# Cleaner Production Assessment for Resource Utilization of Textile Waste Water Treatment Plant

**Tadele Assefa Aragaw**
Faculty
Department of Chemical & Food Engineering
Bahir Dar Institute of Technology, Bahir Dar University, Ethiopia

*Abstract*— The increasing ecological awareness, ambient preservation, social justice and concern with the future generations are directly related to the sustainable development of the companies. This study approaches the concept of cleaner production organized for activities of the effluent treatment plant, ETP and the positive effect to the environment. Appropriate use of the energy and water requirement by optimizing the unit process is a critical issue. It is demonstrated for the improvement in its processes that can adjust the good cooling system for compressor and good maintenance of the electrochemical process.

***Key words:*** Cleaner production, mass balance, energy utilization, wastewater, treatment plant

## I. INTRODUCTION

Production of wastes is an integral part of all industrial activities. The type of industrial processes, raw materials and adopted technology are some of the major factors that determine the constituents of waste residues. The textile industry as well as other industries is responsible for indiscriminate effluent discharges into surrounding water bodies. These effluents contain potential environmental pollutants that tend to accumulate in organisms and persist in the environment due to their chemical stability and/or poor biodegradability. Therefore, understanding and developing effective printing-dye industrial wastewater treatment technology is environmentally important in addition to minimizing the waste from wet textile processes. With this regard, implementation of cleaner production technique is most recommendable.

Cleaner Production is generally defined as “the continuous application of an integrated preventive environmental strategy to processes, products, and services to increase eco-efficiency and reduce risks to humans and the environment” (UNEP, 1994). Cleaner Production aims at progressive reductions of the environmental impacts of processes, products and services, through preventative approaches rather than control and management of pollutants and wastes once these have been created.

Though the main objective of cleaner production technique is to minimize environmental pollution by minimizing waste generation and to maximize profit, the implementation of cleaner production technique has some specific aims for products, production processes and services. For production processes, Cleaner Production technique aims in particular at conserving raw materials and energy, eliminating toxic raw materials, and reducing the quantity and toxicity of all emission and wastes before they leave the process, which is known as source reduction. In the case of products, Cleaner Production technique aims at reducing the environmental impact along the life cycle of a product, from raw materials extraction to its ultimate disposal. Finally, for services, Cleaner Production technique entails the incorporation of environmental concerns during designing and delivering services. Cleaner Production requires changing attitudes, responsible environmental management and evaluating technology options.

Therefore, using cleaner production assessment as a tool to optimize the waste water treatment is important idea. In addition, in textile waste water treatment plant electrical energy consumption by the processes such as blower and electrochemical reactor is very high. Thus optimization is important to save energy loss. This study is to conduct a cleaner production assessment and generate options for textile waste water treatment.

There are different kinds of cleaner production options. These are good housekeeping, input substitution, technology modification and product modification

## II. CLEANER PRODUCTION METHODOLOGY

Initial check list was used to see the significance of cleaner production assessment. Then, based on the methodology developed by UNEP and UNIDO the assessment is described, and it consists of the following basic steps:

- Planning and organizing the cleaner production assessment
- Pre-assessment (gathering qualitative information about the organization and its activities)
- Assessment (gathering quantitative information about resource consumption and waste generation and generating cleaner production opportunities)
- Evaluation and feasibility assessment of cleaner production opportunities
- Implementation of viable cleaner production opportunities and developing a plan for the continuation of cleaner production efforts

### A. *Initial Checklist*

The following simple checklist was used in identifying initial cleaner production opportunities likely to lead to cost savings and increased profitability.

- Does the wastewater treatment provide sources or raw material which use Energy, Water, and Chemicals?
- Are the costs of one or more of these are significant proportion of operating costs?
- Does waste water treatment plant generate solid, gaseous or chemical wastes?

For all the above questions, the answer was ‘yes’. Therefore, cleaner production is likely to lead to cost savings and increased profitability. The details methods and materials used to assess cleaner production opportunities in the waste water treatment are given below.

 

### *B. Planning and Organization*

This section includes obtaining management commitment, setting aims and establishing a proper project organization for conducting the cleaner production assessment. The arrangement for cleaner production team set up identified, investigated and evaluated cleaner production options. The plan was aimed to include a cross-section of staffs on the team from major sections such as finishing, utility, distribution, human resources, environmental protection, finance, and research and development. However, due to staff limitation, it was not possible to organize a team and yet almost everybody in the factory cooperated for the realization of cleaner production assessment.

