules are used as remedial measure.

The beverage industry encompasses a wide variety of beverages, which include soft drinks and malt (non-alcoholic beer). The main raw materials used in this type of industry are malt, flavors, syrups, rice breaking, enzymes and chemicals (kieselgur, formaldehyde, citric acid).

The main objectives of this study can be outlined as follows:

- To control water consumption through installation of water flow meters.
- To reduce wastewater volume by installation of spring valves on water hoses.
- To reduce the energy consumption by design of a steam condensate recovery system.
- To design an end-of-pipe treatment system to complement the in-plant modifications and comply with discharge regulations.
- To develop alternative integrated schemes combining in-plant and end-of-pipe treatment.
- To conduct economic analysis for each proposed scheme.
- To select a preferred integrated scheme (PIS) based on techno-economic comparison between alternatives.

2. MATERIAL

2.1 Basic Information

The beverage production plant used in this case study comprises of five main production units:

- a- Brew House (Malt production).
- b- Non-Alcoholic Beer Processing.
- c- Soft Drink Line & Packaging.
- d- Syrup preparation.
- e- New bottling and packaging line.

A Typical process flow diagram for beverage and soft drink is shown in Fig (1).

Besides the production units, there are service units mainly:

- Steam boiler stations.
- Electric generators.
- Water treatment facility.
- Laboratories.
- Refrigerators.
- Storage facilities for fuel, raw materials and chemical.
- Workshops and garage stations.
- CIP (Clean In Place) facility for washing and sterilization of equipment and connections.

2.2 Water Usages and Distribution

The average water consumption is $\cong 3,600 \text{ m}^3/\text{d}$ reaching a maximum of $\cong 5,000 \text{ m}^3/\text{d}$ in summer. Table (1) shows the distribution of water usage in the plant.

Table (1): Distribution & Usage of Water

Operation	Average daily consumption m^3/d	Maximum flow in summer m^3/d
Process	1,230	1,790
Boilers	660	800
Cooling	300	400
Washing	1,280	1,825
Domestic & Workshops	125	180
Irrigation	5	5
Total	3,600	5,000

Table (1) indicates that washing and cleaning operations consumes about 37 % of total daily water consumption.

2.3 Waste effluent Characteristics

The total end of pipe wastewater effluent reaches a daily average of $2,000 \text{ m}^3/\text{d}$ and a maximum of $3,000 \text{ m}^3/\text{d}$, and the discharged to an agriculture drain.

The waste effluent is mainly wash water, boiler, cooling tower blow downs and steam condensate.

The chemical analysis of the end of pipe stream as compared to the legal limits specified in law 48 /1982 is shown in table (2).

Table (2): Characteristics of end-of-pipe effluent

Parameter	Min	Max	Required legal limits
PH	10-11.7	12	6-9
COD (mg/l)	1,747-2,050	2,460	100
BOD ₅ (mg/l)	1,200-1,800	2,160	60
T.S.S. (mg/l)	566-750	900	60
TDS (mg/l)	1,912-3,326	4,000	2,000
O&G (mg/l)	35	67	10

The above analysis of table (2) shows that final waste effluent is highly contaminated with biodegradable organic matters, which is indicated by the high BOD & COD levels. In addition, high-suspended solids due to residues from malt processing are also above legal limits, while the main source of the high oil & grease level is the garage.

3. METHODS

Treatment schemes based on different possible modules of in-plant modifications and end-of-pipe treatment systems are proposed as integrated remedial measure for solving the wastewater problem.

3.1 In-plant Modifications:

The main purposes of in-plant modifications are:

- To save water and energy consumption.
- To reduce hydraulic load on the wastewater treatment plant.

Fig (2) gives a flow diagram for wastewater streams generated before and after applying the in-plant modifications

3.1.1 Water Saving:

Four water saving projects are proposed, the water saving is calculated as percentage reduction in total daily water consumption

- **Project 1:** Installation of water flow meters to monitor and control water consumption in all activities.
Expected water saving @ 5 %

- **Project 2:** Installation of spring valves on water hoses using for machines and floor washing.
Expected water saving @ 10 %
Equivalent reduction in hydraulic load of IWWTP.
- **Project 3:** Recycle and reuse of pasteurization and wash water.
Expected water saving \cong 15 %
(@100,000 m³/yr)
- **Project 4:** Recycle of backwash water from seven sand filters.
Expected water saving @ 5 %
(105 m³/d)

3.1.2 Energy and Water Saving:

Recovery of steam condensate:

Steam condensate of about 530 m³/d is discharged to sewer at temperature 75-80 °C. This project will collect and recycle the hot steam condensate as boiler feed water to recover both energy and clean water.

