CLEANER PRODUCTION ASSESSMENT AT KAMADHENU DAIRY

by

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Cleaner Production Assessment at Kamadhenu Dairy

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by

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Approval Letter

This dissertation entitled "*Cleaner Production Assessment at Kamadhenu Dairy*" presented by *Richa Humagain* has been accepted as the partial fulfillment of the requirement for the B.Tech. in Food Technology.

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Content

Abstracts

Part I

1. Introduction

1.1 Background

Cleaner Production is defined as the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase overall efficiency and reduce risks to human being and environment (UNEP, 1994).

Cleaner Production techniques include improved housekeeping practices, process optimization, raw material substitution, new technology and new product design. Cleaner Production is new thinking to improve production efficiency (Kunwar, 2003).

In the year 1999, His majesty's Government of Nepal with the financial and technical assistance of government of Denmark introduced the Environmental Sector Support Program (ESPS) in Nepal with an objective of strengthening the management of brown sector environment in the country. Cleaner production (CP) was one of the important components in ESPS. ESPS started the first CP intervention in total 36 industries of HID in 2000 and the program continued up to 2005. Multinational companies like Nepal Bottlers, Gorkha Breweries and Colgate Palmolive were also benefited with the CP program of ESPS. Till to date CP intervention has been conducted in more than 140 industries. The intervention has saved resources like raw material that amounts to over NRs 100 million, NRs 80 million in energy and 3,130 tons in solid waste (Kunwar, 2003).

The government of Nepal has already released effluent standards for industrial sectors requiring them to minimize pollution in their production processes including pashmina, brick, stone crushing, dyeing and dairy industries. The set of rules aims at Cleaner Production (CP) to bring down the level of pollution in these sectors which would increase productivity, improve the quality of their goods, keep the environment clean and uplift their public image through CP by minimizing solid waste, effluents, air pollution, accident risks and occupational diseases (Kathmandu post, 2008).

Similarly, Government of Nepal and Government of Finland established a development co-operation project "Strengthening of Environmental Administration and Management at the Local Level in Nepal" called (**SEAM-N**) in autumn 2001 (SEAM-N Project-phase 1). The overall objective of the Project is to improve environment with the enhancement of environmentally sustainable rural, urban and industrial development and utilization of natural resources. Implementation of CP (Cleaner Production) and OHS (Occupational Health & Safety) at local industries in the project area is one of the three interlinked component of the project. This project is conducting cleaner production assessment programs in all kinds of industry regardless of its scale and size.

1.2 Statement of problem

Kamadhenu Dairy Development Cooperative private limited is a cooperative dairy industry established in 2057 B.S. with a capital investment of Rs. 30,00,000. It is situated at Hansposa-2 Tarahara, Sunsari. The factory involves 45 employees including 5 women. The factory is operating on the basis of 365 working days in a year. It has one working shift of 8 hours a day. The factory has total installed capacity of 18,25,000 liter per year pasteurized milk, yoghurt, butter, Ghee, khoa, paneer, etc. It has occupied a wide range of market share of pasteurized milk and milk products in the major cities of eastern region like Biratnagar, Duhabi, Dharan, Inaruwa, Itahari, Urlabari, etc

Like in many other food processing industries, the environmental issues associated with dairy industries are high water consumption, generation of high-strength effluent streams, and high energy consumption and the drainage of by products as waste. Since the pollutants generated by the industry results losses in production, improvements in production efficiency are recommended to reduce pollutant loads (World Bank, 1996). An examination into milk processing shows the following focal points of milk (and hence fat) losses: dripping pipelines and fittings; leaking plastic containers; spillage, overflowing tanks and reservoirs; rinsing from tanks pipelines and plates; incomplete tank, lines, plate drainage (residual losses); foam; thoughtless or willful dumping of milk products into the drainage system. The first prerequisite of handling dairy waste is to keep it to a minimum or, better yet, to prevent its occurrence (Hall and Trout, 1968). It is expected that Cleaner Production assessment in the dairy industry will effectively reduce the pollution load and increase productivity through reduced losses in the production.