### *C. Pre-Assessment*

Prior to the assessment a process flow diagram, major energy consuming equipment, raw material information, and energy and waste data were collected in the textile factory. Collection of this data prior to the assessment gave an idea of where attention should be focused during the actual assessment.

#### *1) Walk-Through Inspection:*

During the walk-through inspection of textile factory, talking to several staff members, heads of utility and finishing departments, wastewater treatment operators, and laboratory technicians that presented valuable information. Observations about the operations and general appearance of the facility from the treatment plant (e.g., evidence of leaks and spills, waste chemicals) were recorded. The following check-list was used during the walk-through assessment:

- Are there any drips, leaks or spills or emissions during the treatment process?
- Is all equipment operating properly at design capacity/efficiency?
- Are energy and water being wasted?
- Are hazardous materials and wastes stored appropriately? (i.e solid waste)
- Are wastes necessary after treatment?
- Are there any opportunities for reuse or recycling the treated water?

It was necessary to return to the treatment process as often as necessary to gather adequate data to develop a list of opportunities. From the pre-assessment in high electrical energy consumption from the compressor unit and electrochemical reactor, due to improper use of cooler for compressor during air production, and improper maintenance of the electrochemical chamber (electrode replacement at a right time). Also water consumption from the coagulant-flocculants solution preparation was another area which assures high consumptions.

### *D. Assessment*

This consists of in-depth evaluation of selected audit focuses in order to develop a comprehensive set of alternate cleaner production options. This required quantification of volume and composition of the waste which come from the finishing process as well as a detailed understanding of the causes of these waste. Onsite measurements (pH, temperature) and laboratory tests log book, energy consumption records and interview with technical personnel were main sources for data compilation. Compiled data were used for material and energy balance of the whole process.

#### *1) Electrical Energy Consumption:*

The electrical energy consumption for sections and unit operations is estimated by recording the time of consumption and taking the design capacity of processes, motors and pumps.

#### *2) Wastewater Flow Rate Measurement:*

wastewater flow rates were measured by recording the time taken to fill a known volume of flask and in some cases by measuring the change in water level in a tank with a known volume in a given time.

#### *3) Material and Energy Balance:*

The material and energy balances in wastewater treatment plant were evaluated based on the conservation laws of mass and energy.

### *E. Evaluation and Feasibility Study*

A set of cleaner production options were obtained from previous stage of the assessment in textile factory. Next, technical, economical, and environmental feasibility of the options were examined: Evaluation of technical and economic feasibility, and generation of an assessment report.

Evaluation of Technical, Economic and Environmental Feasibility

Following the assessment in Riverhead Sewer District, RSD it was necessary to evaluate the technical, economical and environmental feasibility of each energy conservation and pollution prevention options identified.

#### *1) Technical Evaluation:*

Technical evaluation in textile wastewater treatment plant include calculations of energy conservation and waste reduction and the associated costs, impacts on operations, and its advantages and disadvantages. Additionally, the technical evaluation included evaluation of the implementation aspects of the option including such things as: is there room in the facility for new equipment and will the new process affect the quality of treated water.

#### *2) Economic Evaluation:*

Economic feasibility compares electrical energy savings with costs of implementing the option. The likely payback period for any capital investment is often the simplest method for assessing economic feasibility. The payback period is the time it will take to save the money spent to change or improve a process or operation.

#### *3) Environmental Evaluation:*

The objective of environmental evaluation is to determine the positive and negative impacts of the options generated for the environment.

#### *4) Selection of Feasible Options:*

the technically non-feasible options and the options without a significant environmental benefit were eliminated. All remaining options can in principle be implemented. However, a selection is required in case of competing options. Based on these considerations, the viable options were re-screened and priorities were set for implementation. Priorities were based on greatest return or urgency.

### *F. Implementation and Monitoring*

Management support is the most important element in successful implementing cleaner production, CP opportunities. After successful implementation of the project, it is beneficial to track and advertise the resulting cost savings and impacts to give feedback to facility personnel. This allows personnel to see the results of changes in procedures or installation of new equipment and to participate in the energy conservation and pollution prevention program. The expected results of this phase are:

1) Implementation of the feasible cleaner production measures.
2) Monitoring and evaluation of the progress achieved by implementation of feasible options.
3) Initiation of ongoing cleaner production activities

*1) Energy Requirement*

Treatment plants uses energy for a variety of purposes. Air production via compressors and co- generators is the largest one. Electric motor drive and corresponding pumps, and chemical processing and handling, is the next largest category. Improperly insulated air pipes are a constant source of wasted energy because they radiate heat to the surroundings instead of transporting it to the equipment. The heat losses reduce the pressure at the terminal equipment. This situation increases the compressor load because extra pressure is required to make up the losses.

