CLEANER PRODUCTION OPPORTUNITY ASSESSMENT FOR MARKET MILK PRODUCTION IN ATATÜRK ORMAN ÇİFTLİĞİ (AOÇ) FACILITY

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ABSTRACT

CLEANER PRODUCTION OPPORTUNITY ASSESSMENT FOR MARKET MILK PRODUCTION IN ATATURK ORMAN CIFTLIGI (AOC) FACILITY

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In this study, possible cleaner production opportunities for a dairy processing facility are examined, considering the market milk production process. Cleaner production concept and its key tools of implementation were analyzed to build the basis of study. General production process and its resulting environmental loads are discussed by taking possible CP opportunities as the axis of study. A methodology is developed for cleaner production opportunity assessment in Milk Processing Facility of Atatürk Orman Ciftliği. The methodology covers two major steps; preparation of checklists for assisting auditing and opportunity assessment; implementation of the mass balance analysis. For mass balance analysis, measurements and experimental analysis of the mass flows are utilized to determine the inputs and outputs. Prepared check lists are utilized to determine waste reduction options that could be implemented. Selected opportunities are evaluated considering its environmental benefits and economic feasibility.

Key Words: Cleaner Production, Waste Reduction, Dairy, Market Milk Processing

ÖZ

ATATURK ORMAN ÇİFTLİĞİ (AOÇ) İŞLETMESİNDE PASTÖRİZE SÜT ÜRETİMİ İÇİN TEMİZ ÜRETİM FIRSATLARININ DEĞERLENDİRİLMESİ

Özbay, Arzu

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Bu çalışmada bir süt işleme tesisindeki pastörize süt üretimi prosesini göz önüne alarak temiz üretim fırsatları araştırılmıştır. Temiz üretim kavramı ve ana uygulama araçları analiz edilerek çalışmanın temeli oluşturulmuştur. Temiz üretim fırsatları çalışmanın ekseni alınarak pastörize süt üretim prosesi ve bunun neden olduğu çevresel yükler tartışılmıştır. Atatürk Orman Çiftliği Süt Fabrikasında temiz üretim fırsatlarının değerlendirilmesi için bir metodoloji geliştirilmiştir. Metodoloji iki aşamayı kapsamaktadır; çevresel denetleme ile fırsatların değerlendirilmesine yardımcı olacak kontrol listelerinin hazırlanması; mass-balans analizinin uygulanması. Mass-balans analizinde giren ve çıkanları tespit etmek için ölçümler ve kütle akışlarının deneysel analizlerinden yararlanılmıştır. Hazırlanan kontrol listeleri uygulanabilecek atık azaltımı fırsatlarının tespit edilmesinde faydalanılmıştır. Seçilen fırsatlar çevresel fayda ve ekonomik yapılabilirlik yönünden değerlendirilmiştir.

Anahtar Kelimeler: Temiz Üretim, Atık Azaltımı, Süt Ürünleri Pastörize Süt Üretimi

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LIST OF ABBREVIATIONS

AOC	Atatürk Orman Çiftliği
BOD	Biological Oxygen Demand
CIP	Clean In Place System
COD	Chemical Oxygen Demand
CP	Cleaner Production
CPA	Cleaner Production Assessment
ETA	Environmental Technology Assessment
EIA	Environmental Impact Assessment
GDP	Gross Domestic Product
GHK	Good House Keeping
ISO	International Standards Organization
LCA	Life Cycle Assessment
MB	Mass Balance
UNEP	United Nations Environment Programme
USEPA	United States Environmental Protection Agency

Qm1:	Milk from truck to clarification	Qm17:	Milk in tanks
Qm2:	Milk to pasteurization	Qm18:	Milk spilled from tank
Qm3:	Milk lost during manual connection	Qm19:	Milk foam at the bottom of tank
Qm4:	Milk pumped to market milk line	Qm20:	Milky wastewater discharged to channel before recirculation of rinse water
Qm5:	Milk remained at the bottom of empty tank	Qm21:	Milk disposed to channel
Qm6:	Milk to packaging	Qm22:	Milk and milk foam discharged to channel.
Qm7':	Cream	Qw1:	Service water (in)
Qm8:	Milk spilled in cartoon packaging machine and bottle filling	Qw2:	Clarifier sludge
Qm9:	Milk foam discharged by vacuum	Qw3:	Loss from valves (service water)
Qm10:	Milk packed in bottles	Qw4:	Service water (out)
Qm11:	Milk recycled due to defective packaging and end of the process (cartoon+bottle)	Qw5:	Steam for heating of pasteurizer
Qm12:	Amount of milk sold without packaging	Qw6:	Steam condensate
Qm13:	Milk spilled during filling operation	Qw7:	Water loss from valves and fittings
Qm14:	Milk lost in process and in cleaning	Qw8:	Service water (in)
Qm15:	Bottled milk not shown in AOC records	Qw9:	Discharge water
Qm16:	Total market milk produced	Qw10:	Service water (out)

Qw11:	Separator sludge	Qw31:	Service water flowing to balance tank
Qw12:	Loss of cooling water in the recycle line.	Qw32:	Excess service water
Qw13	Heating water	Qw33:	Service water for rinsing
Qw14:	Heating water discharge	Qw34:	Wastewater purged from system
Qw15:	Cooling water loss from damaged hose	Qw35:	Excess service water
Qw16:	Replenishment water for the losses from cooling water line	Qw36:	Service water for rinsing
Qw17:	Service water for rinsing	Qw37:	Wastewater purged from system
Qw18:	Wastewater from rinsing	Qw38:	Overflow water flowing to channel
Qw19:	Service water for rinsing	Qw39:	Hot water pumped to the system
Qw20:	Wastewater from rinsing	Qw40:	Hot water disposed
Qw21:	Spilled rinse water on floor	Qw41:	Service water for rinsing
Qw22:	Hot water (in)	Qw42:	Wastewater from rinsing
Qw23:	Wastewater	Qw43:	Service for rinsing
Qw24:	Spilled hot water on floor	Qw43:	Service for rinsing
Qw25:	Service water for rinsing	Qw44:	Wastewater from rinsing
Qw26:	Dirty rinse water	Qw45:	Hot water flowing to tank
Qw27:	Service water	Qw46:	Wastewater
Qw28:	Wastewater	Qw47:	Rinse water
Qw29:	Service water for rinsing	Qw48:	Wastewater from rinsing
Qw30:	Wastewater	Qw49:	Water remained open

Qw50:	Water discharged to sewer	Qw71:	Caustic solution discharged to channel
Qw51:	Service water for rinsing	Qw72:	Warm rinse water to tank
Qw52:	Rinse water discharged	Qw73:	Dirty rinse water
Qw53:	Rinse water	Qw74:	Overflow to channel from tank
Qw54:	Wastewater	Qw75:	Rinse water input
Qw55:	Hot water for caustic wash	Qw76:	Wastewater discharged weekly
Qw56:	Caustic wastewater	Qw74:.	Wastewater overflowing to 2nd warm rinse
Qw57:	Service water for rinse (35-40 ºC)	Qw77:	Water sprayed on cases
Qw58:	Rinsing flowing to channel	Qw78:	Waste rinse water flowing to channel
Qw59:	Service water discharging to floor	Qw79:	Service water for rinsing
Qw60:	Water discharging to sewer	Qw80:	Rinse water to channel
Qw61:	Service water for rinsing	Qw81:	Hot rinse water
Qw62:	Rinsing discharging to channel	Qw82:	Water spilled on ground
Qw63:	Hot water filled in bottles	Qw83:	Rinse water flowing to channel
Qw64:	Dirt hot water from bottles	Qw84:	Service water for rinsing
Qw65:	Rinse water input	Qw85:	Rinse water flowing to channel
Qw66:	Wastewater discharged weekly	Qw86:	Rinse water
Qw67:	Wastewater due to replenishment	Qw87:	Dirty rinse water with detergent
Qw68:	Hot water in to tank	Q_{det-5}:	Detergent used
Qw69:	Caustic solution discharged to channel	Qw88:	Warm service water
Qw70:	Hot water in to tank	Qw89:	Amount of water flowing to channel

$Qw90$:	Service water	Q_{NaOH-1}:	Caustic used
$Qw91$:	Solution discharged to channel	Q_{NaOH-2}	Caustic used
$Qw92$:	Water for rinsing	Q_{NaOH-3}:	Caustic poured to balance tank
$Qw93$:	Rinse water discharged to channel	Q_{HNO3-1}:	Nitric acid poured to balance tank
$Qw94$:	Rinse water	Q_{NaOH-4}:	Caustic used
$Qw95$:	Rinse water discharged to sewer	Q_{NaOH-5}:	Caustic used
Q_{det-1}:	Detergent used	Q_{NaOH-6}:	Caustic use
Q_{det-2}:	Detergent discharged with wastewater	Q_{NaOH-7}:	Caustic use
Q_{det-3}:	General cleaning detergent sprayed	Q_{NaOH-8}:	Caustic used
Q_{det-4}:	General cleaner added to solution	V:	Pasteurization system volume
Q_{det-5}:	General cleaner added to solution		

CHAPTER I

INTRODUCTION

Cleaner production is a preventive strategy to minimize the impact of production and products on the environment. Cleaner production approaches includes hardware (goods, services, equipment) and software (technical know-how, organizational and managerial skills and procedures).

Compared with standard method, cleaner production techniques and technologies use energy, raw materials and other inputs material more efficiently; produce less waste, facilitate recycling and reusing resources and handle residual wastes in a more acceptable manner. They also generate less harmful pollutants. Cleaner production methods have significant financial and economic advantages as well as environmental benefits at the local and global level [1].

The pollution prevention philosophy of cleaner production is antithesis of end-of-pipe treatment approach, which aims at cleaning the pollutant after it has been generated.

Although dairy processing occurs world-wide; the structure of the industry varies from country to country. During the processing of milk major environmental loads are due to organic material, suspended solid waste and pollutants due to cleaning agents. In terms of environmental loading most important problem of dairy sector is disposing cheese whey. Another issue is the extensive use of water which changes within a range of 2.2-9.4 L/kg product [2].

Within the context of CP studies, many guides describing CP auditing methodology in general and for dairy processing have been prepared. Although there are various manuals discussing the general principles of CP auditing, comprehensive dairy specific manuals are limited. It is also seen that some of these manuals are developed for special residences considering the special conditions of the country and though includes opportunity lists designed for the location; i.e. Lower Fraser River Basin, Canada.

In this study, comprehensive lists of opportunities for cleaner production assessment in a dairy are prepared and a cleaner production assessment is done for AOC by using developed methodology and check lists.

1.1. Objective and Scope of the Study

The aim of this study was to conduct a cleaner production assessment (CPA) for the AOC market milk production facility to identify the opportunities of CP, corresponding environmental and economical benefits.

The methodology of the CPA used in this study was prepared by compiling and reorganizing different CP manuals developed by several leading institutions in the field of CP.

The basic strategy followed in reorganization of checklists and audit procedure involved literature review, interviews and implementation in a dairy processing facility. As a result, comprehensive checklists covering most of the CP options available and a simple CP assessment methodology were prepared.

In AOC, although various dairy products (cheese, yogurt, ayran, butter, icecream) are produced, market milk production was selected as the boundaries of this study. The focus areas throughout study were determined as water use and waste production in the AOC market milk production facility.

1.2. Outline of the Study

This study consisted of two main phases; evaluation and assessment of guides in literature and implementation of the developed CPA methodology in AOC.

In the first phase, various studies on cleaner production (general and dairy-specific) were analyzed and different recommendations for CP was synthesized into a CPA methodology.

At the second phase the applicability of prepared CP auditing procedure and checklists were assessed by interviews and by implementation in AOC. Interviews were performed to highlight the major opportunities that are appropriate and the ones that are too sophisticated for dairy sector.

CHAPTER II

BACKGROUND

2.1. What Is Cleaner Production

Cleaner production is an environmental management approach, which includes pollution prevention at source and waste minimization. This strategy has different implementation tools for processes, products and services.

Up to date, the concepts of environmental protection and management have been subject to three main stages.

1. There has been a long industrial production stage without any environmental concern. This rapid development of industrial production has speeded up after 1815's with the industrial revolution. The concept of environmental protection came front by the awareness of limited natural resources and health defects caused due to pollution. The first signs of concept were realized with the environmental legislations.
2. The new legislations have effected the production and business in two major ways. While building many equipment and premises for treatment of the pollution (which are commonly called end-of-pipe technologies), on the other side business has internalized the costs of these equipments and though the cost of environmental pollution. In fact, although important budget is set for

the activities, treatment is only transferring pollution from one form to an other by increasing production costs by buying those treatment equipment.

3. After some time, the cost of treatment has become a big burden on the companies and a new approach that reduce both pollution and treatment costs appeared. This new approach, "cleaner production", offers new opportunities for optimization and saving in business and complying, even passing the requirements of regulations [3]. But still, other traditional waste management methods are needed and should not be excluded from a comprehensive environmental protection program [2].

Through these different stages of environmental concern, environmental management hierarchy has changed and after this important step, the environmental management strategy has been pushed one step forward. The final generally accepted hierarchy is illustrated below in Table 2.1.

Table 2. 1. The environmental management hierarchy [4]

Management Method	Example Activities	Example Applications
Source Reduction (Highest Priority)	• Environmentally friendly design of new products • Process changes • Source elimination • Reuse of products & non-product outputs • Closed loop recycling	• Product modification to avoid solvent use • Product modification to extend coating life • Solvent recovery and return to process (hard-piped) • Reuse of product and non-product outputs as raw materials
Recycling (off-site)	• Reclamation	• Industrial waste exchange • Metal recovery from a spent plating bath • Recovery/regeneration of catalysts
Treatment	• Stabilization • Neutralization • Precipitation • Scrubbing	• Thermal destruction of organic solvent • Precipitation of chemicals from a spent bath
Disposal	• Disposal at a licensed facility • Discharge through sewers • Discharge to water courses	• Land disposal • Waste processing site

The Environmental Management Hierarchy used in developing the methodology of this study (Chapter 4) is as follows:

1. Source reduction
2. On-site reuse recycling
3. Offsite reuse recycling
4. Material and/or energy recovery
5. Residual waste management

Cleaner production is continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks for humans and environment. It applies to:

- Production processes: conserving raw materials and energy, eliminating toxic raw materials and reducing the quantity and toxicity of all emissions and wastes.
- Products: reducing negative impacts along the cycle of a product, from raw material extraction to its ultimate disposal.
- Services: incorporating environmental concerns into designing and delivering services [2].

Cleaner production simply aims to prevent pollution before it is generated and to save natural resources and energy by producing more efficiently. Basic means of pollution reduction, which are based on product or process changes, are illustrated in the Table 2.2.

Cleaner production requires; changing attitudes, responsible environmental management, creating conductive national policy environments, and evaluating technology options [5].

Table 2. 2. Examples of cleaner production measures for the dairy processing industry source reduction and process changes [6]

Product Changes	• Product reformulation and redesign for less environmental impact • Increase product life • Use leak-proof containers for finished products
Input Material Changes	• Materials or feed stock substitution • Avoid or minimize the use of toxic materials • Substitution with less toxic materials
Technology Changes	• Redesign equipment layout to minimize losses • Change to Clean In Place from hand cleaning to minimize detergent and sanitizer usage • Increase automation/improved equipment to improve operating efficiencies • Process/technology modification • Install equipment to reduce energy consumption • Provide back-up or standby critical process pumps • Improve instrumentation, such as high/low level alarms and pump shut off
Best Management Practices	• Improve operator training • Improve operation & maintenance procedures • Improve housekeeping practices • Eliminate sources of leaks • Improve inventory control to minimize disposal of outdated materials • Implement segregation of flows to minimize cross-contamination and to facilitate reuse and/or recycling

CP assessments are done for determining CP measures. CP assessments are referred to as “environmental improvement” cycles. Such a cycle serves three functions:

1. Analysis of the environmental burden of the production process and its causes;
2. Inventory and evaluation of improvement options for production processes;
3. Integration of the feasible improvement options into the production processes and into the daily operation of the company [7].

When the techniques and their applications are considered, it is seen that cleaner production has six main components. These are defined by United States Environmental Protection Agency (USEPA) as;

- Waste reduction
- Non-polluting production
- Production energy efficiency
- Safe and healthy work environments
- Environmentally sound products
- Environmentally sound packaging [5].

2.2. Why Cleaner Production

With the continuing increase of performance-based environmental regulations, increasingly more complex treatment technologies are required that inevitably increased environmental compliance costs. On the other side, although this end-of-pipe approach often simply transfer pollutants from one medium to another, and/or moves the pollutants to another location; pollution prevention minimizes non-production related capital and operational costs. Therefore, in addition to the reduction in waste treatment costs, pollution prevention offers other benefits, both tangible and intangible [2].

Actually, the key difference between pollution control and cleaner production is the timing. In principle, cleaner production targets to abate the pollution before it is created. It should be recognized that, it does not mean that pollution control systems will never be required. Rather than their single use, these management methods should be approached to be steps of an environmental strategy that will provide best management with least cost.

When they are carefully evaluated, it is seen that cleaner production options are cost effective overall. World Bank has estimated that as a rough guide, by cleaner production 20-30% reductions in pollution can often be achieved with no capital investments, and a further 20 % or more reduction can be obtained with investments that have a pay back time of only months [8]. Furthermore, even if the need for capital investments of pollution control and cleaner production are similar, the operational costs of control systems will be more than CP. Thus, CP option will generate savings through reduced costs for raw materials, energy, waste treatment and regulatory compliance [2].

Economically, prior experiences with cleaner production programs have proven that further environmental damage can be averted in a cost-effective manner. Moreover, prior experiences shows that cleaner production programs have been more successful than simple pollution control methods in providing social benefits for the public. Because in long-term, comprehensive restoration of the natural environment increases health and living standards, while creating a safer and more enjoyable habitat for all species [5].

Over the past 25 years, countries have increased their restrictions of treatment and some have increased their surcharges nine fold. BOD_5 surcharges now exceed 66 cents per kilogram in some cities. Realizing this, some plant managers have been able to cut waste discharges to as little as 1 kg of BOD_5 per 1000 kg of milk received [9].

Another opportunity for CP is the reduction of some commonly known tradeoffs between environmental protection-economic growth, occupational safety-productivity, consumer safety-competition in international markets. CP is actually a win-win situation that benefits everyone. It protects the environment, the consumer and the worker while also improving industrial efficiency, profitability and competitiveness [2].

To sum up the reasons to invest in cleaner production; [2]

- Improvements to product and processes;
- Savings on raw materials and energy, thus reducing production costs and increase in profitability;
- Increased competitiveness through the use of new and improved technologies;
- Reduced concerns over environmental legislation;
- Reduced liability associated with the treatment, storage and disposal of hazardous wastes thus reduced compliance cost;
- Reduced risk to workers and to the community;
- Improved health, safety and morale of employees;
- Improved company image;
- Reduced costs of end-of-pipe solutions
- Reduced future clean-up costs;
- Reduced future risk of environmental liability.
- Reduction of tradeoffs such as; environmental protection-economic growth, occupational safety-productivity, consumer safety-competition in international markets.

Although cleaner production presents many opportunities, there are some barriers that preclude its implementation. Most important of them is the reluctance to change behaviors and existing method of production. In fact, the major reason of reluctance is the way of approach to environmental management systems. Cleaner production is seen as an unnecessary economic load since cost of end-of pipe technologies are accepted to be the cost of doing business. Many peoples' first impression is that pollution prevention programs will cost more than the current practices. Even some employees may think that cleaner production initiatives may cause them to loose their jobs. Other barriers are the lack of knowledge, unawareness of benefits, the mismatches of responsibilities in production line between the producing and treating unit, regulatory systems that focus on end-of-pipe solutions.

2.3. Where Cleaner Production Is Applied

The major aim of cleaner production is to increase eco-efficiency and reduce risks for humans and environment. The implementation of cleaner production increases the process efficiencies. Though CP makes it possible to produce the same product with less cost since it is a win-win strategy. Therefore, cleaner production is beneficial especially for developing countries. It provides industries in these countries with an opportunity to increase their production and export capacity with respect to industries using pollution control. Cleaner production depends only partly on new or alternative technologies. Other than technologies, cleaner production is much about attitudes, approaches and management. On the other side, while it is true that cleaner production technologies do not yet exist for all industrial processes and products, it is estimated that 70% of all current wastes and emissions from industrial processes can be prevented at source by the use of technically sound and economically profitable procedures [2].

Many different variables determine the success of a cleaner production program. These factors include the availability of resources, cultural acceptance, acceptance by industry, as well as historical and current governments and markets. Also, the degree to which environment is a national, regional, and local priority is important in terms of the availability of resources. Additionally, technical, financial, scientific, and engineering capacity is important in terms of the approach to the program and the sophistication of it. But the most important of all is the willingness to change since major barrier is the human approach to the concept [5].

2.4. Key Tools Of Cleaner Production

There are many tools to find out the cleaner production opportunities for implementation of CP. Since cleaner production is a newly developing concept, development of its tools and how to utilize them are ongoing processes. In this section the tools that have been most popular up to date will be briefly discussed.

These are;

- Environmental impact assessment
- Life cycle assessment
- Environmental technology assessment
- Chemical assessment
- Environmental audit
- Waste audit
- Energy audit
- Risk audit

2.4.1. Environmental Impact Assessment (EIA)

An environmental impact assessment estimates the possible environmental consequences of a new or a major modification of an existing plant during the planning phase of the facility or modification. As a result of the assessment both impacts and the possible mitigation measures for avoiding impacts are defined. The targets of EIA are [10];

- Identification of the possible adverse environmental impacts;
- Addition of the measures to the project to prevent adverse environmental impacts;
- In addition to the environmental, detection of the economic acceptability of the project by the public ;

- Determination of the additional studies to be done to prevent from adverse environmental impacts and their monitoring mechanisms;
- Ensuring participation of the public to the decision mechanisms related with their environment;
- Assisting the groups that are concerned with the environmental impacts of the project to understand their roles, responsibilities and relationships with other groups.

2.4.2. Life Cycle Assessment (LCA)

A life cycle assessment (LCA) is an evaluation of the environmental effects associated with any given activity from the initial gathering of raw material from the earth until the point at which all residuals are returned to the earth. LCA is used to identify both direct (e.g. emissions and energy use during manufacturing process) and indirect (e.g. energy use and impacts caused by raw material extraction, product distribution, consumer use, and disposal) impacts [11].

LCA is an aid tool to the decision makers, rather than a decision mechanism. LCA is generally performed for products to analyze the production and consumption of goods and services, with the aim of minimizing the use of resources and preventing the production of waste [12]. LCA is also used to develop the criteria of environmental labeling, changing of the raw materials, redesigning of the production processes and equipment to minimize or eliminate the environmental impacts [10].

2.4.3. Environmental Technology Assessment (ETA)

ETA examines the effect of a technology on the natural systems, resources and human health. It may be defined as a part of a technology assessment that will be utilized in an industry, zone or a country. ETA is covered within the concept of below stated issues:

- Strategic environmental assessment that examines the relationship between the policy, plan and programs about development of a technology and environment;
- Environmental impact assessment of facilities;
- Quantitative and qualitative determination of the discharges resulting from use of different industries;
- Life cycle assessment [10].

2.4.4. Chemical Assessment

It is the determination of the potential toxicity of chemicals by using different information sources and databases. Materials Safety Data Sheets and International Program on Chemical Safety are examples to the information sources, which are used to determine the hazards of a chemical on human health and environmental quality. By using these sources, chemical that is less harmful to the environment and human health may be selected.

Chemical assessment may be used as a part of the risk audit (see Section 2.4.8) [10].

2.4.5. Environmental Auditing

Environmental auditing is the most important and often used tool of cleaner production. Its objective is to identify and characterize the waste streams associated with a process or service so that intelligent decisions can be made concerning pollution reductions.

Since it is a very effective tool, it has many versions for different purposes. Management audits or operational audits are used by the mangers to establish companies' environmental policy, where environmental compliance audit is used for detecting compliance with environmental regulations. Other types of auditing which are used commonly (waste auditing, energy auditing and risk auditing) will be discussed in the following sections (Sections 2.4.6-2.4.8). The audits are designed to provide management with complete assessment of the environmental issues. The items that should be addressed are;

- Sources of waste generated (manufacturing and storage facilities);
- Inputs to the process and process efficiencies;
- Types, amounts, and characteristics of the waste streams being generated;
- The frequency of waste generation;
- Fugitive emissions of wastes;
- Waste handling;
- Energy use;
- Housekeeping procedures;
- Record keeping;
- Regulatory status of the waste. [11].

Both for company and the government, environmental auditing is an important mechanism of the environmental management systems since it evaluates the compliance with the environmental policy and standards. This mechanism also provides the company to determine the important measures to be taken for the environmental management at the right time and ensures the prevention from regulatory penalties [10].

2.4.6. Waste Reduction Auditing

Waste reduction audit is a complete account of the wastes from an industry, a plant, a process or a unit operation. In fact, it is the most important analytical tool to be used by companies.

In a waste reduction audit, a material balance for each scale of operation is derived. The waste audit should result in the identification of wastes, their origin, quantity, composition and ways to reduce or eliminate the generation of wastes [12].

A good waste reduction audit;

- Defines the sources, quantities and types of waste being generated;
- Collects information on unit operations, raw materials, products, water usage, and wastes;
- Highlights process inefficiencies and areas of poor management;
- Helps to set targets for cleaner production;
- Permits the development of cost effective waste management strategies;
- Raises awareness in the workforce regarding benefits of cleaner production;
- Increases knowledge of the process;
- Helps to improve process efficiencies.

The main activities in a waste reduction audit are as fallows;

1. Prepare audit procedures
2. Determine process inputs
3. Determine process outputs
4. Derive a material balance
5. Identify waste reduction options
6. Evaluate waste reduction options

7. Prepare a waste reduction action plan
8. Implement the action plan [12].

2.4.7. Energy Audit

Energy audit is a procedure that defines the type and amount of energy used per product, the seasonal and annual changes in the quantity, value of the energy and the amount of loss. It is a part of energy management program that is prepared to reduce the amount of energy expenditures per product.

An energy audit;

- Defines the source, quantity and value of the energy used;
- Determines the amount of energy used per product produced;
- Determines the inadequacies, and weaknesses of the process in terms of energy;
- Determines the targets for energy in terms of savings;
- Helps to develop economic and efficient energy strategies;
- Increases the awareness of the employees about the amount of energy used and its value.

As a result of energy audit, an energy management action plan is developed in a process discussed in waste minimization audit and it is implemented. The evaluation of implementation is done periodically to upgrade the plan [10].

2.4.8. Risk Audit

Risk auditing is used for determination of all the risks to the human health, and environmental values by assessing all the components of an activity. Risk assessment, which is an important part of risk management, is composed of five major steps.

- Determination of possible raw material, product and byproduct losses and the risks produced by these on the human health and environmental values.
- Evaluation of the possible adverse effects resulting from these risks.
- Determination of the measures to be taken for eliminating or reducing the losses of raw materials, products and by products.
- Implementation of those measures.
- Monitoring of the implementation and reporting of the positive and negative impacts.

Like waste minimization audit, an action plan is designed as a result of risk audit and it is implemented. The plan is improved continuously by monitoring and detecting the deficiencies of the plan [10].

CHAPTER III

OVERVIEW OF DAIRY PROCESSING

3.1. Process Overview

3.1.1. Milk Processing

Raw milk is generally received at processing plants in milk tankers, aluminum or steel cans or in plastic barrels.

At the central collection facilities, the quantity of milk and the fat content are measured. The milk is then filtered and/or clarified using centrifuges to remove dirt particles as well as udder and blood cells. The milk is then cooled using a plate cooler and pumped to insulated or chilled storage vessels, where it is stored until required for production.

Steps of market milk production starts with separation and standardization. Dairies that produce cream and/or butter separate fat from the raw milk. Separation takes place in a centrifuge, which divides the milk into cream with about 40% fat and skimmed milk with only about 0.5% fat. The skimmed milk and cream are stored and pasteurized separately. Standardization is achieved by the controlled remixing of cream with skimmed milk to achieve a determined fat content. Finished milk in Turkey has fat content of approximately 3.8% [13].

Standardized milk is pasteurized to disinfect the microorganisms. Pasteurization may be done either in batch or in continuous process. In the batch process, milk is heated to 63-66 °C for at least 15 seconds, whereas in continuous pasteurizers temperature rises to 85- 90°C. For both batch and continuous processes, the milk is cooled to below 10°C immediately after heating.

The batch method uses a vat pasteurizer, which consists of a jacketed vat, surrounded by either circulating water, steam or heating coils of water or steam.

Continuous process method has several advantages over the vat method, the most important being time and energy saving. For most continuous processing, a high temperature short time (HTST) pasteurizer is used. The heat treatment is accomplished using a plate heat exchanger (PHE), details of which can be seen in Figure 3.1.1 [14]. PHE pasteurizers are more energy efficient than batch pasteurizers because the heat from the pasteurized milk can be used to preheat the incoming cold milk (regenerative counter-current flow) [2]. This piece of equipment consists of a stack of corrugated stainless steel plates clamped together in a frame. There are several flow patterns that can be used. Gaskets are used to define the boundaries of the channels and to prevent leakage. The heating medium can be vacuum, steam or hot water [14].

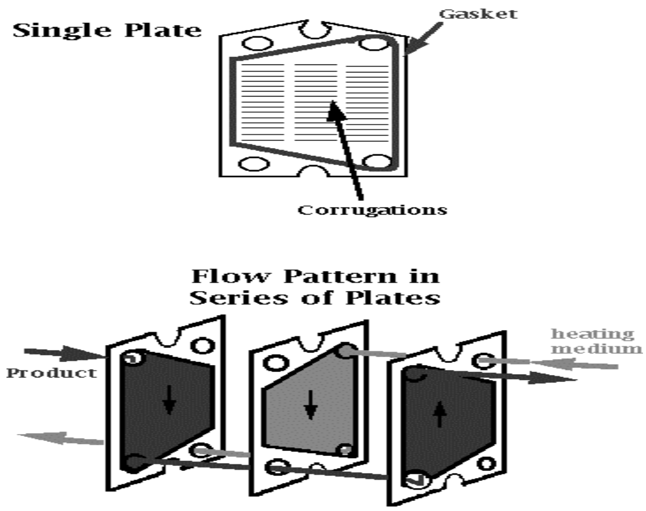

Figure 3.1. 1. Plate heat exchanger [14]

Another method of continuous pasteurization is UHT (Ultra High Temperature) sterilization, which takes place in plate-type heat exchanger. The UHT sterilization conditions are 130 °C for 2 seconds, but long life milk is heated up to 150°C for through sterilization and packed with sterilized filling machines [15].

After pasteurization, for some products milk is homogenized using a pressure pump, which breaks up the butterfat globules to a size that keeps them in suspension [2].

Milk is then deodorized to remove taints and odors from the milk, if required. In deodorization process, either steam may be injected into the system under vacuum or only vacuum alone may be used in case of small problems.

Pasteurized milk is packaged or bottled in a number of types of containers, including glass bottles, paper cartons, plastic bottles and plastic pouches.

Finished products are held in refrigerated storage until dispatched to retail outlets. The storage temperature depends on the product, but for milk and fresh dairy products, the optimum temperature is usually <4°C [2].

The flow diagram of milk processing steps is presented in Figure 3.1.2.

3.1.2. Cleaning Process

After packaging has finished, daily cleaning of equipments starts. Ensuring hygiene of the medium and the product is very important in food processing. This is especially important in dairy sector since contamination may result in impairment of the quality of milk and loss of raw material and product. For preserving hygiene, regular cleaning of the equipment and medium should be done, which should cover the cleaning requirements defined by the regulating authority.

Cleaning may be either manual or by using automated systems like CIP (Clean In Place, see Section 3.2.1.5).

Manual cleaning is still common in dairies and can offer scope for significant water savings. Methods include the use of hoses, pressure washers and conventional bucket techniques [13]. Plastic or wire crates are washed in crate washer with a sequence of rinsing with cold and warm water, washing with a soda solution, and final rinsing with cold water.

Manual cleaning process may differ according to the equipment or area to be cleaned, but basically it is composed of using cleaning chemical or soda and rinsing [2].

In automated systems, the equipment used in production are cleaned simply by pumping cleaning solution and rinsing with water. Some of the equipment may contain nozzles inside to spray the cleaning solution effectively. The cleaning solution drained from equipment may be either pumped to another or may be discharged to sewer. CIP equipment is used to use less cleaning solution and recirculate cleaning waters to certain extend which will allow saving water and detergent [2].

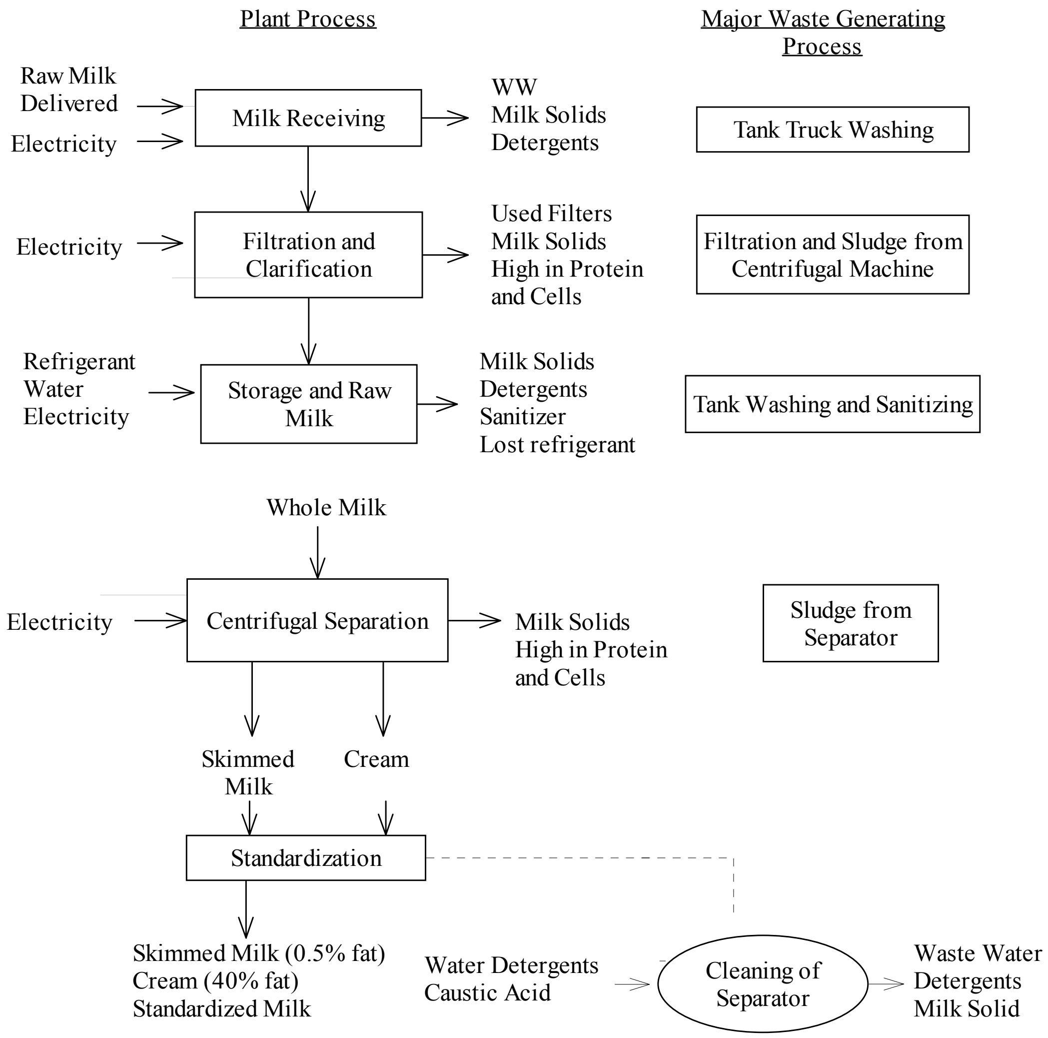

Figure 3.1. 2. Milk processing

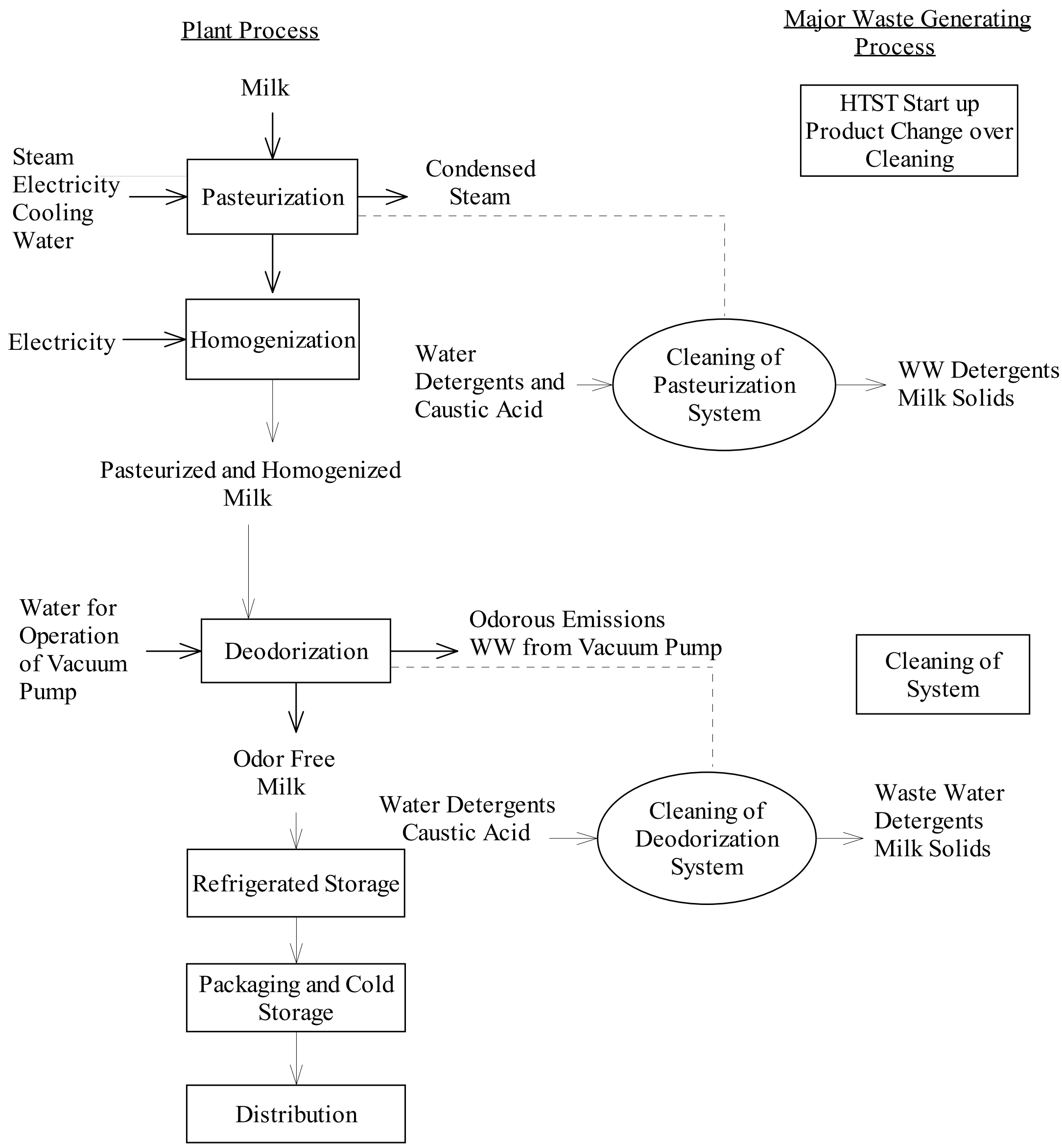

Figure 3.1.2. (continued)

3.2. Environmental Impacts and Possible CP Alternatives

When the major pollutants in the dairy processing wastewater are examined, organic material, suspended solid waste (i.e. coagulated milk, particles of cheese curd, in icecream plants pieces of fruits and nuts), phosphorus, nitrogen, chlorides, heat and acid or alkali content of liquid wastes are determined.

pH, Acidity and Alkalinity [6]

The pH of the raw dairy wastewaters varies from 4.0 to 10.8 with an authentic mean of 7.8. The main factor affecting the pH of dairy plant wastewaters are the types and amount of cleaning and sanitizing compounds discharged to waste at the processing facility. A review of the historical effluent data from the local operating facilities indicates that many of the reported process wastewaters had been consistently exceeded a pH value of 11.5.

Temperature [6]

In general, the temperature of the wastewater will be affected primarily by the degree of hot water conservation, the temperature of the cleaning solutions and the relative volume of cleaning solution in the wastewater. Higher temperatures can be expected in plants with condensing operations, when the condensate is wasted. The temperatures of raw dairy wastewaters are shown in Table 3.2.1.

Table 3.2.1. Temperatures of raw dairy wastewaters

Temperature	High	Low	Mean
Measurement - °C	38	8	24

The pollutants indicated above are originated from the materials wasted, which are basically;

1. Milk and milk products received as raw materials,
2. Milk products handled in the process and end products manufactured,
3. Lubricants (primarily soap and silicone based) used in certain handling equipment,
4. Sanitary and domestic sewage,
5. Non-diary ingredients (i.e. Sugar, fruits, flavors, nuts, and fruit juices),
6. Milk by products (i.e. Whey and sometimes buttermilk).

Organic composition of the waste is mainly due to milk solids, namely fat, lactose and protein. Cleaning agents used include alkalis and acids in combination with surfactants, phosphates, and calcium sequestering compounds. On the other side, sanitizers used in dairy facilities include chlorine compounds, quaternary ammonium compounds, and in some cases, acids. Lubricants used are mainly soap or silicone based soap and contributes to BOD_5 [2]. Milk loss to the effluent stream can amount to 0.5-2.5 % of the incoming milk, but can be as high as 3-4% [16].

The organic pollutant content of dairy effluent is commonly expressed as BOD_5 values. One liter of whole milk is equivalent to approximately 110,000 mg BOD_5 [16].