1.3 Objective of the study

1.3.1 General objective

The general objective of this study is to find out the possibilities of CP in dairy industry and the study also covers investigating, identifying and understanding the environmental problems related to Kamadhenu dairy and identification of Cleaner Production opportunities in the industry.

1.3.2 Specific objective

- To study the existing condition of production processes in kamadhenu dairy with the details about different unit operations in the form of complete flow chart describing clearly the types of wastes generating from each unit operation.
- To analyze the physical and chemical parameters of effluent generated from the industry under consideration to obtain data regarding pollution load exerted by the industry on the environment.
- To obtain data regarding different quality control parameters of milk in the processing line especially in receiving, pasteurization and packaging.
- To suggest suitable CP options.

1.4 Rationale of the study

As we know the high volume of water consumption, waste water generation and solid wastes generation are the main problems of industries, which carries the losses in the production processes, control over these processes can prevent both the loss of valuable products and pollution load on the environment. Therefore the proposed study will be helpful for the industry to improve its process efficiency, reduce waste and develop an environment friendly production.

Following outputs are expected from this study:

- Productivity improvement: The industry will be benefited through improved productivity and reduced losses and will be able to follow the way of controlling its processing using the techniques used in this study.
- Motivation to other industries: Other industries of similar scale industries will be encouraged by the findings (results) from this study for CP assessment in those industries.
- Create awareness on CP: This work will be the footsteps towards the CP implementation in the industry under study.

1.5 Limitation of the study

Due to time constraint, the study will be limited only up to CP option generation and feasibility study because no actual implementation and observation of results was possible within such a short time frame.

Part II

2. Literature review

2.1 Environment Pollution

The world today is facing with three main problems *viz.* population growth, food scarcity and environmental degradation. The last one is a serious problem in the developed and in the developing countries too. Increased rate of industrialization and uncontrolled discharge into the water and air, etc reflects towards environmental degradation in some sense. (Malik *et al.* 2003)

HMG/N, 2000 describes pollution as that activity that significantly degrades, damage the environment or harm the beneficial or useful purpose of the environment, by changing the environment directly or indirectly, the interaction and interrelationship among the components of natural, cultural and social system, economic and human activities and their components. Simply, the adverse impact on the environment resulting from different activities that affect different living and non-living components of the environment is said to be an environmental pollution.

Industrial wastes contain various poisonous salts, alkalis, acids, odor, gases, heavy metals, insecticides and pesticides. These polluted wastes are thrown into the canals, streams or rivers where they deteriorate the quality of water making the water unfit for irrigation purpose and for the use of animals. (Malik *et al.* 2003)

Energy and environmental pollution are the most discussed topics of the day. The former, energy is in short supply and the latter, environmental pollution in abundance. It is, therefore, the endeavor of mankind to efficiently use energy and reduce hazards of pollution. To a little pensive mind, it appears that it is possible to recover energy from some of the systems and in the process reduce pollution. (Tare, 1989)

2.2 Pollution control

When societies became aware of the effects of the environmental degradation caused by human activity, the first strategy conceived was that of building filters to ensure that waste from industries did not “leak” into the environment. However, analysis showed that better strategies were required. The process of building filters only transferred pollutants from one medium to another (e.g. from water to land). The process of building filters was also not very economical. No savings accrued from this process (Erkman and Ramaswamy, 2001).

The traditional way to control emissions or discharges, as developed in the 1970s and 1980s, is with end-of-pipe solutions. In this case, governments impose very specific requirements based on their knowledge of best available technologies. Small and medium-sized industries have always had a hard time meeting end-of-pipe requirements (Bakken, 2001).

The development of new approaches to reduce the impact of industrial activity on the environment is essential to sustainable development. "End-of-pipe" waste treatment approaches have reduced gross pollution yet incremental waste loadings continue to significantly stress natural systems. Issues such as global warming and the decline in biodiversity are alarm bells ringing - as a species; we have to change our ways. We have to find new approaches to sustain the economic and social systems dependant on ecological health. (Robinson, 1999)