Similarly, the electrochemical reactor is also consuming energy. Improperly insulated reactor chambers and corroded electrodes are a constant source of wasted energy because they consume extra current to undergo oxidation reaction. Energy losses can also be reduced with proper attention to maintenance of motor devices pumps.

*2) Water Supply Requirement*

Inadequate water management causes the depletion of surface water and ground water resources. Some process which can use water (as cooling for compressor and for chemical preparation). Whatever their function; water systems tend to have similar inefficiencies and energy management opportunities.

*3) Process Flow Diagram of the Effluent Treatment Plant*

Equalization tank: Because of highly polluted wastewater and its quantity fluctuations, complex components, textile dyeing wastewater is generally required pretreatment to ensure the treatment effect and stable operation. In general, the regulating tank is set to treat the wastewater. In the meantime, to prevent the lint, cotton seed shell, and the slurry settle to the bottom of the tank, it's usually mixed the wastewater with air or mechanical mixing equipment in the tank.

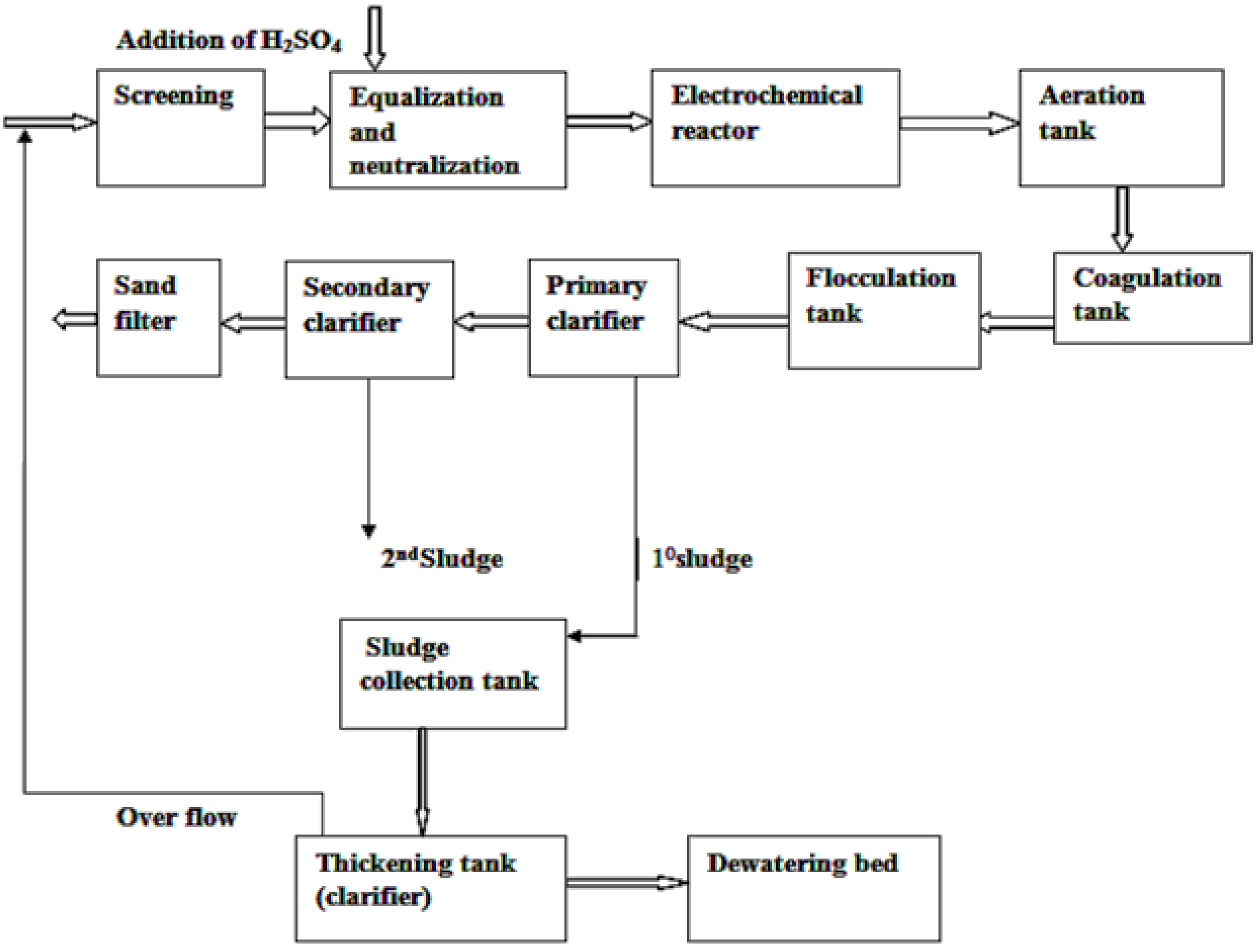


Fig. 2: Flow diagram for Bahir Dar textile waste water treatment plant

## III. Result and Discussion

### A. *Water Supply Requirement*

The daily, monthly and yearly loss of water during leakage and chemical preparation is shown below

| 1. Leakage rate | Daily loss (L) | Monthly loss (L) | Yearly loss (L) |
|---|---|---|---|
| One drop/second | 0.008 | 0.24 | 2.8 |
| Two drops/second | 0.024 | 0.477 | 5.8 |
| Drops into stream | 0.089 | 2.4 | 30.9 |

 

| | | | |
|---|---|---|---|