Expected savings:

- Energy saving 276,000 liter diesel fuel / yr.
- Water saving 266,500 m³/yr \cong 18 % of total water consumption.

Therefore, the in-plant modification projects will save more than 50 % of the total water consumption besides the great energy saving obtained from the condensate recovery. A cost analysis will be discussed later on in this study.

3.2 Housekeeping

- Provide adequate awareness to the company workers in the workshops area to collect the wasted oil spilled during the regular maintenance.
- Provide adequate awareness to the cleaning workers in the fermentation and brewing plant to collect any residual or spilled product from equipment.
- Apply regular maintenance program to minimize any leaks.
- Apply the housekeeping procedures of the open areas and roads in the factory and quick removal of any solid waste.

3.3 End-Of-Pipe Treatment

The treatment system comprises the following:

- Point source removal of oil & greases from garage stream using gravity oil separator (GOS).

- Chemical treatment of final effluent using DAF system. In this stage, 95 % removal of suspended solids and 60 % removal of BOD can be achieved.
- Biological treatment as a second stage after DAF using Sequential Batch Reactor (SBR) technique to reduce the organic pollution load by further 90 %.
- Tertiary treatment using chlorination and sand filtration to reduce the pollution load below the allowable limits (BOD = 60 ppm, COD = 100 ppm).

A schematic flow diagram (Fig 3) shows the detailed components of the treatment system.

4. RESULTS AND DISCUSSION

There are two alternative configurations developed as remedial measures.

4.1 Alternative scheme I

- a- Applying the four In-plant modifications mentioned above in section (4.1).
- b- Using GOS for oil removal from garage stream.
- c- End-of-pipe treatment for 1,500 m³/d effluent.

Figure (4) shows the breakdown for quality and efficiency of treatment (Alternative I). A schematic diagram Fig (5) of the various waste streams for Alternative I showing the present situation (black) and the integrated scheme including the proposed In-plant modifications (blue) and the end of pipe treatment plant (red).

4.2 Alternative scheme II

- a- Using GOS for oil removal from garage stream.
- b- End-of-pipe treatment for 3,000 m³/d effluent.

Figure (6) shows the breakdown for quality and efficiency of treatment (Alternative II). A schematic diagram Fig (7) for Alternative scheme II showing the present situation (black) and remedial measure including GOS and the end of pipe treatment (red).

5. ECONOMIC EVALUATION

An economic and cost benefit analysis were conducted for the two alternatives and were compared based on the following criteria:

- Capital cost
- Total annual benefit
- Payback period

5.1 Cost / Benefit Analysis of In-plant modification:

The following table (3) summarizes the economic savings achieved upon implementing the four proposed in-plant modification projects.

Table (3): Economic savings from in-plant modifications

Project	Capital Cost L.E	Yearly Saving L.E	Pay back Period
1. Installation of water flow meters	167,000	77,000	2 yrs
2. Installation of spring valves	9,000	55,800	2 months
3. Recycle of pasteurization and wash water	250,000	100,000	2.5 yrs
4. Steam condensate recovery	1,015,000	1,147,389	1 yr
5. Recycle of back wash water	60,000	32,180	6 months
Total In-plant modifications	1,501,000	1,682,369	1 yr

5.2 Economic Comparison between Alternatives:

The comparison is illustrated in table (4) as follows:

Table (4): Comparison between Alternatives

Criteria	Alternative I	Alternative II
Capital Cost:		
In-plant modification	1,501,000	-----
Point source GOS	130,000	130,000
End-of-pipe Treatment	6,937,000	8,062,000
Total capital cost	8,568,000	8,192,000
Operating cost	856,800	819,200
Annual Benefit	1,413,069	00.00
Pay back period	6 yrs	-----

6. CONCLUSION

Based on technical and economic comparison between Alternatives I and II; Alternative I is selected to be the Preferred Integrated Scheme (PIS).

This can be justified as follows:

- a- The proposed In-plant modifications will efficiently contribute in saving water and energy consumption throughout the plant in addition to reducing hydraulic load on the wastewater treatment plant.
- b- Alternative I is economically preferable than Alternative II as outlined in section (6):
 - ***In terms of annual benefit:***
Alternative I has an annual benefit of L.E 1,413,069 comparing to nothing for Alternative II.
 - ***In term of payback period:***
Alternative I has a simple payback of 6 yrs against nothing for Alternative II.

Based on the above, Alternative I is found to be the most feasible technically and economically and therefore selected as PIS.