2.3 Pollution prevention/Cleaner Production

Pollution reduction or even prevention rather than control is gaining popularity over the world since the last few decades. This approach is widely known as Cleaner Production, which is the conceptual approach to reducing environmental impact of human activities through a better use of resources, methods, technologies and above all, management of processes and activities. There are several other terminologies used in different countries such as waste minimization, green productivity, pollution prevention, eco-efficiency, source reduction etc., which are the different names of cleaner production. What all these have in common is an attempt to maintain the same level of output using less input (e.g. water, energy, raw materials), thereby improving efficiency and reducing pollution. (Adhikari, 2009)

The concept of Cleaner Production was introduced by UNEP in 1989 as a response to the question of how industry could work toward sustainable development (UNEP, 1994). The main goal of the Industrial Pollution Prevention/Cleaner Production component is to show that significant financial savings and environmental improvements can be made by relatively low cost and straightforward interventions. These consist of pollution prevention through good housekeeping, waste minimization, process modification and technology change. (SEAM, 1999)

Cleaner production is an excellent approach in developing countries where waste water is typically discharged without any treatment at all. End of-pipe treatment is beyond the financial capacity of many industries in the developing world (Taylor, 2005).

The plant-level working method for CP, or assessment, is often characterized as a systematic planned procedure with the objective of identifying ways to reduce or eliminate the generation of waste and emissions (Berkel, 1995).

It has shown that the CP concept has been successfully practiced in Nepalese industries and the concept fits very well into the development efforts of Nepalese industries and the industrial policy of HMG. Implementation of CP will improve the environment around the industries as well (Pradhan, 2001).

2.4 Cleaner production in food industry

The food processing industry is very diverse. Major sectors include fruit and vegetables, dairy, meats and fish, alcoholic and non-alcoholic beverages, oils, and packaged foods. The most common environmental concerns in the industry are water consumption and wastewater discharge, chemicals used in processing and cleaning, packaging reduction and disposal, and food scraps and refuse. Energy efficiency and greenhouse gas emissions are increasingly important issues as well. (Anon, 2002)

The effluents coming from textile, plastic, soap & chemical industry, brewery, vegetable oil and ghee, biscuit and confectionary, straw and paper mill, tannery; pollution prone industries; are expected to be highly alkaline, colored, high biochemical oxygen demand (BOD), chemical oxygen demand (COD), temperature, dyes, bleaching agents, high suspended solids, heavy metals and salts, high turbidity, heavy organic load, high saponified soap, detergents etc. These all have contributed to the pollution of water and adversely affect the environment and public health. Despite these the industries are still operating in a conventional way with a little or no effort for pollution prevention or control measures (ESPS 2001).

Wastes from the food processing industry are, to a certain extent, inevitable. When these wastes, which are fairly wet and contains high carbon ratio, are left untreated, they become a breeding ground for microorganisms. The material starts to decay and smell. Wastes can give a dirty, untidy appearance to factory. (Elwan, Ahmed and Hamed,) It is also not technically or economically feasible, at the last stage, to put a final control on a series of major previous mistakes in the sequence of events. That is why food plants which defy elementary housekeeping principles in-plant usually have major, costly, unmanageable waste treatment problems at the end-of the-pipe. Therefore, the preferential emphasis on process control must always be to throttle down all the sources of variance, proportionately to their size and overall significance, as far to the left of the flow sheet as possible (Green and Kramer, 1979).

2.5 Industrial Wastewater

Industrial wastewater generated from industrial operations includes process wastewater, wastewater from utility operations, runoff from process and materials staging areas, and miscellaneous activities including wastewater from laboratories, equipment maintenance shops, etc. The pollutants in an industrial wastewater may include acids or bases (exhibited as low or high pH), soluble organic chemicals causing depletion of dissolved oxygen, suspended solids, nutrients (phosphorus, nitrogen), heavy metals (e.g. cadmium, chromium, copper, lead, mercury, nickel, zinc), cyanide, toxic organic chemicals, oily materials, and volatile materials. , as well as from thermal characteristics of the discharge (e.g., elevated temperature). Transfer of pollutants to another phase, such as air, soil, or the sub-surface, should be minimized through process and engineering controls (EHS, 2007). In food processing, wastes can be broken down to direct and indirect wastes:

- **Direct waste:** All wastes that can be accounted for, in dumpsters or bins and are comprised of lost raw ingredients and semi-processed or fully processed product. Direct wastes can be further broken down to:
  - Intentional waste- any waste expected as part of the process, such as peeling and pits from vegetable processing, whey from white cheese making, blood and bones from meat processing, and waste water from different processes.
  - Unintentional waste-waste resulting from poor operation, improper maintenance and cleanup practices.
- **Indirect waste:** Waste created as a result of direct waste discharged to the drain. Indirect waste is comprised of sludge which is the solid waste produced from the treatment of effluent wastewater. Sludge generation will depend on the type of food

processed, the amount lost into the drain and the type of wastewater treatment (SEAM, 1999).

2.6 Wastewater Management

Wastewater management includes water conservation, wastewater treatment, storm water management, and wastewater and water quality monitoring. The term "waste-water" refers to the water entering into the sewerage system in the form of water whose character has been changed as a result of domestic or industrial use (particularly water which has been polluted in some way) and rain water run-off from developed land. It also includes water contaminated as a result of agricultural use and water issuing from dumps (GTZ, 1995). The harmfulness of wastewater is determined by specific properties which (both individually and together) can change the quality of a body of water. These include (GTZ, 1995):

- The content of the water in respect of particular substances (concentration),
- The pollutant quantity discharged into the water within a specific period (pollution load),
- Certain properties and effects of the waste-water (e.g.O_2 depletion).

Discharge of waste-waters into surface waters may impair the quality of the latter, i.e., it may cause contamination or lead to other adverse changes in water's physical, chemical and biological properties. Emission standards are used in monitoring waste water at the discharge site; they are intended to preserve the water quality necessary for various forms of use and to protect other aquatic organisms (GTZ, 1995).

Existing standards for the constituents of waste-water in Nepal apply to (HMG/N, 2003):

- Discharges into sewerage system with sewage treatment plant and/or
- Discharges into bodies of water and into sewerages systems without treatment plant.

Emission standards essentially aim to ensure that waste-water is pretreated or the pollution load reduced before waste-water is discharged into surface waters (HMG/N, 2003). Processors must manage 100% of their necessary inputs by minimizing their wasteful outputs, keeping them concentrated and isolated prior to being reprocessed into suitable condition for reuse within and beyond the plant, or for discharge under good control with negligible harmful environmental consequences, or with some environmental benefits (Green and Kramer, 1979).

2.7 Dairy wastes

As for many other food processing operations, the main environmental impacts associated with all dairy processing activities are the high consumption of water, the discharge of effluent with high organic loads and the consumption of energy (UNEP, 1995).

The wastes from milk processing plant consist principally of drainage and washing from cans and equipment, with the occasional discharge of surplus buttermilk and whey and of spoiled materials. Because of this, much can be done to reduce the volume and concentration of the wastes by proper drainage of cans. (Imhoff and Fair, 1956)

In a manufacturing plant with no product losses from any area, the quantity of material sold will be equal to the material delivered to the factory. However, in any manufacturing process there are inherent losses. In market milk dairy, these will include packaging losses due to overweight packs, material used for samples and all losses of liquid and semi-solids associated with operation of the manufacturing, equipment, many of which are avoidable

(Carawan, 1979).

Dairy processing effluent contains predominantly milk and milk products which have been lost from the process, as well as detergents and acidic and caustic cleaning agents. Milk loss can be as high as 3–4%, with the main source of loss being residues which remain on the internal surfaces of vessels and pipes, accidental spills during tanker emptying and overflowing vessels (UNEP, 1995).

Due to the presence of milk solids (e.g. protein, fat, carbohydrates, and lactose), untreated wastewater from dairy processing facilities may have a significant organic content, biochemical oxygen demand (BOD), and chemical oxygen demand (COD).