| 2. during coagulant solution preparation | 0.318 | 9.4 | 111.9 |
| Total loss | 0.439 | 12.517 | 151.4 |

Table 1: Amount of water lost

## *B. Material Balance*

Balances over individual process units set the process stream flows and compositions. It can be used to check performance against design, to extend the limited data available from the plant instrumentation, to check instrument calibrations, and to locate sources of material loss. Wastewater flow rates were measured by recording the time taken to change in water level in a tank of known volume at a fixed time.

The textile wastewater treatment plant, the electrical energy is mainly consumed by pumps, compressors, mixers, and drive motors. However, some difficulties were faced with data collection and acquisition.

The principle of mass conservation states that the amount of a pollutant somewhere in the system increases, if the pollutant have been either carried into the system from elsewhere or produced via chemical reactions. And, if chemical reactions produced the mass increase in pollutant, they must also have caused a corresponding decrease in the mass of some other compounds, reactants. Thus, conservation of mass allows us to compile a budget of mass of pollutant in the system for a given time period. The mass balance flow diagram depicts below with its discharge amount.

## *C. Schematic Representation of Material Balance*

Cleaner production opportunity assessment has gone through steps from initial check list to assessment stage. Therefore, up to this stage a set of cleaner production options were investigated. Hence, in this chapter the technical, financial and environmental feasibility of the cleaner production options will be dealt with.