When two major pollution sources are compared, the pollution is mainly due to the milk and milk products rather than cleaning wastes. This result is illustrated in the Table 3.2.2.

Table 3.2.2. Estimated contribution of wasted materials to the BOD_5 load of dairy wastewater (Fluid Milk Plant) [16]

	kg BOD_5/1000 kg Milk Equivalent Processed	Percent
Milk, milk products, and other degradable materials	3.0	94%
Cleaning products	0.1	3%
Sanitizers	Undetermined, but probably very small	--
Lubricants	Undetermined, but probably very small	--
Employee wastes (Sanitary and Domestic)	0.1	3%
TOTAL	3.2	100%

"The disposal of whey produced during cheese production has always been a major problem in dairy industry. Whey is the liquid remaining after the recovery of the curds formed by action of enzymes on milk. It comprises 80-90% of the total volume of milk used in the cheese making process. Whey contains more than half the solids from the original whole milk, including 20% of the protein and most of the lactose. It has a very high organic content, with a COD of approximately 60,000 mg/L." [2] The characterization of dairy wastewater for whey and other sources are illustrated in Table 3.2.3.

In Turkey, main issue in environmental aspects is determined as cheese whey. Treatment of whey is concerned as very expensive choice and therefore examination of reuse alternatives is suggested. Although whey is currently being used in production of biscuits and chocolates, the use of whey in the nutrition of animals should be examined [17].

Table 3.2.3. Characterization of dairy wastewater [2]

Pollutant	Whey	Other waste water
BOD5 (mg/L)	25000-38000	1000-1200
COD (mg/L)	32000-62000	1400-1600
Suspended solid (mg/L)	3440-4000	615-630
pH	4.46-5.52	6.5-8.0
Total Kjeldahl Nitrogen (mg/L)	260-591	69-88
Total Phosphorus	4.00-28.7	2.0-3.0
Anionic y.a.m (mg/L)	-	3.6
Oil and grease	900-1200	-

A Danish survey found that the effluent loads form dairy processes changes according to the type of product being produced. Also the scale of operation and type of process (batch or continuous) have influence, especially for cleaning. Since the batch operations require more frequent cleaning, continuous systems are advantageous on unit production basis [2].

Performance benchmarks relate effluent parameters to a unit of production and thus they are independent of the volume of production. They provide a useful indication of how well company is performing [13]. As an example of performance indicators; World Bank has calculated the achievable limits of product loss for dairies, which are summarized in the Table 3.2.4.

Table 3.2.4. Product loss benchmarks [8]

Operation	Product losses (% of volume of product)		
	Milk	Fat	Whey
Consumer milk	1.90	0.70	N/A
Butter with skimmed milk transported off-site	0.17	0.14	N/A
Butter and skimmed milk powder	0.60	0.20	N/A
Cheese	0.20	0.10	1.6
Cheese and whey	0.20	0.10	2.3
Full cream milk powder	0.64	0.22	N/A

3.2.1. Waste Sources

The sources of waste in a dairy can be summarized as in Table 3.2.5 [2].

Table 3.2.5. Sources of milk losses to the effluent stream [2]

Process area	Source of milk loss
Milk receipt and storage	• Poor drainage of tankers • Spills and leaks from hoses and pipes • Spills from storage tanks • Foaming • Cleaning operations
Pasteurization and ultra heat treatment	• Leaks • Recovery of downgraded product • Cleaning operations • Foaming • Deposits on surfaces of equipment
Homogenization	• Leaks • Cleaning operations
Separation and clarification	• Foaming • Cleaning operations • Pipe leaks

Table 3.2.5. (continued)

Process area	Source of milk loss
Market milk production	• Leaks and foaming • Product washing • Cleaning operations • Overfilling • Poor drainage • Sludge removal from separators/clarifiers • Damaged milk packages • Cleaning of filling machinery
Cheese making	• Overfilling vats • Incomplete separation of whey from curds • Use of salt in cheese making • Spills and leaks • Cleaning operations
Butter making	• Vacreation and use of salt • Cleaning operations
Milk powder production	• Spills during powder handling • Start-up and shut-down processes • Plant malfunction • Stack losses • Cleaning of evaporators and driers • Bagging losses

On the other side, environmental loads from the above stated operations are illustrated in Table 3.2.6.

Table 3.2.6. Wastewater characteristics from different processes (mg/L)

	Intake and pasteurization	Cheese production	Butter production	Casein production	Combined waste characteristics
pH	8.2	6.7	7.1	7.7	8
Color	white	white	brown	white	white
Total Solids	3640	2300	3460	680	1690
Volatile solids(%)	77	29	72	62	67
Suspended Solids	1320	600	2240	160	690
Alkalinity as $CaCO_3$	500	490	450	490	590
BOD	1820	2150	1377	200	816
COD	2657	3188	3218	372	1340
Total-N	-	-	-	-	84
Total-P	10	12	2	5	12
Oil and Grease	690	520	1320	-	2290

Note: Source industry of analysis processes 360,000L/day raw milk.

Wastewater production: 6-8 L/L milk processed

Temperature: 29.5-25.5 °C

3.2.1.1. Milk Intake

After intake of milk, during cleaning, tanker rinses contain high amount of COD and fat which points at an important CP opportunity (see Table 3.2.7). Dairy automation systems could be used to help recover rinses from tankers, tanks and lines. It is reported that, a 22.7 m^3 raw milk tanker normally was rinsed with 950 L of water and this rinse contained 4.13 kg BOD_5. An initial 114 L burst-rinse could recover 3.4 kg BOD_5. The rinse contained 1.5% butterfat and reduced the receiving process BOD_5 coefficient by 0.05 kg BOD_5 /1000 kg milk received. The fat content was observed to be 3.4% butterfat for high solids products or rinses from tank trucks, which has over 1 hour before unloading [16].

Table 3.2.7. Indicative pollution loads from milk receival area, washing of tankers and milk separation [2]

	Main Product	Wastewater (m^3/tone milk)	COD (kg/tone milk)	Fat (kg/tone milk)
Milk Receiving	Butter plant	0.07 – 0.10	0.1 – 0.3	0.01 – 0.02
	Market milk plant	0.03 – 0.09	0.1 – 0.4	0.01 – 0.04
	Cheese plant	0.16 – 0.23	0.4 – 0.7	0.006 – 0.03
	Havarti cheese plant	0.60 – 1.00	1.4 – 2.1	0.2 – 0.3
Washing of Tankers	Market milk plant	0.08 - 0.14	0.2 - 0.3	0.04 - 0.8
	Havarti cheese plant	0.09 - 0.14	0.15 - 0.40	0.08 - 0.24
Milk Separation	Butter plant	0.20- 0.30	0.3- 1.9	0.05- 0.40
	Market milk plant	0.30- 0.34	0.1- 0.4	0.01- 0.04
	Cheese plant	0.06- 0.30	0.2- 0.6	0.008- 0.03
	Havarti cheese plant	0.60- 1.00	1.4- 2.1	0.2- 0.3

In large dairies with milk receipts into 75 m^3 or larger silo tanks, a 75-150 L water may be used for rinsing the tanker and flushed to the silo where legally acceptable. This should not exceed the dilution factor of 0.1% [16].

3.2.1.2. Clarification

Solid waste is generated from old technology milk clarification process and consists mostly of dirt, cells from the cows' udders, blood corpuscles and bacteria. For standard separators the sludge is removed manually during the cleaning phase, while in the case of new self-cleaning centrifuges it is discharged automatically. If the sludge is discharged to the sewer along with the effluent stream, it greatly increases the organic load of the effluent [2].

3.2.1.3. HTST Pasteurization

Another environmental issue is the amount of milk- solids discharged in the start-up, changeover, and shut down of HTST pasteurizers and the solids coming from returned products. HTST systems are heated to the required temperature (90 ºC) by circulating hot water in the system before starting operation. When the system is to be shut down, water is again used to purge the system and for initial rinsing of cleaning. During these operations, product is diluted during each start-up, switch over, or shut down which is to be disposed of.

Up to 1 kg of BOD_5/ 1000 kg of milk processed could be eliminated through collection and utilization of these solids. In case of highly viscous products like cream, this ratio increases and may be as high as 3 kg/1000 kg of product in some plant operations.

The recovered solids may be used in ice cream mix or any other products where solids must be added to the material. Reverse osmosis may also be utilized to concentrate the materials but this will require additional membrane technology [16].

A HTST recycle system could save 44% of the BOD_5 generated in the pasteurization process and though the BOD coefficient will be reduced from 0.80 to 0.45 kg BOD_5/1000 kg milk processed. On the other side, using a centrifugal machine in the form of clarifier-separator in combination with the HTST system eliminates the intermediate process vats from processes or of fluid milk products. By this way, product change overs could be made with no discharge, and this eliminates product loses with BOD of 0.2 kg BOD_5/ 1000 kg milk processed. This value increases for higher viscosity products i.e. for cream it is 3 kg BOD_5/1000 kg milk [16].

Harper et al. (1971) indicates that lubricants, milk from filling areas, solid particles from cottage cheese operations, HTST (High Temperature Slow Time Pasteurization) discharge and CIP discharges would all be areas to consider segregating and combining into a high strength waste.

As a mean of waste segregation, fats can be prevented from entering waste streams by using save-alls, centrifuges and grease traps [18].

Save-alls are generally defined as receptacles for catching the waste products of a process for further use in manufacture. The function of save-all is to remove fines and other solids from water that it can be reused. Clarified water from save-all also may be discharged to wastewater treatment, minimizing the loss of solids from process. The most widely used types of save-alls use disc screens or drum screens. Dissolved air floatation equipment is also used for floatation save-alls [19].

Steam condensate, produced due to heating the water to be circulated in system, is often considered as a waste by dairies and discharged to drain with the loss of valuable heat. However, it can be used for pre-heating, thus reducing energy costs. A good example is; using it for pre-heating milk prior to pasteurization in older equipment where pre-heating is not already a feature. After the heat has been removed, the water can be re-used in low-grade applications, e.g. pre-rinsing or crate washing [13].

3.2.1.4. Packaging

The material of packaging is also an increasingly important issue. Although glass bottles can be cleaned and recycled (thereby creating minimal solid waste), cleaning them consumes water and energy. Glass recycling systems require large capital investments and involve high running costs since the bottles must be collected, then transported and cleaned. Glass bottles can also be inconvenient for consumers because they are heavier and more fragile than cartons [2].

Cartoons on the other side, create solid waste to be disposed of which may be disposed to a landfill, incinerated or composted. But all of these alternatives have other environmental impacts like leachate or air pollution [2].

3.2.1.5. Cleaning

In the dairy industry, cleaning water can account for 50 - 90% of the site's water consumption. Optimizing the use of water and cleaning chemicals can significantly reduce costs without compromising cleaning efficiency [13].

Most important component of CP opportunities for cleaning are the opportunities prior to cleaning which will decrease the amount of pollutant produced [13].

Clean in Place (CIP) System

CIP is the automated type of cleaning. General procedure of a Clean-In-Place system into operation is as follows;

- The CIP unit is turned of and drained of any fluids. While single-pass units are self draining, multi-pass units may require special drain holes.
- The pre-selected cleaning solution is circulated in the unit through bottom-to-top flow to totally flood the unit and prevent channeling.
- When it is determined that the solution is no longer reacting with the substances inside the unit, the cleaning is deemed to complete.

- The unit can now be drained again and, if necessary, rinsed with water, and then returned to service [20].

Due to CIP principle there are four critical factors to be maximized for effective cleaning of solids or liquids from hard surfaces. These factors are; time, temperature, mechanical action and chemical activity. The efficiency of these factors may be changed internally satisfying all add up to 100%.

Time is important since solubility of each solid/ liquid may change which will effect the rinse time required. Generally increased temperature of water increases the rate of dissolution which will reduce the cleaning cycle time and water consumption. Water for cleaning the tanks are generally sprayed by spraying devices with varying pressures to occur turbulence in the water and the water film on hard surfaced.

For achieving required pressure spray balls, rotating jet cleaners or orbital cleaners may be used. Rotating jet cleaners are the equipments that operate at higher pressures available by compressing air, water or cleaning solution. Orbital cleaners operate at very high pressures to spray a pencil thin jet of cleaning solution. They rotate gradually to clean the surface step by step [21].

As the last factor of CIP efficiency, chemical activity that is available by using cleaning chemicals (detergents, caustics and acids) have the function of reducing time and volume of rinse water required [21].

Basic piping and valve scheme for a stationary Clean-In-Place system can be seen from Figure 3.2.1.

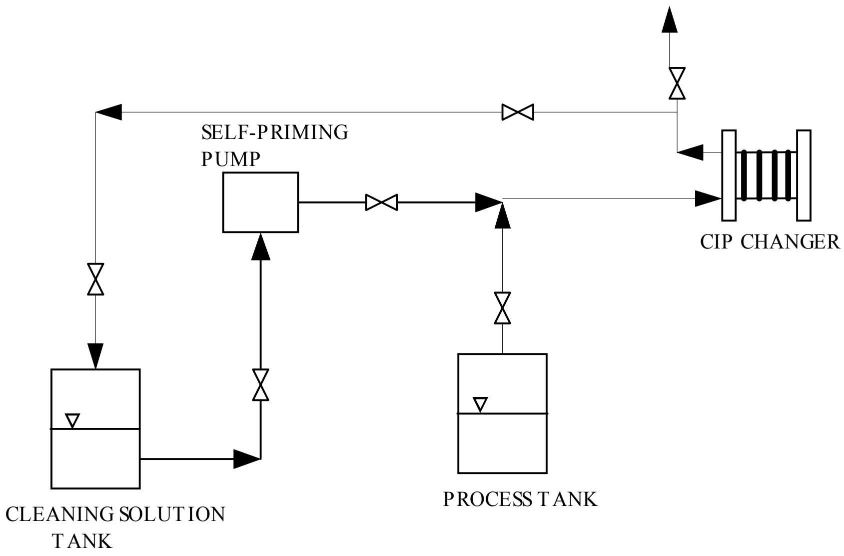

Figure 3.2. 3. Basic piping and valve scheme for stationary CIP system

CIP equipment may be designed as simple systems where a batch of cleaning solutions is prepared to be pumped and drained or as fully automated systems containing different tanks of cleaning solution and water.

In the modern CIP systems there are three tanks of hot water rinsing, alkaline cleaning solution (caustic soda) and acidic rinses (nitric acid). In modern type, cleaning solutions are heated by steam. The equipment to be cleaned is first isolated from product flows and prepared cleaning solutions are pumped through the vessels and pipes and the system is rinsed. Simpler CIP systems may consist only one tank and a pump [2].

For the dairies without CIP systems, the main initiative for CP is installing these equipment due to its various benefits such as recovery and reuse of cleaning solutions, controlling quality of cleaning solutions if in-line monitoring systems are fitted which will maximize the use efficiency of detergents and minimize the water consumption. Therefore, controlling the optimum operational settings is important to reduce water and detergent consumption. (See Table 3.2.8 Case study 4, for benefits of example application of CIP system)

Although water consumption is very high in these systems, they are preferred since they are more effective than hand cleaning. In terms of water consumption, this system uses potable water in the operation and the amount used depends on the type of the system installed and time of rinse. Most modern dairy plants have at least two and possibly three or more CIP systems. When the process is approached from an environmental point of view, it is seen that as the processes in dairy industry are automized and CIP systems are installed, waste loads are decreased. Harper at all observed that as plants incorporated CIP and processes automation capabilities, proper design of plants and processes can afford material reductions in waste loads. Theoretically effect of advanced technology on waste reduction was calculated to be from 2.6 kg BOD_5 / 1000 kg milk to 0.5 kg BOD_5 /1000 kg milk [16].

If the CIP system involves pH control, it is also important to optimize chemical additions to minimize pH fluctuations in the effluent. Otherwise, excessive amounts of chemicals will be needed to control the pH of the effluent. As an example to the chemical control see Table 3.2.8, Case study 7 [13].

Although an optimum amount of detergent consumption is to be determined prior to CIP operation, monitoring of chemical consumption is also important for the pollution load from CIP cycles since detergents and disinfectants can be significant components of pollution load. For assessing the costs and benefits of such chemicals chemical suppliers should be consulted.

The materials used in sanitizing the production area and equipment has two effects on environment. In addition to their toxicity to biological treatment process, they represent a BOD demand. The value of this pollution load is nearly 0.65 kg BOD_5/kg of substance for surfactants.

As a means of CP, recirculation of the fluid containing these compounds decreases the pollution amount. Final use area for the captured liquids may be floor cleaning or use as the fluidizing liquid in sludge pumping [16].

In milk processing facilities, cleaning is done basically by alkaline solutions. After breaking down of residues that are stuck internal surface of equipments and piping, acid wash is done to prevent formation of milk stones and to drop pH of the medium to remove alkalinity [22]. Although caustic is one of cheapest chemicals used it is not effective as special chemicals produced for these purposes. Basic deficiencies of caustic are;

- It cannot influence into the dirt effectively,
- Cannot hold non-dissolved particles suspended
- Sticks and the surfaces and produces much foam
- Rinsing is hard and requires much water
- May cause to become calcareous
- Corrosive to soft metals
- Freezes at +5°C
- Results in disposal of highly alkaline solutions

On the other side, special chemicals overcome the deficiencies listed above and cost of cleaning is less since;

- Use of water for rinsing and disinfecting is less
- Less workers pay

- Less wastewater produced
- No contamination with product since it does not stick on surfaces [22].

Changing of raw materials and inputs from more hazardous substance with a substitute that is more environmentally friendly is one of the major methods of CP, which results in very considerable benefits from environmental point of view. On the other hand, the decision of changing raw materials is a strategic point since their costs are outside the manageable side of the company and they have direct effect on profitability [18]. In AOC study, this opportunity was utilized for replacing the cleaning chemicals used in facility.

CIP systems provide excellent opportunities to re-use the final rinse water as a pre-rinse. Although the final rinse may, high quality water is not required for the pre-rinse (designed to remove solids before the main cleaning cycle). To evaluate the potential benefits of re-using final rinse water, compare the cost of installing the necessary pipe-work and a holding tank with the anticipated savings in water and effluent costs.

Caustic and acid solutions from CIP of operations can be re-used following the removal of fine particles, color and BOD/COD using nanofiltration membranes [13].

Although cleaning process produces the largest quantity of environmental load, with CIP systems, water use and effluent generation can be minimized in a number of ways [13]. The items to be taken into consideration during running CIP system for effluent reduction are listed in Worksheet B-3 in Appendix II.

Pigging Systems

As it is indicated in Section 3.2.1.3, there is important amount of milk solids discharge during start-up, change over of systems during operation and cleaning. A ‘pigging’ system is the most effective method of purging a pipe. Such systems remove product from a line using a ‘ram’ (or pig) and without using any water. Pigging systems can be used in most processes and offer good paybacks [13].

A pigging system normally uses water or air to propel a rubber bullet, the pig, along a length of pipe and hence forces any residual product from the line. This results in reductions in the effluent. It can also be used to provide a physical interface between different products, enabling faster change-overs between production runs. The technique of pigging originated in the petrochemical industry where residual waste product has an extremely high value [23]. A schematic view of the system is shown in Figure 3.2.2.

Pigging systems may be used to remove product residues from internal surfaces of pipeline prior to cleaning. This may allow to decrease the pollutant load of the cleaning and be an initiative for product recovery [13].

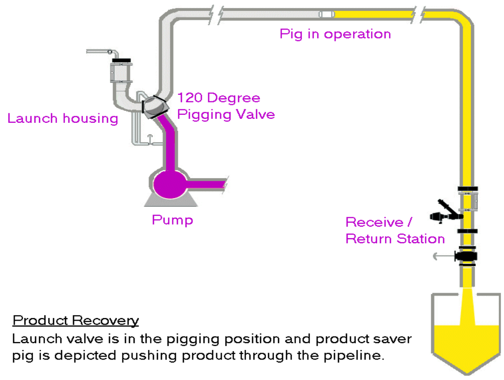

Figure 3.2. 4. Pigging system in operation

Since water discharge during cleaning is more than 50%, use of spray nozzles makes a significant difference in water use. Spray nozzles work with pressure, which causes deterioration of their orifices which leads to increased water consumption. In general 10% deterioration of nozzle will result in 20% increase in water consumption.

The measures of cleaner production discussed above and other CP opportunities in the area of cleaning are listed in Worksheet B-3 in Appendix II. Besides these measures, the results of application of various CP opportunities about cleaning are summarized in Table 3.2.8.

Table 3.2.8. Example case studies for cleaning opportunities

CP Measure	CASE
1- Improved operation and monitoring of the CIP equipment	In a Dutch dairy, an analysis of the custard preparation and filling units found that a significant cause of product loss was the cleaning of the pipes and machines. Consequently, monitoring equipment was installed in the cleaning circuits to measure the conductivity and temperature of the rinse waters. The company modified its procedure by installing a level controller, lowering the temperature of the heat exchanger, shortening the cleaning program by 20 minutes, and buying a new software program to monitor the system. As a result of these changes, consumption of cleaning agents was reduced by 23% and the organic load of effluent discharged to sewer fell significantly. Expenditure on detergents fell by US$28,500/year and effluent charges by US$4200 a year. The capital outlay required for the system was US$3150, so the payback period was only one month [2].
2- Replacement of nitric and phosphoric acids	An Australian dairy was using a mixture of nitric and phosphoric acids for its CIP operations. The company found that 200 liters of these acids were being used each day, eventually ending up in surface drains. The potential risks to the nearby river motivated the company to look for other cleaning agents. The company found a new cleaning compound that, when used with caustic soda, virtually eliminated the need for an acid wash. Only 150 liters of the new compound was needed and the wash time was reduced by 25%. The reduction in wash time meant an increase of 1.5 production hours a day. Overall savings from switching cleaning chemicals amounted to US$220 per day [2].

Table 3.2.8. (continued)

CP Measure	CASE
3-Improved operation procedure in yogurt production	In a Dutch dairy, rinsing after each batch of yogurt was resulting in significant product loss and an over-consumption of water. To improve this situation, the dairy modified its process by allowing each batch to drain out and then mixing the remaining product with the next batch. Only 50 liters of 'mixed' product had to be sold as cattle feed, compared to 110 liters ending up as wastewater. By not rinsing between batches, 12,500 liters of product a year was recovered, resulting in a cost saving of US$4,600. Effluent treatment costs fell by US$2,100 and water charges by US$800. The dairy saved US$7,400 per year with no capital investment or loss of product quality [2].
4-Dairy reduces effluent COD/tone of milk processed by 65% by monitoring	Many dairies monitor the amount of biodegradable material in their effluent per tone of milk processed. For example, over the last five years Taw Valley Creamery has reduced this 'effluent to milk factor from 7.9 kg COD/tone of milk processed to 2.5 kg COD/tone of milk. This reduction has been achieved by decreasing product loss and improving the CIP system [13].
5-Major benefits from new detergent system	The acid solution used by an Australian dairy in its CIP system contained nitrates and phosphates that had implications for its effluent. The dairy examined alternatives and introduced a new detergent, a mixture of cleaning activators, wetting agents and anti-foaming agents. When used in conjunction with caustic soda, the detergent eliminates the need for an acid cleaning stage. The new detergent system uses 25% less water and reduces the cleaning time by 25%, thus decreasing production downtime [13].
6-New CIP controls save US$11,420 /year	Dansco Dairy Products installed new programmable logic controllers on its milk intake CIP system. The new controls allow Dansco to optimize CIP water use by adjusting the time settings. Water consumption has fallen by 24 m^3 /day - a saving worth US$ 11420 /year. The new controls cost US$13,052, giving a payback period of just over a year. Plans to make similar changes to Dansco's larger CIP systems are expected to produce even greater savings [13].
7-pH control produces significant savings	At Dansco Dairy Products, careful control of the CIP chemical dosing system maintains the pH of the effluent entering the ETP (effluent treatment plant) in the range pH 5-7. Improved control has reduced the amount of balancing chemicals required, saving an estimated US$27,735/year compared to previous performance. After allowing for the costs of extra sampling, net savings are estimated at US$24472/year [13].

US$1.63=1£ (TC Ziraat Bank A.S., 27.1.2003)

3.2.2. Water Use

Since hygiene is crucial, water is the most important auxiliary raw material of dairy processing. As in most food processing facilities, water is used extensively in dairy for cleaning, and sanitizing plant and equipment to maintain hygiene, cooling products, make-up for products, and for employee needs [16]. Typical values of wastewater generated range from 0.5 to 37 m^3 wastewater per m^3 of milk processed, worldwide. With good waste management procedures 0.5 to 2.0 m^3 wastewater per m^3 milk can be achieved [24]. When the trend towards water consumption at dairy processing plants is examined it is seen that although 3.25 L of water is used on average in year 1973, this number falls to 1.3-2.5 in year 1990 for 1 kg of milk. Table 3.2.9 shows the areas of water consumption and its extend [2]. Minimizing water use is one of the most important opportunities for efficiency since it will reduce water purchase costs, the costs of effluent treatment or disposal and the waste of valuable product.

Table 3.2. 9. Areas of water consumption at dairy processing plants [2]

Area of use	Consumption (L/ kg product)	Percentage of total
Locker room	0.01-1.45	2%
Staff use	0.02-0.44	2%
Boiler	0.03-0.78	2%
Cold storage	0.03-0.78	2%
Receipt area	0.11-0.92	3%
Filling room	0.11-0.41	3%
Crate washer	0.18-0.75	4%
Cooling tower	0.20-1.8	5%
Cleaning	0.32-1.76	8%
Cheese room	0.06-20.89	13%
Utilities	0.56-4.39	16%
Incorporated into products	1.52-9.44	40%
TOTAL	2.21-9.44	100%

The losses that occur due to holes in water pipes and running taps can be considerable. Table 3.2.10 shows the relationship between size of leaks and water loss.

Table 3.2.10. Water loss from leaks at 4.5 bar pressure [2]

Hole Size (mm)	Water Loss (m^3/day)	Water Loss (m^3/year)
0.5	0.4	140
1	1.2	430
2	3.7	1300
4	18	6400
6	47	17000

Water consumption can be reduced by 10–50% simply by increasing employees' awareness and by educating them on how to reduce unnecessary consumption [2].

Using automatic shutoff valves on all water hoses will prevent waste when hoses are not in use. A running hose can discharge up to 1.13- 1.51 m^3 of water/hour. See Table 3.2.11 for examples of implementation [18].

Practices of water reuse are very common since the amount of water consumed is nearly three times of the milk volume processed. Water should be free of microorganisms, toxic/harmful chemicals, color and odor to be recirculated if it will be in contact with food [12].

For successful results, careful planning with well-defined objectives is required to create resources from wastes. Food as particulate matter is often separated from liquids by settling, screening, skimming, or centrifuging. In addition to the possibilities in recycle, area for recovery of reject, spoiled materials, off-site reuse/recycle is an obvious environmental benefit. The most promising option for collected particulate matter by these processes is use of them in animal foods.

Water saving ideas discussed in this section and other opportunities for water saving are listed in Worksheet B-1.2 in Appendix II. Results of example case studies about general CP ideas are given in Table 3.2.11.

Table 3.2. 11. Example case studies for general CP ideas[1] [11]

Water Saving Idea	
Automatic shutoff valve	Installation of self-closing hose nozzles at one factory with an initial investment of US$ 1,070 gave annual savings of US$1,965, giving a pay-back period of 6.5 months.
Automatic shutoff valve	At one factory, using average monthly water consumption values, an initial investment of US$1,310 in automatic shut-offs for hoses resulted in annual savings of US$3,493.
Condensate recovery	In a factory the condensate is recovered with an initial investment of US$8,733. Annual benefits of US$7,205 were generated, giving a pay back period of 15 months. When factory is working at full capacity, the annual savings would increase to US$14,410.
Automatic shutoff nozzles Cooling tower Rehabilitation of water collection system	The industrial audits recognized that many firms in Egypt had severe problems with water usage and lack of systematic policies in place to manage water utilization. A project was designed to alleviate these problems and show that effective water and steam use, including low cost and easily implemented measures could bring about large savings to the firm. An implementation of the project is done in Edfina Preserved Foods company. Industrial audits picked up on the fact that substantial problems existed in the sector with water use and misuse and there was lots of scope for improvement with minor interventions. Advices to the company were; _ Automatic shut-off nozzles installed on hoses around the factory. _ Cooling water deficiency in the juice line was noted and a cooling tower installed. _ Rehabilitation of the Dowe Pack water collection system. Water conservation is expected to save some 119,400 tons/annum of water with an approximate payback time of less than one year. Loads on treatment systems or sewers will be proportionately lower. This significant saving in water will have been achieved by replacing the once through water cooling system by a recirculating cooling tower. Also condensate recovery is being started. The effect of such intervention on staff is expected to flow through as staff members start to become aware of the savings that can result from conserving water. Such savings will ultimately result in a better company performance and a better employment workplace.

Table 3.2.11. (continued)

Effluent Load Reducing Idea	
Level control with automatic shut off	Actioning these 2 items in a dairy factory in Egypt has resulted in annual savings of US$27,511, for an initial investment of US$14,028.
Energy Saving Idea	
Housekeeping	In Egypt, under the SEAM project Kaha Factory water and energy use was studied. For energy the followings are recommended to the factory management; _ Insulation of bare steam lines. _ Replacement of leaking steam traps. _ Pressure regulators installed. _ Repair and replacement of leaking steam valves replaced. _ Condensate return system installed. If the calculated amount of energy savings result, this will mean Solar (diesel) usage is reduced by 788 t/a, corresponding to annual savings of over US$77,292. Obviously significant savings will pass on to the environment as this represents a large reduction in fuel usage, if all the calculated savings result.
Reuse/ Recovery Ideas	
Reverse Osmosis	Use of reverse osmosis permeate saves US$22,005/year Dansco Dairy Products uses water from a reverse osmosis plant to feed its hose network. This reduces the site's demand for mains water by an estimated 50 m^3 /day, saving US$22,005/year.
Re-using water to wash crates	A dairy has implemented a series of measures to minimize effluent, including reducing product waste and re-using lightly soiled water for washing bottle crates. Effluent costs have been reduced by 50%, saving US$57,050/year.
Steam Condensate	Heat recovery from steam condensate saves dairy US$19,560/year. An Australian dairy used to send steam condensate to drain. Installing new equipment to use the condensate to pre-heat milk prior to pasteurization and then re-using the water in a CIP system, saved the company US$19,560/year. With an initial investment of US$10,595, the payback period for the project was 6.5 months.

[1] 1 US$= 4.58 EGP (Egyptian Pound)

1.63 US$= 1£ (T.C. Ziraat Bank A.S. 27.1.2003)

3.2.3. Wastewater Characterization

Table 3.2.12 summarizes wastewater discharge and corresponding BOD values for various plant operations [2].

Table 3.2.12. Wastewater discharge and corresponding BOD values [2]

Type Operation	kg Wastewater/ kg milk	kg BOD /100 kg Milk Processed.
1. Market milk with initial rinses saved from processes	0.50	0.46
2. Market milk-subprocesses: skimmilk, creams and special milks by continuous process alternatives	1.14	2.2
3. Market milk-subprocesses: Buttermilk, yogurt and sour cream	1.16	Buttermilk-1.85 Yogurt-1.89 Sour Cream- 2.90
4. Butter-churn process	1.45	2.6
5. Butter- continuous process	1.06	1.96
6. Cottage cheese	11.6	2.85
7. Cheddar cheese mfr.	0.77	Cheddar- 1.25 Washed curd- 1.7
8. Cheese- Provolone and Mozzarella mfr.	1.09	1.37
9. Ice cream	1.15	2.09
10. Ice cream novelties- stick	0.37	1.3
11. Ice cream novelties- stickless	0.46	0.95
12. Condensed milk process	11.5	1.88
13. Spray drying process	0.44	1.25

Reuse alternatives of less polluted waters in other areas should be studied, for prevention of wasteful practices, supplying of the optimum amount and discharging of less polluted water directly without treatment. But for using water coming from different sources, they have to be segregated. As a general rule, all plants should be provided with three water discharge systems, namely 1) storm and cooling water, 2) sanitary waste, and 3) industrial waste [16].

The matrix in Table 3.2.13 summarizes water reuse opportunities in dairies.

Table 3.2.13. Water re-use opportunities at a dairy [13]

Re-use activity / *Wastewater*	*Vehicle Washing*	*Crate Washing*	*Manual cleaning of equipment*	*CIP pre-rinse*	*CIP main Wash supply*	*CIP final rinse*	*Water purge of product*
CIP used cleaning solution	***1***	***2***	***3***	***1***	***2***	***3***	***3***
CIP final rinse	***1***	***1***	***3***	***1***	***3***	***3***	***3***
Condensate	***1***	***1***	***2***	***1***	***2/3***	***3***	***3***
Permeate from osmosis plant	***1***	***1***	***1***	***1***	***1***	***1***	***1***

Key: 1 Direct re-use.

2 Some screening of solids required.

3 Re-use after suitable membrane separation.

3.2.4. Energy Consumption

Energy is used at dairy processing plants for running electric motors on process equipment, for heating, evaporating and drying, for cooling and refrigeration, and for the generation of compresses air.

The energy consumed depends on the range of products being produced. For example, processes which involve the concentration and drying of milk, whey or buttermilk are very energy intensive. On the other side, the production of market milk involves only some heat treatment and packaging, and therefore requires considerably less energy. Table 3.2.14 provides some energy figures of different products [2].

Table 3.2.14. Specific energy consumption for various dairy products [2]

Product	Electricity consumption (GJ/Tone product)	Fuel consumption (GJ/tone product)
Market milk	0.2	0.46
Cheese	0.76	4.34
Milk powder	1.43	20.60
Butter	0.71	3.53

Another consideration for the energy consumption is the technology of the plant. This factor is illustrated by the Table 3.2.15. As an example, new and efficient pumps can reduce energy consumption by up to 50% compared with standard pumps. It is very important to select a pump with optimum pumping capacity and position it close to the required pump work [2].

Table 3.2. 15. Energy consumption for a selection of milk plants [2]

Type of Plant	Total Energy Consumption (GJ/ tone milk processed)
Modern plant with high-efficiency regenerative pasteurizer and modern boiler	0.34
Modern plant using hot water for processing	0.50
Old, steam based plant	2.00
Range for most plants	0.5-1.2

Plants producing powdered milk requires evaporation and drying systems, which are major energy consumers. The number of evaporation effects and efficiency of power dryers changes the energy amount.

Ancillary operations are the support processes of a dairy, which it requires during processing of product. These operations cover compressed air supply, steam supply, refrigeration and cooling.

In the process of compressed air supply, since air is pressurized along the pipelines, a small hole in the line leads to large amount of air loss and loss in the pressure of the system. In this case, the electricity used for compressing that air would also be lost. Table 3.2.16 illustrates the amount of electricity lost by leaks in the compressed air system.

Table 3.2.16. Electricity loss from compressed air leaks [2]

Hole Size (mm)	Air losses (L/s)	KW.h/year	MW.h/year
1	1	6	3
2	19	74	27
5	27	199	73

Air compressors are also very noisy equipments exceeding the limits, which may cause some health defects of workers.

For air compressors keeping the optimum temperature conditions by cooling is important. The results of a case study that air cooling is converted to water cooling are summarized in Table 3.2.18, Case study 2.

During the process of steam supply, the combustion process results in production of sulfur dioxide (SO_2), nitrogen oxides (NOx) and polycyclic aromatic hydrocarbons (PAHs). The emission of sulfur dioxide varies according to the sulfur content of the fuel.

Sulfur dioxide has the potential of forming basis for acid rain, which has various detrimental effects to the land, agriculture and natural resources. On the other side, nitrogen oxides contribute to smog and can cause lung irritation.

Recently Turkey has the energy policy of using natural gas, which has lowered values of those pollutants. But since the accessible area of natural gas is limited, those effects are still important especially in rural areas.

Table 3.2.17 illustrates the composition of the burning effluents of a fuel oil.

Table 3.2.17. Emissions from the combustion of fuel oil [2]

Input		Outputs	
Fuel oil (1% sulfur)	1 kg	Energy content	11.5 kWh
		Carbon dioxide (CO_2)	3.5 kg
		Nitrogen oxides (NO_x)	0.01 kg
		Sulfur dioxide (SO_2)	0.02 kg

1kg oil = 1.16 L of oil (0.86 kg/L) & 1kWh= 3.6 MJ

Use of fuel oil with a low sulfur content (less than 1%) increases the efficiency of the boiler and reduces sulfur dioxide emissions. There are no investment costs involved, but the running costs will be higher because fuel oil with lower sulfur content is more expensive.

If the boiler is old, installation of a new boiler should be considered. Making the change from coal to oil, or from oil to natural gas should also be considered. In some burners it is possible to install an oil atomizer and thereby increase efficiency. Although both options (new boiler and atomizer) will often pay back the investment within 5 years, the actual payback period depends on the efficiency of the existing boiler, the utilization of the new boiler, the cost of fuel and other factors.

Insulation of hot surfaces is a cheap and very effective way of reducing energy consumption. The equipment that are often not insulated are; valves, flanges; scalding vats/tanks; autoclaves; cooking vats; pipe connections to machinery [2].

Through proper insulation of this equipment, heat losses can be reduced by 90%. Often the payback period for insulation is less than 3 years. If steam condensate from some areas is not returned to the boiler, both energy and water are wasted. Piping systems for returning condensate to the boiler should be installed to reduce energy losses. The payback period is short, because 1 m^3 of lost condensate represents 8.7 kg of oil at a condensate temperature of 100°C.

In big dairies cogeneration may be an alternative to use energy effectively. Cogeneration involves the combustion of fuel to produce two forms of energy output; typically heat or steam for manufacturing use and electricity.

Results of application of a combination of the issues discussed above are summarized in Table 3.2.18. Benefits of worker training on the boiler efficiency are also shown in the same Table.

In refrigeration and cooling systems a refrigerant, typically ammonia or a chlorofluorocarbon (CFC)-based substance, is compressed, and its subsequent expansion is used to chill a closed circuit cooling system.

The refrigerant itself can act as a primary coolant, recirculated directly through the cooling system, or alternatively, it can be used to chill a secondary coolant, typically brine or glycol. CFCs were once extensively used in refrigeration systems, but they are now prohibited in most countries, and their use is being phased out as a result of the Montreal Protocol on ozone-depleting substances [2].

In refrigeration systems, the consumption of electricity and of water can be quite high. If CFC-based refrigerants are used there is a risk that refrigerant gases will be emitted to the atmosphere, contributing to the depletion of the ozone layer. There is also a risk of ammonia and glycol leaks, which can be an occupational, health and safety problem for workers, but can also result in environmental problems.

Therefore, CFC-based refrigerants should be replaced by the less hazardous hydrogenated chlorofluorocarbons (HCFCs) or, preferably, by ammonia. Replacing CFCs can be expensive, as it may require the installation of new cooling equipment.

Minimizing the ingress of heat into refrigerated areas can reduce energy consumption. This can be accomplished by insulating cold rooms and pipes that contain refrigerant, by closing doors and windows to cold areas, or by installing self-closing doors.

If water and electricity consumption in the cooling towers seems high, it could be due to algal growth on the evaporator pipes. Another reason could be that the fans are running at too high speed, blowing the water off the cooling tower. Optimizing the running of the cooling tower can save a lot of water.

Results of example case studies about reuse of cooling water and upgrading refrigeration systems are given in Table 3.2.18.

Table 3.2.18. Example case studies for ancillary operations CP ideas[1]

CP Idea	CASE
1-Steam Supply	The SEAM Project identified interventions whose savings averaged US$192,360 for an average capital investment of US$94,806. Actions included: [18] – Implementation of suitable preventative maintenance programs. – Regular boiler tuning. – Proper insulation of steam pipes. – Repair of broken and steam pipes and connections. – Heat recovery from boiler blow down water. – Installation of steam flow meters for each processing department. – Proper storage and transfer of mazot, to avoid wastage through leaks and spills. – Recovery of steam condensate. – Installation of pressure regulators on steam lines. Typical modifications for energy conservation include: – Fluidized bed boilers, three pass package boilers and thermic fluid heaters. – Water treatment to control the total dissolved solids (TDS). – Effluent heat recovery from process water (especially hot water washed) through installation of heat exchangers. – Optimizing boiler efficiency by controlling draft (implementation of damper and fuel firing practices). – Optimization of the burner. – Avoidance of space heating. The use of mazot generates emissions with high sulfur and particulates. Its use as a fuel in food processing factories in Egypt is no longer permitted.

Table 3.2.18. (continued)

CP Idea	CASE
2-Poorly operated coal-fired boiler	Samples of coal and waste ash were taken from coal-fired boilers and were measured for specific energy (kJ/kg), ash percentage and moisture percentage. Results showed that up to 29% of the total fuel supply was not being combusted in the boilers, with the least efficient boiler generating an additional 230 kg of unburned material per tone of coal. This unburned material was retained in the ash and disposed of in landfill. To improve performance, the company trained employees in efficient boiler operations, so that boilers could be run on automatic control. After this training boiler efficiency increased by 25%, and the specific energy fell to 6 kJ/kg. Coal use has been reduced by 1500 tons, making an annual saving of US$45,000. Improved boiler operation has also reduced annual landfill disposal by 275 tones. The company has hired a specialist company to monitor boiler efficiency on an ongoing basis. The cost of this service is US$2100 per month [2].
3- Reuse of cooling water	An air-cooled system for an air compressor was replaced with a water-cooled one. The water absorbs the heat from the compressor and is then reused in the boilers. Energy is saved in the boilers because the water preheated. The installation of the water-cooling system cost US$18,000 and had a payback period of less than two years [2]
4- Increasing Efficiency of Refrigeration Units	In one factory, the refrigeration system was upgraded so that temperature could be fully controlled. This resulted in a more efficient refrigeration system and reduced reject rates of the final product. For an investment of US$121,370, annual savings of US$181,368 were made, giving a payback period of 8 months. Phasing out freon, which is a hazardous material, is also recommended [18].

[1] 1 US$= 4.58 EGP (Egyptian Pound) (23.1.2003)

3.2.5. Site Selection and Siting

Site selection is a crucial component of environmental management. It affects the optimum usage of resources and deterioration of them, which are discussed quantitatively through Sections 3.2.1 to 3.2.4.