(**Environmental, Health and Safety (EHS) Guidelines** General EHS Guidelines: Introduction, IFC-international Finance Corporation, World Bank group april, 2007)

An excessive waste load means wasted product and lost income. More than 90 percent of a plant's total waste load comes from milk components that are lost and flow into floor drains during processing. Lactose, proteins, and butterfat are the major components. The wastewater also may contain cleaning agents, lubricants, and solids removed from equipment and floor. Wastewater analysis is useful to indicate a plant's processing efficiency. MDairy Processing Methods to Reduce Water Use and Liquid Waste Load

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Whenever waste material from industry or from a municipality is introduced into the receiving water stream, this material requires large amounts of oxygen to be decomposed: the polluting material has a biochemical oxygen demand (B.O.D). If this B.O.D is high enough it will use up oxygen which might otherwise be available to aquatic organisms. The lowering of dissolved oxygen in streams, as a result of pollution, is one of the key factors in the destruction of streams and rivers by polluting sources (Brittin *et al.*, 1970).

Harper *et al.* (1971) found that 90% of the five day biochemical oxygen demand (BOD) in dairy wastewaters could be attributed to milk products. The BOD concentration of dairy wastewaters ranges from 750 mg/l to 4,200 mg/l (Harper, 1974). Over 96% of the BOD load from fluid milk processing plants has been estimated to come from milk solids (DPRA, 1975).

Fats, oil and greases (FOG) are important to dairies primarily because many municipalities have sewer use ordinances which restrict FOG to 100 mg/l (WPCF, 1975). Milk fat, which is biodegradable, is the main fat found in dairy wastewaters (EPA, 1974).

Harper *et al.* (1971) cautioned that when planning new dairy plants or remodeling existing facilities, consideration should be given to the segregation of those sewers expected to receive high BOD wastewaters. These wastewaters could be returned to a tank for waste load equalization or subjected to pretreatment. These wastes included lubricants, milk from filling areas, solid particles from cottage cheese operations, high temperature short-time (HTST) discharge and cleaning-in-place (CIP) discharge.

The filling area is another area reviewed by Elliott (1973) for measures to conserve water and prevent product wastes from going into the plant wastewater system. He concluded that a plant recovery system was desirable to collect product from defective or damaged cartons.

Essentially, cleaner production opportunities can arise in all of the factory operations. Given the environmental impacts identified in the study, efficiency in energy use is paramount in achieving cleaner production in the process. The other major factor in cleaner production is the amount of wastewater disposed of as this contains milk solids and chemical cleaners. Optimization of the cleaning processes to make them efficient with respect to water and energy use is important. Minimizing of wastage and losses in the filling and packaging steps will reduce the environmental impacts from these sources. Reducing the waste of packaging materials during the filling processes would assist in achieving cleaner production goals (Centre for Integrated Environmental Protection, http// www.ens.gu.edu.au/ciep/dairyfarmers.pdf)

Measurement of losses

A waste minimization program in the dairy industry is governed by the loss monitoring program. In the past, yields in the dairy industry have been calculated as:

$$\text{Yield} = \frac{\text{Milk fat in product}}{\text{milk fat processed}}$$

This was changed to incorporate the losses determined by the loss monitoring technique which is given below:

Quantity of product packed = potential product in raw material - losses

Po = Pi - L

Direct measurement of losses, even with quite a low degree of accuracy, leads to an order of magnitude increase in the degree of the estimation of the yield. Areas which must be measured to determine losses are: wastewater, stack losses, product weights, product composition and stock food. (J. W. Barnett, S. L. Robertson and J. M. Russell, Environment Portfolio, New Zealand Dairy Research Institute, Private Bag 11 029, Palmerston North)

2.8 Water consumption in dairy

In the dairy processing industry, water is used principally for cleaning equipment and work areas to maintain hygienic conditions, and accounts for a large proportion of total water use. Rates of water consumption can vary considerably depending on the scale of the plant, the age and type of processing, whether batch or continuous processes are used and the ease with which equipment can be cleaned, as well as operator practices. A typical range for water consumption in reasonably efficient plants is 1.3–2.5 litres water/kg of milk intake (UNEP, 1995). Plants with the least amount of water use per unit of product processed have the least amount of pollutants per unit processed (Carawan, 1988).

The dairy industry reportedly takes in more water than it does milk (Renwick, 1975). Each gallon of milk processed was said to require about 1.5 to 2.0 gal (gallons) of water (Renwick, 1975). Hall and Trout (1968) reported dairy water use at 0.75 to 1 gal/lb of milk Processed. As the water is used in the food plant, parts of the food product being processed are deposited in the water, and this wastewater must be properly handled to prevent pollution (Carawan, 1988).