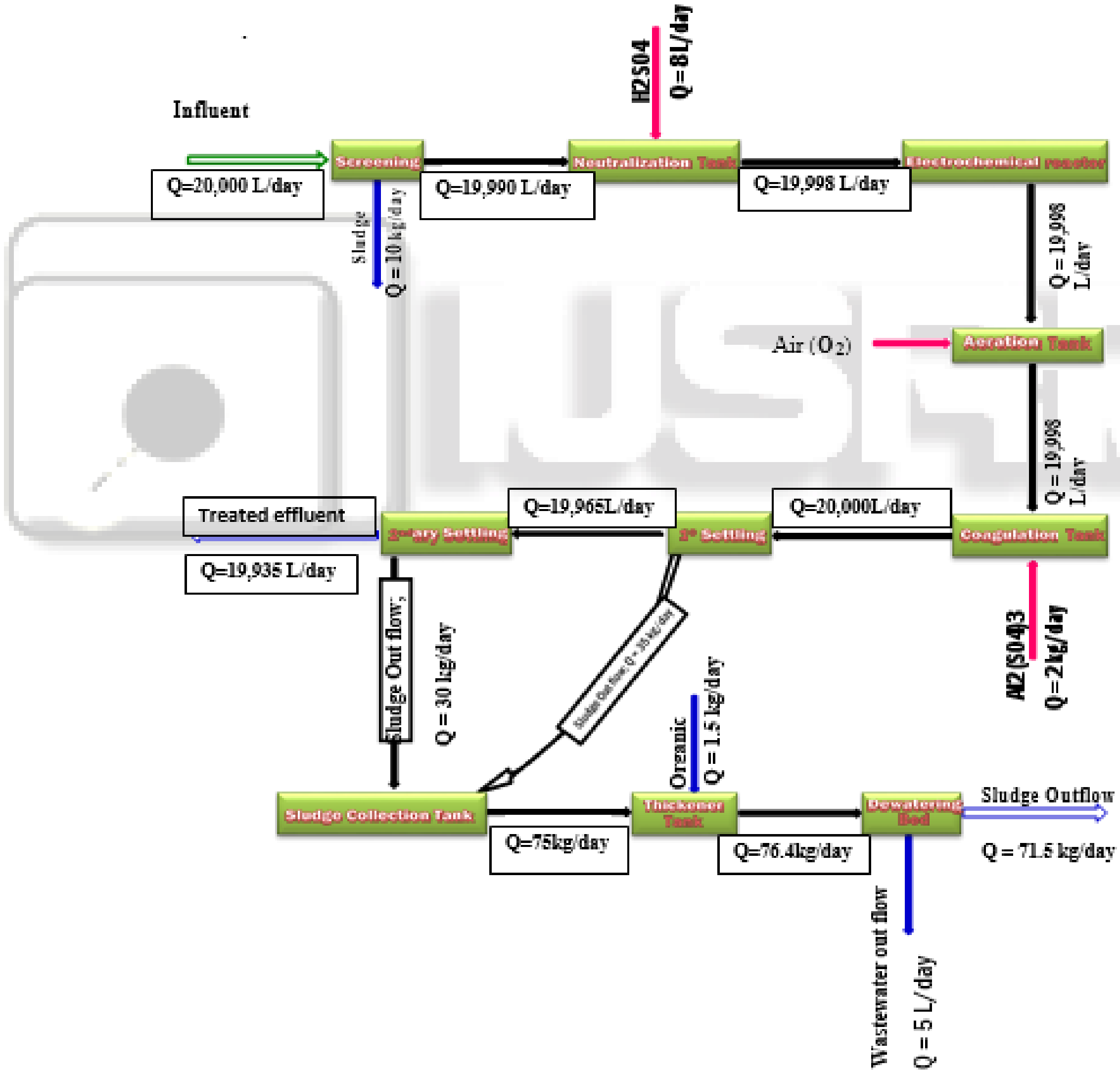


Fig. 2: Material Balance

## *D. Cleaner Production Options*

### *1) Good Housekeeping and Staff Training*

Good Housekeeping' and 'Input substitution' can be undertaken to improve quality of treated wastewater, obtain cost savings, and reduce the environmental impacts of operation. The adoption of 'Good Housekeeping' practices does not require major investments in cleaner technologies. It can be achieved by information dissemination, awareness creation, organizational culture change and taking simple actions such as rational use of resources and optimizing treatment processes.

 

*2) Electrical Energy Loss*

Huge amount of electric power is consumed on the electrochemical reactor unit process. Mostly this is due to improper mechanical maintenance. Similarly, compressor consumes large amount of electric power on improper cooling water and motor lubricants.

*3) Service Water Loss*

Service water lost by washing of coagulant &flocculants tank for solution preparation amounted to 2500 L/yr. This water could be reused for electrochemical chamber washing. Therefore, if this water was to be recycled, wastewater volume from the collection tank can be reduced by 3.96%.

NB. All water for any service is flow to the equalization tank.

Pump cooling water used for compressor and high pressure pumps was overflowing. This was because of the amount of water used for cooling was more than the required. This water is amounted to 22.36 L/ year. By supplying just the right amount of cooling water controlled by valve, the service water loss can be reduced. By doing so, 328 kWh can be saved per year. And this decreases the volume of wastewater from the equalization tank by 12.5%.

*4) Treated Wastewater*

The treated wastewater from the treatment plant is very high in quantity. If it is treated well, have potential on the plantation and results good global view on the subject.

*5) Using Treated Wastewater for Chemical Preparation*

It is evident that tape water can contribute to clog problem for pipes and chemical tanks if it is turbid water. On this basis, it is better to use treated wastewater for coagulation-flocculation solution preparation. The key benefit associated with moving from treated tape water is reducing the load to the equalization tank which, in turn, will reduce total volume of discharge water.

*6) Wastewater for Irrigation Purpose*

According to food and agriculture organization, FAO irrigation and drainage paper number 47, properly planned use of treated wastewater alleviates surface water pollution problems and not only conserves valuable water resources but also takes advantage of good ecosystem contained by growing crops. The availability of this additional water near population centers will increase the choice of crops which farmers can grow. It is advantageous to consider treated effluent reuse at the same time as wastewater collection and disposal are planned so that effluent system design can be optimized in terms of effluent transport and treatment methods.