The selection of site for construction, replacement of a dairy plant should take into consideration nearby land uses, possible future developments, the volumes and nature of wastes produced and the proposed nature of waste recycling, reuse or disposal.

3.2.6. Management Control

One of the most important factors in success of a CP program is the approach and commitment of the management to the issue.

Management decides on the shutdown or operating procedures of the dairy, which are key factors for pollution creation. Unnecessary shut downs are important sources of discharges to the sewer. For preventing this, the scheduling of the plant operation has a key role. During scheduling, if corrective action can be taken by using the written records, the unnecessary shut downs may be prevented [16].

For waste management, training of the workers is important in terms of using the equipment correctly and efficiently. In this manner the educations to be explained to the operator are listed in Table 3.2.19 [16].

The measures that can be taken under management control for waste reduction are listed in Worksheet B-1.5 in Appendix II.

Table 3.2.19. Educations to be taken by workers [16]

1	How to disassemble the equipment, especially the metal-to-metal contact surfaces that could cause leakage.
2	Instructions about machine settings.
3	How to assemble lines and equipment and how to check on proper alignment and set-up.
4	Interrelations between the operator’s job and other operations in the plant that may result in wastes.
5	Proper shut down procedures.
6	How to initiate maintenance requests.

Another important duty of the management is providing the regular maintenance so that product losses due to equipment defects are prevented.

The aim of the operational maintenance is keeping the performance of the equipments high and avoiding damages. During operational maintenance, operators should check all the equipments before start up and ensure that the fittings are tight and there is no leakage. Items to be covered during carrying such a program are listed in worksheet B-1.6 in Appendix II.

Inspection of the operators by a supervisor is beneficial for ensuring the detection of the new problems and fixing of them immediately.

3.2.7. Environmental Standards of Dairy Processing in Turkey

Environmental and health standards for dairy industry are set by two regulations in Turkey. The regulation about dairy processing facilities and dairies health standards is under responsibility of Ministry of Agriculture and Ministry of Health [25]. On the other side, the wastewater quality standards given in Table 3.2.20 are set by Ministry of Environment [26].

Table 3.2. 20. Turkish dairy industry wastewater discharge standards [26]

Parameter	Unit	Composite 2 hr sample	Composite 24 hr sample
BOD_5	mg/L	50	40
COD	mg/L	170	160
Oil and Grease	mg/L	60	30
pH		6-9	6-9

3.3. Dairy Industry in Economy of Turkey

When the agriculture sector is concerned, 45 percent of Turkey's overall population is engaged in agriculture and livestock production. Where about 15 percent of total income is obtained from these sources. Together with the agro-industry and agriculture-based service sector, the ratio is about 40 percent of the Gross Domestic Product (GDP). In terms of employment, the agriculture sector covers more than 260,000 people [27].

According to the Food Industry Inventory study done by Ministry of Agriculture and Rural Affairs there exists approximately 24,000 enterprises producing food products. When ratio of milk and milk products industry is concerned, it covers 18 percent of the food industry [27].

In Turkey, when milk and milk products demand projections are examined for the years 1999-2005, at least 2.7 percent increase in production is targeted [17].

In Turkey the number of milk and milk products enterprises which have capacity over 1000 tone/year is 1300. Total capacity of these enterprises adds up to 6,153,772 tones. The ownership structure of enterprises is not included in this datum because of privatization of Turkish Milk Industry Association (SEK) and 6 percent of 1300 enterprises are cooperatives.

Value of dairy sector production in 1998 covering both public and private sector is given in Table 3.3.1.

Table 3.3.1. Milk and milk products sector production values [17]

MAIN GOODS	Value (Million US Dollars)
Pasteurized Milk	88.8
Sterilized Milk	103.2
Milk Powder	-
Feta Cheese	49.3
Cheddar Cheese	40.3
Cream Cheese	14.8
Other Cheeses	24.7
Butter	37.6
Ice Cream	119.6
Yogurt	113.2
Butter Milk (Ayran)	29.8

Data covers the state enterprises, private enterprises with more than 10 workers and big enterprises that covers 80% of the production industry enterprises.

As it was indicated above, one of the biggest problems of milk industry is raw material. Due to stockbreeding policies implemented until today, modern stables could not be established and the established stables had to shut down due to economic difficulties. Another problem is the deterioration of milk quality until it is transported to dairy due to lack of a proper cold chain.

Until now, Turkish Standards Institute has made 112 standards concerning raw milk and milk products. Five of these standards are compulsory and the other standards are optional [27]. In terms of International Standards Organization (ISO) standards, only 4 firms took license of TSENISO 9001 standards in Turkey and 28 could take license of TSENISO9002 standard, which serve for quality production that has also environmental improvement effect [17].

CHAPTER IV

METHODOLOGY

This chapter describes a cleaner production assessment (CPA) methodology which was used in AOC market milk production facility to identify the opportunities of CP and assess the most feasible options.

A CP audit helps the dairies to explore the CP opportunities, address the most important pollution sources and figure out a list of feasible corresponding CP opportunities for implementation. The steps of the CP audit undertaken in this study are summarized in the Table 4.1.

The methodology of the CPA used in this study was prepared by compiling and reorganizing different manuals developed by several leading institutions in the field of CP such as Environment Canada, UNEP, Sustainable Business Associates, New York State Department of Environmental Conservation and EPA of Australia. These manuals can be listed as; Technical Pollution Prevention Guide for the Dairy Processing Operations in the Lower Frazer Basin [6], Cleaner Production Assessment in Dairy Processing [2], Good Housekeeping Guide for Small and Medium-sized Enterprises [28], Environmental Self-Assessment for the Food Processing Industry [29] and Environmental Guidelines for the Dairy Processing

Industry [30]. Finally after implementation of the CPA methodology in AOC, the prepared methodology was revised.

During developing methodology instead of using one of the guides in literature, a new guide and its check-list is compiled both to be more comprehensive and to simplify the audit procedure. Although the above stated guides have some points in CP opportunities each of them has some differences from the others. In addition since some of the guides are developed for certain areas of CP opportunities they concentrate on a specific issue i.e. GHK guide. Therefore by compiling all the opportunities and classifying them under specific headings (See check list B in Appendix II) a more comprehensive list of opportunities is prepared.

On the other side, when the guides are examined, it is seen their depth of audit procedure changes. Some of them involve questions and procedures not applicable to Turkish dairies i.e. amount of wastewater discharges to storm wastewater system. Therefore methodology is reorganized to be simpler, applicable and to remove inapplicable steps from utilized guides.

After application of the methodology on AOC it is seen that some steps are not easy to implement i.e. implementing some selected projects and monitoring pollution prevention progress. Therefore these steps are removed and the methodology is revised to include only the implemented steps of audit procedure.

The mass balance approach was selected as CPA methodology or the strategy of analysis adopted. Since mass balances are the most descriptive instruments of analysis for complex operations, it provides the opportunity to limit the scope of the analysis to certain unit operations. During implementation of the methodology on AOC, the outline borders were drawn as market milk production, which can be divided into two main procedures namely; raw milk intake and pasteurization. To quantify the inputs and outputs to the mass balance, measurements and experimental analyses were performed to determine pollution loads from different steps of operation. COD, TSS, Alkalinity and pH analysis of the apparent wastewater sources are done. Measurements were made for every visible mass flow for quantifying flow rates of discharges or raw material use.

Table 4. 1. Pollution prevention plan development overview

Step	Task	Sub-Task Description
1- Planning and Organization	Establishing and organizing a CPA Program	A. Obtain management commitment B. Select team members to develop cleaner production plan
2- Pre-assessment (qualitative review)	Compilation of background information	A. Develop facility profile
3-Assessment (quantitative review)	Conducting Environmental Review	A. Compile facility data B. Conduct site inspection C. Identify cleaner production options D. Organize cleaner production options
4- Evaluation and Feasibility Study	Conducting Feasibility Assessment	A. Conduct feasibility assessment

4.1. Establishing and Organizing a CP–Assessment Program

In a cleaner production assessment study both obtaining the management commitment and drawing the outline of the study is important to achieve successful results and realize the target.

4.1.1. Task A: Obtain Management Commitment

In a facility, management commitment is crucial for realizing the benefits of CP that involves great opportunities for both economic and environmental performance of the company [2]. Therefore firstly a partnership both with management and employees was searched. A fairly well cooperation was established and support was received both from the management and the engineers. In AOC although management have not committed to implement the CP opportunities determined in this study, it was especially helpful in terms of encouraging its employees towards assisting the CPA study.

4.1.2. Task B: Select Team Members to Develop Cleaner Production Plan

The project team members were responsible from analysis and review of present practices; development and evaluation of proposed cleaner production initiatives. Therefore during selecting the members, areas of expertise that were sought are management, engineering, operation and maintenance.

Since the CPA study was conducted for market milk production, team members were selected considering all the personnel related with this product.

As a result of consultancy, main team members to assist the CPA study were determined as the chief operator, an engineer (Mr. Sahin Durna) and the facility manager. Moreover, other engineers and workers have also been consulted whenever necessary.

A positive interaction with the employees was crucial for the success of the study. Since a significant amount of data needed for mass balance analysis was gathered by personnel interviews and communication with the employees in addition to several measurements conducted. It must be underlined here that AOC is a very old plant, and most of the documents on technical specifications of equipments used were not available.

4.2. Compilation of Background Information

In the second stage, pre-assessment of the facility was performed and information about the facility was compiled to develop facility profile, details of which are given in Section 5.4. The aim of developing facility profile was to overview the production facility and environmental aspects.

4.2.1. Task A: Develop an Industry/Facility Profile

The industry/facility profile is a characterization of the industrial facility under consideration. The profile contains information on raw materials, processes, waste materials and waste management practices for the industry and the specific facility [6].

For describing the facility, flowcharts were used. Flow chart production was a key step in the assessment and formed the basis for material balances which occur later in the assessment.

The flowcharts during the whole study were completed at two steps; pre-assessment and the assessment. In this pre-assessment step, aim was to illustrate the inputs and outputs to the system as much as possible without quantification. To this purpose, related information about raw and auxiliary materials and products were taken from facility records. The results of this preliminary assessment, a flowchart, is presented in Section 5.4.1.

The information to figure out preliminary mass balance was mostly gathered by a walk-through inspection of the company by concentrating on where products, wastes and emissions are generated. During this inspection, it was important to cooperate with the operators to learn about the source and amount of wastes generated and to identify potential CP options. The key questions that were utilized during this inspection are presented in Appendix I- A.

During the walk-through, problems and corresponding CP opportunities encountered along the way were listed. Special attention was paid to no-cost and low-cost solutions.

4.3. Conducting Environmental Review

After determining the basic steps of the process and respective flowcharts, the facility was assessed more deeply to determine the waste streams and their sources.

Another concern during environmental review was determining the process to be focused. Although many opportunities could be found at each step of the process, due to time and resource limitations (data collection and CP evaluation costs), focusing to a fewer points with greater CP opportunities is necessary.

The screening criteria for the selection of process(es) to be focused on can be summarized as follows;

- Generation large quantity of waste and emissions;
- Use or production hazardous chemicals and materials;
- Entailing high financial loss;
- Having numerous obvious cleaner production benefits[2].

In the AOC case, it was observed during the preliminary assessment that there is an important amount of water and chemical use during cleaning stage. Therefore, the major focus point was determined as the cleaning procedures of the facility. The following tasks were followed during performing the environmental review.

4.3.1. Task A: Compile Facility Data

The activities undertaken for environmental review program are:

- Plant data collection
- Site inspection including observations of the immediate environment adjacent to the facility
- Identification of CP potentials

Data collected during this study were used for setting a brief mass balance of the raw materials, products, byproducts and losses, wastes and emissions so that the flow charts prepared in pre-assessment stage was completed. During this step, information presented in Table 4.3.1 were collected.

Sources of information for facility data were mainly measurements, facility records for purchase, operation and interviews with the facility engineers. By measurements the flow rates of discharges, and amount of raw material use were determined. Flow rates were mostly measured by determining the time required to fill a known volume of vessel. Sources of information based on requirement categories in general are presented in Table 4.3.2.

In AOC, since the book keeping system is not very effective, required data for mass balance analysis had to be measured in most of the cases. Chemical characterization of the streams had to be done for determining raw material losses, and pollution loads to environment. For chemical characterization COD, TSS, Alkalinity and pH analysis were done. In fact, these measurements were conducted in the stage of site inspection, which is discussed in Section 4.3.2.

Information collected from these sources and measurements were used to produce flow charts showing:

- Types and quantities of all dairy products processed and manufactured
- Sources/locations and quantities of raw materials, by-products, and products spillage
- Sources/locations, quantities and characteristics of wastewater and solid wastes

Worksheets A-1 to A-3 presented in Appendix II were used for identification of data requirements and organizing the compiled data. Outputs of the step 3 (Table 4.1) after performing Task A were as follows;

- Partially completed data worksheets from facility records and interviews
- Raw materials and waste materials mass balances
- Unit operations of the facility
- Waste flow diagrams

Table 4.3.1. Environmental review – Plant Data Compilation Program

Category	Facility-Specific Information
Dairy Products Processed and/or Manufactures	• Volume of dairy products processed and/or manufactured • General shipment schedule • Active ingredients or components of concern
Unloading	• Spillage control system • Operating schedule/periods • Site cleanup method
Process Unit Operation	• Spillage control system • Wastewater generation rate • Quantity of spillage • Site cleanup method • Wastewater treatment/ disposal method • Operating schedule
Storage	• Storage method
Fuel, Lubricants, Chemicals	• Quantity of materials • Spill prevention and cleanup method
Wastewater Management Practices	• Quantity of wastewater • Wastewater management method
Environmental Permit Requirements	• Position of the firm with respect to wastewater discharge limits on regulations.

Table 4.3. 2. Plant Data Compilation Program – Data sources

Category	Facility-Specific Information
Raw Materials	• Facility records and interviews.
Process Unit Operation and Storage	• Equipment list and specifications • Equipment layouts and logistics • Operating manuals and process description • Operator data logs
Fuel, Lubricants, Chemicals	• Purchasing records • Interviews with operators and engineers.
Waste water	• Interviews with operators and engineers.
Waste Materials (Solids)	• Interviews with operators and engineers. • Visual inspection of the wastes.
Environmental Permit Requirements	• Interviews with engineers.

4.3.2. Task B: Conduct Site Inspection

A detailed site inspection was performed at this step to ensure the correctness of mass balances and flow diagrams. During this task, the operating procedures were also examined thoroughly to find out CP opportunities.

Inspection activity had three internal steps. First, the operating procedures were inspected on various documents to completely familiarize with the processes. At this stage, data collected in Task A (Compile Facility Data) were utilized. During the on-site inspection, processes were analyzed deeply to complete the mass balances and to build a correct basis for the CP opportunities that would be advised. Setting a correct mass balance is important in terms of evaluating priority and feasibility of the determined measures. Because, these issues are directly related with the amount and pollution load of discharges or amount of material use. Required measurements and experiments are done to quantify inputs/outputs to the processes. Finally, worksheets, mass balances and flow diagrams were revised. Table 4.3.3 presents the guidelines followed for preparing and conducting site inspection. Outputs of Task B were; updated worksheets, mass balances and process flow diagrams.

During inspection of the AOC, since book keeping system was not working well, flow rates of milk and wastewater discharges were measured to quantify the discharges to environment. For this purpose, water use rates or the rate of discharges given in mass balance are measured by determining time to fill a known volume of vessel or bucket. Also their COD, TSS, Alkalinity and pH were determined experimentally to assess their pollution loads.

In characterization of waste streams, COD, TSS, Alkalinity and pH analysis were done by using standard methods [31].

COD analysis was used to determine both pollution load and amount of raw material losses. Since most of the waste is composed of milk and water, and milk is the only component that may lead COD, this analysis was used to determine milk content of waste as well.

Table 4.3. 3. Site inspection guidelines [6]

Pre-Inspection Activities	• Evaluate data compiled along with mass balance calculations and flow diagrams to gain familiarity with the targeted processes and to identify additional data requirement. • Review existing documents such as operators' manuals and purchasing and shipping records. • Prepare an inspection agenda that identify the targeted processes and the data requirement. • Schedule the inspection to coincide with operations of the targeted processes.
On-site Inspection Activities	• Monitor the raw materials handling process from the point where bulk materials enter the plant site to the point where finished products and wastes exit. • Identify all wastewater discharges including leaks and spills. • Monitor the process unit operations to identify unmeasured or undocumented releases of products and wastes. • Make necessary measurements to identify flow rates of specific discharge sources. • Make necessary experiments to characterize wastewater sources where there are obvious CP opportunities or high pollution loads to environment. • Interview the operators in the targeted dairy products processing areas to identify operating parameters, wastewater generation and spill reduction opportunities. • Evaluate the general conditions of the processing equipment. • Examine housekeeping practices throughout the facility. • Check for spillage and leaks at the equipment/valve vehicle maintenance area. • Check waste storage area for proper waste segregation.
Post-inspection Activities	• Update mass balance calculations and flow diagrams with new or correct information. • Conduct follow-up site inspections to collect additional data or to clarify questions identified during data analysis.

4.3.3. Task C: Identify Potential Cleaner Production Options

In AOC CP opportunities found out from different case studies (Appendix IV) and creative ideas set forth by the interviewed experts and operators were highlighted. Also the worksheets (B-1 to B-4) in Appendix II that are present opportunities of CP in a dairy on product and unit operation basis were utilized. After Task C potential CP options were listed.

4.3.4. Task D: Organize Cleaner Production Options

Organization and classification of the CP options identified by Task C was done by considering both environmental management hierarchy (see Chapter II, list with 5 items) and problem type as explained below.

After determining the order of option in the hierarchy, below stated steps were applied for each category of hierarchy.

1. "Organize the options according to unit operations or process areas, or according to inputs/outputs categories (e.g. problems that cause high water consumption).
2. Identify any mutually interfering options, since implementation of one option may affect the other.
3. Opportunities that are cost free or low cost, that do not require an extensive feasibility study, or that are relatively easy to implement, should be implemented immediately.
4. Opportunities that are obviously unfeasible, or cannot be implemented should be eliminated from the list of options for further study" [2].

After Task D, a listing of the CP options organized within the environmental management hierarchy was prepared.

4.4. Evaluation and Feasibility Study

Objective of evaluation and feasibility study was to select the options that are suitable for implementation from the list of Task D.

At the evaluation stage, options are examined in terms of preliminary, technical, economic and environmental feasibility. But the depth of the evaluations changes according to the complexity of the alternative [2]. List of questions given in Appendix I-B guides to evaluate the general aspects to be considered under each heading.

In the process of evaluation of AOC opportunities, a simple feasibility analysis covering technical and economic feasibility was accepted to be enough since the benefits of most of the opportunities were obvious. Each option was discussed with the facility engineers or related experts for technical and economic feasibility. Environmental feasibility of the opportunities was noticeable, since most of them resulted in waste minimization.

CHAPTER V

RESULTS AND DISCUSSION

In this Chapter results of the assessment study are given and the opportunities of CP determined are discussed. Although outline of the presentation follows the order described in methodology, some steps are combined for the sake of clear understanding.

5.1. General Description of the Ataturk Orman Ciftligi Facility

Ataturk Orman Ciftligi (AOC) Milk and Milk Products Facility is a dairy products processing plant located in Ankara. In the plant, both milk and cultured milk products are produced. About 18 million liters of milk is processed yearly into several products. Since there is no wastewater treatment facility, wastewater is directly discharged to Ankara River. Therefore, minimization of the pollution load by cleaner production techniques is not only an urgent necessity but also a very significant opportunity.

The characterization of the final product, pasteurized milk, was done and results of measurements are shown in Table 5.1.1.

Table 5.1. 1. Characteristics of pasteurized milk

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurized Milk	254200 ±282.8	59722.2	6.7	737.4

In AOC 83 workers, 3 engineers and a manager are employed in milk processing facility. The factory operates for 8 hours/day; 7 days/week and 51 weeks/year.

5.2. Process Description

Although AOC produces various products, in this study only market milk production is investigated. Therefore process description covers only the processes of market milk production and flow diagram of the process is given in Figure 5.2.1.

Market milk production procedure can be divided into two main process stages namely; raw milk intake and pasteurization (see Figure 5.2.1). While raw milk intake covers procedures up to raw milk storage tanks, pasteurization of milk is defined as all the procedures up to pasteurized milk storage tanks. Process losses and wastes produced during pasteurized milk production are discharged to channels that are located at the sides of production site and flows to sewer. Pollution load is mainly due to the milk loss and chemical discharges.

Raw Milk Intake Process:

Flow diagram of this process is illustrated in Figure 5.2.1-A. Raw milk is bought from four different sources; Burdur-Antalya, Nevsehir-Avanos-Acıgol, Kayseri and AOC. Raw milk is received by tanker trucks, each of which has 3 tanks with 5 tones capacity. 3-4 trucks of milk are bought daily.

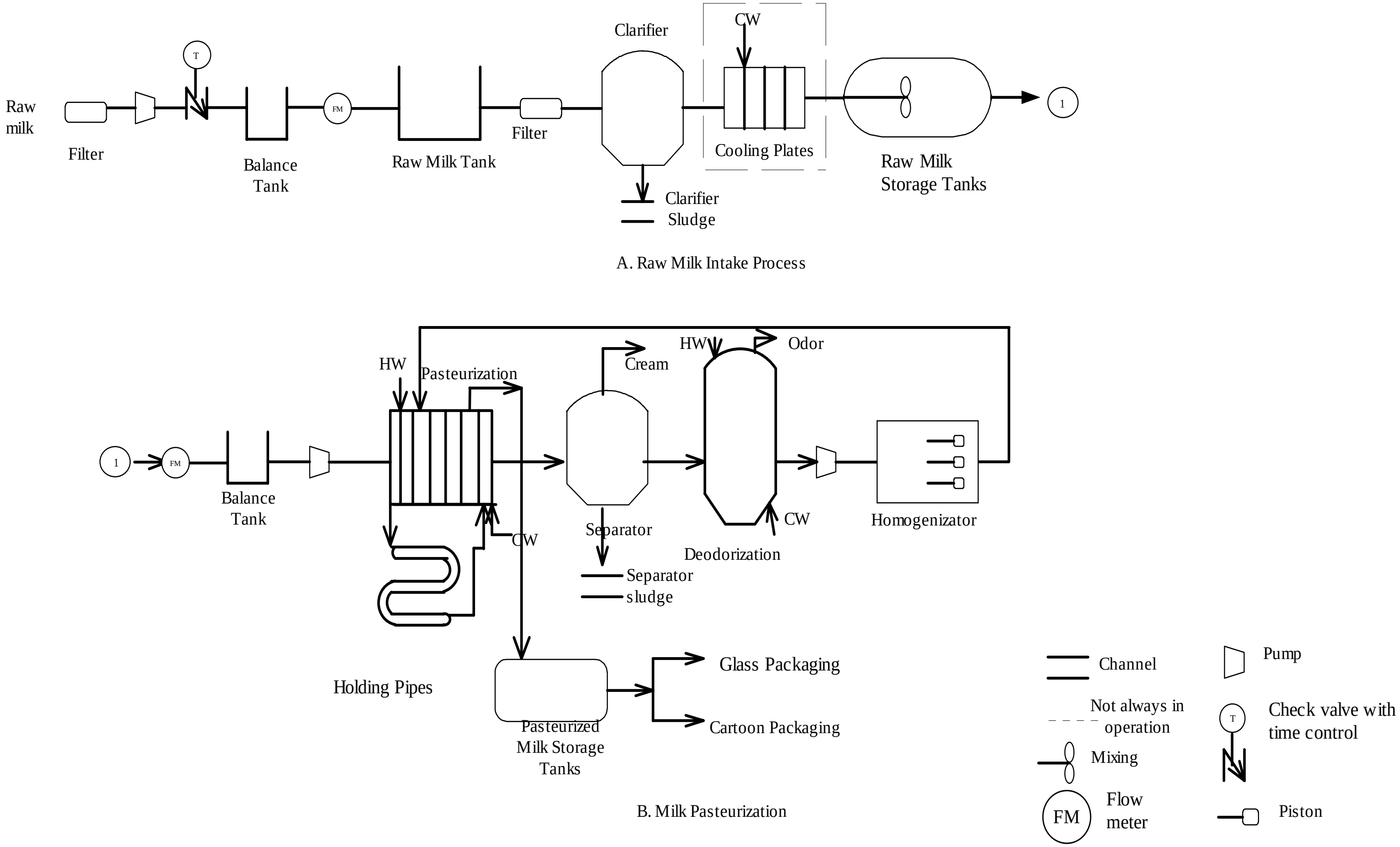

Figure 5.2. 1. Flow diagram of AOC market milk production

Milk in the tanks is pumped to a pool of 650 L volume for flow equalization. Before pump, there is a steel filter to remove coarse particles in the milk, i.e. sand, stone, hair.

Clarifier:

Raw milk is pumped to clarifier from the equalization basin. In the equipment, milk is rotated with 1800 rpm velocity. By centrifugal force, solids and foreign materials in the milk is collected at the sides. Water flowing through inside surface of clarifier is used to sweep up these particles. Water together with collected particles is called as milk sludge and discharged automatically to channel at every half hour.

Service water introduced is used for sludge formation and excess of it is discharged to channel continuously. In addition to that there is loss of water from valves.

Cooling Plates:

Clarified milk at 4-5 °C flows to the cooling plates to cool down to 2 °C. Cooling water at 0 °C flows between the plates to decrease temperature of milk and recycled to cooling tower. Cooling plates are used only if there is extra milk over daily consumption which has to be stored.

Raw Milk Storage Tanks:

After cooling plates, milk is stored in 4 tanks, 2 of which has 15000 L and other 2 has 11250 L capacity. In each tank a mixer is provided to prevent impairment of milk structure. The fat content, acidity and the density of milk at this stage is 3.1%, 7.5 SH and 1.028 kg/L.

Pasteurization:

As it is indicated above, although AOC produces various milk products, this study covers only market milk production. In line with this, after raw milk storage there are two lines of pasteurization system, one is for market milk other for other products. From this point on "pasteurization line" represents market milk pasteurization. Pasteurization system covers the processes starting from High Temperature Short Time (HTST) pasteurization up to pasteurized milk storage tanks which are illustrated in Figure 5.2.1-B.

<u>HTST Pasteurizer:</u>

Raw milk storage and HTST pasteurization systems are connected by steel pipes. At the inlet of pasteurization there is a flow meter before pump. Raw milk flows to balance tank at the inlet of HTST pasteurizer for flow equalization before pumping.

HTST pasteurizer is composed of parallel plates, separated to four different sections; hot, cold and two regeneration sections (see Figure 3.1.1 in Chapter 3). In HTST pasteurizer milk flows, from one side of plates, while water (cold/hot) flows from the other side without being mixed. In the regeneration sections cold and heated milk flows from different sides of plates and exchange heat without being mixed.

Before the onset of operation, HTST pasteurizer is heated with hot water every day. During this procedure, water at 90 °C flows through plates and is discharged to the channel afterwards.

During pasteurization, milk coming from balance tank at 6 °C flows first to the 2nd section (regeneration) to be heated with milk flowing at 85-90 °C from other side. Pre-heated milk at 45-50 °C flows to separator for separation of cream.

After processes of separation, deodorization and homogenization milk flows to the 3rd section (regeneration) of pasteurization to be heated to 65-70°C. After pre-heating, milk flows to 4th section (pasteurization) to be heated to 89-90°C. During this process while milk flow one side, water at 90 °C flows on the other side. Water used at this stage is heated with steam and condensed steam is discharged to the channel.

Milk heated to 90 °C passes through holding pipes to keep its temperature constant for some time and then flows to last stage of pasteurization. In this step, water at 0 °C flows one side of plates to cool the milk to 6 °C, while the water at 15-20 °C is recycled to cooling tower.

Since pasteurization is a pressurized system, pasteurized milk flows to pasteurized milk storage tanks, which are placed on a higher hydraulic level.

Separator:

Separator has the same working principle with clarifier. In separator while particles are collected at the sides by centrifugal force, fat content of the milk is expelled from top. Since fat is lighter, it is collected at the top when milk is rotated with high speed. Separator sludge is again discharged to channel at every half hour. Excess of the discharge water flows to channel continuously by two separate hoses.

Deodorization:

At this stage milk coming from separator is subject to vacuum to expel odor content. There is two water source used in deodorization unit; heating water and cooling water. While cooling water is recycled to the cooling tower, heating water is discharged to channel. There is a loss in the cooling water return pipe since the pipe is bored due to corrosion. After deodorization, milk is pumped to homogenization.

Homogenizator:

In the homogenization unit, fat and liquid content of milk is homogenized by 3 pistons under pressure of 100-150 Bar. Homogenized milk at 45-50 °C flows to 3rd section of pasteurization.

Pasteurized Milk Storage Tanks:

There are 3 tanks, 2 with 6 tones and one of 5 tone capacity. Before packaging, the quality of milk (fat content, acidity, density and coliform) is analyzed at this stage.

Cartoon Packaging:

Cartoon packaging is done automatically. Daily about 80 cartoon packages are defective and therefore disposed while milk in packages are recycled to the starting of process.

Cold-Storage of Cartoon Packed Milk:

There is no conveyor for transportation of filled cartoons to cold storage, and the cases are carried manually to storage area as soon as the case is filled. Since filling of cartoons and carrying them to storage are parallel procedures, door of the cold-storage area is kept open until packaging process ends, for about 3 hours.

Bottle Packaging:

Milk from storage tanks is bottled automatically and carried to cold storage by a belt conveyor. During this process milk in the uncapped or fissured bottles are collected in vessels and recycled to the beginning of process to be used in production of cheese and yogurt.

Cold-Storage of Bottles:

Bottles are placed automatically to cases and those cases are carried on a conveyor to the cold-storage area.

5.3. Establishing and Organizing CP Program

Before starting assessment study, support of the management was taken and the engineers were consulted for assistance. As a result, main team members that would assist during the study were determined as the chief operator, an engineer (Mr. Sahin Durna) and the manager. Other engineers and workers have also provided assistance at different stages of the study.

A positive interaction with the employees was crucial for the success of the study since significant amount of data needed for MB analysis was gathered by personnel interviews and communication with the employees in addition to several measurements conducted. It must be underlined here that AOC is a very old plant, and most of documents on technical specifications of equipments used were not available.

5.4. Compilation of Background Information

In this stage information about facility were gathered to make a pre-assessment of the facility and develop a rough mass balance. To this purpose related information about raw and auxiliary materials and products were gathered from facility records.

Although this study covers only market milk production, figures in Table 5.4.1 cover total quantity of materials used in the whole facility since separate records for different products were not available. Table 5.4.2 illustrates total amount of products produced per year taking 2002 as basis.

In the MB analysis, figures for market milk is found by measuring flow rates of discharges in market milk production and doing the calculations accordingly. Also a factor of conversion is used for the processes that are common with other products. This conversion factor (56.15 %) is found by measuring the amount of raw milk used daily for market milk production (see Section 5.5.3.2.7).

During pre-assessment a walk through inspection was performed to list the processes and to learn the general operation procedures of the facility. In this study major pollution sources and potential CP options, mainly the good house keeping opportunities, were determined. As a result of pre-assessment, a flowchart of the firm that is shown in Figure 5.4.1 was prepared.

Table 5.4. 1. Raw and auxiliary materials used in AOC

Raw and Auxiliary Materials	Quantity Used
Raw Milk	18,134,528 L/yr
Natural gas for steam	951,086 m^3/yr
Water	Since service water used is produced by another directorate of AOC quantity of water used is not known.
NaOH	81,500 kg/yr
HNO_3	~ 3,500 L/yr
HCl	8,065 L/yr
Electricity	Since bill is paid by AOC directorate, quantity is not known.
General cleaning agent	Since supplied by AOC directorate, quantity is not known
Bottles (1/2 L)	1,000,000/yr
Cartoon packages	~6,195,800 /yr

Source: AOC Facility Records (2002)

Table 5.4. 2. Products of AOC milk and milk products facility

Products	Quantity
Pasteurized milk (market milk)	10,045,083 L/yr
Yogurt	33,204,012 kg/yr
Ayran	615,421 L/yr
Butter	116,268 kg/yr
Ice cream	405,088 L/yr
Cheese	~ 102,000 kg/yr

Source: AOC Facility Records (2002)

5.5. Conducting Environmental Review

5.5.1. Compiling Facility Data

For setting a brief mass balance of the facility quantification of all inputs, products, and wastes is necessary. In AOC, since the bookkeeping system is not very effective, required data for mass balance analysis had to be measured in most of the cases. Chemical characterization of the streams had to be made for determining raw material losses, and pollution loads to environment. (See Tables 5.5.3.2, 5.5.3.3., 5.5.3.6, 5.5.3.7, 5.5.3.8, 5.5.3.15, 5.5.3.19, 5.5.3.21, 5.5.3.25, 5.5.3.26, 5.5.3.27, 5.5.3.30, 5.5.3.33)

In this stage of analysis, data worksheets that are presented in Appendix II A-1 to A-3 are filled in partially by the data gathered from records and the interviews with engineers.

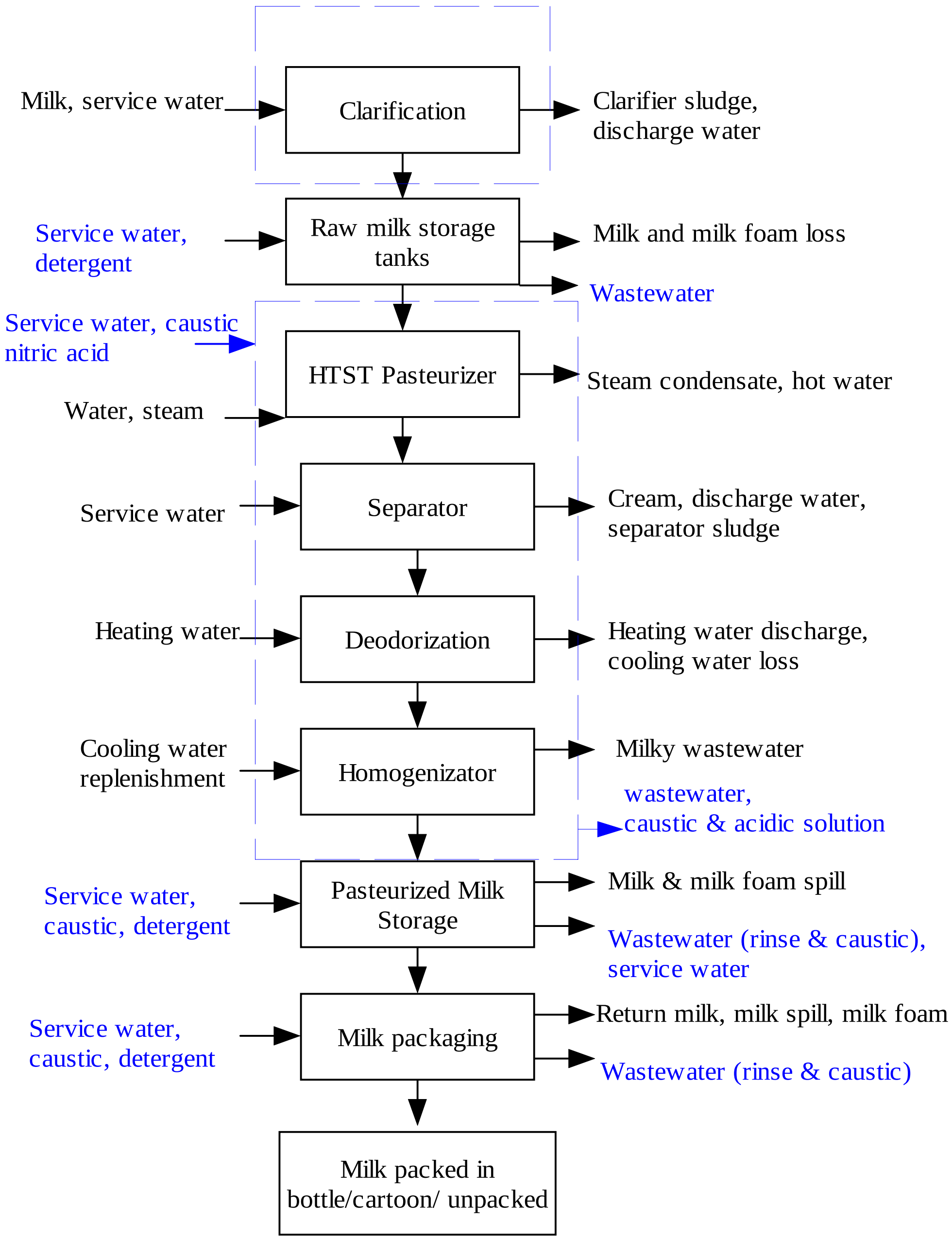

Figure 5.4. 1. Flow diagram of the AOC milk processing plant[1]

[1] Flows shown in blue represents flows due to cleaning activities. Unit operations in dashed lines are subject to the same flows in cleaning procedure.

5.5.2. Conduct Site Inspection

Since the bookkeeping system was not working well, for the requirements of this study, whole mass balance had to be designed on measured flow rates of inputs and discharges. For this purpose, water use rates or the rate of discharges given in mass balance are measured by determining time to fill a known volume of vessel or bucket. Detailed mass balance calculations of each stream are given in sub-sections of Section 5.5.3.

By using the results of measurements which are given under each section of MB analysis and the reviewing the worksheets, a detailed mass balance of AOC is set. The mass flows for the entire market milk production process of AOC are illustrated in Table 5.5.2.1. Three different mass balances are set up for market milk production namely; raw milk intake, pasteurization process and cleaning the details of which is provided in Section 5.5.3.

5.5.3. Mass Balance of Market Milk Production

Mass balance (MB) of AOC market milk production is set-up on mass flow (kg/day) and annual data, where available, was used for production levels (i.e. raw milk introduced to plant, market milk produced, yogurt production etc.).

As indicated previously (see Section 5.4.), AOC produces various products. Of these, market milk production is done 6 days/week while facility works 7 days of week. Pasteurized milk production can be differentiated to two main systems. While raw milk intake works 7 days/week (360 days/year), pasteurization system works for 6 days of week (308 days/year).

Daily facility work can be differentiated into two main parts; production process and cleaning work. Production process covers both raw milk intake and pasteurization processes. Although water is used in both production and cleaning, milk flows through system only during production process. In line with this, while milk balance is based on 4 hours/day, water is used in system 7 hours/day.

Table 5.5.2. 1. Mass flow of AOC market milk production & cleaning[2,3]

Source of mass flow	Quantity (kg/day)
Raw milk	33,985.8
Service water	94,661.1
Steam	2,677.9
Caustic	142.2
Detergent	2.4
Acid	10
TOTAL	131,479.6
AOC MARKET MILK PRODUCTION (PRODUCTION & CLEANING)	
Packed milk	33,527.1
Cream	119
Recycled milk to other products	271.2
Wastewater	69,827.1
Water spill and cooling water loss	15,911.4
Clean discharge water	11,747.5
Milk and milk foam loss by spill and due to cleaning	302.6
Milk sludge	58.4
TOTAL	131,764.3

As it is described above, market milk production is a closed system process with two main stages. Therefore, it is not possible to calculate total amount of milk flowing from one process to another. Since at the end of the day, milk left in the pipes is

[2] Figures given in Table shows sum of mass flows, each of which is calculated throughout MB. During calculation of MB amount of raw and auxialiary materials introduced to system is taken from Table 5.4.1. Calculations are discussed briefly in following sections.
[3] In plant although raw milk intake system works 360 days/yr, pasteurization system works 308 day/yr. Values are calculated as if raw milk intake system worked 308 days/yr, and iterated accordingly.

purged out during cleaning, by taking samples from this flow, amount of milk in the pipes were determined by measurement and given in the related section (Section 5.5.3.3.4, 1st Rinsing) of MB.

Since it is not possible to determine the amount of milk transfer between the equipments of raw milk intake and pasteurization system internally, each system is taken as a single unit in the MB (see Figure 5.2.1).

In description of the MB, it will be seen that the flow rates are indicated as either Qw or Qm, representing flow of water or milk respectively and numbering of the indicators is done according to the order of process that milk flows through. The respective meanings of all indicators are presented in list of Abbreviations. In this chapter a series of calculations done for setting mass balance are presented briefly, whereas complete list of mass flows can be seen in Appendix III, Table 3.1.

5.5.3.1. Raw Milk Intake

As it is discussed in Section 5.2, raw milk intake is composed of two main procedures namely; clarification and raw milk storage. Although AOC produces various products this study covers only market milk production. Therefore some part of the discharges and raw material uses are for market milk. Amount of milk used for market milk production is calculated as 56.15 % in Section 5.5.3.2.7. Therefore, amount of discharges due to market milk production are accepted as 56.15% of the calculated values. Mass flows of raw milk intake procedures are illustrated in Figure 5.5.3.1 and the results of mass balance analysis of this system are shown in Table 5.5.3.1. Total raw milk introduced to plant is 18.134.528L/yr [32].

ρmilk = 1.028 kg/L [33]

Daily milk processed (Qm1) = 18,642,294.7 kg/yr*1/360*56.15%= 51,784.1 kg/day*56.15% = 29076.8 kg/day

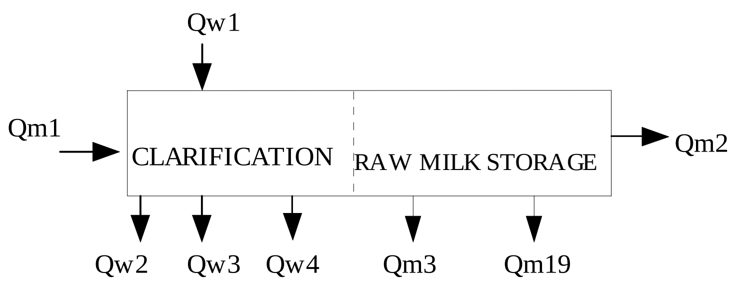

Figure 5.5.3.1. Clarification flow diagram

Table 5.5.3. 1. Raw milk intake mass flow

Notation	Name	Quantity
Qm1	Raw milk	29076.8
Qw1	Service water	424.1
Raw Milk Intake		
Qw2	Clarifier Sludge	15.5
Qw3+Qw4	Discharge water (loss from valves + service water)	408.7
Qm3+Qm19	Milk loss (manual connection loss+ milk foam)	25.1
Qm2	Milk to pasteurization	29051.4

Clarification

Main waste discharge during clarification is the clarifier sludge (Qw2), which is composed of 51.3% milk. Clarifier sludge discharge system opens for 5.7±0.99 seconds every 30 minutes interval and system discharges 8 times/ day. Therefore daily 15.5 kg of sludge is wasted to sewer (see calculations below). The characterization of the sludge in terms of COD, TSS and pH is given in Table 5.5.3.2. By using this data, density of clarifier sludge is calculated as 1.014kg/L.