Quality of water used in dairy processing is of great importance as it is one of the major raw materials that directly come in contact with the milk. Bacteriological examination of water is necessary for determining its fitness for use of human consumption, and for use in industries such as food processing and dairy, photo film, etc. Water used for drinking, food processing and dairying should be free from fecal or sewage contamination because micro-organisms causing water-borne disease such as typhoid and parathyroid fevers, food poisoning, gastroenteritis, cholera, dysentery and diarrhea are excreted in the feces of individuals suffering from the disease (Kudesia and Kudesia, 1998).

Unit Water Use

This unit performance ratio would be calculated using the following formula, and reported in units of liters of water per liter of Raw Milk, as follows:

Unit Water Use = Total m^3 Water Used over 12 Month Period x 1,000 L/ m^3

Total Litres Raw Milk Received Over Same 12 Months

This value is expected to be in the range of 1 to 3 Litres per Litre for fluid milk plants, and upwards of 5 Litres per Litre for industrial milk plants. Water employed in products or reconstitution is not to be included in total water use. (NDCC, 1997)

2.9 Energy consumption in dairy

Energy consumption depends on the age and scale of a plant, the level of automation and the range of products being produced. Process which involve concentration and drying, for example the production of milk powder, are very energy intensive, whereas market milk, which requires only some heat treatment and packaging, requires considerably less energy. A typical range for energy consumption in plants processing milk is 0.5–1.2 MJ/kg of milk intake. [cleaner production assessment in dairyprocessing,UNEP) http://www.unep.fr/shared/publications/pdf/2480-CpDairy.pdf]

Energy and water are important components contributing to the production cost. Water conservation projects therefore environmental protection since depletion of natural resources is considered an environmental hazard. (SEAM, 1999)

Industrial pollution by industries has been measured in terms of waste water volume, biological oxygen demand (BOD), and total suspended solid (TSS) loads of the effluents. (Anon, 1991)

2.10 Dairy wastewater quality parameters

2.10.1 Flow rate

The flow rate determines the extent of pollutant load on the receiving water bodies. Greater is the volume of flow of effluent, lesser is the dilution effect in the river and more is the pollution load. Some of the pollutants get biomagnified in the waters and get accumulated in higher trophic levels, e.g., fish, crabs and other aquatic organisms. This level of biomagnifications is considered important in water pollution studies and can be studied through the proper knowledge of the flow rate (Trivedy and Goel, 1986).

2.10.2 pH

The pH of dairy effluent varies between 2 and 12 as a result of the use of acid and alkaline detergents for plant cleaning both low and high pH values interfere with the activity of the micro organisms that break down organic pollutants in the biological treatment stage of the sewage treatment plant, transforming them into biological sludge (cell detritus). As a rule, waste water with a pH of over 10 or below 6.5 must not be discharged to the sewage system, as it is liable to corrode the pipes used detergents are therefore normally collected in the mixing tank, often located close to the cleaning plant, and the pH is measured and regulated to, say pH 7.0 before it is discharged to drain. (Dairy Processing Handbook. Tetrapak)

Industrial processes and some municipal sewage can result in effluents which drastically change the pH values of the receiving waters. Ordinarily living organisms have a relatively narrow range of tolerance of pH changes. The majority of desirable living organisms require water with a pH value somewhere between 6 and 8. It is true that some organisms can live in waters having pH values outside that range. However, as a generalization, it is safe to say that waters which support desirable aquatic life have a pH values somewhere between 6 and 8. (Air and water pollution: proceedings of the summer workshop, august 3-15, 1970.university of Colorado-Wesley E. Brittin, Ronald West, Robert Williams)Book ko reference halne

2.10.3 TSS

One of the major pollutants in dairy plant discharges is suspended solid waste, such as coagulated milk, particles of cheese curd, and in ice cream plants, pieces of fruits and nuts. The measurement of this pollutant is called "total suspended solids," or TSS. These solids discolor and cloud water. They impair photo-synthesis in aquatic plants. They can settle on the bottom. When they contain organic matter - as dairy wastes do - the bottom deposits become sludge beds that can further deplete the water's oxygen content. As the sludge decomposes, it gives off gases that are toxic to aquatic life and cause odor problems. (Carawan, Chambers and Zall, 1979)