However, from the health point of view, a very important consideration in agricultural use of treated wastewater, the contaminants of greatest concern are the micro and macro pathogens. Even if toxic materials are not present in concentrations likely to affect humans, they might well be at phytotoxic levels, which would limit their agricultural use. Therefore, treated wastewater reclamation for irrigation purpose and discharging it require scrutiny to prevent their impact on the environment and human health.

The textile treated wastewater is good to grow vegetable and grass in the factory compound based on the evidence treatment plants which contain this unit process. By obtained water quality results of the treated water, a comparison can be taken with the standard water quality and can be recommending for irrigation. Therefore, direct reuse for irrigation is quite reasonable with the quality requirement for irrigation.

## *E. Implementation and Monitoring*

Now a list of options has been studied with their feasibility. To get the best out of the cleaner production assessment, the cleaner production implementation plan in textile waste water treatment plant should be integrated into the company’s business and operating plants. Resources needed for these initiatives need to be provided in the company’s budgeting process. The options to be implemented, first operational or procedural changes with least cost should be involved. This will provide speedy results and greater momentum for implementing other options. This approach will also highlight the need for a new discipline in the operations, and the need to establish a cleaner production culture in the business. Without this cultural change, isolated measures (such as installing equipment or instruments) will not be fully effective, and will not yield long-term improvement.

Cleaner production assessment is not a one-time-task. Once cleaner production is implemented in this treatment plant it is a process that should be monitored and undertaken continuously. Then, the company will benefit a lot from it. The summary of the cleaner production opportunities in textile waste water treatment plant is given in the following table.

| Problem Area | CP Opportunities | Amount saved | Electrical energy | Economic Benefits | Qualitative |
|---|---|---|---|---|---|
| Electrical power | Effective maintenance of electro-chemical reactors (electrode replacement) | ------------ | 16,468.27 | 19,540.12 | Meets environmental standards and prevents health risk |
| | Optimization of cooling water and proper lubrication of compressor | ----------- | 30,456.75 | 45,349.23 | |
| Service water loss | Avoiding spillage and use treated water rather than tap water for coagulation-flocculation solution preparation | 500,000 | ------- | 25,000 | Good company image |
| Treated wastewater for irrigation | Use treated wastewater for irrigation 12,000 m3/day treated water have been discharge in to rivers | 43,800,000 | --------- | 125,000 | Personnel safety |

Table 2: Summary of Cleaner Production (CP) Opportunities

## IV. Conclusion and Recommendation

Cleaner production options for textile wastewater treatment plant are technically, financially and environmentally feasible. The economic and environmental benefits that can be obtained from implementing cleaner production are substantial. As a result, prevents pollution, rewards the company financially, creates good company image, and enables the company to meet environmental standards. In the idea of using treated wastewater for irrigation purpose can be encouraged. However, the treated wastewater having the quality that exceed the limits in light of both local and international standards should not be released to surface water nor be used for irrigation purpose because of its potential hazard to the public and the environment. Implementing Cleaner production opportunities forwarded in this paper is very important. Nevertheless, even after implementation of these cleaner production opportunities, the quality of water should be checked periodically whether to use it for irrigation purpose or release it to the nearby river.

Effective maintenance of electrochemical reactors can save 16,468.27 kwh/yr electrical energy. As a result, has 19,540.12 Birr/yr Economic benefits and by optimization of cooling water and proper lubrication on compressor it can save 30,456.75 kwh/yr electrical energy. Correspondingly, have 45,349.23 Birr/yr Economic benefits also by just undertaking well housekeeping 500,000 L/yr service water can be saved and has 25,000 Birr/yr Economic benefits. Therefore, it can be concluded that textile factory can obtain wide financial and environmental rewards, if it implements and continues to implement these cleaner production options.

Use the treated wastewater for irrigation purpose, for chemical preparation, for tank washing or what so ever activities except for drinking are strongly recommended. Also Implement the proposed cleaner production opportunities continually is important. The standard requirements for industrial effluents need to be adjusted to enable it protect the environment from eutrophication problem especially in relation to the standard requirement of phosphates and nitrates. In this study of CP opportunity assessment, the methodologies and procedures taken to assess the treatment processes, pinpoint problem areas and addressing them can also be used in industries having similar treatment plants.

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