Table 5.5.3. 2. Clarifier sludge analysis results

Sample Name	COD (mg/L)	TSS (mg/L)	pH
Clarifier Sludge (Qw2)	130400 ± 1131.3	26680	6

Assume no milk is lost in the pipeline pumping from trucks and raw milk tank. To calculate Qw2;

Qw2= 600 ml/sec*5.7sec/discharge = 3.4 L/discharge

Qw2= 3.4 L/hr*8= 27.3 L/day

To find density of clarifier sludge, assume all the COD of sludge comes from milk solids and neglect COD of hair and blood tissue found in milk.

% of milk in the sludge= COD_{sludge}/COD_{milk} = (130,400/254,200)*100= 51.3%
Assume ρ_{water} =1 kg/L

$\rho_{clarifier\ sludge}$ =(1.028*0.51+1*0.49)/1L=1.014 kg/L

Qw2=27.3*1.014*56.15%= 27.7 kg/day*56.15%=15.5 kg/day

In clarification, all discharges to sewer are due to the service water used. Service water is used for internal self-cleaning of the clarificator and to liquidify the foreign materials collected on the edges of the equipment by high-speed circular movement to form clarifier sludge. Therefore it is assumed that the volume of the clarifier sludge (Qw2) is equal to the volume of service water used for liquidification purpose.

Another source of loss is the water from valves and fittings (Qw3), which amounts 106.1 L/day. Moreover, excess amount of service water used for operation of machine is discharged continuously to channel (Qw4). Daily 302.6 L of water is discharged to channel characteristics of which is determined experimentally and is shown in Table 5.5.3.3. Due to the analysis results, it can be concluded that the water is clean and has similar characteristics with service water. Therefore, these results reveal possibility of reuse of 408.7 L/day of water (Qw3+Qw4) in the operations where service water is being used, i.e. cleaning activities. Mass flow calculations of these sources are illustrated below.

Table 5.5.3.3. Experimental analysis results of clarifier discharge water

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Total Coliform
Clarifier Discharge Water (Qw4)	0	0	7.4	0

Qw1= Qw2+Qw3+Qw4

Since loss from valves (Qw3) is measured as 27± 4.2 L/hr and assuming ρ_{water} =1 kg/L;

Qw3=27L/h*7hr/day*56.15%=189 L/day*56.15%= 106.1 L/day (loss from valves)

Since flow rate of discharge water from clarifier is measured as 77±4.2 L/hr;

Qw4=77L/h*7h/d*56.15%=539 L/day*56.15%= 302.6 L/day.

Therefore total amount of service water used in the clarification procedure is;

Qw1= (27.36+189+539)*56.15%= 755.3 L/d*56.15% = 424.1 kg/day

Raw Milk Storage Tanks

In the plant there is a single pipeline connecting pasteurization unit and the raw milk storage tanks. During connection of these units, for each tank, the valves of the last tank emptied are disconnected and the line is connected to the proceeding tank. During this process although milk in the pipe is collected in a vessel, milk left at the bottom of the tank and some milk in the pipe flows to the ground (Qm3). Also after emptying of tanks it is observed that some amount of milk foam remains at the bottom of tank. Calculations related with this milk foam can be seen from Section 5.5.3.3.3.

Milk lost during manual connection (Qm3) is 3L/tank, which is totally 6.9 kg/day [34].

Qm3= 3L/tank*4tanks*1.028kg/L*56.15% =12.3 kg/day *56.15% = 6.9 kg/day

Qm2= Qm1+Qw1-Qw2-Qw3-Qw4-Qm3-Qm19

Qm2= 29,051.4 kg/day (milk flowing to pasteurization)

Since pasteurization system works 6 days and 56.15 % of milk should flow to market milk pasteurization, amount of milk that should be introduced to pasteurization is 33,956.2 kg/day.

29,051.4*360/308= 33,956.2 kg/day.

5.5.3.2. Pasteurization

Since the milk is processed into market milk, cheese, yogurt, ayran, ice cream and butter there are two different lines for pasteurization. One of them serves for market milk and the other for other products. Although there is a flow meter at the start of market milk pasteurization, since its regular records are not kept, total amount of milk that is pumped to market milk pasteurization is not known. Therefore, amount of milk that is pumped to the pasteurization line is calculated by adding losses to the amount of final packed products. As can be seen from the explanations in Section 5.5.3.2.7, the amount of total milk loss in the pasteurization system is calculated as 1.35% of the total milk introduced. By using this ratio and the total amount of market milk produced, amount of milk introduced to pasteurization system is calculated.

Starting from pasteurizer, pasteurization unit is a closed system involving separator, deodorization, homogenization, holding pipes and pasteurized milk storage (see Figure 5.5.3.2.). Therefore amount of milk left in the system during production could not be measured. As mentioned in Section 5.2, at the end of the day, milk left is washed off the system by rinsing. In the MB for cleaning, milk left in system during market milk production is calculated by experimental analysis of these wash-off waters.

As MB approach, this closed system that is composed of various equipments, is taken as a single system and input/output analysis is done. Results of the analysis are summarized in Tables 5.5.3.4 and 5.5.3.5.

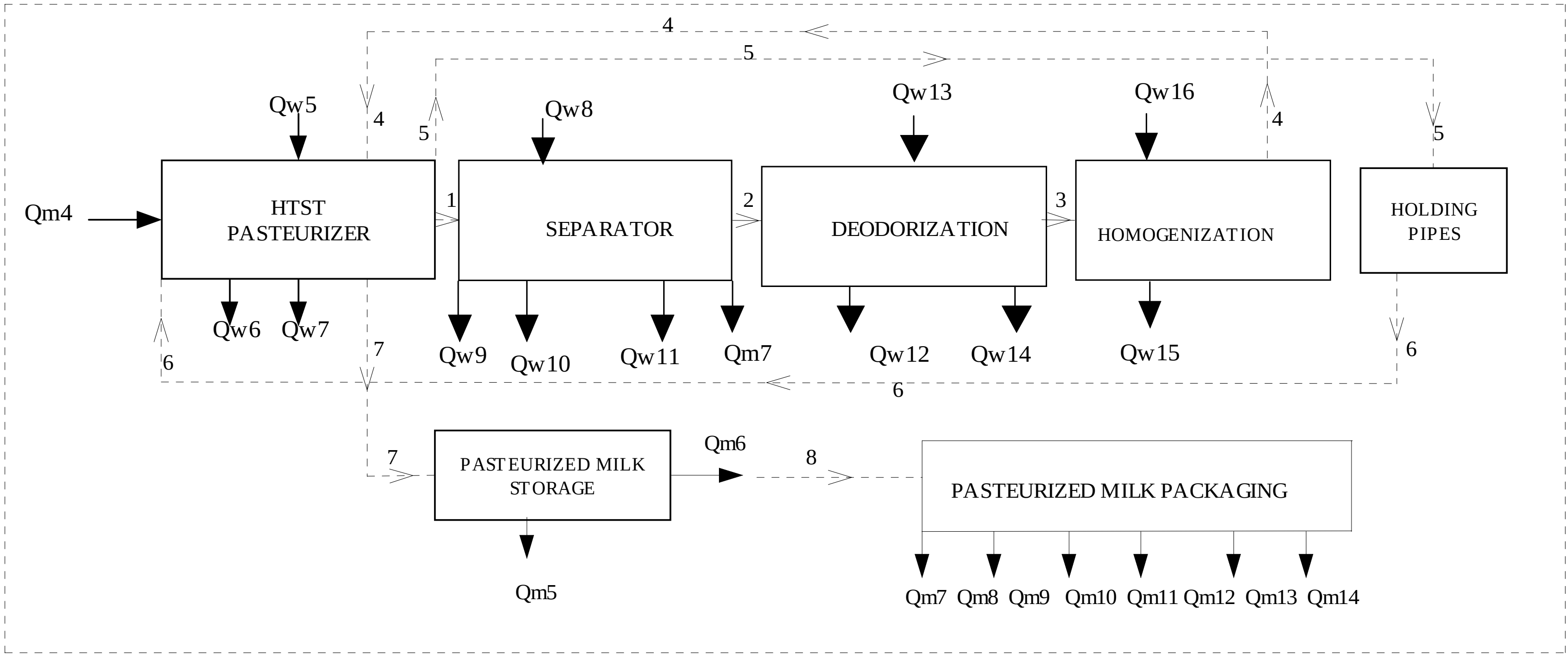

Figure 5.5.3.2. Pasteurization flow diagram

Table 5.5.3.4. Mass flow of pasteurization

Notation	Name	Quantity (kg/day)
Qm4	Milk input	33985.9
Qw5	Steam input	2677.9
Qw8+Qw13+Qw16	Service water input	10520
MILK PASTEURIZATION		
Qw6+Qw7+Qw9+Qw10+Qw14	Discharge water that can be used for other purposes	11269.7
Qw11	Separator sludge	40.2
Qm7’	Cream	119
Qw12+Qw15	Cooling water loss	1917.2
Qm5	Milk spill	12.4
Qm6	Milk to packaging	33825.2

Table 5.5.3. 5. Mass flow of milk packaging

Notation	Name	Quantity (kg/day)
Qm6	Milk to packaging	33825.2
MILK PACKAGING		
Qm7+Qm10+Qm12	Packed milk (cartoon+bottle+unpacked)	33527.1
Qm8+Qm13	Spilled milk	47.5
Qm9	Milk foam	0.5
Qm11	recycled milk	271.4
Qm14	Milk loss in cleaning	18.9
Total (outflow)		33865.4

5.5.3.2.1. HTST Pasteurizer

Pasteurization system works 6 days in a week. Therefore it is in operation in 308 days of the year. Since 10,045,083 L of milk is produced in 2002, daily 33,527.1 kg/day of milk is produced.

Since 1.35% of the milk introduced to system is lost due to system discharges, cleaning and recycling to other products, amount of packed milk at the end should be

98.65% of the milk introduced to system. By using this percentage milk pumped to market milk line (Qm4) is calculated to be 33,985.9 kg/day (see Section 5.5.3.2.6).

During HTST pasteurization, steam is used to heat the water for supply of hot water to HTST pasteurizer. After heating, condensed steam (Qw6), which can be reused for any purpose, at 70°C is discharged to sewer. The characterization of the condensate is shown in Table 5.5.3.6. Total amount of steam condensate is assumed to be equal to the amount of steam supplied to the system for hot water generation. Since no steam loss is observed visually, it is assumed that there is no steam loss in the heating process. Flow rate of steam condensate is measured as 380.5±72.7 L/hr. In addition to steam condensate discharge, there is a continuous spill of water from fittings as droplets, which is about 2 L/hour. Results of calculations given below indicate that, while steam condensate is 2664 kg/day; losses from fittings (Qw7) amounts 14 kg/day.

Table 5.5.3. 6. Experimental analysis results of steam condensate

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Total Coliform
Condensed Steam (Qw6)	0	0	6.9	0

Qw6= 380.5L/hr*7hr/day=2664 L/day hot water at 70°C. Assume ρ_{water} =1kg/L

Qw7= 2L/hr*7hr/day= 14 L/day

Qw5= 2664+14= 2678 kg/day (steam input)

5.5.3.2.2. Separator

Separator water discharge is due to two main functions. Firstly, it is used for formation of separator sludge within the same principle as clarifier sludge; secondly it is used to keep the sludge channels of separator clean. For first purpose, service water flows continuously to a tank of nearly 5 L volume, while excess of water is disposed to channel (Qw10). Tank is used to pour water when separator sludge is to be discharged. Flow rate of excess water discharge (Qw10) is measured as 2100±457.3 L/day, experimental analysis of which shows no total coliforms and a pH of 7.3.

Separator sludge discharge system opens for about 8.2± 0.3 seconds at every half hour. For 4 hr working, system opens 8 times. Therefore, separator sludge (Qw11) that flows to channel amounts 40.2 kg/day (see calculations below). COD, TSS and pH values of separator sludge was examined experimentally and, results are illustrated in Table 5.5.3.7.

Qw11=600 ml/sec* 8.2 sec/discharge = 4.9 L/discharge.

For a day; Qw11=4.9 L*8 times/day = 39.7 L/day.

Assume $\rho_{separator\ sludge}=\rho_{clarifier\ sludge}=1.014$ kg/L

Qw11= 40.2 kg/day

Table 5.5.3. 7. Analysis results of separator sludge

Sample Name	COD	TSS	pH
Separator Sludge (Qw11)	178,700 ± 2,404.1	32,480	6.1

As discussed above, second water discharge source (Qw9) is the service water used to keep sludge channels of separator clean. To this purpose, there are two discharge water hoses each discharging at a rate of Qw9. Since Qw9 is measured as 2180.2 ± 494.6 L/day, water discharged from two pipes is 4360.5 L/day.

To determine total amount of service water use (Qw8) in this process, since volume of separator sludge equals to the volume of water used for this purpose, separator sludge and other discharges are added on volume basis. After calculation of volume of Qw8, density of water is assumed as 1 kg/L to calculate Qw8 in mass basis.

Qw8= Qw9+Qw10+Qw11=6500.2 L/day = 6500.2 kg/day

As it is discussed in Section 3.1.1, main function of separator is separating cream from the milk with high fat content. Amount of expelled cream is calculated by using quantity of butter produced. In AOC plant, while cream is composed of 65% fat and 35% milk; butter fat content is 82%. For butter production 25% of cream is taken from pasteurized milk line, where rest is supplied from yogurt pasteurization system. By using these ratios cream (Qm7’) is calculated as 119 kg/day. (See calculations below).

Total Butter Produced = 116268kg/yr*1/360day= 377.5 kg/day [33]

For 10 kg of cream; 6.5*100/82= 7.9 kg of butter is produced.

Total cream requirement= 377.5*10/7.9= 476.2 kg/day

Qm7’= 476.2 kg/day*25% = 119 kg/day (cream expelled from pasteurized milk line)

5.5.3.2.3. Deodorization

Heating water in the deodorization unit (Qw13) flows from internal wall of the deodorizer to keep medium warm, without any contact with milk. After heating the equipment, this water flows to channel. The quality of the water is expected to be same with the service water since it has no contact with milk. Therefore, it is accepted as a clean water source that can be used for other purposes.

Flow rate of heating water discharge (Qw13) could not be measured since pipe discharging to channel is fixed and very close to the crenel that it was not possible to take sample. To estimate the flow rate, visual observations are utilized. When the diameter of pipes of steam condensate discharge and Qw13 discharge are compared, it is seen that they are nearly same. Consequently, their flows are compared and it is decided that the amount Qw13 discharged is nearly 80% of the steam condensate. Therefore its quantity is calculated as 304.4 ± 58.1 kg/hr. Since this water flows to sewer for 7 hours per day, its quantity is calculated as 2131.2 kg/day.

Although there is a recycle system for cooling water used in the plant, main pipeline is bored by corrosion and this result in a continuous loss of water with coolant; that is measured as 840 L/day. By assuming $\rho_{\text{cooling water}}$ = 1 kg/L; loss is calculated as 840 kg/day.

5.5.3.2.4. Homogenization

In the homogenizator, water is used in the cooling of motor working pistons. Due to a defect in one of the pistons, some amount of milk mixes with water that is used for homogenizator. Under homogenizator there is a hose through which this cooling water passes. But since this hose is torn, water mixed with milk spills on floor and flows to sewer. The discharge rate of the milky water (Qw15) is measured as 153 ± 89.1 L/day. Density of mixture is calculated as 1.0058 kg/day. (See density calculation in Section 5.5.3.1.) Thus, daily milky water discharge is calculated as 1077.2 kg/day.

Pollution load from this milky wastewater is analyzed experimentally and the results are summarized in Table 5.5.3.8. Amount of milk in the mixture is calculated as 2.1 %, which corresponds to a milk loss of 22.4L/day (see calculations below).

Milk content in mixture= 2.1 %*1071 L/day=22.4 L/day

Water content= 1071 L/day-22.4 L/day= 1048.6 L/day =1048.6 kg/day

Table 5.5.3. 8. Analysis results of water loss from homogenization

Sample Name	COD (mg/L)	TSS (mg/L)	pH
Water lost by the damaged hose (Qw15)	5317.5 ± 625.8	740	6.7

Cooling water replenishment in market milk production is due to the losses from hose under homogenizator (Qw15) and the loss from hole in the recycle line (Qw12). Total amount of replenishment water (Qw16) required for market milk production is calculated as 1888.6 kg/day.

Qw16=1048.6+840 =1888.6 kg/day

5.5.3.2.5. Pasteurized Milk Storage

After HTST pasteurization, milk is stored in pasteurized milk storage tanks before packaging. Although pasteurized milk flows to the packaging by gravity, some amount of milk and milk foam remains at the bottom of storage tanks. These are washed of by 1st rinse during cleaning. Therefore the amount of milk lost in the tanks is 12.4 kg/day (Qm22) (see Section 5.5.3.3.5) and milk flowing to packaging (Qm6) is 33,825.2 kg/day.

$Qm5 = Qm22 = 12.4$ kg/day

$Qm6=(Qw5+Qm4-Qw6-Qw7)+(Qw8-Qw9-Qw10-Qw11-Qm7)+(Qw13-Qw12-Qw14)+(Qw16-Qw15)-Qm5= 33,825.2$ kg/day

5.5.3.2.6. Milk Packaging

In AOC milk is packed in cartoons, glass bottle or filled in steel vessels and sold as unpacked milk. As indicated above, milk flows to packaging by gravity.

One of the major losses during this process is the amount of milk recycled due to defective packaging and milk remained in the pipes of packaging machines (cartoon and bottle) at the end of the day. This amount remained in the pipes and packed defectively, are collected (Qm11) to be used in the production of another product. (i.e. economic cheese and yogurt). Total amount of milk recycled to use for production of economic cheese/ yogurt is 271.39 kg/day.

Cartoon Packaging

Amount of milk packed in cartoon in 2002 is 12,147.6 kg/day that is illustrated in Table 5.5.3.9. In cartoon filling, about 250 ml of milk is spilled daily in the packaging machine during filling operation. Besides in bottle filling, milk spilled on floor due broken to bottles in the filling line amounts about 2L/day. Therefore total amount of milk spill in packaging is;

$Qm8= (2+0.25)*1.028=2.3$ kg/day

Amount of milk foam discharged (Qm9) is about 1L/day. Therefore; $Qm9=0.5$ kg/day (Assume $\rho_{milk\ foam}=0.5$ kg/L)

Table 5.5.3. 9. Milk packed in cartoon

	Cartoon (1/5 L)	Cartoon (1/2 L)	Light (1/2 L)	Cartoon (1 L)	Total	Unit
Cases	6,085	160,209	3,929	106,935		
Bottle/Case	48	28	28	12		
Volume (L)	58,416	2,242,926	55,006	1,283,220	3,639,568	L/yr
					3,741,476	kg/yr
Total(Qm7)					12,147.6	kg/day

Glass Bottle Packaging

Amount of milk packed in bottles in 2002 is 18,486.1 kg/day that is illustrated in Table 5.5.3.10.

Table 5.5.3. 10. Milk packed in bottles

	Bottle (½ L)	Unit
Cases	553,864	
Bottle/case	20	
Total Volume (L)	5,538,640	L/yr
	5,693,721.9	kg/yr
Total (Qm10’)	18,486.1	kg/day

In year 2002 bottle cases used were changed with smaller capacity cases. Consequently some amount of bottled milk produced is missing (Qm15) in calculations of Table 5.5.3.10 since this change is not reflected to bookkeeping procedures. Therefore the notation of Qm10’ represents only the bottle milk production in AOC records. Total amount of Qm10 is calculated as 19,581.7 kg/day after calculation of Qm15, which shows the unrecorded bottle milk production (see Qm15 calculation under discussion of milk sold in vessels).

Qm10= Qm10’+Qm15= 19,581.7 kg/day

Amount of milk recycled (Qm11) to use for production of economic cheese are 6 vessels in a day from cartoon packaging and 5 vessels from bottle packaging. Although each vessel has a volume of 40L, each vessel is filled more than a half (60%) of its volume for easy carrying. Total amount of recycled milk is;

Qm11 = (6+5)*40 L* 1.028 kg/L*60% = 271.39 kg/day

Milk Sold in Vessels

Although most of the milk produced in AOC is packed, some of the milk is sold to the state offices in 40L steel vessels as unpacked. Amount of milk sold without packaging (Qm12) is 538,599 L in 2002 which corresponds to a daily production of 1797.6 kg/day that is nearly 44 vessels/day [32].

In process of vessel filling, since the valve is not closed during changing of vessel and due to over filling, about 1L of milk is spilled on ground (Qm13) per vessel, adding up to 45.2 kg/day.

Qm13=44vessel/day*1L/vessel *1.028 kg/L= 45.2 kg/day

As explained in glass bottle packaging, in year 2002 bottle cases used were changed and the bottled milk amount that is not seen in records of AOC due to this change is 1095.6 kg/day. (See calculations below.)

Qm15: Bottled milk not shown in AOC records (difference in the production)

Qm16: Pasteurized milk sold daily.

Qm16=10,045,083L/yr*1.028(kg/L)/308day=33,527.1 kg/day

Qm15= Qm16-Qm7-Qm10-Qm12= 1095.6 kg/day

If the values of milk flowing to packaging (Qm6) and outflow from packaging (Qm7+Qm8+Qm9+Qm10+Qm11+Qm12+Qm13+Qm14) are compared (Figure 5.5.3.2), it will be seen that, they are slightly different. Qm6 is 327.7 kg/day less than the amount of milk introduced to packaging. This difference means 0.12% error in the MB. The difference may be accounted for the water introduced to pasteurized milk storage tanks while purging the system with water prior to cleaning. This difference may also be accounted for the errors in measurements and their standard deviations indicated throughout sub-sections of 5.5.3.

5.5.3.2.7. Milk Lost Due to Cleaning and the Process Losses

As it is discussed in Section 5.5.3.2.1, since the print-out records of the flow meter at the start of pasteurization is not kept, it is not possible to measure amount of milk that is introduced to pasteurization. In addition to that, since the pasteurization system is a closed system, it is not possible to measure milk losses at each step of operation. In this section, the amount of milk losses in the whole process is calculated and this value is added to milk produced to determine amount of milk introduced to pasteurization.

Qm14: Amount of milk lost in the process and cleaning

Qm4: Milk introduced to pasteurization.

Qm11: Recycled milk to other products.

Milk is lost in the pipes and equipments besides the amount discharged or spilled during processes. Amount remained in equipments and pipes are purged out by the rinsing water. To estimate the amount of milk lost, daily figures of the production level and flow meter measurement at the start of pasteurization were used. When ratio of these two values is taken in different days it is seen that loss is about 1.35%. This number is also verified with the general experience of the engineers.

By using this ratio amount of milk introduced to pasteurization system (Qm4) is calculated as 33985.9 kg/day. Using this figure, total amount of recycled milk and milk lost in process and cleaning is calculated as 458.8 kg/day, while milk loss in cleaning and process (Qm14) is 187.42 kg/day (see calculations below).

Qm4= Qm16/(100-1.35)*100=33985.9 kg/day

By using amount of recycled milk calculated (Qm11), milk lost in process and cleaning is calculated as;

Qm14+Qm11=Qm4-Qm16=458.8 kg/day

Qm11= 271.39 kg/day

Qm14=187.42 kg/day

Milk loss due to cleaning (18.9kg/day) comes from 1st rinse of pasteurization and rinse of bottle filling, detailed calculation of which is shown below.

Pasteurization 1st rinse; 0.7kg/day*2+1.7kg/day=3.1 kg/day (See Section 5.5.3.3.4)

Bottle packaging; 15.8 kg/day (See Section 5.5.3.3.7)

To find the ratio of milk that is introduced from raw milk storage tanks to pasteurization system;

Qm4=10,467,659 kg/yr

Qm1=18,642,295 kg/yr

Ratio = Qm4/Qm1*100=56.15%

As a result, ratio of milk that is introduced from raw milk storage tanks to pasteurization system is 56.15%.

5.5.3.2.8. Analysis of Mass Balance in Production Process

As it is indicated before (Section 5.2), production process covers both raw milk intake and pasteurization processes. In this section, water use and milk discharges at different steps of mass balance are analyzed and results are presented in three different tables. While these tables presents general scene of discharges and reuse opportunities, CP opportunities will be discussed on water source basis in discussion section (see Section 5.5.4).

Table 5.5.3.11 shows the water discharges that can be reused for cleaning or for requirements of water in other steps of the process. Reuse opportunities of each water source can be followed from its respective heading under discussion (Section 5.5.4). Table 5.5.3.12 illustrates milk and milky wastewater disposals, which can be reused as raw materials of other products so that organic discharge to sewer is reduced. Finally Table 5.5.3.13 illustrates water discharge sources that can be eliminated completely by GHK opportunities i.e. repairing of equipments.

Table 5.5.3.11. Wastewaters discharged that can be reused for other purposes

Water Source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Total Coliform	For details see Section
Service water	*Clarifier* Qw4	302.6	0	0	7.4	0	6.5.3.1
Steam condensate	*Pasteurizer* Qw6	2664	0	0	6.9	0	6.5.3.1
Discharge water	*Separator* 2*Qw7	4360.5	-	-	7.3	0	6.5.3.2.2
Heating water	*Deodorization* Qw13	2131.2	-	-	-	-	6.5.3.2.3
TOTAL		9458.4					

Table 5.5.3. 12. Reusable milk and milky wastewater discharges

Waste source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	For details see Section
Clarifier sludge	*Clarifier* Qw2	15.5	130,400	26.6	6	6.5.3.1.
Spill in manual connection	*Raw milk storage* Qm4	6.9	-	-	-	6.5.3.1
Separator sludge	*Separator* Qw10	40.2	178,700	32,480	6.1	6.5.3.2.2
Milk foam	*Cartoon packaging* Qm9	0.5	-	-	-	6.5.3.2.6
Return milk to beginning	Qm11	271.4	254,200	59,722.2	6.7	
Spill on ground	*Unpacked* Qm13	45.2	254,200	59,722.2	6.7	6.5.3.2.6
TOTAL		560.8				

Table 5.5.3. 13. Water discharges that can be eliminated

Waste source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	For details see Section
Loss from valves	Clarifier Qw3	106.1	-	-	-	6.5.3.1
Cooling water loss	Deodorization Qw12	840	-	-	-	6.5.3.2.3
Damaged hose	Homogenization Qw15	1071	5317.5	740	6.7	6.5.3.2.4
Service water	Separator Qw8	2100	-	-	-	6.5.3.2.2
TOTAL		4117.1				

5.5.3.3. Mass Balance of Cleaning Process

5.5.3.3.1. Cleaning of Tanks on Trucks

Raw milk is brought to AOC in tanks on trucks. After intake of milk to plant, tanks are rinsed with hot water, which results in milky wastewater. Mass flow of this process is illustrated in Figure 5.5.3.3 while flows are given in Table 5.5.3.14. For rinsing, a hose is used to spray water inside the tank. Wastewater flows to a channel, outside of the plant, which is connected to sewer. Before this operation about 1L of milk left at the bottom of tank is spilled on ground (Qm18). There are 3 tanks on each truck and measurements showed that rinsing of each tank takes 3.1 ± 1.7 minutes. Hose used for rinsing flows 1.57 ± 0.04 L/sec. There are 3 tanks on each truck and 4 trucks of milk are bought daily. Therefore, total amount of wastewater discharge due to market milk production is 2008.9 kg/day, while milk spilled on ground is 6.9 kg/day (see calculations below). COD, TSS and pH of truck rinsing is determined by experimental analysis of wastewater and results are illustrated in Table 5.5.3.15. The sample for this analysis is taken by mixing different samples taken in the first 1.5 minute of discharge.

Qw17=1.57 L/sec *60sec/min * 3.1 min * 12 tanks*56.15% = 2008.9 L/day.

Qin=Qout

Assume $\rho_{wastewater} = \rho_{water} = 1$ kg/L

Qw18 = Qw17 = 2008.9 L/day = 2008.9 kg/day.

Qm18= 1L/tank*12 tank/day*1.028* 56.15% = 12.3 kg/day*56.15%= 6.9 kg/day

Qm1= 51,784.1 kg/day*56.15%=29076.8 kg/day (Raw milk for market milk production)

Qm17 =Qm18+ Qm1 = 29083.7 kg/day

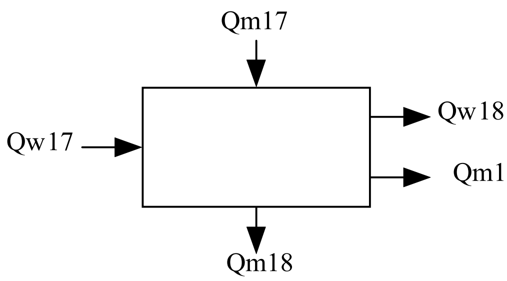

Figure 5.5.3.3. Flow diagram of cleaning of tanks on trucks

Table 5.5.3. 14. Mass flow of cleaning tank on trucks

	Notation	Name	Quantity (kg/day)
Qin	Qw17	Service water	2008.9
	Qm17	Milk in tanks	29083.7
	Cleaning Tank on Trucks		
Qout	Qw18	Wastewater	2008.9
	Qm18	Spilled milk from tank	6.9
	Qm1	Milk to clarification	29076.8

Table 5.5.3. 15. Characteristics of truck rinsing

Sample Name	COD	TSS (mg/L)	pH
Truck-tank rinsing WW (Qw18)	111,650 ± 353.5	33,820	6.3

5.5.3.3.2. Cleaning of Steel Vessels

Steel vessels, each of which is 40L, are used to carry orders from state institutions and the return milk from packaging. Vessel cleaning process has two main stages; manual and mechanical cleaning. Mass flow of vessel cleaning is illustrated in Figure 5.5.3.4 while a summary of cumulative values of the masses are presented in Table 5.5.3.16.

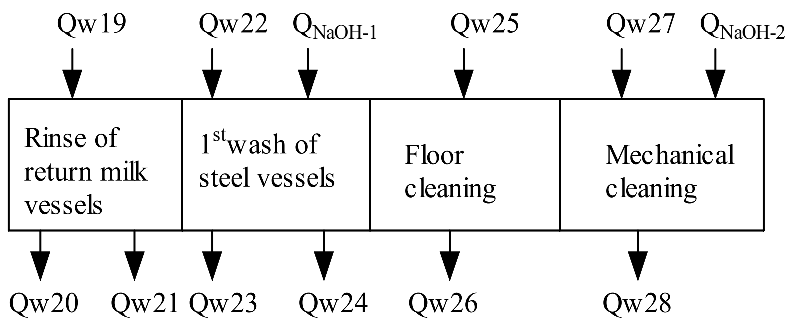

Figure 5.5.3. 4. Cleaning of return milk vessels

Table 5.5.3. 16. Mass flow of steel vessel cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw19+Qw22+Qw25+Qw27	Service water	2206.7
Qin	QNaOH-1+QNaOH-2	Caustic use	12.2
	Steel Vessel Cleaning		
Qout	Qw20+Qw23+Qw26+Qw28	Wastewater	2157.1
Qout	Qw21+Qw24	Water spill	61.8

Cleaning of vessels that returned milk is collected

Milk recycled from market milk production process (Qm11) are used for other products; i.e. economic cheese, yogurt. It is collected in steel vessels and poured into the raw milk tank (equalization basin). After pouring of milk, vessels are rinsed for about 2 minutes before being introduced to mechanical washing.

In rinsing of vessels, water is sprayed on the vessels (Qw19) with a filling efficiency of nearly 95%, which are gathered in the washing area. Total amount of water used at this stage is (Qw19) 188.3 kg/day, while 9.4 kg/day of it is spilled on ground (Qw21).

Assume $\rho_{wastewater} = \rho_{water} = 1$ kg/L

Qw19 = 1.57L/sec*2 min*60sec/min = 188.3 L/day = 188.3 kg/day.

To find Qw20;

Qw20=188.3*0.95= 178.9 kg/day

Qw21= 188.3*0.05= 9.4 kg/day

Cleaning of vessels used for selling non-packed milk and yogurt

As indicated above, yogurt and milk are sold to the state institutions in steel vessels. Cleaning of these vessels starts with manual cleaning which proceeds to mechanical wash. About 100 vessels are washed daily. Considering amount of unpacked milk (Qm12) calculated in Section 5.5.3.2.6, it is calculated that daily 43.7 vessels of market milk is sold. Since in this study only market milk production is the concern and total number of vessels to be rinsed is 100, although values of mass balance under this section are calculated on cumulative basis, they should be corrected by 43.7%.

In the manual cleaning, vessels are filled with hot water at about 70°C with a filling efficiency of 97% since some of water spills on ground while passing hose from one vessel to other. 200g of NaOH is added to each vessel. After internal cleaning with brushes, vessels are introduced to washing machine. For manual washing of market milk vessels 1748.8 kg/day of water (Qw22) and 8.7 kg/day of caustic (Q_{NaOH-1}) is used. (See calculations below.)

Qw22=40 L/vessel*100 vessel/day = 4000 L/day =4000 kg/day*43.7%= 1748.8 kg/day

Q_{NaOH-1} = 0.2 kg/vessel*100 vessel*43.7% =20 kg/day*43.7%=8.7 kg/day

Qw23 = (Qw22*0.97 + Q_{NaOH-1}) = 705 kg/day

Qw24= Qw22*0.03= 52.4 kg/day

<u>Washing of floor</u>

At the end of the day, pipeline carrying the milk pumped from tank-trucks to the plant and floor of the vessel cleaning area is rinsed with 164.6 kg/day of water (Qw25). While rinsing of pipeline takes for about 1-2 minutes, time for floor rinsing is measured as 2.5±0.7 minutes/day. During rinsing, water is sprayed on the floor by a hose and wastewater flows from ground to channels at the sides of vessel washing area. The calculations of water use can be seen below.

Qw25= 1.57 L/sec*(1.5+2.5) min*60 sec/min*43.7% = 376.6 L/day*43.7%=164.6 kg/day

Qw26= 164.6 L/day= 164.6 kg/day

Mechanical Wash

Manually pre-rinsed vessels are introduced to vessel washing machine. Machine is composed of 3 tanks, each of which has 500L volume. Water and the caustic solution in the machine are replaced weekly. Although caustic solution is prepared with 25 kg NaOH weekly, some amount of caustic is added daily to sustain the effectiveness of solution. Amount of this extra caustic adds up to 25 kg in a week.

1st Tank: 500L water + 25 kg NaOH +25 kg NaOH

2nd Tank: 500 L (Hot water)

3rd Tank: 500 L (Cold water)

% of the milk vessel, used for carrying pasteurized milk, which are introduced to mechanical washing is different from manual washing since vessels coming from returned milk (11 vessels /day) are added.

Correction ratio = (43.7+11)/ (100+11)*100= 49% (49 % of values should be taken)

Therefore, when mass flow values are corrected to calculate raw material use for market milk vessels, 105 kg/day of water (Qw27) and 3.5 kg/day of NaOH (Q_{NaOH-2}) is used. (See calculations below)

Qw27= 500L*3 tanks* 1wk/7day*49%= 214.29 L/day*49% =105 kg/day

Q_{NaOH-2}= 50 kg/wk*1wk/7day*49%= 7.1 kg/day*49%=3.5 kg/day

Qw28 =Qw27 + Q_{NaOH-2} = 108.3 kg/day

5.5.3.3.3. Cleaning of Raw Milk Storage Tanks

Although raw milk is pumped to the pasteurization system, about 1.5 cm thick milk foam is left at the bottom of the empty tank. These residues are drained of the tank by rinsing with water. After rinsing, tank is washed internally with detergent on weekly basis. Mass flows of raw milk storage tank cleaning are illustrated in Table 5.5.3.17, while the process is shown in Figure 5.5.3.5.

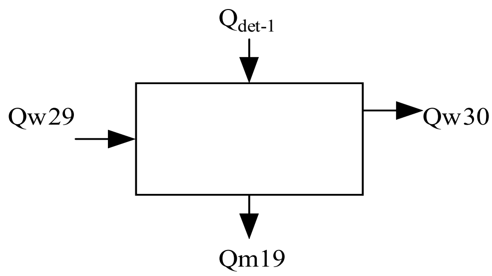

Figure 5.5.3. 5.Flow diagram of raw milk storage tank cleaning

Table 5.5.3. 17. Mass flow of raw milk storage tank cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw29	Service water	808.8
Qin	Qdet-1	Detergent	0.1
	Raw milk storage tanks cleaning		
Qout	Qm19	Milk foam	18.2
Qout	Qw30	Wastewater	808.9

First rinsing is done for purging of milk foam and washing of outer surface of tank and floor. Time for rinsing of four tanks is measured as 5 ± 1.4 minutes while time for washing of outer surface is nearly 1 minute per tank. The flow rate of hose used for rinsing is measured as 2.47 ± 0.4 L/sec. In the process of detergent washing, time for rinsing of detergent is same with daily rinsing. Therefore water use may be calculated on 8 rinsing/week. Mass flows calculated should be corrected with 56.15% since all of milk introduced is not used for market milk production.

Qw29=2.47*5*60sec/ min*8rinse/ 7days+2.47 L/sec*1min*60sec/min*4tanks

=1,440.5 L/day= 1,440.5kg/day*56.15%=808.8kg/day

Since the detergents used in houses has a density of nearly 1.2 kg/L, it is assumed that $\rho_{\text{detergent}}$ =1.2 kg/L

$Q_{det\text{-}1}$= 0.2 L/tank* 1.2 kg/L* 4 tanks* 1 wk/7 day *56.15% = 0.1 kg/day

Qw30=(1,440.5 kg/day+0.1 kg/day)*56.15%= 1,440.6 kg/day*56.15%=808.9kg/day

An estimation based on cream products to make cakes is done to find density of milk foam. These products sold in powder form has a density of nearly 150 g/L. In these creams since sugar and other ingredients are found, milk foam should have a lower density. Therefore it is assumed that $\rho_{\text{milk foam}}$ =0.1 kg/L

Qm19 = (0.18 m^3/tank * 0.1 kg/L* 4 tanks* 1000L/m^3)*56.15%=32.4*56.15 %

=18.2 kg/day

As it is seen, corrected values for market milk production shows 808.8 kg/day of water and 0.1kg/day detergent are used. Furthermore amount of milk foam at the bottom of tank is 18.2 kg/day.

5.5.3.3.4. Cleaning of Pasteurization System

Cleaning of pasteurization system takes place in 5 steps. Firstly water is pumped to purge the system filled with milk and to make an initial rinse. While water is being pumped, some amount of water and milk mixes in the line. When the color of the milk coming to pasteurized milk storage tanks changes, outlet of line is diverted to channel. After diversion of the line, some amount of water mixed with milk flows to channel to discharge the milk solids.

After discharge of more concentrated rinse water, line is connected to pasteurization to recycle the 1st rinse water. 1st rinse together with purging the milk takes place at about 10 minutes.

After initial rinse, 10 kg of NaOH is poured to the balance tank at the start of pasteurization to prepare a caustic solution of 2%. (Volume of pasteurization system is 500L). This solution is circulated in the system for 20 minutes.

During 2nd rinse water is pumped to system for 5 minutes to purge the caustic solution to sewer. After discharging of NaOH, 10L of HNO_3 (72%) is poured to the balance tank to recycle in the system for 20 minutes.

At the end of acid-wash, water is used again for both to purge the system and for final rinse. Final rinse lasts for 15 minutes. Presence of the caustic is detected by naphthalene test to stop rinsing.

In the morning of the following day, hot water is pumped to the system for 15 minutes to heat the HTST pasteurizer.

Mass flows in pasteurization cleaning are illustrated in Figure 5.5.3.6, and summarized in Table 5.5.3.18. The calculation of each step and details of each process are explained in the following sub-sections.

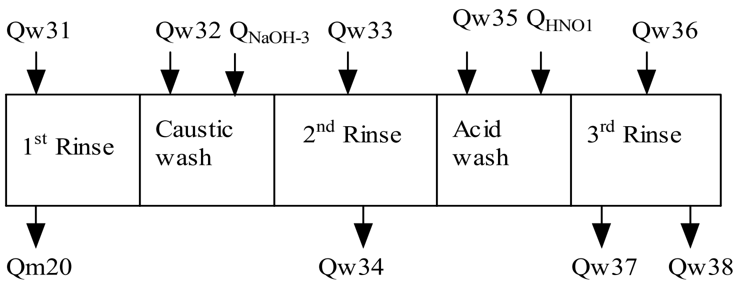

Figure 5.5.3. 6. Cleaning of pasteurization system

Table 5.5.3.18.Mass flow of pasteurization system cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw31+Qw32+Qw33+Qw35+Qw36	Service water	5282.1
	QNaOH-3	Caustic	10
	QHNO3	Acid	10
	TOTAL		5302.1
	Cleaning of Pasteurization System		
Qout	Qw20	milky wastewater	167.3
	Qw34	caustic wastewater	843.3
	Qw37	acidic wastewater	2510
	Qw38	overflow water	1297.8
		water remained in system	501.7
	TOTAL		5318.8

1st Rinse

For rinsing both a hose with a flow rate of 2.47 L/sec and a tap at the top of pasteurization balance tank, with a flow rate of 0.38L/sec are used. The hose is used only when needed while tap remains open throughout cleaning. There is a constant overflow of water to channel, due to this tap. Time for purging the milk and flowing of milk residues to channel is about 4 minutes, where first 3 minutes is time for purging, calculation of which can be seen below. Capacity of the pump at pasteurization which pumps water to the line is 10 m^3/hr (2.78 L/sec). After flowing of wastewater (Qm20) for 1 minute to sewer, line is connected to pasteurization to recycle rinse water. One minute after connection of line to recycling, hose is shut-off. Total time for 1st rinsing is about 10 minutes.

Time for purging of milk = 500 L/ (10,000 L/hr)*(1 hr/60min) =3 minutes.

Since water is recirculated in the system, after discharging of milk-water mixture, 500L of water remains in the system. Time for the hose flowing is nearly 5 minutes. (3 purging+ 1 discharging to sewer+1 during recycling).

Total amount of service water flow to balance tank (Qw31) is 966.4 kg/day. Of this quantity 301.8 kg/day overflows from balance tank directly to sewer. Calculation of the amount of water that overflow from balance tank during cleaning of pasteurization is summarized in Table 5.5.3.22.

Qw31= (2.47 L/sec)* 5 min*60 sec/min+ (0.38 L/sec)* 10 min*60 sec/min =966.4 L/day

As it is explained above (see general description of Section 5.5.3.3.4), some amount of water-milk mixture is let to flow sewer (Qm20) before starting recirculation of rinse water. During this procedure 167.3 kg/day of water is discharged to channel, calculations of which can be seen below. To determine the pollution load coming from this discharge and the recycling rinse water, COD, TSS, pH and alkalinity were analyzed, results of which are illustrated in Table 5.5.3.19. In Table 5.5.3.19 while sample 1 represents the rinse water discharged to sewer before diversion of line to recycling, 2 is the sample from recycling rinse water. Amount of milk in the discharged mixture is calculated as 0.7kg/day, while milk content of recirculating rinse water is 1.7 kg/day (see calculations below).

Table 5.5.3. 19. Characteristics of pasteurization cleaning 1st rinse water

Sample Name	COD	TSS (mg/L)	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurization 1st Rinse Water (1)	38850± 494.9	9320	6.9	70.9
Pasteurization 1st Rinse Water (2)	30850± 1131.3	-	-	-

Since pasteurized milk COD is 254,200 ± 282.8 mg/L, by taking the COD ratio of samples to the COD of milk, percentage of milk in the rinse water is calculated. Later by using the milk content, density of the rinse water (1 and 2) are calculated respectively. (See density calculation in clarification in Section 6.5.3.1.) In the calculations density of water is assumed to be 1 kg/L. Results of these calculations are illustrated in Table 6.5.3.20.

Table 5.5.3.20. Percentage of milk in 1st rinse water

Sample	% of Milk	Density(kg/L)
1	15.2	1.0043
2	12.1	1.0034

Wastewater flowing to channel (Qm20) = 2.78*1*60=166.6 L/sec

Qm20= 166.6L/day*1.0043kg/L= 167.3 kg/day

Taking density of water 1 kg/L amount of milk wasted to channel due to mixing with rinse water is calculated as;

Milk washed off with rinse water= 167.3 -166.6L/day*1kg/day=0.7 kg/day

Milk content of recirculating 1st rinsing is;

500L*(1.0034 kg/L-1 kg/L) = 1.7 kg/day

Caustic wash

During caustic wash, since the system is already filled with water and the valve of the 2nd water source (tap) at the top of pasteurization balance tank remains open 450 kg/day of water overflows (Qw32) to channel (see calculations below). For caustic solution 2% solution by mass is prepared. Since system volume is 500L, 10 kg of NaOH (Q_{NaOH-3}) is used daily and caustic solution is recirculated in the system for 20 minutes.

Flow rate of the tap at the top of balance tank is measures as about 0.38 L/sec.

Qw32=0.38L/sec*20min*60sec/min= 450 L/day=450 kg/day

2nd Rinse

This rinsing is done to purge the caustic solution from the system prior to acid wash and it takes about 5 minutes. During rinsing 853.9 kg/day of water (Qw33) is used while 21 kg/day of it overflows from balance tank (see Table 5.5.3.22).

Since both hose and tap remains open, flow rate of the water equals to 1st rinse; 2.85 L/sec.

Qw33=2.85*5*60= 853.9 L/day =853.9 kg/day

Assume all of NaOH is purged from the system by this rinsing. Therefore, all of caustic solution in system is discharged, while pasteurization system is filled with service water. Consequently amount of wastewater discharge should be equal to sum of water pumped for 5 minutes and the chemical addition in the previous stage.

$Qw34= 2.78L/sec*5min*60sec/min+ Q_{NaOH-3}$

Qw34 = 843.3 kg/day. (Wastewater purged from system)

Characteristics of caustic wastewater (Qw34), that is 843.3 kg/day, discharged to sewer is illustrated in Table 5.5.3.21.

Table 5.5.3. 21. Characteristics of caustic wastewater

Sample Name	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurization Caustic WW Discharge (Qw34)	10.4	12254.1

Acid wash

2% acid solution is used for washing the system. To prepare solution, 10 kg of HNO_3 (Q_{HNO3-1}) is poured to the balance tank and recirculated for 20 minutes. Excess service water, that directly overflow (Qw35) during this procedure is 450 kg/day.

Qw35= 0.38 L/sec*20min*60sec/min= 450L/day=450kg/day

3rd Rinse

Final rinse is done to purge the acid from the system as well as remained caustic. Both hose (2.47 L/sec) and tap at the top of pasteurization (0.38 L/sec) is used during rinsing, which takes about 15 minutes. Water pumped is discharged to channel. At the end of rinsing, naphthalene test is done to the final rinse for detection of caustic presence. Amount of service water used (Qw36) at this stage is 2561.8 kg/day and 63kg/day of it is directly overflowed (Qw38).

Since both hose and tap remains open, flow rate of the water equals to 1st rinse; 2.85 L/sec.

Qw36=2.85*15*60= 2,561.8 L/day = 2,561.8 kg/day

At the end of rinsing all of HNO_3 should be purged from the system, which is confirmed with a test for caustic presence. Consequently besides rinsing, neutralization of acid is another mechanism for acid removal. Therefore during final rinsing, all of acid solution in system that is 500 L is discharged, while pasteurization system is filled with service water. The pH of this water was 2.48 while acid is being purged.

Amount of wastewater discharge (Qw37) should be equal to sum of water pumped for 15 minutes and the chemical addition in the previous stage.

Qw37= 2.78L/sec*15min*60sec/min+ Q_{HNO3-1}

Qw37 = 2,510 kg/day.

Total amount of overflow water during cleaning of pasteurization system is calculated in Table 5.5.3.22. In the Table time of overflow together with source process are given. Results of calculations indicates that total amount of water overflowing from balance tank (Qw38) due to operating deficiencies is 1297.8 L/day. When the mass flow illustrated in Table 5.3.5.18 is examined, it is seen that there is a difference of 16.7 kg/day, which is about 0.31% of total input to the pasteurization system for cleaning (5302.1 kg/day), which is mainly due to the standard deviations of measurements that are indicated where results of measurements are given.

Table 5.5.3. 22. Calculation of overflow water from balance tank during pasteurization cleaning

Source	Q (L/sec)	t (min)	Q*t*60 (L/day)
1st rinse	0.07 [1] 2.85 [2] 0.38 [3]	4 1 5	16.8 171 114
		TOTAL	301.8
Caustic wash	0.38	20	456
2nd rinse	0.07	5	21
Acid wash	0.38	20	456
3rd rinse	0.07	15	63
		TOTAL (Qw38)	1297.8

[1] Overflow before starting recirculation

[2] Overflow after starting recirculation while hose is open

[3] Overflow after starting recirculation while hose is closed

Heating of Pasteurization System

At the beginning of the day, pasteurization system is heated by pumping hot water at 90º C to the system for about 15 minutes. It should be remembered that system is already filled with water (500L) from the cleaning of previous day. After heating, milk is pumped to the line. As in the case of 1st rinsing of cleaning, when the color of incoming water changes, line is diverted to the pasteurized milk storage tanks. But up to this time, some water-milk mixture is disposed to channel. Amount of milk disposed at this stage is assumed to be nearly same with amount disposed in evening since the mechanism and rates of water flow are same. Therefore 2500 kg/day of water (Qw39) is used for heating and 167.38 kg/day of it is the water-milk mixture (Qm21) with a COD of 38850 mg/L that is disposed to channel. Mass flows of this procedure is illustrated in Figure 5.5.3.7.

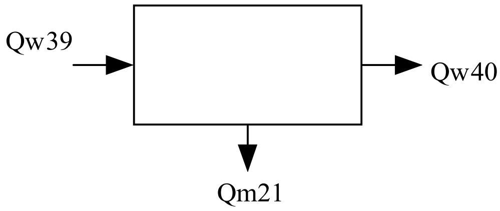

Figure 5.5.3. 7. Flow Diagram of Heating of Pasteurization

Qw39= 2.78 L/sec*15 min*60sec/min= 2500L/day=2500kg/day

Qm21=Qm20= 167.3 kg/day.

Qw40=2500kg/day-167.3 kg/day+ 500kg/day=2832.6 kg/day (Hot water disposed)

Total amount of water used in pasteurization cleaning and heating is 7,782.1 L/day.

Cleaning of Floors and Surface of Equipments of Raw Milk Storage and Pasteurization System

After finishing of pasteurization cleaning, floors are cleaned by first spraying a detergent with spray-gun than rinsing thoroughly. 1.5 bottles of cleaner is sprayed on the floors and equipment. Time for rinsing is measured as 9.5±0.7 minutes for floors and 4±1.4 minutes for equipments. 2001.8 kg/day of water (Qw41) and 1.7 kg/day of detergent (Q_{det-3}) is used during this procedure. Mass flows of this procedure are illustrated in Figure 5.5.3.8.

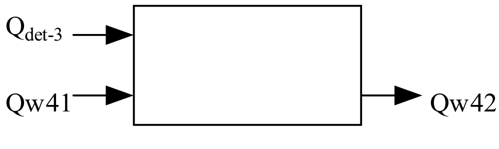

Figure 5.5.3. 8. Floor cleaning of pasteurization and raw milk storage

Qw41= 2.47 L/sec*(9.5+4) min*60 sec/min=1,408.7 L/day=2,001.8 kg/day

Assume $\rho_{cleaner}$=1.2 kg/L

Q_{det-3}= 950ml/bottle*1.5 bottle/day*1.2 kg/L*1L/1000ml=1.7 kg/day

Qw42=Qw41+ Q_{det-3}=2,003.5 kg/day (Wastewater from rinsing)

Although a summary of pasteurization cleaning mass flow is given in Table 5.3.5.18, these figures do not cover the morning heating and surface cleaning procedures. Table 5.3.5.23 illustrates whole mass flow during cleaning of pasteurization system including heating and surface cleaning procedures as well. As it is seen from Table, total amount of water used for cleaning this system is 9784 kg/day.

Table 5.5.3. 23. Pasteurization system cleaning total mass flow

	Notation	Name	Quantity (kg/day)
Qin	Qw31+Qw32+Qw33+ Qw35+Qw36+Qw39	Sevice water	9784
	Q_{NaOH-3}	Caustic	10
	Q_{HNO3}	Acid	10
	Q_{det-3}	Detergent	1.7
		TOTAL	9805.7
Qout	Pasteurization cleaning (Total)		
	Qw20+Qw34+Qw37+ Qw38+Qw40+Qm21	Wastewater	9822

5.5.3.3.5. Cleaning of Pasteurized Milk Storage Tanks

Pasteurized milk storage tanks are the most critical point for cleaning since milk flows to packaging after this unit. In this unit there are three tanks, which flows to packaging by gravity. Daily cleaning of tanks is done in 4 steps; i.e. warm rinse, caustic wash, warm rinse and cold rinse. These steps together with side procedures are illustrated in Figure 5.5.3.9. Quantities of mass flows are shown in Table 5.5.3.24 in a cumulative approach.

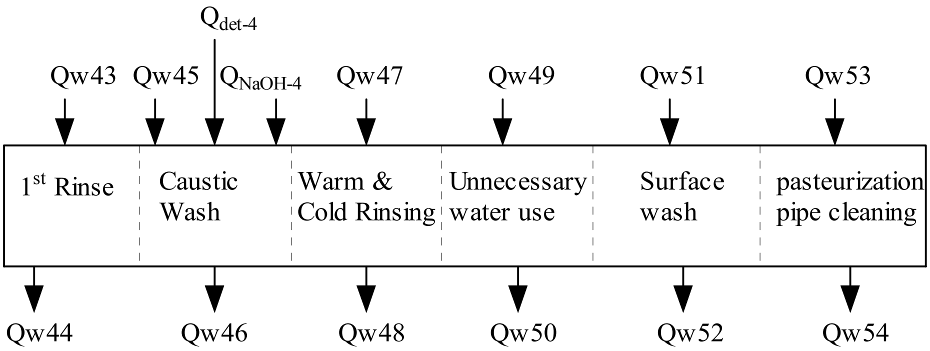

Figure 5.5.3. 9. Pasteurized milk storage cleaning

Table 5.5.3. 24. Mass flow of pasteurized milk storage cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw43+Qw45+Qw47+ Qw49+Qw51+Qw53	Service water	17365.5
Qin	QNaOH-4	Caustic	30
Qin	Qdet-4	Detergent	0.3
	Pasteurized Milk Storage Cleaning		
Qout	Qw44+Qw46+Qw48+ Qw52+Qw54	Wastewater	11696.2
Qout	Qw50	Unnecessary water spill	5712

1st Rinse:

Although milk flows to packaging by gravity, some amount of milk and milk foam remains at the bottom of storage tank. First rinsing is done to remove this milk and milk foam. Volume of milk and milk foam is measured by visual inspection as 3 L each. Hose used in cleaning of pasteurized milk storage tanks has flow rate of nearly 1.7 L/sec. Time for rinsing of each tank is measured as 1.7±0.3 minutes. During rinsing 535.5 kg/day of water (Qw43) is used to purge out 12.4 kg/day of milk and milk foam (Qm22).

Qw43= 1.70 L/sec*1.7 min*60sec/min*3tanks = 535.5 L/day =535.5 kg/day

To calculate Qm22;

Milk discharged; 3L/tank*3 tanks*1,028kg/L= 11.5 kg/day

Milk Foam discharged; 3 L/tank* 3 tanks*0.1 kg/L=0.9 kg/day

Qm22=11.5+0.9=12.4 kg/day.

Qw44= Qw43+Qm22=547.9 kg/day

By doing the calculations of density of Qm22 and percentage of milk content which have been previously illustrated for Qm20, amount of milk solids discharged to sewer are calculated as 0.014 kg/day.

COD, TSS, pH and alkalinity values of the 1st rinse wastewater (Qw44) are given in Table 5.5.3.25.

Table 5.5.3. 25. Characteristics of pasteurized milk storage 1st rinsing

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurized Milk Storage Tanks 1st rinsing (Qw44)	235.5±60.1	360	8.7	93.5

Caustic wash:

10 kg of NaOH per tank, some detergent and hot water (70-75 ºC) is used to prepare the solution. Solution prepared is sprayed and recirculated in the tank by help of an equipment and pump. The equipment is a pipe through which solution passes and has a perforated knob at the end, that water is sprayed. For preparing solution 1683 kg/day of water (Qw45), 30 kg/day caustic (Q_{NaOH-4}) and 0.3 kg/day of detergent (Q_{det-4}) are used. After preparation of solution, it is recirculated in the tank for 30 minutes. When the caustic wash finalizes, solution is discharged to channel by gravity. COD, TSS, pH and alkalinity values of the wastewater (Qw44) are analyzed experimentally and results are given in Table 5.5.3.26.

Qw45=1.7 L/sec*5.5min*60sec/min*3tanks =1683 L/day=1683 kg/day

Q_{NaOH-4}= 10 kg/tank*3 tanks=30 kg/day

Q_{det-4}= 100g/tank*3 tanks=300g/day=0.3 kg/day.

Qin=Qout

Qw46=1,713.3 kg/day

Table 5.5.3. 26. Characteristics of pasteurized milk storage cleaning- caustic wastewater

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurized Milk Storage-Caustic Wastewater (Qw46)	94±26.8	860	12.2	23448.4

2nd Rinse-Warm & Cold:

After chemical wash, tank is first rinsed with warm water and later with cold water and during this procedure 7344 kg/day of water (Qw47) is used. Time for warm rinsing is about 9 minutes and 15 minutes for cold rinsing of each tank.

Qw47=1.7 L/sec*(9+15) min*60sec/min*3 tanks = 7344 L/day=7344 kg/day

Qw48=Qw47=7344 kg/day (Wastewater from rinsing)

pH and alkalinity values of the warm rinse wastewater discharged to channel are also analyzed and illustrated in Table 5.5.3.27.

Table 5.5.3. 27. Characteristics of pasteurized milk storage 2nd rinse wastewater

Sample Name	pH	Alkalinity (mg/L as $CaCO_3$)
Pasteurized Milk Storage Warm Rinse Wastewater	9.4	40.8

Discharge due to hose remained open:

Washing procedures discussed above involves water required directly for each washing step. Between these steps, hose used for water supply is remained open. Measurements showed that hose remains open unnecessarily for about 17 minutes when discharging warm water and about 13 minutes when hot water is being used. While time for warm water discharge could be accepted to cover all three tanks, hot water values are measured for each tank. Therefore total amount of water wasted (Qw49) is 5712 kg/day.

Qw49=1.7 L/sec*(17min+13min*3tanks)*60 sec/min = 5712 L/day

Qw50=Qw49 = 5712 L/day (Wastewater discharged to sewer)

Surface Wash:

Outer surface of the tanks are rinsed thoroughly with water by spraying with hose and this procedures takes nearly 5.5±0.7 minutes for each tank. Below calculations show that during this procedure 1683 kg/day of water (Qw51) is used.

Qw51=1.7L/sec*5.5min*60sec/min*3tanks=1683 L/day

Qw52=Qw62=1683 kg/day. (Rinse water discharged)

Cleaning of pasteurization line pipes:

Although the pipes of pasteurization are cleaned by recycling chemical solution and rinsing, some milk may be remained in the fittings. To clean these surfaces, valves are removed and pipes are rinsed with water. This procedure takes nearly 4 minutes and 408 kg/day of water (Qw54) is used.

Qw53= 1.7 L/sec*4 min*60sec/min= 408 L/day

Qw54=408 L/day (Wastewater)

Morning wash:

Although cleaning of storage tanks is done at the end of the day, since it is most critical point for hygiene, in the morning before starting operation, same cleaning procedure is repeated. Only difference is the amount of caustic used is half and solution prepared in one tank is reused in 3 tanks. The process of morning wash is illustrated in Figure 5.5.3.10, and the related mass flows are summarized in Table 5.5.3.28. Calculations of mass flow are given below.

Total amount of water used for daily cleaning of pasteurized milk storage tanks is 33,665.5 L/day.

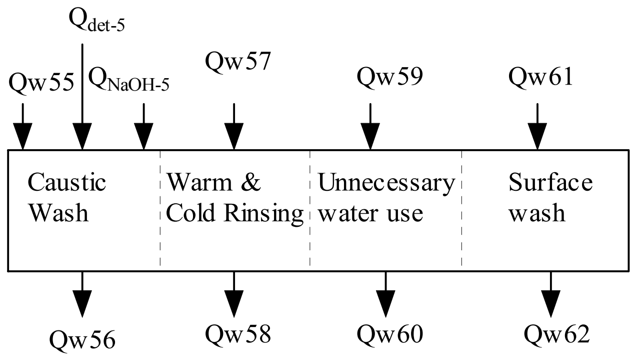

Figure 5.5.3. 10. Morning wash of pasteurized milk storage tanks

Table 5.5.3. 28. Mass flow of pasteurized milk storage morning wash

	Notation	Name	Quantity (kg/day)
Qin	Qw55+Qw57+Qw59+Qw61	Service water	15300
	QNaOH-5	Caustic	10
	Qdet-5	Detergent	0.1
	Pasteurized Milk Storage Cleaning		
Qout	Qw56+Qw58+Qw62	Wastewater	9598.1
	Qw60	Unnecessary spill	5712

Q_{w55}= 1.7L/sec*5.5min*60sec/min =560 L/day

Q_{NaOH-5}=5 kg/day

Q_{det-5}= 0.1 kg/day

Q_{w56}=571.1 kg/day

Q_{w57}=1.7*(9+15)*60*3=7344 L/day (Service water for rinse (35-40 ºC))

Q_{w58}=7344 kg/day

Q_{w59}=1.7*17min*60sec/min+1.7*13min*60sec/min*3tanks=5712L/day (Service water flowing to floor)

Q_{w60}=5712 kg/day (Water discharging to sewer)

Q_{w61}=1.7L/sec*5.5min*60sec/min*3tanks= 1683 L/day

Q_{w62}= 1683kg/day

5.5.3.3.6. Cleaning of Bottles and Bottle Cases

5.5.3.3.6.1. Cleaning of Bottles

Bottles coming from households and new bottles bought are washed mechanically in a machine at 5 steps. For dirty bottles, which milk residues are stuck in, there is a sub-procedure before mechanical washing. If bottle is not cleaned properly in the machine, hot water is filled in the bottle to wait until next day. To this purpose, dirty bottles are located in bottle cases and water is filled to bottles by spraying with a hose on the cases. Although each bottle has a volume of 0.5 L during filling, some of water is spilled on floor. By visual inspection it is decided that water-filling efficiency is about 60%. It is Therefore volume of water used to fill 240 bottles is taken as 200L/day (Qw63).

Q_{w63}=200L/day=200kg/day

Q_{w64}=Q_{w63}=200kg/day

In the mechanical washing stage 38,147 bottles/ day are washed. System is in operation 6 days per week. Machine is composed of 5 tanks; warm rinse, caustic wash-1, caustic wash-2, warm rinse, and cold rinse. Process steps of bottle washing are illustrated in Figure 5.5.3.11, while mass flows are summarized in Table 5.5.3.29. Although each flow indicated in Table 5.5.3.29 is calculated in the below sub-sections, complete list of them can be seen from Table 3.1 in Appendix III.

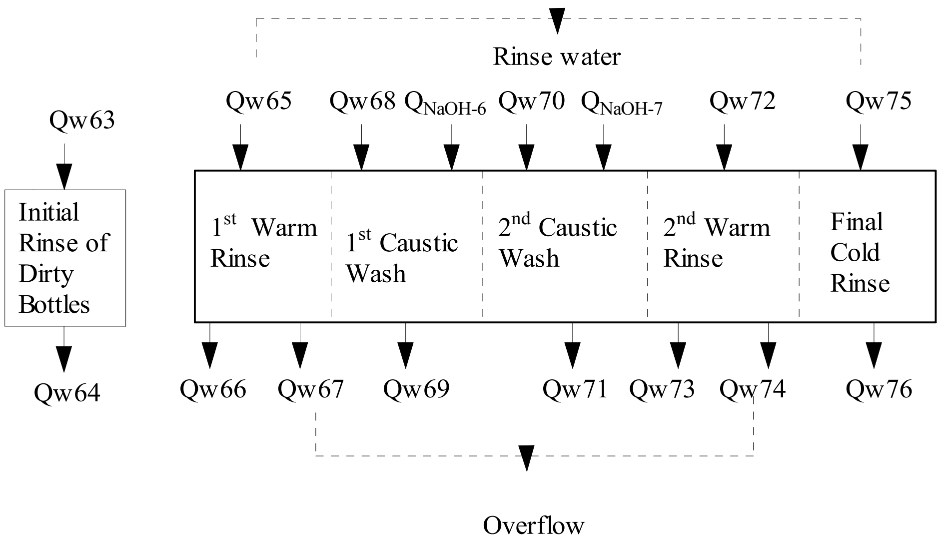

Figure 5.5.3. 11. Bottle washing

Table 5.5.3. 29. Mass flow of bottle washing

	Notation	Name	Quantity (kg/day)
Qin	Qw63+Qw68+Qw70+ Qw72+Qw65+Qw75	Service Water	12045.2
	QNaOH-6+QNaOH-7	Caustic	75
	Bottle Washing		
Qout	Qw64+Qw66+Qw69+Qw71+ Qw73+Qw67+Qw74+Qw76	Wastewater	12120.2

1st Warm Rinse:

This section has a capacity of 2 m^3. Incoming bottles are rinsed with warm water (35-40 ºC), which is collected and recycled in the tank. But there is a continuous input of replenishment water to the tank. Excess water from this tank combines with excess water of last cold rinse tank and discharged to channel. Flow to the channel is from a hole on a pipe that is collecting excess water. Since it is not possible to differentiate the mass coming from these two sources, discharge is taken on cumulative basis in the mass balance. Excluding replenishment water, water in the all tanks of machine is replaced weekly. Amount of wastewater discharge during this change (Qw66) is 333.3 kg/day.

Qw66=2000L/wk*1wk/6day =333.3L/day=333.3kg/day

See calculations of final cold rinse, for values of Qw65 and Qw67.

1st and 2nd Caustic Wash:

Hot caustic solution is prepared weekly in a tank of 4 m^3 by using 150 kg of NaOH. For sustaining its effectiveness, daily 12.5 kg of NaOH is added to the tank. Temperature of the solution is about 75-80 ºC. The same procedure is also applied in 2nd caustic wash. For each tank 666.6 kg/day of water (Qw68 & Qw70) and 37.5 kg/day of caustic (Q_{NaOH-6} & Q_{NaOH-7}) are used.

Qw68=4000L/wk*1wk/6day=666.6 L/day=666.6 kg/day

Q_{NaOH-6}= 150kg/wk*1wk/6day+12.5kg/day =37.5 kg/day

Qw69=Qw68+ Q_{NaOH-6}= 704.1 kg/day (Caustic solution discharged to channel)

2^{nd} Warm Rinse:

Volume of tank that warm water (40 ºC) is collected is 4 m^3. Water in the tank is recycled during the whole week and changed weekly. During operation, overflow water from final rinse is poured to this tank and overflow from this tank is discharged to channel (Qw74).

While amount of rinse water use at this stage is 666.6 kg/day (Qw72), amount of total overflow water during mechanical bottle washing is 9178.5 kg/day. Results of experimental analysis of this overflow water reveals that it has a high alkalinity (see Table 5.5.3.30).

Qw72= 4000L/wk*1wk/6day= 666.6 L/day=666.6 kg/day

Qw73=666.6 kg/day (Dirty rinse water)

For calculations of Qw74 see calculations of final cold rinse.

Table 5.5.3. 30. Characteristics of overflow wastewater of mechanical bottle washing

Sample Name	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as $CaCO_3$)
Overflow WW to Channel (Qw74+Qw67)	0	40	10.5	719.5

Final Cold Rinse

This section has a capacity of 2 m^3. Incoming bottles are rinsed with service water and water used for rinsing is collected in the tank. During operation, although tank is filled with water, there is a continuous flow of replenishment water. Due to this flow, the excess water coming from rinsing overflows to the tank of 2nd warm rinse. Since this tank is also filled with water, the tank overflows to the discharge pipe. By this way dirty rinse water with caustic is discharged to channel. Overflow water combines with the replenishment water of the 1st rinsing and flows together to channel. Flow rate of discharge pipe is measured as 0.5 ± 0.1 L/sec. As calculated below, the rate of this flow is 9178.5 kg/day.

Qw76: Wastewater discharged weekly

Qw74: Wastewater overflowing to 2nd warm rinse.

Qw76=2000L/wk*1wk/6day =333.3L/day=333.3kg/day

Qw75=Qw76+Qw74

Flowrate discharge pipe is measured as 0.5±0.1 L/sec.

Time for operation of the machine;

$$t = \frac{38{,}117 bottle}{1500 bottle / period} * 12 \min / period * \frac{1 hr}{60 \min} = 5.08 hr$$

Qw67+Qw74= 0.5 L/sec*5.08 hr*3600sec/hr=9,178.5 L/day

By using these discharge rates, amount of service water input in the 1st and final stage (Qw65+Qw75) is calculated as 9845.2 kg/day.

Qw75=Qw76+Qw74

Qw65=Qw66+Qw67

Qw75+Qw65=Qw76+Qw66+ (Qw74+Qw67)

Qw75+Qw65=333.3+333.3+9,178.5= 9,845.2 L/day

5.5.3.3.6.2. Cleaning of Bottle Cases

Bottle cases are washed in machine by spraying of service water on them. In 2002 AOC has produced 553,864 cases of milk. Therefore amount of cases used per day are 1799. For washing of them, 12801.6 kg/day of water (Qw77) is sprayed. Mass flow of this process is shown in Table 5.5.3.31, while calculations can be seen below.

Flowrate of the water to the machine is about 0.7 L/sec and the machine works synchronously with bottle washing for about 5.08 hrs in a day.

Qw77= 0.7L/sec*4.8hrs/day*3600sec/hr= 12,801.6 L/day

Qw78=12,801.6 kg/day

After washing, surface of equipments and floor are rinsed thoroughly with water by spraying with hose for about 20 minutes by using 2965.7 kg/day of water (Qw79).

Flowrate of the hose used for rinsing is assumed to be same with Qw30 since both have the same diameter.

Qw79 =2.47L/sec*20min*60sec/min= 2,965.7 L/day

Qw80=2,965.7 kg/day

Table 5.5.3. 31. Mass flow of bottle case washing

	Notation	Name	Quantity (kg/day)
Qin	Qw77+Qw79	Service water	15767.3
Qout	Bottle case and floor washing		
	Qw78+Qw80	Wastewater	15767.3

Total amount of water used for cleaning of bottles, bottle cases and floor in this area is 27,812.5 L/day.

5.5.3.3.7. Cleaning of Bottle Packaging

Bottle packaging is done automatically in a machine. At the end of the day, cleaning of this equipment is done in 3 steps. These are illustrated in Figure 5.5.3.12 while mass flows are summarized in Table 5.5.3.32.

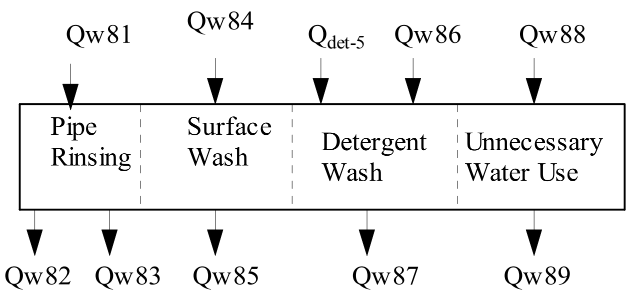

Figure 5.5.3. 12. Cleaning of bottle packaging

Table 5.5.3. 32. Mass flow of bottle packaging cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw81+Qw84+Qw86+Qw88	Service water	7108.7
Qin	Qdet-5	Detergent	0.2
	Bottle Packaging Cleaning		
Qout	Qw83+Qw85+Qw87	Wastewater	5890.9
Qout	Qw82+Qw89	Spilled water	1218

Rinse of Pipeline:

Initially, line which connects pasteurized milk storage and tank of the packaging machine is rinsed with hot water for about 5 minutes by inserting a hose to the inlet of pipe. During this procedure, water flows from pipe to bottle filling tank. Although hose is inserted into the pipe, some of the water spills on floor. After flowing into bottle filling tank, nozzles under the tank are opened to discharge the milky rinse water to channel. By this method both pipe and the filling tank is rinsed.

During rinsing 510 kg/day of water is used (Qw81) while 31.7 kg/day is spilled on floor (Qw82). Since bottle filling tank is also rinsed, milk left in the tank is also discharged together with rinsing. Experimental analysis of rinsing shows that the wastewater has COD of 8425 mg/L (see Table 5.5.3.33) that shows milk loss of 15.8 kg/day.

Assume ρ_{water}=1kg/L

Qw81= 1.7L/sec*5min*60sec/min=510 L/day=510 kg/day

By visual observation it is decided that amount of water flowing to ground can be taken as equal to the condensed steam flow rate in pasteurization (Qw6). Assume mass coming from milk solids in Qw83 is negligible.

Qw82= 380.5 L/hr*5min*1hr/60min= 31.7 L/day=31.7 kg/day

Qw83=510-31.7=478.3 L/day=478.3 kg/day

Table 5.5.3. 33. Characteristics of bottle filling 1st rinse

Sample Name	COD (mg/L)	TSS (mg/L)	pH
Bottle Filling 1st rinse (Qw83)	8425 ± 883.8	194	7.1

Surface Wash of Equipment and Conveyors:

For cleaning of surface of equipments and conveyors, they are rinsed with service water and brushed for about 27 ± 4.2 minutes by using 4003.7 kg/day of water (Qw84). The hose used for washing of equipment in this area has the same diameter with hose of raw milk storage tanks area. Therefore their flowrates are assumed to be equal.

Qw84=2.47 L/sec*27 min*60sec/min=4003.7 L/day=4003.7 kg/day

Qw85=4003.7 kg/day

Detergent wash:

Equipments and bottle filling tank are washed manually by foaming with a detergent and rinsed thoroughly with water. Time for rinsing of these equipment is measured as 9.5±0.7 minutes. Amount of water used for rinsing (Qw86) is calculated as 1408.7 kg/day.

Qw86=2.47L/sec*9.5min*60sec/min= 1,408.7 L/day=1,408.7 kg/day.

Amount of detergent used is about 200ml/day. Assume $\rho_{detergent}$=1.2kg/L

Q_{det-5}= 0,2L/day*1.2kg/L=0.2 kg/day

Qw87= 1,408.7+0.2=1,408.9 kg/day.

Unnecessary water discharge:

After initial rinse, inside of the bottle filling tank and equipment is washed with detergent. During the procedure of foaming the detergent and brushing water is left flowing to channel for about 7 minutes. Also after foaming of the lids of tank and nozzles, they are rinsed 3 times. During this procedure water is used unnecessarily for 1 minute. Cumulatively, it is calculated that amount of water used during cleaning of bottle packaging is 7,108.7 kg/day, whereas 1186.3 kg/day (Qw88) is discharged to sewer due to hose left open and unnecessary rinsing.

Qw88=2.47L/sec*8min*60sec/min=1,186.3 L/day

Qw89=1,186.3 kg/day

5.5.3.3.8. Cleaning of Cartoon Packaging

Cartoon packaging machine has CIP system for cleaning. Washing is done in two steps; caustic wash and rinsing. The process steps are shown in Figure 5.5.3.13 and the respective mass flows are summarized in Table 5.5.3.34. Quantity of each mass flow indicated in Table 5.5.3.34 can be seen in Table 3.1 of Appendix III.

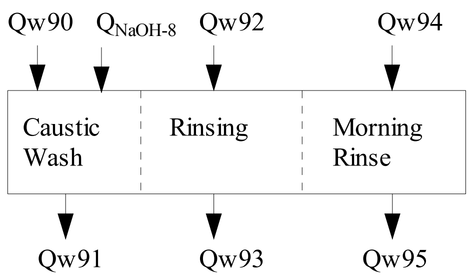

Figure 5.5.3. 13. Cleaning cartoon packaging

Table 5.5.3. 34. Mass flow of cartoon packaging cleaning

	Notation	Name	Quantity (kg/day)
Qin	Qw90+Qw92+Qw94	Service water	1250
	QNaOH-8	Caustic	5
Qout	Cartoon Packaging Cleaning		
	Qw91+Qw93+Qw95	Wastewater	1255

Caustic Wash:

Tank of 250L volume is used to prepare solution. 5 kg of NaOH is added to tank and solution is recycled in the system for 20 minutes.

Assume ρ_{water}=1kg/L

Qw90= 250L/day=250kg/day

Q_{NaOH-8}= 5kg/day

Qw91=250+5=255kg/day

Rinsing:

For rinsing, CIP system has a tank of 250L volume. According to the principle of CIP, this volume of water should be circulated in the system. But AOC uses continuous discharge of rinse water to be sure of proper rinsing. During this procedure 3 tanks of water is passed through system and though 750 kg/day of water is discharged to channel.

Qw92= Qw93= 250L/tank*3tanks=750L/day=750kg/day

Morning Rinse:

In the beginning of the day, before starting operation, machine is rinsed with one tank of cold water. Therefore 250 kg/day of service water (Qw95) is discharged to sewer.

Qw94= Qw95= 250L/day=250kg/day

Total amount of water used in cleaning of cartoon packaging is 1,250L/day.

5.5.3.3.9. Analysis of Mass Balance for Cleaning

In this section water use, wastewater and milk discharges at different steps of mass balance are analyzed and results are presented in Tables 5.5.3.35, 5.5.3.36, 5.5.3.37. While these tables presents general scene of discharges and uses, CP opportunities related with these uses or discharges will be discussed on source basis in the Discussion Section (see Section 5.5.4).

Table 5.5.3.35 shows milk and milky wastewater discharged to channel that can be prevented or reduced by using in other products or process as ingredients. Although it will be discussed briefly in sub-sections of 5.5.4.2, the major opportunity for milky wastewaters is use of them as animal feed [2]. Further discussion of these opportunities are presented in Sections 5.5.4.2.1, 5.5.4.2.3 and 5.5.4.2.4. Table 5.5.3.36 presents the chemicals used in cleaning process, which could be reduced by applying CP opportunities. Table 5.5.3.37 illustrates unnecessary water use sources, which can be eliminated. Finally Table 5.5.3.38 illustrates wastewater or water use sources that can be reduced by applying CP opportunities.

When the total MB is examined, it is seen that including the losses and spills 97486 kg/day of wastewater is discharged, while 33527.1 kg/day of raw milk is introduced to plant for market milk production (see Table 5.5.2.1).

Total wastewater discharge= 69827.1+15911.4+11747.5 = 97486 kg/day.

Therefore wastewater discharge for unit market milk production is;

97486 kg/day/33527.1 kg/day= 2.9 kg wastewater/ kg milk

When the general MB of AOC (Table 5.5.2.1) is concerned, a difference of 284.7 kg/day is observed, that corresponds to a 0.84% error in the mass balance. This difference may be accounted for the errors in measurement of flow rates and standard deviations of the experimental results.

Table 5.5.3. 35. Milk and milky wastewater that can be reduced

Waste source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	For details See Section
	Cleaning tanks on trucks						
Milk spilled on ground	Qm18	6.9	254,200	59,722.2	6.7	737.4	6.5.3.3.1
	Raw milk storage tanks						
Milk foam	Qm19	18.2	-	-	-	-	6.5.3.3.3
	Pasteurization 1st rinse						
milky water to channel	Qm20	167.3	38,850	9,320	6.9	70.9	6.5.3.3.4
	Pasteurization heating						
milky water to channel	Qm21	167.3	38,850	9,320	6.9	70.9	6.5.3.3.4
	Cleaning bottle packaging						
Rinse of pipeline	Qw83	478.3	8,425	194	7.1	-	6.5.3.3.7
TOTAL		843.9					

Table 5.5.3. 36. Chemical uses that can be reduced

Name	Quantity (kg/day)	For details see Section
Vessel manual washing QNaOH-1	20	6.5.3.3.2
Vessel mechanical cleaning QNaOH-2	7.1	6.5.3.3.2
Pasteurization caustic wash QNaOH-3	10	6.5.3.3.4
Pasteurization acid wash QHNO3-1	10	6.5.3.3.4
Pasteurized milk storage tanks caustic wash QNaOH-4	30	6.5.3.3.5
Bottle washing QNaOH-6 QNaOH-7	37.5 37.5	6.5.3.3.6.1
TOTAL	152.1	

Table 5.5.3. 37. Unnecessary water use sources that can be eliminated

Waste source	Name	Quantity (kg/day)	For details see Section
Spill on floor in vessel rinsing	***Vessel cleaning*** Qw21	9.4	6.5.3.3.2
Spill on floor in vessel rinsing	Qw24	52.4	6.5.3.3.2
overflow water	***Pasteurization cleaning*** Qw38	1297.8	6.5.3.3.4
hose remained open	***Pasteurized milk storage tank Cleaning*** Qw50	5712	6.5.3.3.5
hose remained open	Qw59	5712	6.5.3.3.5
water filled in bottles	***Bottle washing*** *Initial rinse of dirty bottles* Qw63	200	6.5.3.3.6.1
water sprayed on cases	*Bottle case washing* Qw77	12801.6	6.5.3.3.6.2
spill on floor	***Cleaning bottle packaging*** *Rinse of pipeline* Qw82	31.7	6.5.3.3.7
hose remained open	Qw88	1186.3	6.5.3.3.7
TOTAL		27003.2	

Table 5.5.3. 38. Wastewater or water use sources that can be reduced

Waste source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	For details see Section
	Cleaning Tanks on Trucks						
Waste rinse water	Qw18	2017.9	111650	33820	6.3		6.5.3.3.1
	Rinse of return milk vessels						
dirty rinse water	Qw20	178.8					6.5.3.3.2
	Rinse of unpacked milk vessels						
dirty rinse water	Qw23	1705					6.5.3.3.2
Spill on ground in vessel rinsing	Qw24	52.4					6.5.3.3.2
	Floor cleaning of vessel washing						
dirty rinse water	Qw25	164.6					6.5.3.3.2
	Mechanical vessel washing						
water used in machine	Qw27	214.3					6.5.3.3.2
	Raw milk storage tanks rinsing						
service water for rinsing	Qw29	808.8					6.5.3.3.3
	Pasteurization cleaning *2nd rinse*						
caustic solution discharged	Qw34	843.3			10.7	12254.2	6.5.3.3.4
	3rd rinse						
acidic solution discharged	Qw37	2510			2.4		6.5.3.3.4
	Pasteurization heating						
heating water	Qw39	2500					6.5.3.3.4
	Surface and floor cleaning of pasteurization						
service water for rinsing	Qw41	2001.8					6.5.3.3.4
	Cleaning of pasteurized milk storage 1st rinse						
rinse for purging of milk and milk foam	Qw44	547.9	235.5	360	8.8	93.5	6.5.3.3.5
	Caustic wash						
caustic solution discharged to sewer	Qw46	1713.3	94	860	12.7	23448.8	6.5.3.3.5

Table 5.5.3.38. (continued)

Waste source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	For details see Section
	Final rinse(warm and cold)						
Dirty rinse water	Qw48	7344			9.4	40.8	6.5.3.3.5
	Surface cleaning of pasteurized milk storage tanks						
Waste rinse water	Qw52	1683					6.5.3.3.5
	Rinse of pasteurization line pipes						
Waste rinse water	Qw54	408					6.5.3.3.5
	Morning caustic wash						
Wasted alkaline solution	Qw56	571.1					6.5.3.3.5
	Rinse of morning wash(warm and cold)						
Service water for warm rinse	Qw57	7344					6.5.3.3.5
	Surface cleaning of pasteurized milk storage tanks-morning						
Waste rinse water	Qw62	1683					6.5.3.3.5
	Bottle washing						
	Mechanical washing						
Overflow water	Qw74+Qw67	9178.5	0	40	10.5	719.5	6.5.3.3.5
	Floor cleaning						
Service water for rinsing	Qw79	2965.7					6.5.3.3.6.1
	Cleaning bottle packaging						
	rinse of pipeline						
Surface rinsing water	Qw84	4003.7					6.5.3.3.7
detergent rinsing water	Qw86	1408.7					
	Cleaning cartoon packaging						
Service water for rinsing	Qw92	750					6.5.3.3.8
TOTAL		52589.3					

5.5.4. Discussion of CP Opportunities for AOC

In this section, results of the mass balance for AOC that are reviewed in sub-sections of Section 5.5.3 are discussed and respective CP opportunities are presented. Respective heading of this section in Methodology (Chapter IV) is “Identification of Potential Cleaner Production Options”. In order to provide parallel perspective with previous section, discussion of the opportunities for production process and cleaning are held in different sections.

5.5.4.1. CP Opportunities for Market Milk Production

When the process of AOC market milk production is examined, it is obvious that the major environmental loads are due to the discharges of chemicals and milk residues during cleaning procedures. It is also observed that since the hygiene of production is critical, there is an extensive use of chemicals. Organic load is due to the first rinsings of cleaning, since this rinsing collects the milk residues remained in the piping and equipments. These issues will also be discussed in Section 5.5.4.2, under discussion of CP opportunities for cleaning.

On the other hand, pollution load is mainly organic during production of market milk and this comes from the milk sludge (clarifier and separator) and milk spills.

World Bank performance indicators for consumer milk indicates that milk loss up to 1.90% of volume of product is acceptable (see Table 3.2.4). In a study made in Egypt losses of raw milk in receiving was 0.7 tons/day for a daily intake of 20 tons of milk. (see Case study 1 in Appendix IV) If the milk intake were corrected to AOC levels (50373 kg/day), daily loss of Egyptian firm would be 1.75 ton/day, which is 3.5 % of intake. Since this value is 1.35% in AOC, the efficiency of AOC process is higher.

Although loss in AOC (1.35%) is below the limits of World Bank, it may definitely be decreased by the CP opportunities developed and proposed in this study.

In Table 3.2.3, it is mentioned that dairy wastewater has COD within the ranges of 1400-1600 mg/L. Although COD analysis of AOC main wastewater stream could not be done, COD, TSS, pH and alkalinity of different sources were measured. By only considering the amount of COD that could be reduced by implementation of opportunities that will be suggested (181,9 kg/day) and the amount of current wastewater discharge (97486 kg/day) (see Table 6.1 and Table 5.5.2.1) it is calculated that that currently, wastewater has a COD of greater than 1866 mg/L, which is greater than values indicated in Table 3.2.3. If the same approach is used for TSS concentration, 212.6 mg/L of TSS discharge is calculated, that is below the limits indicated in Table 3.2.3.

In Table 3.3.12, it is stated that generally, 0.5 kg of wastewater is produced per kg of market milk production when the initial rinses are saved. In spite of that, in AOC 2.9 kg wastewater/ kg market milk is produced (see Section 5.5.3.3.9). In this quantity no recovery of rinses and inefficient use of water is the main factor. In Table 3.3.12 also, 0.46 kg BOD/100 kg milk processed is indicated as the common value in dairies. In AOC if a factor of 73% is taken as BOD/COD value (see Table 3.2.3) more than 0.41 kg of BOD[4] is produced per 100 kg milk processed. Although milk loss is in the acceptable range according to World Bank product loss benchmarks (see Table 3.2.4), there is an important inefficient water use problem.

Results of discussions and CP opportunities for market milk production are illustrated in Table 5.5.4.1. Moreover, detailed figures for each opportunity on source basis are given in Appendix III, in Table 3.2.

[4] Since all discharge sources could not be analyzed experimentally but major sources are chracterized, this value is expected to be higher.

5.5.4.1.1. Clarification

During clarification of milk there are two water discharge sources; discharge of excess service water (Qw4) and losses from valves (Qw3) (see Tables 5.5.3.11 and 5.5.3.13). By implementing good house keeping approach, maintenance of equipments may eliminate serious losses [28] (see Section 3.2.2). Therefore, maintenance of the valves and fittings may eliminate spill of 106.1 kg/day of water.

As it is discussed in Section 3.2.2, water should be free of microorganisms, toxic/harmful chemicals, color and odor to be recirculated if it will be in contact with food [12]. When the characteristics of discharge water (Qw4) that are illustrated in Table 5.5.3.3 are examined, it is seen that Qw4 is a source of service water quality with volume of 302.6 L/day. Table 3.2.13 indicates that condensate, which is a water of similar characteristics may be used in manual cleaning options and as pre-rinse water [30]. Therefore clarification discharge water can be used in cleaning of any equipment. Similarly, discharge water of separator (Qw9) has the same characteristics with a flow rate of 4360.5 kg/day and can also be used for cleaning purpose.

As it is discussed in Section 5.5.3.1 and 5.5.3.2.2 for liquidification of clarifier and separator sludge totally 55 L/day ((15.3+39.7) L/day) of service water is used. Therefore, as another alternative, clarifier and separator discharge water together with steam condensate (see Section 5.5.4.1.3) may be recirculated for sludge liquidification. If a tank with a small pump is installed, it may be used for recycling of water with service water quality, thus these and other similar water sources may be reused for cleaning or for equipment operation requirements, i.e. sludge production.

Current water use in AOC is supplied by AOC General Directorate by processing and pumping of water sucked from wells. As the water is currently being pumped and electricity is used, it is thought that installing a recycle system with definitely a smaller pumping capacity will be feasible.

In clarification, in terms of organic load, main issue is the clarifier sludge discharged to sewer. Actually, it is a very valuable source as animal food due to its nutritional value. Therefore the most promising option for sludge is use of it in animal feed (see Section 3.2.2) [13]. World Bank suggests collection of waste product for use in lower-grade products such as animal feed, where it is feasible without exceeding cattle feed quality limits [8]. Mr. Durna mentioned that, although clarifier sludge is a valuable source, it may need pre-treatment i.e. pasteurization for the health of animals and suggested that sludge may be send to fodder production facilities [33]. Amount of clarifier sludge (Qw2) in AOC market milk production is 15.5 kg/day, environmental load of which is illustrated in Table 5.5.3.2 in Section 5.5.3.1. Since AOC is a large facility that also feeds cattle, sludge can be used in their feeding or it may be used in fodder industry, some of which are found in the vicinity of Ankara. To this purpose, collected sludge may be kept in refrigerated storage for weekly transfer of it to fodder industry. By this way, 2 kg/day of COD and 415.6 g/day of TSS may be eliminated.

5.5.4.1.2. Raw Milk Storage Tanks

UNEP suggests that, to reduce the amount of milk that is lost to effluent stream, wastewaters from initial rinses may be collected to return them to the dairy farm for watering cattle [2]. As it is discussed in Section 5.5.3.1, about 6.9 kg/day of milk spills at each disconnection of piping. It is thought that milk-water mixtures can be used for watering cattle similar to the case with milk sludge (see Section 3.2.2). Technical possibility of this issue was also discussed with the firm engineers and a positive response was taken. Mr. Durna mentioned that, due to contents of milk, animal fed with this source will have higher milk production efficiency. Therefore it is principally suggested that concentrated 1^{st} rinsings can be collected in a tank and used for watering cattle.

In the light of this approach, to prevent milk spill on floor, raw milk storage tanks can be connected to a single pipe, which will be connected to pasteurization. The connection to pasteurization should be manually controllable and milk flow from three tanks should be controlled by valves. By this system, milk spill to ground and first rinse wastewater of this tanks (see Section 5.5.3.1) could be collected at the end of new pipe installed. This water that is rich in milk may be used in animal feeding. By this implementation, 6.9 kg/day of milk and 18.2 kg/day of milk foam discharge to sewer could be prevented corresponding pollution load of which is illustrated in Table 5.1.1. By only preventing milk spill 1.7 kg/day of COD and 413.6 g/day of TSS can be prevented to be discharged to sewer.

5.5.4.1.3. Pasteurization

In Section 5.5.3.2.1, it was indicated that there is a continuous discharge of steam condensate, which has a quality of service water (see Table 5.5.3.6). UNEP indicates that $1m^3$ of lost condensate represents 8.7 kg of oil at a condensate temperature of 100ºC. Therefore it is strongly suggested that piping systems should be installed for returning condensate to the boiler and indicated that payback period of such systems is short [2]. In AOC, during previous studies of ISO 9000, the necessary piping for condensate return was installed. But the operators mentioned that, since system was not efficient they have cancelled the return line. If the problems with this pre-installed piping are handled, this valuable heat may be reused. In a factory a similar project has annual savings of US$ 14,410 [11]. (See Table 3.2.11) Alternatively, in Table 3.2.13, it is indicated that condensate may be reused for crate, vehicle washing and as CIP pre-rinse. Therefore if the tank system discussed above (Section 5.5.4.1.1) is set up, it can provide reuse of this source for cleaning. Amount of condensate discharge that will be reused is 2664 L/day.

In addition to reuse of condensate, amount of spills from fittings of HTST pasteurizer (Qw7=14 L/day) can be prevented by maintenance of fittings.

5.5.4.1.4. Separator

In principle, CP opportunities for separator are same with opportunities for clarifier since their operation principle are same. As it is previously discussed in Section 5.5.4.1.1, water discharge from separator (Qw9), which is 4360.5 kg/day, can be reused for another cleaning activity (see Table 5.5.3.11). Since discharge water has the same function as in clarifier discharge (Qw4), characteristics of these sources are expected to be same. Results of total coliform and pH analysis of Qw9 can be accepted as verification of this assumption (see section 5.5.3.2.2).

Excess of the water used for liquidification of sludge (Qw10) that is discharged to sewer is 2100 kg/day. In GHK Guide, it is mentioned that inexpensive water-saving devices should be installed where appropriate to stop water sources that are absolutely not needed [28]. If a level control is affixed to the tank in which service water is stored for separator sludge, this discharge can be eliminated. The function of level control should be closing incoming service water line when the tank is filled.

In terms of organic load, main source is separator sludge (Qw11), as it is discussed in Section 5.5.3.2.2 and illustrated in Table 5.5.3.7. As indicated in Section 5.5.4.1.1 most promising option for this sludge is use of it as animal feed. If this sludge is not let to flow sewer and collected for mixing with animal feed, 40.2 kg/day of sludge with 7.1 kg/day COD and 1289.3 g/day TSS will be prevented.

5.5.4.1.5. Deodorization

During operation of deodorization, water used for heating of deodorizer (Qw13) is discharged to sewer continuously. Since this water has the characteristics of service water, if it is diverted to the proposed tank-pump system it could be reused in cleaning procedures (see discussion in section 5.5.4.1.1). Amount of Qw13 is 2131.2 kg/day.

Another continuous water loss source is the hole in the main pipeline due to corrosion (Qw12). Qw12 is the loss from cooling water and though there is a continuous loss of coolant, which is an expensive chemical. In GHK Guide, it is suggested that leakages in pipes and equipments should be repaired for reducing losses and use of raw material inputs efficiently [28]. This discharge, 840 kg/day, can be eliminated if the pipe is repaired.

5.5.4.1.6. Homogenization

As it is discussed in Section 5.5.3.2.4, there is a continuous milky water loss (Qw15) due to a defect in a piston and rupture of a hose, which is 1077.2 kg/day. In line with the above stated suggestion of Sustainable Business Associates (SBA) (see Section 5.5.4.1.5, this leakage should be repaired [28]. Environmental pollution load resulting from these defects are illustrated in Table 5.5.3.8. If these defects are repaired, discharge due to Qw17 could be eliminated. As a result of implementation 5.7 kg/day of COD and 792.5 g/day of TSS may be eliminated.

5.5.4.1.7. Pasteurized Milk Packaging

Cartoon Packaging

During packaging there are three sources of milk loss; spill in filling, milk foam and recycling milk to other products. Of these losses, milk foam (Qm9) and return milk to the beginning of process may be the main CP opportunity areas. Milk foam discharge, which is about 0.5 kg/day, can be collected in a vessel to be used as fodder. But since its quantity is very small, and for its collection a separate vessel is required, which should be cleaned daily, it does not seem feasible.

On the other side, milk due to defective packaging and remainings in the pipe is already collected as return milk (Qm11). If defective packaging is minimized, amount of return milk will be reduced. Daily 80 packages of milk is packed mistakenly, which is equal to 40 L/day if all of damaged packaging were ½ L volume packages. Reducing amount of return milk is important for preventing use of chemicals, energy and water once again for the same amount of milk.

If packages are stored in better conditions; i.e. at optimum moisture levels, the amount of return due to sticking defects will be reduced. Respecting the stacking conditions recommended by the suppliers of raw materials is important for their durability. Also stocks should be kept at levels based on actual needs that excessive buying of raw materials should be avoided [28]. Therefore, in addition to adjusting moisture level, the policy of purchase may be directed to buying in smaller quantities. This may prevent storage of packages for long time, which makes them to be more confronted with environmental effects. By applying these measures, it is believed that defective packaging will be reduced by 40% (16.45 kg/day). Consequently, milk that will be returned to the beginning of process will be reduced to 131.58 kg/day.

Glass Bottle Packaging

In the process of bottle packaging CP opportunity is reducing amount of milk recycled to beginning of process (Qm11). 123.3 kg of milk is recycled daily due to defective packaging and collection of milk left in piping at the end of day. Reducing the amount recycled milk will reduce operation costs since it will reduce second time pasteurization.

Defective packaging is mostly due to uncapped bottles. If they can immediately be capped manually, this milk will be prevented to be recycled without contamination. Also milk remained in tank at the end of the day may be filled into bottles and capped manually. During site visit, it was observed that, only about 5 L of milk was returned due to remaining in the tank. The rest of return milk comes from defective packaging; uncapped bottles and defective cartoon packaging. Therefore if 70% of return milk could be reduced by implementation of these measures, recycle due to bottle packaging will be reduced to 37 kg/day. When the return milk from cartoon packaging is also considered, 271.4 kg/day of return (Qm11) may be reduced to 168.6 kg/day.

Unpacked Milk Filling

Discussions in Section 5.5.3.2.6 put forward that, environmental load while filling the vessels is the result of spills on ground (Qm13) due to valve remained open and overfilling. Amount of spill is 45.2 kg/day. SBA suggests that simple equipment changes may reduce effluents [28]. In line with this, if the global valve used to control the milk pipe is changed with a check valve and if this is closed at every vessel change, this spill will be eliminated. Consequently, 11.1 kg/day of COD and 2627.7 g/day of TSS will be prevented from flowing to sewer.

5.5.4.1.8. Potential Benefits of Implementation of CP Opportunities for Market Milk Production Process

The results of implementation of opportunities discussed above are illustrated in Table 5.5.4.1 on opportunity basis. In addition to this, detailed figures for result of each opportunity on each water/waste source can be seen in Table 3.2 in Appendix III.

In Schroeder Company (Minnesota), which has 340 m^3 /day raw milk processing capacity, improving maintenance and tightening up existing systems to avoid leaks reduced product loss and water use significantly. In Company, these measures saved 5450 L of product and 19252 L of water daily. This corresponds to a factor of 0.07 m^3 savings/m^3 of milk processed (see Case study 5). The same figure for AOC is 0.06 m^3 saving/m^3 of milk which is a very close value (see Table 6.1). Therefore it can be concluded that, although it is a very rough generalization, facilities may reduce their losses by a factor of nearly 0.06 m^3 milk & water discharge/ m^3 milk processed without paying any new investment cost.

Table 5.5.4. 1. Potential benefits of implementation of CP opportunities for market milk production process

Opportunity	eliminated discharge (kg/day)	reduced recycling (kg/day)	recycled water (kg/day)	reduced COD (kg/day)	reduced TSS (g/day)
Clean water recycle			9458.4		
GHK/ repair	2037.3			5.7	792.5
Off-site reuse/ milk sludge	55.8			9.1	1704.9
Off-site reuse/ milky water	6.9			1.7	413.6
GHK/ small equipment change/water& milk	2100 45.2	(water) (milk)		11.1	2627.7
GHK/ operating practices/milk		102.8			
TOTAL	4245.3	102.8	9458.4	27.7	5538.9

5.5.4.2. CP Opportunities for Cleaning Process of Market Milk Production

Mass balance discussions in Section 5.5.3.3 puts forward that major environmental load in market milk production facilities comes from cleaning procedures since there is an extensive use of chemicals and water. Although it is stated that pollution in dairy wastewaters is mainly due to milk and milk products rather than cleaning wastes (see Table 3.2.2), in AOC it is observed that problem is mainly extensive use of chemicals.

This factor directly effects the sudden discharges of very alkaline or acidic wastewater to receiving medium, Ankara River. As it is mentioned in Table 5.5.2.1 daily 142.2 kg of NaOH is used and discharged to the receiving medium as concentrated solution of 2-3.75% by mass. (See calculations in Sections 5.5.3.3.4 and 5.5.3.3.6.1.) For acid use the same problem cames in front.

Table 5.5.3.37 shows that water use in cleaning procedures could be reduced significantly by eliminating unnecessary water use and by using CP opportunities. This would be significant achievement since, water discharged due to cleaning adds up to 48,738.2 kg/day.

From the literature review (Section 3.2.1.5), it is obvious that one of the most important opportunities that is emphasized in every CP document is the use of CIP systems for cleaning. Advantages of this system were elaborated separately in Section 3.2.1.5.

Similar to CIP system, another very common suggestion is the use of shut-off spray nozzles on all water hoses (see Section 3.2.2). Results of its implementation at different plants can be seen from Table 3.2.11. Therefore, another important opportunity for reducing the use of water in AOC is assembling shut-off spray nozzles at the end of hoses to pressurize water and increase water use efficiency.

Possible CP opportunities corresponding to above discussion and some others are presented in detail in the following sections as well as Table 5.5.4.5, details of which is given in Table 3.3 in Appendix III.

5.5.4.2.1. Cleaning of Tanks on Trucks

As can be seen from mass balance analysis of cleaning (Section 5.5.3.3), there is an extensive use of water for rinsing and manual washing. These operations are done by spraying water with hose on equipments or surfaces. Use of shut-off nozzles at the open-ends of these hoses will both reduce the water consumption and provide a better cleaning due to pressurized flow. For water efficiency, there are two mechanisms; ability to shut-off water flow immediately when the operation is finished and spraying of less volume of water. It is seen that using such equipments decreases water consumption by nearly 70% [35]. In the following sections benefit of using this equipment will be discussed briefly.

In Estonia by only use of shut-off spray nozzles water consumption eliminated is 0.64 m^3 water/ m^3 milk processed (see Case study 4 in Appendix IV). The same figure for AOC is 0.34 m^3 water/ m^3 milk. Therefore, there may be more opportunities for AOC for use of this equipment. In fact, use of this shut-off spray nozzles in other areas of AOC, besides market milk production will certainly increase this ratio.

For intake of milk, as indicated in section 5.5.3.3.1, 6.9 kg/day of milk (Qm18) is spilled on ground after detaching of the intake pipe from tanks. In addition to that 2,008.9 kg of milky rinse water (Qw18) is discharged to sewer.

By using shut-off spray nozzle at the open end of hose, water consumption (Qw17) may be reduced by 70% that amounts 1406.2 kg/day.

In literature, it is stated that first 12% of the rinse water carries 82% of the BOD. Therefore dilution factor up to 0.1 % of the intake milk is admissible to mix the rinse water with milk [16]. Using this approach, pollution load may be reduced by letting some of the rinse water to go to processing. Since UNEP suggests to collect wastewaters from initial rinses to return them to dairy farm to water cattle, a part of remaining rinse water, that is milk-water mixture may be collected in a separate tank for animal feeding.

Since yearly milk intake is 18,134,528 L, for reaching a dilution factor of 0.1%, it is admissible to rinse each tank for 9 seconds before detaching of line. In current situation, time for rinsing each tank is 3.17 minutes. By this application milk spill (Qm18= 6.9 kg/day) and thus 7.4 kg/day of COD will be prevented from reaching sewer (see calculations below).

Q_{rinse}=1.57 L/sec*0.3%* 9sec/tank*12 tanks=50.8 L/day.

Since rinse water has a COD of 111,650 mg/L (see Table 5.5.3.15)

COD_{rinse}= 50.8 (L/day)*111,650 (mg/L)*10^{-6} (kg/mg) = 5.6 kg/day

COD_{Qm18}= 6.9 kg/day/1.028(kg/L)*254200(mg/L)* 10^{-6} (kg/mg) =1.7 kg/day

5.6+1.7= 7.4 kg/day COD

While taking samples from wastewater (Qw19) for analysis, it is observed that milky wastewater flow continues for about 1.5 minutes. After this period, the concentration drops and water becomes colorless. Therefore if rinse water discharged within first 1 minute is collected, this milky water may be used in watering cattle.

If the use of, the recommended (shut-off spray nozzles) is adopted, wastewater will have the same mass of COD and TSS in a more concentrated form.

Amount of water that may be reused as animal feed is 339.1 L/day, which will eliminate a COD of 126.2 kg/day flow to sewer.

$Q_{animal\ feed}$= 1.57L/sec*1min*60 sec*12 tanks/day*0.3 = 339.1 L/day.

$COD_{animal\ feed}$= 339.1* 111,650mg/L*10^{-6} (kg/mg) =126.2 kg/day

5.5.4.2.2. Cleaning of Steel Vessels

Return Milk Vessels

By using nozzles discussed in Section 5.5.4.2.1, service water use for rinsing will be reduced by 70% [35]. In rinsing procedure if pouring of water to vessels is done separately for each vessel instead of spraying on a group of vessel water, spill to floor (Qw21) will be eliminated, saving a mass of 9.4 kg/day. Effective use of water will result decrease of dirty rinse (Qw20) by 125.2 kg/day and discharge will be 53.6 kg/day.

Vessels for Selling Non-Packed Products

In Section 5.5.3.3.2 it is stated that cleaning of vessels has both manual and mechanical washing stages. In the manual washing step, considerable amount of caustic is used. After this step, a second alkaline washing is done in the mechanical washing.

In the recommended case, after a rapid initial rinse to discharge coarse particles, solution prepared for a vessel is used for 5 vessels by pouring of solution to other. As it is mentioned in Section 5.5.3.3.2, 200 gr of NaOH is used per vessel during manual washing. In the recommended case, since same caustic solution will be used for 5 vessels, instead of 1000 g of NaOH, 200 g will be used. Therefore, caustic use will be reduced by 80%, water use will decrease due to increase in efficiency and using the same solution for 5 times. Although chemical use may be reduced by 80%, reduction in water consumption should be less since an initial rinsing procedure is suggested. If the reduction is assumed 50%, for only caustic wash 349.7 kg/day of water should be used, due to 80% reduction in requirement.

Water for caustic wash= 1748.8*20%=349.7 kg/day.

Water for initial rinse= 1748.8*50% - 349.76 = 524.6 kg/day.

Water for initial rinse of each vessel= 524.64/44= 12 kg/vessel.

Since 12 kg of water could be enough for initial rinse of a vessel with 40 L volume, this assumption is taken as acceptable. If these procedures are applied, water use for manual washing will be reduced by 878.7 kg/day, while NaOH use will drop by 7 kg/day to 1.7 kg/day.

Currently in the mechanical washing, prepared solution could not be used more than one week due to chemical characteristics of NaOH discussed in Section 3.2.1.5. If another chemical can be used for CIP system, it is possible to use same solution for at least one month. For selection of a proper chemical, Mr. Ergun Mert from Ecolab Co. was consulted. After evaluating different chemical alternatives, P3-asepto was recommended together with assembling of a dosing system, characteristics of which is discussed in Section 5.5.4.2.4.

By installations of suggested LMI01 dosing system, and use of P3-asepto, although hot and cold rinsing water tanks may require to be changed weekly, alkaline wash solution with 1.5 % concentration would last for one month. Therefore total water use in three tanks would be reduced by 53.5 kg/day, while alkaline chemical use would be reduced by 6.6 kg/day. (See calculations below)

Since caustic solution tank has volume of 500 L;

NaOH requirement= 500*1.5% = 7.5 kg (for initial solution)

As in the current practice, if it is accepted that an additional 7.5 kg of NaOH will be used for sustaining effectiveness of solution, monthly requirement of caustic is 15 kg. If these values are expressed on daily basis;

500L/month* 1 wk/7day* 1 month/4 wk = 17.8 kg/day.

15 kg/month* 1 wk/7day* 1 month/4 wk = 0.5 kg/day.

1st Tank: 500 L + 15 kg chemical (monthly solution)

1st Tank: 17.8 L/day + 0.5 kg/day

Washing of Floor

If shut-off spray nozzles were used, dirty rinse water of floor (Qw26) will be reduced by 70% and instead of 164.6 kg/day, 49.4 kg/day of water would be enough for cleaning. (See Section 5.5.3.3.2.)

5.5.4.2.3. Raw Milk Storage Tanks

As it was discussed in Section 5.5.3.3.3, after evacuating of storage tanks at the end of the day, there are leftovers from milk and milk foam, which are discharged with rinse water. At this part, it should be remembered that UNEP suggest use of 1st rinse wastewaters to water cattle [2]. In line with this, if piping of raw milk storage tanks are changed as discussed in Section 5.5.4.1.2, it would be possible to collect the spilled milk and milk foam at the end of pipe by first rinsing. Thus discharge of milk foam (Qm19), which is 18.19 kg/day, to sewer would be eliminated. Moreover, if shut-off spray nozzles are used on the open ends of hoses, water use (Qw29) would be reduced by 70% which means a more concentrated first rinse wastewater that is richer in nutritional value [35].

If this shut-off spray nozzles system is implemented, wastewater (Qw30) would fall to 242.6 kg/day. Thus first rinse water will contain milk with a concentration of 7.5% by weight.

5.5.4.2.4. CIP System for Pasteurization, Pasteurized Milk Storage Tanks and Bottle Packaging

Conventional CIP systems are composed of three tanks that serve for rinsing, alkaline solution, acid solution; a dosing system for chemicals; heating system for increasing effectiveness of solutions and a pumping system for recycling in the closed system. Together with these, globular knobs are assembled inside the equipments to be cleaned to spray solutions and rinse water effectively. CIP system suggested for AOC covers the cleaning of pasteurization, pasteurized milk storage tanks and glass bottle filling. In AOC, tanks of 1 tone capacity each is expected to be enough and LMI01 dosing system could be used for adjusting of a constant concentration of chemicals. Also a heater is required to keep the solution hot for increasing effectiveness. The first investment cost of such a CIP system is 19,750 Euro [22].

LMI 01 is a dosing system that measures the conductivity set for each solution. It measures conductivity on the return line of the recycling solution in the system and operates the dosage pump of respective chemical to keep a constant concentration.

In terms of chemicals, in the present case NaOH and HNO_3 are used to clean pasteurization and pasteurized milk storage tanks. As it is discussed in Section 3.2.1.5, if a special chemical developed for CIP of milk processing facilities is used, it would decrease both operation costs and environmental loading. For selection of the chemicals Mr. Ergün Mert from Ecolab Co. was consulted and alkaline and acidic chemicals are selected for AOC. He suggested that P3-mip CIP, an alkaline product designed for cleaning of closed systems may be used in the alkaline tank of CIP system. P3-mip CIP is used in concentrations of 1-2% at temperatures 60-80°.

For preparation of acidic solution P3-horolith flüssig may be used, which is an acidic cleaning agent that contains nitric, phosphoric acid and inhibitors. This chemical is used in concentrations of 1-2% at 50-60 °C [22].

The cost of P3-mip CIP is 1,609,606+VAT[5] TL/kg and P3-horolith flüssig is 2,009,600+VAT TL/kg. On the other side cost of caustic and nitric acid is about 500000 TL/kg. Although synthetic chemicals are 3-4 times expensive than the current chemicals, they are still definitely feasible since the amount required is 80 times less for alkaline and 20 times less for acidic chemical. Advantages of using CIP system in AOC could be observed from Table 5.5.4.2, which illustrates water and chemical use of CIP system. Actually, use of CIP system for cleaning is a very common practice in the world that, CP studies concentrates on increasing the process efficiencies of CIP systems. Some examples to these implementations can be seen from Table 3.2.8. Water use of this system suggested to be installed is discussed below.

In Australian firm a multi-use CIP system is installed and its benefits are discussed (see Case study 2 in Appendix IV). In the Australian plant, previously used single use CIP system resembles to the cleaning system of AOC very much. Therefore the experiences of this case study are important for AOC. Since the payback period for firm is less than 1 year, installation of this system should be a priority also for AOC.

5.5.4.2.4.1. Water use of suggested CIP System

1st rinse

Cleaning of system starts with a first rinse to purge milk and remove the coarse dirt in the piping. Rinsing is done by recycling water in the whole system by using the rinsing tank of 1 tone capacity. Rinse water is heated to 60°C by the heating system of CIP before pumping to the line. During spraying of rinse water globular knobs assembled in tanks are used to increase efficiency of rinsing (see Section 3.2.1.5). After rinsing, in conventional case, this water of 1000 L is discharged to sewer. But

[5] VAT: Value Added Tax Which is about 18% of the price.

this rinsing will contain milk solids due to 1^{st} rinse of pasteurization and pasteurized milk storage, bottle packaging cleaning.

Besides these sources, in current operation, a volume of 500L (V) milky wastewater that has same characteristics with 1^{st} rinse water, is remained in the pasteurization system. As previously stated, UNEP suggests use of 1^{st} rinse wastewaters for watering cattle [2]. Thus, this wastewater, rich in nutritional value, can be used in animal feeding. Characteristics of this rinse is expected to be similar with the 1^{st} rinse water of 500 L that recycled and remained in the system in the current operation (see Table 5.5.3.19).

Qw-cıp1: 1^{st} rinse water used in CIP system

Qw-cıp1= 1000L/day=1000 kg/day.

Qm20+Qw44+Qw83+V= 1695.3 kg/day

As a result of this implementation 1695.3 kg/day of milky wastewater, containing 26.6 kg/day COD and more than 1843.3 g/day TSS that is produced in current operation would not be discharges to sewer. On the contrary, this environmental load will be collected in a volume of 1000L and may be used for animal feeding. As a result of this 1000L of wastewater with 1.5% milk content will be produced.

For design of system that will collect water for cattle feeding, piping work and a tank is required. The tank for collection of milky water can be placed slightly below the ground level since all the sources that will flow to tank is on or above the ground level. A small pump will also be required for pumping of this water to truck. In terms of feasibility, although the first investment cost may seem high, actually this line will collect all major organic sources and use of them will result in increase of milk production capacity (see discussion in Section 5.5.4.1.2). Considering the applications in other case studies in literature it is expected to be feasible.

Alkaline wash

In the suggested case, alkaline solution (P3-mip CIP) of 1.5% concentration by weight is prepared in 1000 L tank and it is recycled in the system for 20 minutes at a constant concentration and at 60°C, which is controlled by mounted LMI 01. Although Mr. Ergün Mert claimed that this solution could be used at least 1.5 months in the system, calculations are done on 1 month basis for factor of safety.

Qw-cıp2: Water used for preparing alkaline solution

Qw-cıp2= 1000L/30day=33.3 L/day= 33.3 kg/day

Qalkaline: Alkaline chemical used to prepare solution

Qalkaline= 15kg/30 day= 0.5 kg/day

By this application alkaline wastewater of pasteurization and pasteurized milk storage cleaning (Qw34, Qw46) in the current application are not discharged to sewer but reused.

Amount of discharge that is prevented to go sewer is 2556.6 kg/day (Qw34+Qw46) that contain 50.5 kg/day of alkalinity as $CaCO_3$. In other words, 40 kg/day use of NaOH could be replaced by 0.5 kg/day use of synthetic chemical.

2nd Rinse

Rinsing tank (1000 L volume) filled with fresh water is used for recycling of water that is heated to 60°C. It is done to purge solution and remove alkalinity. Due to the surface tension characteristics of synthetic chemical suggested in alkaline cleaning, rinsing is easier and though rinsing time drops by 50%, which means less use of energy for working of pump and heater [22].

By this application compared to the current process there is a big saving in terms of service water used. In current operation, 15939.3 kg/day of water is used for rinsing of caustic wash (see calculations below). If CIP system is installed, amount of water usage would drop to 1000kg/day since water will be recycled in the system. Consequently, water efficiency may be increased nearly 16 times by use of CIP system.

Qw34+Qw47+Qw53+Qw57= 853.3+7344+408+7344= 15939.3 kg/day.

Acid Wash

Acid solution of 1.5% concentration by weight is prepared in tank of 1000L volume. This solution is recycled in the system for 20 minutes at a constant concentration and at 60 °C, which are controlled by LMI 01 mounted. Although Mr. Ergün Mert claimed that this solution could be used at least 1.5 months in the system, calculations are done on 1 month basis for factor of safety.

Qw-cıp4: Water used for preparing alkaline solution

Qw-cıp4= 1000L/30day=33.3 L/day= 33.3 kg/day

Qacid: Acidic chemical used to prepare solution

Qacid= 15kg/30 day= 0.5 kg/day

By this application wastewater (Qw37) that contain very high acidity is not discharged to sewer but reused. In the current system, 500 L/day of discharge (Qw37=2510 kg/day) is the amount of acidic solution and rest is due to excess water flow to rinse system after purging this solution.

In the proposed system, amount of acidic solution discharge to sewer that would be prevented is 510 kg/day with a pH of 2.4. In addition to that, 10kg/day use of HNO_3 could be replaced by 0.5kg/day use of synthetic acid (P3-horolith flüssig).

Final rinse

Rinsing is done to purge the acidic solution and to make system completely free of chemicals. In conventional CIP systems, rinse water is directly discharged to sewer without recycling. In AOC on the other hand, it is believed that it will increase the efficiency of water use if rinse water is recycled for 2 minutes because by this implementation, chemicals stuck on the pipes could be dissolved in the recycling water. Then rinsing with fresh water should be done to which would continue for 10 minutes. Pump capacity of CIP system is taken as 2 L/sec instead of the pump capacity at the beginning of pasteurization (2.78 L/sec). It is considered that, since water use would be more effective with global sprayers, less water would be required [22]. Under these assumptions, in addition to 1000 L of water to be recycled, total fresh water required is 1200 L/day (see Table 5.5.4.3). As a result, in the proposed system, 2200 L/day of water would be used for final rinsing.

In present case, water used for final rinsing are from pasteurization and bottle packaging (Qw37 and Qw86), which adds up to 3918.7 kg/day of water use[6]. As it can be observed, current water use is nearly 1.8 times of water use of CIP system.

Morning Heating of Pasteurization

CIP system and its rinsing tanks could be used in the heating of pasteurization system in morning [22]. In present case as it is discussed in Section 5.5.3.3.4, water

[6] Although caustic solution rinsing of pasteurized milk storage (2nd rinsing) is also final rinsing, since it is shown in 2nd rinse of CIP system it is not shown here for preventing double counting.

heated to 90 °C is constantly discharged to sewer for 15 minutes. Since the CIP system has both heating and recycling system for rinse water, this system may also be used for heating purpose. By this choice, system could be heated with a volume of 1000 L; in addition to that, this heated water may be used as the rinse water of morning cleaning of pasteurized milk storage tanks.

In existing case, volume of water used (Qw39) to heat system is 2500 L/day. Recycling of the water presents an opportunity to heat system with a volume of 1000 L/day.

Morning Wash of Pasteurized Milk Storage Tanks

As indicated above, this cleaning may be done by CIP system. For implementation, there should be a by-pass system for pasteurization and bottle filling.

In morning wash, since tanks have already been cleaned in evening of previous day and the concentrations of solutions (alkaline and acidic) of CIP system are more than current practice, time for recycling of solutions may be halved while time for rinsing remains same (see Section 3.2.1.5) [21]. In the proposed system, cleaning starts with recycling of alkaline solution. Later tank is rinsed in two steps. First, water of pasteurization heating collected in rinsing tank is recycled for two minutes to remove most of alkalinity. Then, tanks are rinsed by pumping fresh water to the line for 10 minutes.

In CIP system, since chemical usage calculation is done on daily basis and same chemicals are recycled in line throughout the day, for morning wash chemical solution consumption is zero. Moreover, since recycled water will come from pasteurization heating, water consumption of CIP during rinsing covers only fresh water calculation. Therefore total water consumption is 1200 kg/day.

Although currently, 7344 kg/day of water (Qw57) is used in the morning, by installation of CIP system it would be possible to rinse same tank with of 1200 kg/day of water.

In Table 5.5.4.2, water and chemical use in case of using CIP system for morning rinse are given.

Table 5.5.4. 2. Water and chemical use for morning wash with CIP

Source	Quantity (kg/day)
	Alkaline wash
water use	0
chemical use	0
	Rinsing
recycling rinse*	0
freshwater rinse	1200

* (from Qw-cıp6)

5.5.4.2.4.2. Water that can be eliminated by CIP system

In Table 5.5.3.37 unnecessary water discharges to sewer were summarized. In the proposed case due to automation of cleaning system, consumptions under heading of pasteurization cleaning, pasteurized milk storage tank cleaning and cleaning bottle packaging would be totally eliminated. These water saving totally add up to 13932.3 kg/day.

When the CIP system is considered as a whole, water and chemical requirement of the system is illustrated in Table 5.5.4.3.

Table 5.5.4. 3. CIP system water and chemical use

Source	Name	Quantity (kg/day)
	1st rinse of system	
Rinse water used	Qw-cıp1	1000
	Alkaline Wash	
Water used	Qw-cıp2	33.3
Chemical used	Qalkaline	0.5
	2nd Rinse	
Rinse water used	Qwcıp-3	1000
	Acid Wash	
Water used	Qw-cıp4	33.3
Chemical used	Qacid	0.5
	Final Rinse	
Recycling rinse		1000
Fresh water rinse		1200
Total	Qw-cıp5	2200
	Heating of pasteurization	
Recycling hot water	Qw-cıp6	1000

Section 5.5.4.2.4.1 discusses the potential benefits of CIP system with respect to each process step of current cleaning practices. In addition to that Table 5.5.4.4 illustrates Potential benefit of CIP and nozzle use in cleaning.

5.5.4.2.5. Cleaning of Cartoon Packaging

As it is discussed briefly in Section 5.5.3.3.8, cartoon packaging machine has its own CIP system for cleaning. During operation of this system although water should be recycled by using CIP tank to rinse chemical, all the rinsing is done by fresh water (Qw92) which amounts 750 kg/day. As it is indicated in Section 3.2.1.5, caustic sticks on the surfaces and produces much foam. If rinse water is recycled, those stuck

NaOH may be removed from equipment surfaces [22]. As it is also stated in Section 3.2.6, management control is very important for the operating practices [12]. If management changes the rinsing procedure that rinsing is done first by recycling of the water for 2-3 minutes, a large amount of caustic may be removed. Later, using of an extra one tank (250L) fresh water for rinsing is expected to be enough to clean the system, in view of the fact that in morning another 250 L rinsing with fresh water is done. Thus, by changing the operation procedure, it is possible to save 250 kg/day of water.

5.5.4.2.6. Cleaning of Pasteurization System

In the process of surface and floor cleaning, as it is discussed in Section 5.5.3.3.4, equipments are rinsed thoroughly with water that amounts 2001.8 kg/day. If shut-off spray nozzles were affixed at the hose outlet, this consumption would decrease to 600.5 kg/day (see Section 5.5.4.2.1). By this opportunity totally 1401.3 of water may be saved.

5.5.4.2.7. Cleaning of Pasteurized Milk Storage Tanks

If shut-off spray nozzles were attached to hose used for rinsing, volume of water used for surface washing (Q_{w51}) would decrease from 1683 kg/day to 504.9 kg/day (see Section 5.5.4.2.1). Same saving also applies for surface wash of morning cleaning (Q_{w61}) that water use would drop to 504.9 kg/day.

5.5.4.2.8. Bottle Washing

In washing of bottles, main environmental concern is the highly alkaline solution used and discharged to sewer weekly. To prepare solution 37.5 kg/day of caustic is used as solute. As it is discussed in Section 5.5.3.3.6.1, weekly 150 kg of NaOH is poured to a tank of 4 m^3 to prepare a solution of 3.75 % concentration.

As CP opportunity, chemical additives can be used in these tanks to increase effectiveness and though to decrease the concentration of solution, which means decrease amount of chemical used. It was proved by Ecolab engineer (Mr. Ergün Mert) that, addition of P3-stabilon WT in concentrations of 0.2% increases the efficiency twice [22]. Therefore if this chemical were used together with LMI 01 dosing system, NaOH usage would decrease by 50% and Q_{NaOH-6} and Q_{NaOH-7} would drop to 18.75 kg/day each. Price of this chemical is about 2,500,000 TL/kg.

Another environmental concern is the continuous discharge of the overflow water (Qw67+Qw74) from mechanical washing, which has high alkalinity (see Table 5.5.3.30). As discussed briefly in Section 5.5.3.3.6.1, total amount of water discharged is 9178.5 kg/day. In Section 3.2.1.5 it is mentioned that caustic and acid solutions of CIP systems may be reused following removal of fine particles, color and COD by nanofiltration membranes [30]. By a similar approach, the use of caustic discharge is discussed with firm engineers without a pre-processing. It was decided that it is technically feasible [33]. If this water is collected in a small tank as equalization basin and pumped continuously, it could be reused for washing of bottle cases and filling of the dirty bottles at the end of day.

Although above stated opportunities may be utilized for the present type of packaging, it is believed that the strategy of packaging should be overviewed by the facility. Although glass bottles can be cleaned and recycled, cleaning of them consumes water and energy. In addition glass recycling systems require large capital investments together with high running costs. Moreover, glasses are more fragile compared to cartoons. Although cartoons create solid waste, it has advantages due to above stated reasons [2]. More briefly, if bottle packaging is replaced by cartoon packaging, both cleaning of packaging machine will be more efficient and also the procedure of bottle washing will be eliminated.

Initial Rinse of Dirty Bottles

Amount of recycle that would be used for the filling of dirty bottles is 200 kg/day (Qw63). If this is done by the recycle of overflow from mechanical wash, 9311.8 kg/day of recycle could be used in bottle case washing. Although this opportunity is found technically feasible by the facility engineers, its financial feasibility is in question since the volume of water is low [33].

Surface Wash of Equipment and Conveyors

Rinse water used at this process (Qw84) is 4003.7 kg/day, which could be decreased by 70%, by using shut-off spray nozzle at the outlet of hose (see Section 5.5.4.2.1). If this were implemented, water use would drop to 1201.1 kg/day.

5.5.4.2.9. Bottle Case Washing

During process of case washing, service water is sprayed on cases continuously. Amount of water used is 12801.6 kg/day. Instead of using fresh water, if the recycle line, from mechanical washing of bottles, defined in the previous section were used, cleaning efficiency would increase since an alkaline solution is sprayed on cases. Although this recycle line would not be enough to meet the whole requirement, rest of water may be supplied from service water line. In this case, amount of fresh service water use will reduce to 3089.7 kg/day but, as it was indicated previously (Section 5.5.4.2.8), financial feasibility of the opportunity is in question.

During cleaning of floors in area of bottle case washing, much water is used since a regular hose is used. If spray nozzle is mounted on the hose, with an efficiency of 70 % (see Section 5.5.4.2.1), water use will decrease from 2965.7 kg/day to 889.7 kg/day.

5.5.4.2.10. Potential Benefits of Implementation of CP Opportunities for Cleaning of Market Milk Production

The potential benefits of implementation of opportunities discussed above are illustrated in Table 5.5.4.5 on opportunity basis. In addition to this, detailed figures for result of each opportunity on each water/waste source can be seen in Table 3.3, in Appendix III.

In Table 3.3.9, it is indicated that cleaning and crate washing covers about 12% of water consumption at a dairy. In the scope of AOC study, although ancillary operations such as cooling and boiler are not covered, a calculation for the water use may be done. By considering the total amount of water consumption, it is calculated that cleaning facilities consumes 88.3% of the water within the boundaries of MB. Although AOC CPA study does not cover same processes accounted in Table 3.3.9, comparison shows that there is a big gap between plant efficiencies in cleaning.

In Section 3.2.2 it is stated that with good waste management procedures 0.5 to 2 m^3 wastewater per m^3 milk can be achieved [24]. In line with this, Table 3.2.12 indicates 0.5 kg wastewater production /kg milk can be achieved when initial rinses are saved. In AOC although 2.9 kg of wastewater is produced per kg of milk currently, by the implementation of proposed opportunities a level of 0.24 kg/kg milk can be achieved.

If a comparison between current water use scheme with proposed system with CIP and shut-off spray nozzle use is done, it is seen that 41270.4 kg/day of water may be saved. This calculation is illustrated in Table 5.5.4.4.

Table 5.5.4. 4. Potential benefit of CIP and nozzle use in cleaning

Present situation		CIP system	
water use (kg/day)		water use (kg/day)	
pasteurization	9784	CIP	5267.6
pasteurized milk storage	32665.5	surface cleaning*	3054.1
bottle packaging	7108.7		
Total	49558.2		8287.4
CIP& nozzle system benefit in terms of reduction in water use			41270.4

* this figure is valid in case of nozzle system use

In addition to that, in Schroeder Company considerable water savings were achieved by optimization of water consumption of equipments; (i.e. time settings of CIP system, separator and case washing water requirements). In AOC, a similar approach was developed for time settings of proposed CIP system during final rinsing that recycling the rinse water for 2 minutes before starting to pump fresh water was recommended (see Section 5.5.4.2.4 and 5.5.4.2.5)

Table 5.5.4. 5. Results of implementation of CP opportunities for cleaning of market milk production process

Opportunity	eliminated water use (kg/day)	eliminated discharge (kg/day)	eliminated chemical use (kg/day)	recycled water (kg/day)	reduced COD (kg/day)	reduced TSS (g/day)	Alkalinity as CaCO3 (kg/day)
CIP system	26,110.3	3,262.7			4.2	1,566.2	40.1
Off-site reuse/ Milky rinse as animal food*		1581.2			23.7	2,153	
Shut-off nozzle use	11,727.8				126.2	11,469	
GHK-change operating practices	259.4		7				
Chemical change	53.5		94.1				
Alkaline water reuse in cleaning bottle cases	9,178.5			9,178.5			
TOTAL	47,329.7	4,843.9	101.1	9,178.5	154.1	15,188.2	40.1

* In the proposed case 1364.2 kg/day of waste rinse water will be collected as animal feed.

CHAPTER VI

CONCLUSION

The CPA methodology applied to AOC market milk production facility in this study revealed several significant CP opportunities. Furthermore, it has been observed that implementation of the outcomes of this study will lead to notable pollution prevention and economical savings especially in terms of water and chemical use as well as COD and TSS loadings to the sewer system.

Water use and the milk losses in the AOC market milk production facility constitute major CP opportunities that can be implemented without very high cost and technical difficulty. Therefore, water use and the milk losses were determined as the focus points in this study and the CP opportunities related with these issues were considered. In fact, a broader study covering all the possible CP opportunities especially energy losses in the market milk production will provide more significant CP opportunities.

By the execution of the guide compiled for this study in AOC, it was evaluated that the maximum extent of pollution prevention level with minimum cost could be realized through installation of a CIP system and adoption of shut-off spray nozzles. Through implementation of these two measures the water use of 49558.2 kg/day (mainly for cleaning of pasteurization, pasteurized milk storage tanks and bottle packaging) could be reduced to 8287.4 kg/day of water use, which translates into a water saving of 41270.7 kg/day.

Within the context of pasteurized milk production; wastewater that may be used for other purposes, reusable milky wastewater discharges and unnecessary water use in the system totally add up to 14136.3 kg/day (see Table 5.5.3.11, Table 5.5.3.12 and Table 5.5.3.13). If corresponding CP opportunities given in sub-sections of Section 5.5.4.1 are implemented, 9458.4 kg/day (52%) of water could be recycled while 4245.3 kg/day (30%) of water use is totally eliminated. Furthermore, 27.7 kg/day of COD and 5.5 kg/day of TSS could be prevented from being discharged to sewer by increasing water use efficiency, as explained in Sections 5.5.4.1.1, 5.5.4.1.2, 5.5.4.1.4, 5.5.4.1.6 and 5.5.4.1.7.

When the cleaning procedure of the facility is examined, milky wastewater discharges which can be reduced, unnecessary water uses that can be totally eliminated, and reducible water uses totally adds up to 80423.3 kg/day (see Table 5.5.3.35, Table 5.5.3.37 and Table 5.5.3.38). Moreover, 142.1 kg/day of NaOH and 10 kg/day of HNO_3 are used during process (see Table 5.5.3.36).

By using CP opportunities indicated for cleaning activities in sub-sections of Section 5.5.4.2, 47329.7 kg/day of water use could be eliminated and discharge of 4843.9 kg/day of wastewater of chemical solution could be prevented by reuse (See Table 3.3 in Appendix III). Besides, 9178.5 kg/day of water could be recycled (Section 5.5.4.2.8).

On the other hand, as suggested, the same cleaning procedure can be done by a CIP system by using 5266.6 kg/day of water and 0.5 kg/day alkaline, 0.5 kg/day acidic chemical for preparing solution. This means 41237.4 kg/day (see Table 5.5.4.4) and

49 kg/day (see Table 5.5.3.36) reduction in water use and chemicals respectively First investment cost of suggested CIP system is 19750 Euro.

By execution of the suggested opportunities, AOC may eliminate at least 181.9 kg/day of COD, 20.7 kg/day of TSS and 40.1 kg/day of alkalinity as $CaCO_3$ (see Table 6.1). These values are expected to be greater since chemical analysis of each discharge point could not be done.

In a study made in Egypt, net benefits due to GHK opportunities was 82% of the total benefits of study (see Case 1 in Appendix IV). Similar to the study, as in most case, in AOC particular attention was paid to improvements, which could be carried at low or no cost to the factory. GHK opportunities are considered to be very important especially to eliminate unnecessary discharges. Therefore, in AOC 0.55% of water use and 46 % of discharges could be eliminated by using GHK opportunities (see Table 6.1).

In Schroeder Company expired milk returned is used as animal feed instead of pouring it down the drain (see Case Study 5). By a similar approach in AOC all first rinsings that contain milk residues is proposed to be collected in a tank to be send to water cattle or use them in fodder industry. In Schroeder, while this eliminates discharge of 136 kg of COD, in AOC this proposal would eliminate discharge of 1588.1 kg/day of water and reduce 25.5 kg/day of COD and 2566.6 g/day of TSS reaching sewer (see Table 6.1).

To sum it up, results of the opportunities discussed are illustrated in Table 6.1 on opportunity basis. When these values are compared with the mass flow of the whole facility that is shown in Table 5.5.2.1,

- 50% of the service water used can be eliminated (Sub-Sections of 5.5.4.2 details of which can be seen from Table 3.3 in Appendix III)
- 9.3 % of the current wastewater discharge can be eliminated. (Sections 5.5.4.1 and 5.5.4.2.1, 5.5.4.2.3, 5.5.4.2.4, details of which can be seen from Table 3.2 and Table 3.3 in Appendix III)
- 65.36% of the chemical use can be eliminated by replacing with other chemicals.(Section 5.5.4.2.2, 5.5.4.2.4.1, 5.5.4.2.8 details of which can be seen from Table 3.3 in Appendix III)
- 19.6 % of the service water used can be recycled to be reused. (Sections 5.5.4.1.1, 5.5.4.1.3, 5.5.4.1.4, 5.5.4.1.5, 5.5.4.2.8 details of which can be seen from Table 3.2 and Table 3.3 in Appendix III)
- 181.91 kg/day of COD and 20.7kg/ day of TSS can be eliminated. (Sections 5.5.4.1.1, 5.5.4.1.2, 5.5.4.1.4, 5.5.4.1.6, 5.5.4.1.7, 5.5.4.2.1, 5.5.4.2.4 details of which can be seen from Table 3.2 and Table 3.3 in Appendix III)

During presentation of the analysis of CP options for AOC, although the options are elaborated, they are not presented in the form of a cleaner production plan. Since all the details of a CP plan are covered in the study, writing a plan would create much paper work without adding a value to the study.

When the results of the study is examined within the context of Turkish dairy sector which has greater than 6,153,772 tone/year production capacity, it is believed that use of CP tools will reduce water and chemical consumption of facilities leading them to achieve higher profits while executing an environmental friendly production. Since total value of market milk production in Turkey is 88.8 million US Dollars, this figure is expected to rise by working more efficiently.

Although the number of firms with ISO 9002 standards is 28, with a CP view, companies would be more close to reaching these standards, which would increase their trade capacity. Since EU has specific quality and hygiene directives, this is especially important for EU trade, which can be an important zone in future [17].

Table 6. 1. Results of CP opportunities suggested for AOC[1]

Opportunity	eliminated water use (kg/day)	eliminated discharge (kg/day)	eliminated chemical use (kg/day)	recycled water (kg/day)	reduced COD (kg/day)	reduced TSS (g/day)	red. alkalinity as CaCO3 (kg/day)	reduced recycling (kg/day)
clean water recycle				9458.4				
GHK/ repair		2037.3			5.7	792.5		
Off-site reuse/ milk sludge		55.8			9.1	1704.9		
GHK/ small equipment change/water& milk		2100 45.2	(water) (milk)		11.1	2627.7		
GHK/ operating practices/milk &water	259.4		7					102.8
CIP system	26110.3	3262.7			4.2	1566.2	40.1	
Off-site reuse/ animal food*		1588.1			25.5	2566.6		
Shut-off nozzle use	11727.8				126.2	11469		
Chemical change	53.5		94.1					
Alkaline water reuse/ cleaning	9178.5			9178.5				
TOTAL	47329.7	9089.2	101.1	18636.9	181.9	20727.2	40.1	102.8

[1] In plant although raw milk intake system works 360 day/yr, pasteurization system works 308 day/yr. Values are calculated as if raw milk intake system worked 308 days/yr, and iterated accordingly.

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APPENDIX I

I- A Questions to be answered during walk-through inspection

- Are there signs of poor housekeeping (untidy or obstructed work areas etc.)?
- Are there noticeable spills or leaks? Is there any evidence of past spills, such as discoloration or corrosion on walls, work surfaces, ceilings and walls, or pipes?
- Are water taps dripping or left running?
- Are there any signs of smoke, dirt or fumes to indicate material losses?
- Are there any strange odors or emissions that cause irritation to eyes, nose or throat?
- Is the noise level high?
- Are there open containers, stacked drums, or other indicators of poor storage procedures?
- Are all containers labeled with their contents and hazards?
- Have you noticed any waste and emissions being generated from process equipment (dripping water, steam, evaporation)?
- Do employees have any comments about the sources of waste and emissions in the company?

Is emergency equipment (fire extinguishers etc.) available and visible to ensure rapid response to a fire, spill or other incident?

I -B Aspects to be Considered in the Evaluation [2]

Preliminary evaluation

- Is the cleaner production option available?
- Can a supplier be found to provide the necessary equipment or input material?
- Are consultants available to help develop an alternative?
- Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience?
- Does the option fit in with the way the company is run?

Technical evaluation

- Will the option compromise the company's product?
- What are the consequences for internal logistics, processing time and production planning?
- Will adjustments need to be made in other parts of the company?
- Does the change require additional training of staff and employees?

Economic evaluation

- What are the expected costs and benefits?
- Can an estimate of required capital investment be made?
- Can an estimate of the financial savings be made, such as reductions in environmental costs, waste treatment costs, material costs or improvements to the quality of the product?

Environmental evaluation

- What is the expected environmental effect of the option?
- How significant is the estimated reduction in wastes or emissions?
- Will the option affect public or operator health (positive or negative)? If so, what is the magnitude of these effects in terms of toxicity and exposure?

II-A

Worksheet A-1		Facility Information
Prepared by:	Date:	
General Facility Information		
Facility Subject to Survey		
Name:	Ataturk Orman Ciftligi Milk and Milk Products Facility	
Address:	AOC Milk Factory Ciftlik	
City:	ANKARA	
Province/ Postal Code:		
Telephone:		
Lead Person:	Levent Sıdal	
Contact Person for CP Study:	Levent Sıdal & Sahin Durna	
Facility Production Information		

Dairy Products Processed/ Manufactured	Quantity Processed /Manufactured (previous calendar year)	
* Pasteurized milk	10.045.083,00	L/yr
* Yogurt	3.320.401,20	kg/yr
* Ayran	615.421,00	L/yr
* Butter	116.268,00	kg/yr
* Ice cream	405.088,00	L/yr
* Butter	102.000,00	kg/yr

Schedule of Operation:	7:00-17:00
Seasonal Operating Schedule:	N.A.
Regulatory Information (check all that apply)	
* Wastewater Permit	+
* Air Permit	-
* Solid Waste Permit	-
* Other	-

	Worksheet A-2						
Worksheet A-2.1					Bulk Raw Materials Information		
Prepared by:		Date					
	Material 1	Material 2	Material 3	Material 4	Material 5	Material 6	Material 7
Bulk Raw Materials Name	Milk	NaOH	HNO3	Water	General disinfectan	Cartoon Packages	Glass Bottle
Milk Products that Bulk material is used							
1. Milk	+	+	+	+	+	+	+
2. Cream	+	+	+	+	+	-	-
3. Butter	+	+	-	+	-	-	-
4. Cheese	+	+ (negligible)	-	+	-	-	-
5. Yogurt	+	+	-	+	-	-	-
6. Other (..Ayran..)	+	+	-	+	-	-	-
Annual Throughput (past year) of the material	19573 m3	81500 kg/yr	3500 kg/yr				
Delivery Mode	Tank on trucks	25 kg sacks	2.5 ton tank non-corrosive	AOC service water Municipal supply	30 L plastic vessels	pallet (44 boxes)	16400 bottle/pallet
Unloading mode	Pumping	Man power	Bucket	N.A.	Man power	Forklift	Forklift
Storage mode	Tanks	On wooden pallets	non-corrosive tank	N.A.	30 L plastic vessels	Storage area	Storage area
Loading mode	Vessels to tank	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
Worksheet A-2.2							
Non-Dairy Ingredients sub- categories	1. Sugar	2. Corn syrup	3. Fruits	4. Flavors	5. Nuts	6. Fruit Juice	7. Salt
Annual Throughput (past year) of the material							
Delivery Mode							
Unloading mode							
Storage mode							

Worksheet A-3	Unit Operation and Process Stream Mass Balance Data Information		
Prepared by:		Date	
Process Stream Data	Milk Intake		
Stream Name/ Equipment Name			
Stream Description (via initial to final process operation)	Input: Raw Milk	Output: Clarified Milk	
Operating Schedule/ Duration			
Process Flow Rate **(kg/hr or kg/day)**	Minimum	Average 13 m3/hr	Maximum
Raw Materials			
Liquid Ingredient Name: 1.Milk 2.Service water (production process) 3. Service water (cleaning process)(a)		 29076.8 kg/day 424.13 kg/day 2817.8 kg/day	
Dry Ingredient Name: 1.- 2.- 3.-			
Other			
Products (kg/hr or kg/day) Milk to pasteurization		 29051.39	
By-Products/ Intermediates **(kg/hr or kg/day)** N. A.			
Waste Products (kg/hr or kg/day) (b)			
1. Milky waste name: A. Clarifier Sludge			
Effluent volume		15.58 kg/day	
BOD5(c)		95192 mg/L	
TSS		26680 mg/L	
Oil & Grease		-	
Temperature		Room	
pH, Acidity/ Alkalinity		pH= 6	
Others		-	
Disposal Method		sewer	
B. Rinsing of truck washing			
Effluent volume		2008.96 kg/day	
BOD5(c)		81504.5 mg/L	
TSS		33820 mg/L	
Oil & Grease		-	
Temperature		Room	
pH, Acidity/ Alkalinity		pH= 6.29	
Others		-	
Disposal Method		sewer	
2. Wasted water source: Discharge water			
Effluent volume		408.77 kg/day	
Temperature		10 C	
BOD5		0	
TSS		0	
Oil & Grease		-	
pH, Acidity/ Alkalinity		pH=7.40	
Others		-	
Disposal Method		sewer	
3. Cleaning and Sanitizing Agents (b)			
Caustics		-	
Acids		-	
Detergents		0.08 kg/day	
Others		-	
Disposal Method		sewer	

Figures in 1st & 2nd raws do not cover the raw material and water uses/discharges

(a) Figures cover material use during cleaning of raw material storage tanks & tanks on trucks since clarification system is cleaned together with pasteurization.
(b) Assume BOD/COD=73%

Worksheet A-3	Unit Operation and Process Stream Mass Balance Data Information		
Prepared by:		Date	
Process Stream Data			
Stream Name/ Equipment Name	Pasteurization system		
Stream Description (via initial to final process operation)	Input: Clarified Mil	Output: Pasteurized Milk	
Operating Schedule/ Duration			
Process Flow Rate **(kg/hr or kg/day)**	Minimum	Average 10 m3/hr	Maximum
Raw Materials			
Liquid Ingredient Name: (kg/day)			
1. Clarified milk		33985.9	
2. Service water (process requirement)		10520.05	
3. Steam		2677.99	
4. Service water (cleaning process) (a)		37714.97	
Dry Ingredient Name: 1.- 2.- 3.-			
Other			
Products (kg/hr or kg/day) Packed milk (kg/day)		33527.10	
By-Products/ Intermediates **(kg/hr or kg/day)** Cream (kg/day)		119.06	
Waste Products (kg/hr or kg/day)			
1. Milky waste name: Separator sludge			
Effluent volume		40.25 kg/day	
BOD5		130451 mg/L	
TSS		32480 mg/L	
Oil & Grease		-	
Temperature		Room	
pH, Acidity/ Alkalinity		pH= 6.15	
Others		-	
Disposal Method		sewer	
2. Wasted water source: A. Discharge water			
Effluent volume		11269.74	
Temperature		10 C (b)	
BOD5		0	
TSS		0	
Oil & Grease		-	
pH, Acidity/ Alkalinity		pH= 6.90-7.40	
Others		-	
Disposal Method		sewer	
2. Wasted water source: B. Milky cooling water			
Effluent volume		1077.21 kg/day	
Temperature		-	
COD		5317.5 mg/L	
TSS		740 mg/L	
Oil & Grease		-	
pH, Acidity/ Alkalinity		pH= 6.75	
Others		-	
Disposal Method		sewer	
3. Cleaning and Sanitizing Agents (a)			
Caustics		57.24	
Acids		10	
Detergents		2.25	

(a) This quantity involves water/chemical requirement in cleaning of pasteurization system, pasteurized milk storage tanks, pasteurized milk packaging (bottle, cartoon, vessel)

(b) Except steam condensate that is 70 C

Worksheet A-3	Unit Operation and Process Stream Mass Balance Data Information		
Prepared by:		Date	
Process Stream Data			
Stream Name/ Equipment Name	Cleaning/ Bottle & bottle case		
Stream Description (via initial to final process operation)	Input:Dirty bottle/ case	Output: Clean bottle/ case	
Operating Schedule/ Duration			
Process Flow Rate **(kg/hr or kg/day)**	Minimum	Average 38147 bottle/day 1799 case/day	Maximum
Raw Materials			
Liquid Ingredient Name: 1. Service water 2. 3.		27812.52 kg/day	
Dry Ingredient Name: 1.- 2.- 3.-			
Other			
Products (kg/hr or kg/day) Bottle Case		38147 1799	
By-Products/ Intermediates **(kg/hr or kg/day)**			
Waste Products (kg/hr or kg/day)			
1. Milky waste name: - Effluent volume BOD5 TSS Oil & Grease Temperature pH, Acidity/ Alkalinity Others Disposal Method			
2. Wasted water source: Bottle washing Effluent volume Temperature (a) BOD5 TSS Oil & Grease pH, Acidity/ Alkalinity Others Disposal Method		 12120.21 kg/day 30-40 C 0 40 - pH= 10.4 Alk= 719.49 mg/L sewer	
2. Wasted water source: Case washing Effluent volume Temperature (a) BOD5 TSS Oil & Grease pH, Acidity/ Alkalinity Others Disposal Method		 15767.31 kg/day 10 C 0 0 - pH= 7 - sewer	
3. Cleaning and Sanitizing Agents Caustics Acids Detergents Others Disposal Method		 75 kg/day - - -	

(a) Although effluent volume is for whole bottle cleaning, characteristics indicated are for mechanical washing.

II-B

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.1	Process Unit Operation	
Prepared by:	Date:	
General housekeeping ideas		
	Yes	No
Keep work areas tidy and uncluttered to avoid accidents.	+	
Maintain good inventory control to avoid waste of raw ingredients.		+
Ensure that employees are aware of the environmental aspects of the company's operations, true cost of water and effluent and their personal responsibilities.		+
Train staff in good cleaning practices.		+
Schedule regular maintenance activities to avoid breakdowns.	+	
Optimize and standardize equipment settings for each shift.	+	
Identify and mark all valves and equipment settings to reduce the risk that they will be set incorrectly by inexperienced staff.	N.A	
Improve start-up and shutdown procedures.		+
Store dry materials appropriately.		+
Minimize clean out waste by increasing batch size.	N.A	
Collect and resale used oil from the garage, to reduce the strength of the wastewater.		+
Segregate and sale solid wastes.	+	
Improve drainage and remove blockages, pave all roadways and put signs on them.		+
Improve people control to reduce anthropogenic contamination of the product.	+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.2	Process Unit Operation	
Prepared by:	Date:	
Water Saving Ideas		
	Yes	No
Use continuous rather than batch processes to reduce the frequency of cleaning	+	
Use automated cleaning-in-place (CIP) systems for cleaning to control and optimise water use		+
Adopt definite water conservation program and make all personnel familiar with the program.		+
Install fixtures that restrict or control the flow of water for manual cleaning processes.		+
Use automatic shutoff valves on all water hoses to prevent waste when hoses are not in use.		+
Use solenoid valves for equipment, which is operated intermittently such as can washers, condensers, and other equipment.		+
Use low-volume, high-pressure nozzles rather than low-pressure sprays for cleanup.		+
Avoid unnecessary water overflow from equipment, especially when not in use, and provide automatic fresh water makeup valves.	+	
Do the cleaning by recirculation with re-use of cleaning solutions as long as they are effective.		+
Reuse/ recirculate relatively clean wastewaters (such as those from final rinses) for other cleaning steps or in non-critical applications.		+
Wherever economical, reuse the water used for cooling purposes for other purposes or recirculate over a cooling tower, in a spray pond, or through an evaporative condenser.	+	
Wherever economical, return the condensate from heaters and overflows from hot water circulating systems.		+
Install meters on high-use equipment to monitor consumption.		+
Thoroughly drain all lines, tanks and processing vats before rinsing and rinse the process equipment surfaces as possible after use.	+	
Supply hot water from a hot water tank rather than from mixing tees.		+
Use compressed air instead of water where appropriate.		+

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.2	Process Unit Operation	
Prepared by:	Date:	
Water Saving Ideas (continued)		
	Yes	No
Ensure water hoses are not used for chasing waste or debris, use long handled brushes or rubber bladed devices instead.	+	
Avoid using water to transport the product or solid waste when the material can be moved effectively by dry conveyors.	+	
Use water regulating valves for refrigeration systems where the volume of water needed is influenced by the system head pressure.		+
Use evaporator condenser instead of shell-and-tube condenser, which reduces the water consumed as much as 95%.	N.A	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.3	Process Unit Operation	
Prepared by:	Date:	
Effluent Reduction		
	Yes	No
Install modern equipment and piping in order to reduce loss of products.	+	
Collect spills of solid materials (cheese curd and powders) for reprocessing or use as stock feed.	N.A	
Ensure that employees either eliminate the cause of spillage or report it to the waste control supervisor rather than washing away spilled product.	+	
Correct drips and leaks occurring during processing runs if possible and if it is not possible, then collect the drips in containers and do not allow to go down the drains.	+	
Where drip shields are supplied, keep them in a certain place and provide with adequate containers for each day's operation.	+	
Fit drains with screens and/or traps to prevent solid materials entering the effluent system.	+	
Prevent fats entering waste streams by using save-alls, centrifuges and grease traps.		+
Install in-line optical sensors and diverters to distinguish between product and water and minimise losses of both.		+
Minimise spillages by ensuring that all milk storage tanks and vessels have level controls with automatic shutoffs and ensure that all valves are of food quality and not leaking.		+
Use dry cleaning techniques where possible, by scraping vessels before cleaning or pre-cleaning with air guns.		+
Use starch plugs or pigs to recover product from pipes before internally cleaning tanks.		+
Handle all sanitary fittings, valves, rotary seals, pump parts, and filler parts with extreme care during every phase of operation to prevent damage to the surface which may cause leaks.	+	
Wash the small parts properly in small parts washers and place on rubber mats for draining to minimize any damage.	+	

Cleaner Production Potential Assessment Worksheets			
Worksheet B-1.3	Process Unit Operation		
Prepared by:	Date:		
Effluent Reduction (continued)			
		Yes	No
Secure the proper separation of wastes into process wastes, sanitary sewage and clean water for reuse and recycling.			+
Recover by-products and waste products.		+	
Utilize an equipment maintenance program to minimize product losses.			+
Design CIP circuits to reuse fluids that are recirculated, if applicable.			+

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.4	Process Unit Operation	
Prepared by:	Date:	
Energy Saving Ideas		
	Yes	No
Implement switch-off programs and installing sensors to turn off or power down lights and equipment when not in use.	N.A	
Improve insulation on heating or cooling systems and pipework.	+	
Favour more energy-efficient equipment.	+	
Improve maintenance to optimize energy efficiency of equipment.	+	
Maintain optimal combustion efficiencies on steam and hot water boilers.	+	
Eliminate steam leaks, and replace leaking steam traps.	+	
Capture low-grade energy for use elsewhere in the operation.		+
Measure boiler efficiency and improve by optimizing the air fuel ratio.*	+	
Install condensate recovery system.		+
Install meters for water and oil.	+	
Install steam pressure regulators.	+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1.5 Process Unit Operation		
Prepared by: Date:		
Management Control		
	Yes	No
Provide the workers see that the entire program has the active support of management.	+	
Improve the processes and systems by installing modern equipment, piping and systems in order to reduce loss of products as rapidly as economically feasible. (see Table 4.1.6. in section 4.1.4)		+
Impress the people working in the plant with the importance of reducing wastes.		+
Instal and use waste monitoring system to evaluate progress.		+
Utilize of a product and process scheduling system to optimize equipment utilization, minimize distractions of personnel, and assist in making supervision of the operation possib	+	
Supervise the operations contributing to either volume or BOD coefficients.		+
Ensure required trainings are taken by workers to use equipments efficiently. (See Table 4.:	+	
Ensure the required maintenances are done regularly.	+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-1	Process Unit Operation	
Prepared by:	Date:	
Maintenance		
Preventive Maintenance [10]		
	Yes	No
Replace worn parts, gaskets, and fittings regularly.	+	
Inspect the plant for leaking connections, valves and pump seals regularly and fix them as soon as they are detected.	+	
Where leaks are found, place a work order for routine repair on a priority basis.	+	
Check of pipelines, lines that have retained their pitch and that are free from vibrations routi	+	
Replace rubber gaskets and O rings on automated valves, filler parts, etc.	+	
Check air- blow systems.	+	
Check on operation of high level and low level controls.	+	
Check on accuracy of indicating thermometers	+	
Inspect settings on packaging machine.	+	
Check filling valves and regrind as required.	+	
Check homogenizer packings.	+	
Check on seals and automatic desludging systems on separators.		+
Check on equipment leaks that may cause over flows.	+	
Check on flow and pressure drops in CIP systems to insure proper operation.	N.A	
Operational Maintenance [10]		
Ensure no leakage from shut off valves or supply lines of hoses and repairing the defective parts.		
Inspect and replace manual and CIP fittings.	+	
Check the pump seals in spite of leakage.		
Check pipe connection for preventing from product leakage or intrusion of air to the pipeline of a foaming product.		+
Check all lines on the suction side of pumps to ensure that they are properly sealed to avoid air leaks and resultant foaming which can cause excessive waste.		+
Avoide jamming and product loss from cases, conveyors and stackers by proper adjustmen	+	
Check filler valves to fill the correct capacity and prevent leakage.	+	

Cleaner Production Potential Assessment Worksheets			
Worksheet B-1	Process Unit Operation		
Prepared by:	Date:		
Operational Maintenance (Continued)			
		Yes	No
Adjust the machines for proper filling, capping and sealing.		+	
Provide the optimum conditions to prevent breaking or loosing product from the plastic and glass fillers and cappers.		+	
Check the centrifugal machines to ensure that seals are maintained in good condition to prevent leakage of product.		+	
Check automatic desludging systems for not remaining open.		+	
Check high level controls to ensure that they are working permanently.		+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-2 Process Unit Operation: Market Milk Production		
Prepared by: Date:		
Receipt and Storage of Milk		
	Yes	No
Be sure that each tank is properly connected to the transfer pump on initial unloading of the first tank.	+	
Do not wait tank trucks more than one hour to be unloaded since the quiescent conditions may lead to creaming	+	
Do not exceed dilution factor of 0.01 % for the rinsing water tanker which will be flushed to silo where legally acceptable.	N.A.	
Avoid milk spillage when disconnecting pipes and hoses.		+
Make certain that solid discharges from the centrifugal separator are collected for proper disposal and not discharged to the sewer		+
Collect wastewaters from initial rinses and return them to the dairy farm for watering cattle		+

Cleaner Production Potential Assessment Worksheets		
Worksheet B-2	Process Unit Operation	
Prepared by:	Date:	
Separation and Standardization		
	Yes	No
Collect the milk sludge and dispose it with other solid waste.	+	
Use the collected waste sludge as animal feed.		+
Pasteurization and Homogenization		
Replace batch pasteurisers with continuous process.	+	
Be sure that correct connectors are made on plate type heat exchangers so that there is no possibility of milk being pumped to the water side of the exchanger or water being pumped to the milk side	+	
Install new manufacturing equipment, which will result in less waste of milk products than the equipment currently used in many dairies	+	
Avoid stops in continuous processes.	+	
Consider high-volume pasteurizing units in the event of upgrades to process equipment.	N.A	
Reduce the frequency of cleaning of the pasteurizer and optimize the cleaning process.	+	
Optimize the size of balance tanks before and after the pasteurizer for continuous operation of the pasteurizer.	+	
Collect and recover the milky wastewater generated at start-up of pasteurization and supply it to farmers as animal feed.		+
Find alternative policies to reprocess the excess returned market milk without affecting the quality of the freshly pasteurized product	+	
Check the quality of returned milk before introducing to process to prevent pasteurization equipment.	+	
Capture and reuse silo tank, blending vat, processing piping and equipment rinsings.		+

Cleaner Production Potential Assessment Worksheets		
Worksheet B-2 Process Unit Operation: Market Milk Production		
Prepared by: Date:		
Pasteurization and Homogenization		
	Yes	No
Capture CIP sludge as solid waste and search for reuse alternatives.	N.A.	
Use CIP centrifuge or similar process equipment for solid separation.	N.A.	
Use management techniques to reduce amount of returned market milk.		+
Deodorization		
Recirculate the water used for vacuum pump.		+
Recirculate the cooling water of the deodorization equipment.	+	
Storage and Packing		
Inspect all bottles carefully at the beginning of the bottle washing operations so that defective bottles do not get to the filler and thus avoid product losses.	+	
For plastic and glass bottle fillers, maintain the cappers in first-class condition to avoid breakage and/or product loss.	+	
Collect more highly concentrated milk wastewater at start-up and shut-down for use as animal feed.		+
Clear milk residues from the pipes using compressed air before the first rinse.		+
Optimize the accuracy of filling operations.	+	
Ensure operators check the filler supply bowl for foam and eliminate any foam to minimize spillage and help insure proper operating of packaging machine.	+	
Check the settings on paper forming equipment frequently to insure proper package formation and sealing to minimize leaking.	+	
Establish a plant recovery system for products from defective or damaged containers.	+	
Empty and collect product from wrongly filled containers for use as animal feed.		+
Recover the damaged products that will be dumped at the fillers in a sanitary recovery system without allowing them to warm.	+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-2	Process Unit Operation	
Prepared by:	Date:	
Storage and Packing		
	Yes	No
Drain and collect the product remaining in the filler bowls of milk operation at the end of the processing day and not merely rinse to drain.	+	
Reduce energy consumption through improved insulation, closing of doors to cold areas, good maintenance of room coolers and regular defrosting.		+

Cleaner Production Potential Assessment Worksheets		
Worksheet B-3	Process Unit Operation	
Prepared by:	Date:	
Cleaning Ideas		
	Yes	No
Check that vessels, tanks and pipes have been drained as fully as possible.	+	
Install collection trays or containers that can be removed before running the CIP cycle.	N.A.	
Shut off the pre-rinse water by considering visual inspection or use of turbidity meters.	+	
Optimize CIP control by use of optimum water and tailor individual programs to avoid excessive use of chemicals and energy.		N.A.
Integrate cleaning chemicals use to the CIP system if not present. Consult chemical suppliers for the benefits/costs of the chemical to be selected.		N.A.
Ensure the correct cleaning aids are used and that they are in good condition.	+	
Check cleaning equipment is being operated properly.	+	
Use a chemical dosing system to ensure the concentrations are correct.		+
Investigate alternative equipment and methods.		+
Optimize chemical additions to minimize pH fluctiations in effluent.		+
Recycle the final rinse water to be used initial rinse in the next cycle.		+
Use compressed air to blow pipelines to reduce any milk that has adhered to the walls of the vessels and pipelines.		+
Pre-soak floors and equipment to loosen dirt before the final cleaning. Collect solid particles on the floor and equipment by the help of a btush prior to manual cleaning.	+ 	 N.A.
Use pigging system for purging pipes.		+
Use water or air for purging pipes if pigging is not suitable.	+	
If water is used for purging, ensure that controls are in place to minimize carryover to process.		+
Monitor against wear of nozzles during regular maintenance.		N.A.
Minimize use of lubricant in filling area since they contain 25% hexane solubles.		N.A.

Cleaner Production Potential Assessment Worksheets		
Worksheet B-3 Process Unit Operation		
Prepared by: Date:		
Crate Washing and Manual Cleaning		
	Yes	No
Optimize water consumption by monitoring the water pressure and the condition of the water spray nozzles.		+
Turning off the crate washer when not in use.	+	
Recirculate wash water through a holding tank.		+
Dry cleaning waste on floors, eg with a rubber blade wiper, before hosing down areas.		+
Place trays and containers under machines or within a process to catch solid wastes prior to washing down.		N.A.
Ensure that trays are emptied regularly so that you avoid overfilling.		+
Fitting trigger-action guns to hoses		+
Using low-cost screens to prevent solids entering the wastewater stream and increasing the effluent load. This is particularly effective in creameries where solids are often washed down the drain.		N.A.

Cleaner Production Potential Assessment Worksheets		
Worksheet B-4 Process Unit Operation		
Prepared by: Date:		
Compressed air supply ideas		
	Yes	No
Check the compressed air system to prevent leakage.	+	
Adjust the consumption of cooling water accordingly by a temperature sensitive valve.		+
Use cooling tower to to cool the heated water and either to recirculate the water or use it in another place such as cleaning.	+	
Steam Supply Ideas		
Use the condensate from system either for heating in other processes or return to condensate tank to be recycled.		+ +
Use fuel oil with low sulfur content.		+
Institute a procedure for handling oil and oil spills.	+	
Change the fuel used from coal to oil or from oil to natural gas.	+	
Install oil atomizer to increase efficiency.	+	
Insulate hot surfaces.	+	

Cleaner Production Potential Assessment Worksheets		
Worksheet B-4 Process Unit Operation		
Prepared by: Date:		
Compressed air supply ideas		
	Yes	No
Take precaution against algal growth on evaporator pipes.	O.B.	
Optimize the running of the cooling tower fans to preclude blowing of water off the cooling tower.	O.B.	
Ensure that doors are closed whenever the unit is not being used.	O.B.	
Install and maintain insulation of refrigeration unit.	+	
Improve maintenance of condensers.	+	
Install curtains on freezers to prevent ice build up.		+
Ensure freezers are energy efficient.		+
Keep doors closed in cold areas.		+
Undertake regular defrosting of cold rooms and maintaing refrigeration systems regularly.	+	
Avoid refrigerants that contain CFCs and prefer refrigeration systems based on ammonia.	O.B.	

OB: Outside Boundaries of Study

APPENDIX III

APPLICATION OF CP IN AOC

Table 3. 1. Mass flows of AOC market milk production and cleaning processes

Source process & flow	Quantity (kg/d)
Clarification	
Qm1	29,076.8
Qw1	424.13
Qw2	15.58
Qw3	106.12
Qw4	302.65
Raw milk storage tanks	
Qm2	29,051.39
Qm3	6.93
Qm19	18.19
HTST pasteurizer	
Qm4	33,985.90
Qw5	2,678
Qw6	2,664
Qw7	14
Separator	
Qw9	2180*2
Qw10	2100
Qw8	6500.21
Qw11	40.25
Qm7’	119.06
Deodorization	
Qw13	2131.22
Qw14	2131.22
Qw12	840

Table 3.1. (continued)

Source process & flow	Quantity (kg/d)
Homogenizator	
Qw15	1077.21
Qw16	1888.59
Pasteurized milk storage tanks	
Qm5	12.42
Qm6	33,825.26
Packaging	
Qm7	12,147.65
Qm8	2.31
Qm9	0.50
Qm10	19,581.78
Qm11	452.32
# of Washed Bottles (1/2 L) Entering	38,117
# of damaged bottles	20
Qm12	1797.66
Qm13	45.23
Qm14	6.49
Tank-truck cleaning	
Qw17	2,008.96
Qw18	2,008.96
Qm18	6.93
Qm17	29,083.73
Qm1	29,206.80
Cleaning of returned milk vessels	
Qw19	188.31
Qw20	178.89
Qw21	9.42
Cleaning of unpacked product vessels	
Qw22	1,748.80
Q_{NaOH-1}	8.74
Qw23	1,705.08
Qw24	52.46
Floor cleaning in vessel cleaning area	
Qw25	164.66
Qw26	164.66
Mechanical vessel washing	
Qw27	105
Q_{NaOH-2}	3.5
Qw28	108.5

Table 3.1. (continued)

Source process & flow	Quantity (kg/d)
Raw milk storage tanks cleaning	
Qw29	1,440.49
Qw30	1,440.63
Q_{det-1}	0.08
Qm19	18.19
Pasteurization cleaning	
Qw31	966.43
Qm20	167.38
Qw32	450
Q_{NaOH-3}	10
Qw33	853.93
Qw34	843.33
Qw35	450
Q_{HNO3-1}	10
Qw36	2,561.79
Qw37	2,510
Qw38	1297.8
Heating of pasteurization system	
Qw39	2500
Qw40	2,832.62
Qm21	167.38
Floor cleaning of pasteurization and raw milk storage	
Qw41	2,001.86
Qw42	2,003.57
Q_{det-3}	1.71
Pasteurized milk storage tank cleaning – 1st rinse	
Qw43	535.5
Qw44	547.92
Qm22	12.42
Pasteurized milk storage tank cleaning – caustic wash	
Qw45	1683
Q_{NaOH-4}	30
Q_{det-4}	0.3
Qw46	1,713.30
Pasteurized milk storage tank cleaning – final rinse	
Qw47	7,344
Qw48	7,344
Pasteurized milk storage tank cleaning – unnecessary water discharge	
Qw49	5,712
Qw50	5,712

Table 3.1. (continued)

Source process & flow	Quantity (kg/d)
Pasteurized milk storage tank cleaning – surface wash	
Qw51	1,683
Qw52	1,683
Cleaning line from pasteurization	
Qw53	408
Qw54	408
Pasteurized milk storage morning wash	
Caustic Wash	
Qw55	560
Qw56	571.10
Q_{NaOH-5}	5
Q_{det-5}	0.1
Warm and Cold Rinse	
Qw57	7344
Qw58	7344
Hose Remained Open	
Qw59	5712
Qw60	5712
Surface Wash	
Qw61	1683
Qw62	1683
Bottle washing	
Initial Rinse of Dirty Bottles	
Qw63	200
Qw64	200
1st Warm Rinse	
Qw65	Qw65+Qw75= 9854.21
Qw66	333.33
Qw67	Q67+Qw74 =9178.54
1st Caustic Wash	
Qw68	666.67
Qw69	704.17
Q_{NaOH-6}	37.5
2nd Caustic Wash	
Qw70	666.67
Qw71	704.17
Q_{NaOH-7}	37.5
2nd Warm Rinse	
Qw72	666.67
Qw73	666.67
Qw74	

Table 3.1. (continued)

Source process & flow	Quantity (kg/d)
Final Cold Rinse	
Qw75	
Qw76	333.33
Bottle case washing	
Qw77	12,801.60
Qw78	12,801.60
Cleaning in bottle and bottle case washing	
Qw79	2,0965.71
Qw80	2,0965.71
Cleaning of bottle packaging	
Rinse of Pipeline	
Qw81	510
Qw82	31.71
Qw83	478.29
Surface Wash of Equipment and Conveyors	
Qw84	4003.71
Qw85	4003.71
Detergent Wash	
Qw86	1,408.71
Qw87	1,408.95
Q_{det-5}	0.24
Unnecessary Water Discharge	
Qw88	1,186.29
Qw89	1,186.29
Cleaning of cartoon packaging	
Caustic Wash	
Qw90	250
Qw91	255
Q_{NaOH-8}	5
Rinsing	
Qw92	750
Qw93	750
Morning Rinse	
Qw94	250
Qw95	250

Table 3. 2. Results of implementation of CP opportunities for market milk production process

service water reuse	repair	milk sludge/ animal food	off-site reuse/ animal food	GHK/level control & valve change/ser.wat.	GHK/operating practices/milk

Water Source	**Name**	**Quantity (kg/day)**	**COD (mg/L)**	**TSS (mg/L)**	**pH**	**Alkalinity (mg/L as CaCO3)**	**Total Coliform**	**Reduced COD (kg/day)**	**Reduced TSS (g/day)**	**Recycled Water (kg/day)**	**Eliminated Discharge (kg/day)**	**Reduced Recycling (kg/day)**
Service water	*Clarifier* Qw4	302,6	0	0	7.4		0			302.6		
Loss from valves	Clarifier Qw3	106.1									106.1	
Clarifier sludge	Clarifier Qw2	15.5	130400	26680	6			2	415.6		15.5	
Spill in manual connection	Raw milk storage Qm4	6.9	254200	59722.2	6.7	737.4		1.7	413.6		6.9	
Steam condensate	Pasteurizer Qw6	2664	0	0	6.9		0			2664		
Spills from HTST fittings	Qw7	14									14	
Discharge water	Separator Qw9	4360.5			7.3	0				4360.5		
Service water	Separator Qw10	2100									2100	

Table 3.2. (continued)

Water Source	**Name**	**Quantity (kg/day)**	**COD (mg/L)**	**TSS (mg/L)**	**pH**	**Alkalinity (mg/L as CaCO3)**	**Total Coliform**	**Reduced COD (kg/day)**	**Reduced TSS (g/day)**	**Recycled Water (kg/day)**	**Eliminated Discharge (kg/day)**	**Reduced Recycling (kg/day)**
Separator sludge	Separator Qw11	40.2	178700	32480	6.1			8	1289.3		40.2	
Heating water	Deodorization Qw13	2131.2								2131.2		
Cooling water loss	Deodorization Qw12	840									840	
Damaged hose	Homogenization Qw17	1077.2	5317.5	740	6.7			5.7	792.5		1077.2	
Return milk to beginning	Cartoon packaging Qm11	246.7	254200	59722.2	6.7	737.4						16.4
Return milk to beginning	Bottle packaging Qm11	205.6	254200	59722.2	6.7	737.4						143.9
Spill on ground	Unpacked Qm13	45.2	254200	59722.2	6.7	737.4		11.1	2627.7		45.2	
TOTAL		14156						27.7	5538.9	9458.3	4245.3	160.3

Table 3. 3. Results of implementation of CP opportunities for cleaning of market milk production process

off-site reuse/ animal food	shut-off spray nozzle use	GHK/ operating practices	chemical change	CIP system savings	reuse/cases &cleaning
(purple)	(red)	(light green)	(cyan)	(orange)	(magenta)

Water Source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	Reduced COD (kg/day)	Reduced TSS (g/day)	Reduced Alkalinity (kg/day)	Eliminated Water use (kg/day)	Eliminated Discharge (kg/day)	Recycled Water (kg/day)	Eliminated Chemical Use (kg/day)
	Cleaning tanks on trucks												
milk spilled on ground	Qm18	6.9	254200	59722.2	6.7	737.4	1.7	402.4			6.9		
	Cleaning Tanks on Trucks												
waste rinse water	Qw18	2008.9	111650	33820	6.3		126.2	11469		1406.2	339.12		
	Vessel cleaning												
Spill on ground in vessel rinsing	Qw21	9.4								9.4			
	Rinse of return milk vessels												
dirty rinse water	Qw20	178.9								125.2			
	Vessel manual washing												
	QNaOH-1	8.7											7
	Rinse of unpacked milk vessels												
dirty rinse water	Qw23	1705								852.5			
Spill on ground in vessel rinsing	Qw24	52.4								26.2			
	Mechanical vessel washing												
water used in machine	Qw27	214.3								53.5			
	Vessel mechanical cleaning												
	QNaOH-2	7.1											6.6
	Floor cleaning of vessel washing												
dirty rinse water	Qw26	164.6								115.2			

Table 3.3. (continued)

Water Source	**Name**	**Quantity (kg/day)**	**COD (mg/L)**	**TSS (mg/L)**	**pH**	**Alkalinity (mg/L as CaCO3)**	**Reduced COD (kg/day)**	**Reduced TSS (g/day)**	**Reduced Alkalinity (kg/day)**	**Eliminated Water use (kg/day)**	**Eliminated Discharge (kg/day)**	**Recycled Water (kg/day)**	**Eliminated Chemical Use (kg/day)**
	Savings Due to CIP System												
	1st Rinse of Systems												
milky water to channel	*Pasteurization 1st rinse* Qm20	167.3	38850	9320	6.9	70.9	6.4	1553.3			167.3		
rinse water recycled and wasted	V	501.7	30850				15.4				501.7		
rinse for purging of milk and milk foam	*Cleaning of Pasteurized milk storage* 1st rinse Qw44	547.9	235.5	360	8.7	93.5	0.1	197.2			547.9		
rinse of pipeline	*Cleaning bottle packaging* Qw83	478.3	8425	194	7		4	92.8			478.3		
	Alkaline Wash of Systems												
Alkaline chemical used	*Pasteurization cleaning* Caustic wash QNaOH-3	10											10,00
hot water for solution	*Cleaning of pasteurized milk storage* Caustic wash Qw46	1713.3	94	860	12.2	23448.4	0.1	1473.4	40.1		1713.3		

Table 3.3. (continued)

Water Source	**Name**	**Quantity (kg/day)**	**COD (mg/L)**	**TSS (mg/L)**	**pH**	**Alkalinity (mg/L as CaCO3)**	**Reduced COD (kg/day)**	**Reduced TSS (g/day)**	**Reduced Alkalinity (kg/day)**	**Eliminated Water use (kg/day)**	**Eliminated Discharge (kg/day)**	**Recycled Water (kg/day)**	**Eliminated Chemical Use (kg/day)**
Alkaline chemical used	Pasteurized milk storage tanks caustic wash QNaOH-4	30											30
	Rinsing of Alkaline Solution												
caustic solution discharged	*Pasteurization cleaning* 2nd rinse Qw34	843.3			10.4	12254.1				843.3			
dirty rinse water	*Cleaning of pasteurized milk storage* 2nd rinse Qw48	7344			9.4	40.8				2754			
waste rinse water	Rinse of pasteurization line pipes Qw54	408								408			
service water for warm rinse	Rinse of morning wash Qw57	7344								2754			
	Acidic Wash of Systems												
acidic solution discharged	*Pasteurization cleaning* 3rd rinse Qw37	500			2.4						500		
acid used for solution	Pasteurization acid wash QHNO3-1	10											10

Table 3.3. (continued)

Water Source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	Reduced COD (kg/day)	Reduced TSS (g/day)	Reduced Alkalinity (kg/day)	Eliminated Water use (kg/day)	Eliminated Discharge (kg/day)	Recycled Water (kg/day)	Eliminated Chemical Use (kg/day)
	Final Rinse												
acidic solution discharged	*Pasteurization cleaning* 3rd rinse Qw43	2510			2.4					2510			
detergent rinsing water	*Cleaning bottle packaging* Qw86	1408.7								1408.7			
heating water	**Pasteurization cleaning** Pasteurization heating Qw39	2500								1500			
wasted alkaline solution	**Pasteurized Milk Storage Morning wash** Morning caustic wash Qw56	571.1									571.1		
overflow water	**Pasteurization cleaning** Qw38	1290.3								1290.3			
	Pasteurized milk storage tank cleaning												
hose remained open	Qw49	5712								5712			
hose remained open	Qw59	5712								5712			

Table 3.3. (continued)

Water Source	Name	Quantity (kg/day)	COD (mg/L)	TSS (mg/L)	pH	Alkalinity (mg/L as CaCO3)	Reduced COD (kg/day)	Reduced TSS (g/day)	Reduced Alkalinity (kg/day)	Eliminated Water use (kg/day)	Eliminated Discharge (kg/day)	Recycled Water (kg/day)	Eliminated Chemical Use (kg/day)
	Cleaning bottle packaging Rinse of pipeline												
hose remained open	Qw88	1186.3								1186.3			
spill on floor	Qw82	31.7								31.7			
	Savings due to other opportunities besides CIP												
	Cleaning cartoon packaging												
service water for rinsing	Qw92	750								250			
	Raw milk storage tanks rinsing												
service water for rinsing	Qw29	808.8								566.1			
milk foam	Qm19	18.2									18.2		
	Surface and floor cleaning of pasteurization												
service water for rinsing	Qw41	2001.8								1401.3			
	Surface cleaning of pasteurized milk storage tanks												
rinse water	Qw51	1683								1178.1			
	Morning surface wash												
rinse water	Qw61	1683								1178.1			
	Bottle Washing *Mechanical washing*												
	QNaOH-6	37.5											18.7
	QNaOH-7	37.5											18.7
overflow water	Qw67+ Qw74	9178.5	0	40	10.5	719.4						9178.5	

Table 3.3. (continued)

Water Source	**Name**	**Quantity (kg/day)**	**COD (mg/L)**	**TSS (mg/L)**	**pH**	**Alkalinity (mg/L as CaCO3)**	**Reduced COD (kg/day)**	**Reduced TSS (g/day)**	**Reduced Alkalinity (kg/day)**	**Eliminated Water use (kg/day)**	**Eliminated Discharge (kg/day)**	**Recycled Water (kg/day)**	**Eliminated Chemical Use (kg/day)**
	Initial rinse of dirty bottles												
water filled in bottles	Qw63	200								200			
	Surface wash of Equipments												
surface rinsing water	Qw84	4003.7								2802.6			
	Bottle case washing												
water sprayed on cases	Qw77	12801.6								8978.5			
	Floor cleaning												
service water for rinsing	Qw79	2965.7								2076			
TOTAL							154.1	15188.2	40.1	47329.7	4843.9	9178.5	101.1

APPENDIX IV

CASE STUDIES

1. Industrial Pollution Prevention, Food Sector, Reduction of Milk Losses at Misr Company for Dairy and Food, Mansoura, Egypt

1.1. Introduction

A range of pollution prevention opportunities have been identified and are currently being implemented by Misr Company for Dairy and Food in Mansoura, Egypt. To date, this has involved a total investment of US$24,727 and resulting in annual savings of US$67,521. A summary of how these improvements were identified and the underlying problems solved, follows.

1.2. The Factory

The Mansoura factory, one of the largest producers of dairy products in Egypt, was built in 1965 and has a workforce of around 420. The factory annually processes an average of 7200 tons of milk, producing mainly pasteurised milk, white cheese, blue cheese and mish. Yoghurt, sour cream, ghee and processed cheese are also produced.

1.2.1. Process Description

After receival of milk and pasteurizing milk is processed to produce; Market milk, white cheese, ghee, roquefort cheese, processed cheese, yogurt and sour cream and mish (salty cheese mix).

1.2.2. Service Units

Factory service units include tin can manufacturing, refrigeration and storage, a boiler station, a quality control laboratory, a warehouse and maintenance workshops.

1.2.3. Water Consumption

The factory uses about 37,080 m^3/year of water from the Mansoura City potable water supply;

- Processing - 2,880 m^3/year.
- Equipment and floor washing - 20,160 m^3/year.
- Boiler feed and cooling water - 6,840 m^3/year.
- Domestic use - 7,200 m^3/year.

1.2.4. Wastewater Characteristics

- Volume: 30,240 m^3/year of industrial wastewater from different factory streams,
- BOD: 13,160ppm,
- COD: 18,800ppm,
- TSS: 10,640ppm.

There is no industrial wastewater treatment facility and the wastewater is disposed into the city sewerage system.

1.3. Pollution Prevention Opportunities

Pollution prevention opportunities were identified by means of an industrial audit. This identified various improvement opportunities; a description of the most important being:

1. Different solid wastes stored haphazardly in open areas and roads, constituting a fire risk and impairing the general appearance of the premises.
2. Considerable amounts of milk were wasted due to overflow during the filling of storage and service tanks.
3. Milk leakages in the milk packaging and refrigeration units.
4. Oils used in the car and truck maintenance facilities was drained to factory sewers, encouraging drain blockage and consequent development of foul odours.
5. Excessive consumption of mazot in the boiler house, due to poorly tuned boilers. This also resulted in excessive air emissions (mainly smoke and carbon monoxide) being discharged from the boiler stacks.

Summary of Cost Benefits				
Factory Unit	**Action**	**Capital and Operation Costs (US$)**	**Yearly Savings (US$)**	**Payback Period (month)**
All	Improve Housekeeping and Solid Waste Removal	2,838	26,200	1
Milk Packaging and Storage	Rationalise Milk Packaging and Increase Milk Refrigeration Efficiency	5,786	8,646	8
White Cheese	Reuse Whey	0	436	Immediate
Boiler House	Upgrade Boiler and Restore Softening Unit	436	4,094	<1
Garage	Collect Used Oil	109	546	<3
Milk Receiving and Pasteurisation	Milk Tank Level Controls	2,238	27,511	7
	Food Quality Valves	13,974		
Total		25,382	67,434	<5

1.4. Cleaner Production Applications

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 were given high priority as they are easy to implement and often entail significant savings.

The measures which have already been implemented by the factory or under implementation through the Cleaner Production Demonstration Projects of the steam project are briefly outlined below.

1.4.1. Improve Housekeeping

In-plant housekeeping of factory units and buildings was improved, factory drainage, sewers, and manholes were maintained and upgraded to eliminate blockage and overflow problems. In-plant roadways were paved and signposts added to allow for better traffic flow of factory vehicles. Unattended areas were planted with trees and greened. Overall, the factory has improved its image and cleanliness.

Implementation Cost: US$2,183

1.4.2. Used Garage Oil: Collection for Resale

Pollution loads from the garage and workshops constitute the highest level of suspended solids (9,148ppm), and the only source of mineral oil and grease (1,245ppm) generated in the factory. Oil, grease and lubricants are now collected instead of being disposed to the sewer, with the following benefits:

- Approximately 0.75 tons of oil are accumulated monthly and sold at US$60 per ton.
- Reducing the strength of wastewater,
- Improving the cleanliness of the garage and workshops,
- The prevention of serious blockage of sewers and overflow (as oil and grease tend to solidify milk products if mixed in sewers).

Implementation Cost: US$109

Annual Savings: US$546

1.4.3. Solid Waste: Collection and Sale

Solid wastes generated by the factory were initially segregated and then either disposed or sold:

- Garbage and packaging wastes are trucked out daily and disposed a
- Solid wastes such as scrap iron and metals objects are sold in auctions or to special scrap dealers.

This action has achieved an efficient removal of wastes from the site, and improved cleanliness of factory premi from the sale of solid wastes.

Implementation Cost: US$655

Savings: US$26200

1.4.4. Water and Energy Conservation

Boiler Tune-Up and Upgrade

The ratio of air mazot was optimized to increase the efficiency of boilers, hence reducing mazot consumption and gas emissions. Benefits of this measure includes:

- Mazot consumption has reduced by 60 tons/year, saving US$2345
- Solar consumption has been reduced by 12 tons/year, saving US$1087
- Electricity consumption has been reduced by 12,775 kWh/year, saving US$ 545.

Restoration of Softening Unit

The softening unit was restored to prevent the scaling of the boiler by chemical treatment of the feedwater.

As a result of implementing this improvement, tuning and upgrading the boilers, steam generation from $1m^3$ of water has increased from 1 ton to 1.16 tons, corresponding to a 16% increase in boiler efficiency.

Implementation Cost: US$436

Annual Savings: US$4.093.

1.4.5. Reuse and Recycling

Increase Refrigeration Efficiency and Rationalise Milk Packaging

Raw milk storage units and the refrigeration room of the packaged milk products were upgraded to prevent spoilage and loss. This was achieved through investment in a refrigeration system, which permitted temperature to be fully controlled. The benefits from this intervention include:

- Increased production capacity
- Improved process efficiency
- Improved quality control
- Reduced reject rates of the final product

The packaging unit was relocated from a restricted area to be adjacent to the refrigeration facility thus preventing handling losses. This has reduced milk losses by 3.3tons/month, corresponding tp monthly savings of US$727.

Implementation Cost: US$5,786

Annual Savings: US$8,646

Whey Reuse in White Cheese Manufacturing

4.4m³ of permeate with a high lactose concentration (4.5%) is generated as a by-product from ultra-filtration in this process. Originally, this was disposed directly to the sewer. The factory now reuse 50% of this in the cheese packing stage, in place of fresh water.

This has resulted in a 50% drop in organic load generated from white cheese unit from 5,800ppm to about 3,000ppm. Almost 2,200m³ of water are saved on an annual basis.

Implementation Cost: None

Annual Savings: US$436.

1.4.6. Installation of New Equipment

Total loses from factory in both raw milk and products were shown to be 0.80 tons/day. The receiving and pasteurization processes were the greatest sources of wastage, with milk losses of up to 0.7 tons/day, valued at US$55,021 per year.

The Problem: Raw milk coming into the factory is transferred directly from delivery vehicles into the storage tanks. As the were no level gauges or controls on the tanks, overfilling and spillage frequently occurred.

The Solution: Installation of Level Controls - milk storage tanks were equipped with level sensors and stopcocks to prevent overflow particularly during the receiving stage. This type of sensor was selected rather than infra-red sensors, as foaming of the milk as it is transferred can result in inaccurate readings and subsequent overflow.

Implementation Cost: US$2,238.

The Problem: Leakages of milk from valves throughout the system were common, resulting in milk loss and an increased organic load of the final effluent.

The Solution: Installation of Control Valves - the installation of food quality, stainless steel control valves were installed through out the factory where required, including the milk receiving, storage and pasteurisation areas. Forty valves were required.

Implementation Cost: US$13,974.

The implementation of the above improvements has resulted in daily savings of 350 kilograms of milk. A total of 126 tons of milk are recovered annually resulting in savings of US$27,511 per year. Additional benefits include:

- Reduced pollution loads,
- The elimination of floor spills,
- Improved hygiene and safety.

1.5. Economics

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

- Reduced raw materials consumption;
- Waste minimization and
- Reuse or recycling of in-plant materials.

Implementing these measures will also result in reduced environmental pollution and movement towards discharge consent limits.

The total capital and operation costs invested in the cleaner production measures at the Mansoura factory amounts to US$25,382. This has produced total savings of over US$67,434 with an average payback period of around 4 months.

1.6. Benefits and Achievements

- Recovery solutions and better quality control of milk products and by-products has recovered 166 tons of milk/year (2.3%), which was previously wasted.
- Water consumption has dropped by 6%.
- Mazot consumption has decreased by 10%.

- Solar consumption has decreased by 5%.
- Electricity consumption has been reduced by 9%.

Source: http://www.seamegypt.com/CaseStudies/Food_Milk_Loss.PDF [36].

2. Cleaner Production - Multiple Use Clean-In-Place (CIP) System in Milk Processing - Pauls Limited (NT), Australia, 1998

Pauls Limited (N.T.) is the only company that fully processes milk in the Northern Territory. Pauls has completed a major upgrade and expansion of its processing plant in Bishop Street, Stuart Park. The fully automatic plant is built to the highest Australian standards and it replaces the older, manually operated plant. The upgrades cost more than $2.5 million (1998). Major works included the installation of a fully automated cleaning facility for the pasteurized milk vats and associated lines.

2.1 Background

Pauls Limited (N.T.) manufactures and markets a range of recognized brands of dairy food and beverage products for Northern and Central Australia. They are committed to a program of waste management and have established an Environmental Policy which includes minimizing the use of raw materials and energy; ensuring that products and services are produced, packaged, delivered, disposed of and recycled in a responsible manner with minimal adverse impact on the environment; assessment of the environmental impacts associated with new projects at the planning stage; and staff acceptance of environmental responsibilities in day to day activities.

Pauls Limited (N.T.) is legally required to conform to hygiene requirements in milk product manufacture. To achieve this, hygiene must be seen to encompass a consideration of all features of building design and maintenance, engineering services and production procedures. That is, the whole production unit should be designed, maintained and operated with hygiene in mind and with thought given to both minimizing relevant contamination and to the cleanability of equipment and factory environment.

2.2. The Process

Pauls Limited (N.T.) had previously utilized a single use CIP system (Figure 6.2.1). This system was based on the premise that all required chemicals and water were used only once following each clean before they were discharged as waste.

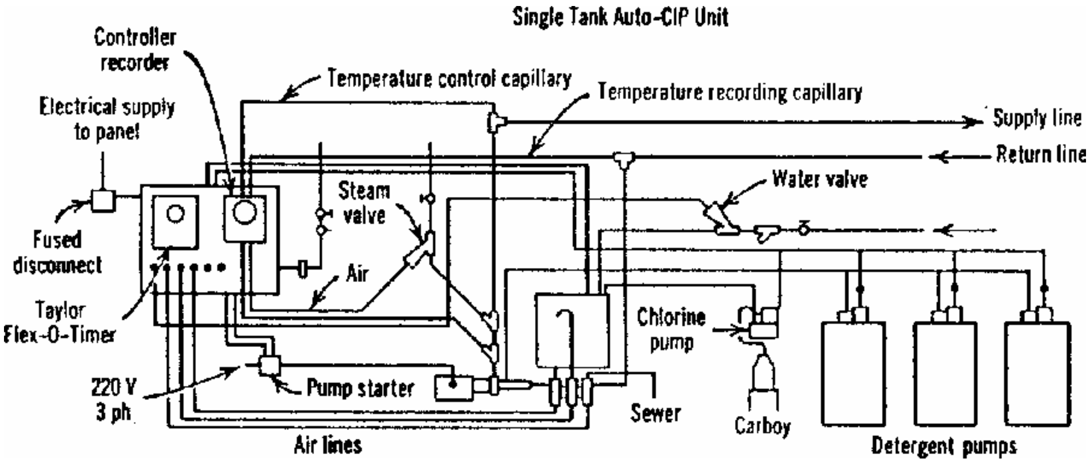

Figure 5.2. 1. Single Use Clean-in-Place (CIP) System

The single use CIP system had a number of associated problems when employed by Pauls Limited (N.T.) such as:

1. Cost inefficiency;
2. Excessive use of cleaning chemicals;
3. Involved too much time out of the production schedule to clean on a continuous basis;

4. Limited documented proof of cleans performed on the milk production system; and
5. Parts were no longer available for repairs.

2.3. Cleaner Production Initiative

Pauls Limited (N.T.) has adopted as part of the plant's $2.5 million upgrade a multiple-use CIP System to replace the single use CIP system. The multi-use Clean in Place (CIP) System embodies the principles of cleaner production and has been adopted by Pauls Limited (N.T.) as it provides the best possible technology for attaining the required hygiene standards whilst simultaneously achieving the goals of their Environmental Policy. The multi-use CIP efficiently cleans and sanitizes all of the milk lines and associated pasteurized milk vats whilst minimizing wastage. Figure 2 is a generic diagram of a multi-use CIP system such as that employed by Pauls Limited (N.T.).

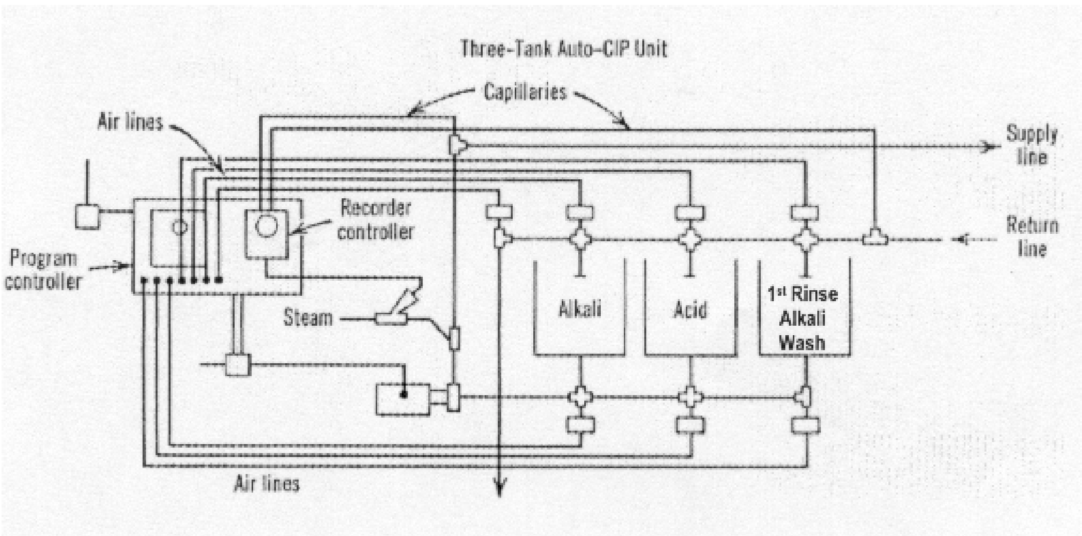

Figure 5.2. 2. Multi-use CIP System

The development of the multi-use CIP system by Pauls Limited (N.T.) as their cleaner production initiative involved the following 7 steps:

1. The determination of process line requirements;
2. The development of CIP circuits;
3. The design of suitable supply return systems to clean these circuits and to handle also all mechanical spray-cleaning operations;
4. The selection of materials for construction;
5. The making of the actual installation;
6. The selection and installation of recirculating equipment; and
7. The application of instrumentation and controls to assist in continuous maintenance of the desired cleaning program.

The Paul's Limited (N.T.) CIP System has the benefit of allowing the operators to select a specific vat or line to be cleaned via a computer interface. The system then proceeds through a preset cleaning regime. A typical CIP clean such as that employed by Pauls Limited (N.T.) involves the following established stages:

1. A cold alkali water pre-rinse that removes any milk product remaining in the lines and utilizes recovered final rinse water from an earlier cleaning cycle;
2. Circulation of an alkaline detergent that is timed from the point when the fluid returns to the CIP tank at the desired temperature;
3. Circulation of potable water;
4. Circulation of approved sanitizer/hot water.

All the chemicals that are used in the system are returned and circulated via holding vats. A conductivity and temperature meter monitors the concentration and temperature of the cleaning solutions used. If either one of these parameters is out of specification, the system will automatically compensate and whilst holding its cycle time ensuring that specifications are met. The chemicals in the system, Acid Sanitizer and Sodium Hydroxide are reused many times until the protein build up in the solution becomes excessive and has to be discarded.

2.4. Advantages of the Process

The advent of automatic multi-use CIP systems has made it economically and physically feasible to install sensitive, complex measuring and control equipment for further process automation. The potential for damage is also eliminated as the necessity for repeated disassembly, washing and reassembly of processing equipment which was common for single use CIP systems is no longer required through the new automatically controlled mechanical cleaning. By utilizing Acid Sanitizer and Sodium Hydroxide within the system, the following direct benefits have also be attained:

1. Reduction in the clean-up labor costs;
2. Improved sanitation of the complete system through the ability to use higher temperatures and stronger chemicals; and
3. Elimination of contamination when assembling dismantled equipment.

The decision to adopt the multi-use CIP System by Pauls Limited (N.T) was based on the obvious cost savings associated with cleaning the system, and operational advantages such as labor saving, reduced product loss and improved process sanitation. Table 1 contains the direct benefits, costs and pay back period attributable to the adoption of the multiple use CIP technology by Pauls Limited (N.T).

Table 5.2. 1. Costs and Savings of the Multiple Use CIP System

	Benefits	**Savings/Costs**
Costs of multi-use CIP installation		**$40,000**
Savings made per annuum by using the CIP System		**$40,000**
Economic	Reduced chemical usage Reduced water usage Improved cleaning effectiveness Enhanced product quality	
Environmental	Reduced chemical waste Reduced water waste	
Health & Safety	Reduced direct handling of chemicals	
Total Savings		**$40,000**
Payback Period		**1 year**

2.5. Incentive

The main incentive for adopting the cleaner production practice was Pauls Limited (N.T) ongoing commitment to minimizing the production of waste and adopting the best available technologies. The cleaner production activities of Pauls Limited (N.T) are successful because the entire organization understands the importance of efficiency through waste minimization; and they are continually identifying new opportunities for improvement.

2.6. Barriers

No barriers were encountered in implementing this cleaner production initiative. The management of Pauls Limited (N.T) is committed to a program of waste minimization through continuous improvement of their production systems and processes. Their commitment to cleaner production through a waste management strategy is driven by management and extends to all functions and levels of the organization.

2.7. Further Developments

A Spinifex CIP Solids Recovery unit (CIP System primary solids removal) was installed in 2001. The unit removes solids (notably pulp) from the CIP fluid at an efficiency of approximately 80% of 10 micron particle size. Continuous removal of solids increases the lifespan of the cleaning fluid and further improves the efficiency of the multiple use CIP System.

The cost of the CIP Solids Recovery unit was $32,000. The savings are difficult to account for, because aside from improved efficiency of the CIP system, removal of pulp from the CIP wash water has enabled milk and juice processing to be consolidated in the same plant, thereby avoiding further plant expansion.

Pauls Limited has several new cleaner production initiatives under development, including several in support of the National Packaging Covenant.

Cleaner Production initiatives include:

1. Trial conversion of truck fleet to combined LPG gas/diesel fuelling to minimize greenhouse gas emissions. LPG gas is used for acceleration, diesel when idling.
2. Reduced use of milk crates and adoption of one-way packaging for situations where milk crates are not being returned. Milk crates must be reused 15 times to justify their manufacture, and as this is not being achieved, a change in practice will minimize the production of milk crates.
3. Reduced use of cling wrap on pallets and where practicable, reuse of strapping. Plastic straps used on oversized pallets are collected on site and reused on average sized pallets fastened with a small plastic buckle.
4. Tolerances and design specifications for PET and HDPE have been reviewed and bottle suppliers retooled to enable the manufacture of lighter weight bottles. The initiative reduces the consumption of raw plastic.

Pauls is also actively involved in community education and conducts touch and feel displays demonstrating the reprocessing of recycled plastics in shopping centers and holds factory open days to show how the company takes efforts to minimize their environmental impacts and what that means for the community.

Implementation: 1998 Further initiatives: 2001

Case study initially prepared: 1999 by Northern Territory Chamber of commerce and Industry Last modified: May 2001

Source: http://www.ea.gov.au/industry/eecp/case-studies/pauls1.html [37].

3. Change in Operating Practice at Dairy Plant Reduces Air Emissions, Latvia, 1994

3.1. Background

The Joint Stock Company "Kurzemes Piens" is a regional dairy with five plants located in the Liepaja region in Latvia. The dairy's main products are milk, yogurt, cottage cheese, kefir, sour cream, and butter. The plant processes about 100 tons of milk per day. The main dairy unit, located in the city of Liepaja, employed 54 people in 1994.

3.2. Cleaner Production Principle

Process modification

3.3. Cleaner Production Application

The five dairies operated by "Kurzemes Piens" are supported by three refrigeration plants. The refrigeration units are over fifty years old. In the past, each refrigeration plant was estimated to lose approximately four tons of ammonia refrigerant per year through leaky piping systems. The dairy usually repaired major and obvious leaks.

However, manual inspections for leaks were unsafe due to the toxicity of ammonia gas. Consequently, minor leaks often were not detected and repaired.

During the waste minimization project, it was determined that rebuilding the refrigeration plants was not cost-effective. Instead, portable ammonia detectors were purchased for use at each of the three refrigeration plants. Using these detectors, the plants have been able to detect and repair virtually all ammonia leaks and maintain the refrigerant systems in leak-free condition.

3.4. Environmental and Economic Benefits

As a result of the project, a total of 12 tons/year of ammonia emissions into the atmosphere have been eliminated form the three refrigeration plants and worker health and safety has been improved.

The portable ammonia detectors were paid for by the United States Agency for International Development for a cost of $3,000. The savings per year is $9,300 with a payback period of less than four months.

Source: http://www.emcentre.com/unepweb/tec_case/ [38].

4. Water Conservation and Waste Reduction at a Dairy Plant, Estonia, 1993

4.1. Background

Tartu Dairy, located in Tartu, Estonia, is a regional dairy cooperative supplied by over 9,000 farmers. In addition to pasteurized milk, the dairy produces cheese, butter, curd, and packaged ice cream. Products are sold primarily within the regional market. Surplus milk and milk that fails bacterial count is processed to manufacture casein. Casein is exported to Germany for use in the manufacture of certain types of plastic and glue. The dairy processes approximately 130,000 liters of milk per day.

4.2. Cleaner Production Principle

Process modification

4.3. Cleaner Production Application

At Tartu, milk delivery trucks and whey delivery trucks are washed once per day with a combination of hot and cold water. Process equipment, storage tanks, and process and milk delivery areas are also washed once per shift with hot and cold water. In the past, all cleaning operations were performed using open ended rubber hoses. Operators used fingers at the discharge end of the hose to develop a spray for cleaning. Spray created manually was relatively inefficient for effective cleaning. Because the hoses were not equipped with shut-off nozzles, the water was often left running for periods of time until the operators had time to shut off the needle valves located on the walls.

During the waste minimization project, methods for reducing water use were investigated and implemented. High pressure washers connected directly to water supply lines were purchased for cleaning of trucks, production area, and equipment. Open ended rubber hoses were equipped with shut-off spray nozzles.

4.4. Environmental and Economic Benefits

As a result of the project, consumption of water was reduced by 30,000 m^3/year and wastewater discharges were reduced by the same amount.

The cost of the equipment was $6,450 paid by the United States Agency for International Development. There is a yearly savings of $10,400 and the payback period is less than eight months.

Source: http://www.emcentre.com/unepweb/tec_case/ [38].

5. Schroeder Milk Saves $400,000 through Product Savings and Water Conservation, Minnesota Technical Assistance Program, University of Minnesota

Schroeder Milk Co. is a dairy processing facility located in Minnesota. The goal of study is to reduce waste and conserve product. At the end of the study, water use and product loss are reduced by improving maintenance and reevaluating existing process techniques. As a result, Schroeder saves $400,000 and 49 million liters of water every year.

5.1.Background

Schroeder Milk Co., St. Paul, produces a variety of dairy and other beverage products. The family-run operation employs 80 people and has been in business since 1884. They process 340,606 liters of milk daily and 30,283 liters of orange juice weekly.

In 1996, the public wastewater treatment facility was going to assess Schroeder with a $200,000 sewer access charge (SAC). Driven to look for opportunities to reduce its wastewater, Schroeder formed a pollution prevention team comprised of production personnel, warehouse workers, engineers, consultants and vendors to reduce waste and improve process efficiency.

Since then, Schroeder has saved over $400,000 through water and product savings, and in reduced industrial fees.

5.2. Product Savings

Schroeder found ways to ensure that more of its product ends up on the retail shelves, instead of down the drain.

- Due to increased production needs, Schroeder needed to install a second pasteurizer. Dedicating this pasteurizer exclusively for white milk reduces the number of changeovers between chocolate milk, white milk, orange juice and other beverages. This saves $180,000 in product annually and 32,554 liters of water a day.
- An antifoam ingredient was added to the chocolate milk to prevent foam overflow as it moves through the storage silo. Reduced product loss resulted in annual savings of $187,000.

5.3. Small Leaks Add Up

Improving maintenance and tightening up existing systems significantly reduced product loss and water use.

- A quarter-inch hose leaking orange juice was fixed, saving 5450 liters of product daily.
- Repairing leaky connections and valves saves 18397 liters of water a day.
- Repairing leaky hoses saves 855 liters of water every day.

5.4. Turn It Off

In certain processes the team determined that a continuous water flow was unnecessary.

- Previously, the washer for cleaning the cases, which hold Schroeder's returnable cartons, ran continuously. A valve was added so the spray bar runs only when cases are present. This saves 9084 liters of water a day.
- Occasionally a carton gets stuck, tears open and clogs the conveyor of the carton filling machine. In the past, a spray nozzle was left on all day to wash spilled milk off the machine. Now the nozzle is triggered only when a carton gets stuck. This saves 26,498 liters of water a day.

5.5. Use Less

The team identified processes where water use could be cut down without affecting product quality.

- The sanitizing stage in the clean-in-place tank (a system for cleaning plumbing without requiring its disassembly) was reduced from four minutes to three, saving 4732 liters of water a day.
- The manufacturer recommended reducing the water flow in the separator bowl (a centrifuge that separates cream from milk) from 681 liters per hour to 113. This saves 11,356 liters of water a day.
- The carton washer was changed from using shower heads and spray bars to smaller nozzles and mist sprays. Instead of running continuously, the washer now only runs when needed. These changes save 20,214 liters of water a day.

5.6. Reuse It

Schroeder had many opportunities for recirculating water and chemicals, instead of immediately discharging them down the drain.

- Excess water from cleaning returnable plastic cartons is now sent to the washer that cleans the cases that hold them. This reduces the total amount of fresh water, chemicals and heat needed, saving 15,898 liters of water a day.
- Expired milk returned to Schroeder is used as animal feed, instead of pouring it down the drain. This reduces biological oxygen demand and chemical oxygen demand (BOD/COD) loading to their wastewater by 136 kg a day.
- The filling machines were cooled with water used only once. Schroeder switched to a recirculating water system. This saved a total of 37,854 liters of water a day.
- In the sanitizing stage of the clean-in-place tank's operation, the chlorine rinse was replaced with an acidic one. The acidic rinse is now recollected and used as prewash for the next cleaning cycle. This saves 378 liters of chemicals and 1893 liters of water every day.

5.7. Conclusion

Using a pollution prevention team, Schroeder Milk Co., identified opportunities for process improvement. According to Carl Schroeder Jr., over $400,000 and 49 million liters of water are saved every year. In the process, Schroeder has become a cleaner, more competitive facility.

Source: http://www.p2pays.org/ref/05/04257.htm [39].

6. The UNEP Working Group for Cleaner Production in the Food Industry Dairy Farmers

Dairy Farmers, Booval, implemented a range of cleaner production initiatives by involving their employees in a number of ‘Quality through Commitment’ teams that focused on reducing water usage, trade waste, solid waste and consumption of cleaning chemicals. The results included a 60% reduction in waste to landfill, a 30% reduction in water usage and a 10% reduction in effluent strength.

6.1. Background

Dairy Farmers manufacture milk products including whole milk, modified milk, flavoured milk, cream and also milk, cream and cheese powders. The factory has been situated in Jacaranda St, Booval for over one hundred years. The factory operates 24 hours per day, 7 days per week and employs over 200 people.

6.2. The Approach

The management realized that long-term improvements could not be made without the involvement and commitment of the Dairy Farmers employees. This was achieved by forming a number of ‘Quality through Commitment’ Teams. These were:

The Squirts – Water Usage and Recovery

The Retrievable – Trade Waste Discharge and COD load

Soap Suds – Detergent Recovery

Yield of Dreams – Product Yield and Milk Overfills

The teams and management looked for simple ideas to reduce waste and came up with the following initiatives:

- Directing appropriate quality dilute milk streams to the milk powder process rather than to trade waste
- Reusing tank rinse-waters for cleaning in less critical areas
- Reusing pasteurizer cleaning waters and chemicals for the first rinse on tanks
- Recovering the energy from steam condensate to pre-heat cleaning solutions
- The recycling of packaging materials - waste plastic and cardboard

To ensure ongoing employee commitment and involvement all supervisors and managers are required to:

- Include a component of waste control in the Key Performance Indicators
- Incorporate data collection into their daily schedule.
- Provide regular feedback on waste control components.

An action group was also formed with the neighbourhood committee to keep the local community informed and to discuss any arising issues.

The improvements led to the following savings:

TEAM FOCUS	**PROJECT COST**	**SAVINGS (p.a.)**	**PAYBACK**
Water Usage & Recovery	$36,800	$73,000	0.5 yrs
Trade Waste Discharge –vol & load	$15,300	$62,000	0.2 yrs
Detergent Recovery	$3,200	$14,400	0.2 yrs
Product Yield	-	$324,000	Immediate

- On site recovery of milk returns $324,000 of milk solids per year.
- Water usage reduced by 30% or 95,000 kilolitres, leading to savings of $73,000 per year.
- COD levels in trade waste reduced by 10% with savings of $62,000 per year.
- Gas consumption reduced due to the recovery of heat from recycled water.
- Solid waste to landfill reduced by 60% by recycling and compacting plastic containers.
- Cleaning chemical costs reduced by recycling chemicals. A direct saving of $14,400 per year was achieved. This does not include savings for effluent, water and energy recovery.

6.3. Other Benefits

- Improved team work within sections of the plant
- Increased staff awareness of how the total site operates
- Increased staff morale by returning a proportion of savings back into the staff social club for site improvements and social activities.
- Reduced total overhead costs.

6.4. Barriers

- Obtaining approved capital whilst the factory upgrade was taking place. The major focus was on the current project to upgrade the existing facilities.

Source: http://www.geosp.uq.edu.au/emc/CP/res/ydairy_farmers.htm [40].