2.10.4 Oil and grease

Oil and grease is defined as any material recovered as a substance soluble in the solvent. Certain constituents measured by the oil and grease analysis may influence wastewater treatment system. If present in excess amount, they may interfere with aerobic and anaerobic biological processes and lead to decreased wastewater treatment efficiency. When discharged in wastewater or treated effluent, they may cause surface films and shoreline deposits leading to environmental degradation. (APHA, 1998)

Knowledge of the quantity of oil and grease present is helpful in proper design and operation of wastewater treatment system and also may call attention to certain treatment difficulty. (APHA, 1998)

2.10.5 Dissolved oxygen

Dissolved oxygen is one of the most important parameters in water quality assessment and reflects the physical and biological processes prevailing in the waters. Its presence is essential to maintain the higher forms of biological life in the water. The effects of a waste discharge in a water body are largely determined by the oxygen balance of the system. Oxygen can be rapidly removed from the waters by discharge of the oxygen demanding wastes. Other inorganic reductants such as hydrogen Sulphide, ammonia, nitrites, ferrous iron, and other oxidizable substances also tend to decrease dissolved oxygen in water. Low oxygen in water can kill fish and other organisms present in water. Low oxygen concentrations are generally associated with heavy contamination by organic matter. In such conditions oxygen may sometimes totally disappears from the water (Trivedy and Goel, 1986).

EPA has set the minimum stream D.O. at 5mg/L. it is important that wastewaters have maximum D.O. levels when they are discharged and have a minimum of oxygen demanding components (Trivedy and Goel, 1986).

2.10.6 Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) is the amount of oxygen utilized by microorganisms in stabilizing the organic matter. On an average basis, the demand for oxygen is proportional to the amount of organic waste to be degraded aerobically. Hence, BOD approximates the amount of oxidizable organic matter present in the solution. BOD value can be used as a measure of waste strength. It is highly important to know the amount of organic matter present in the waste treatment system and the quantity of oxygen required for its stabilization. The BOD values are thus very useful in process design and loading calculation as well as in measuring efficiency and operation of treatment plants. The BOD test is also useful in stream pollution control management and in evaluating self-purification capacities of streams, which in turn serves as a measure to assess the quantity of wastes which can be safely assimilated by the stream (Trivedy and Goel, 1986).

The complete degradation of the organic matter may take as long as 20 days or more. Simple organic compounds like glucose are almost completely oxidized in 5 days while domestic sewage by only about 65%. Complex organic compounds might be oxidized only up to 40% in this period. The 20 or more day's period is of less significance in practice. Therefore, the BOD test has been developed for 5 days at 20°C (APHA, 1998).

Types of microorganisms, pH, presence of toxins, some reduced mineral matter, and nitrification process are the important factors influencing the BOD test. BOD in general gives a qualitative index of the organic substances which are degraded quickly in a short period of time (Trivedy and Goel, 1986; APHA, 1998). The BOD of an effluent is a useful measure of wastage and efficiency of processing (Herschdoerfer, 1967).

Surveys show 1 pound of BOD_5 in wastewater means at least 9 pounds of milk have been lost. By knowing the BOD_5 level in a waste stream, the amount of product flowing down the drain can easily be estimated. (Dairy Processing Methods to Reduce Water Use and Liquid Waste Load, Department of Biological & Agricultural Engineering Kent D.Rausch Extension Specialist, Food Engineering G. Morgan Powell Extension Natural Resource Engineer)

2.10.7 Chemical Oxygen Demand (COD)

Chemical oxygen demand is the oxygen required to oxidize organic substances in water by a strong chemical oxidant. The determination of COD values is of great importance where BOD values cannot be determined accurately due to the presence of toxins and other unfavorable conditions for the growth of microorganisms (Trivedy and Goel, 1986).

The COD test continues to remain a very important parameter in management and design of the treatment plants because of its rapidity in determination. For all practical purposes its values are very close to the amount of chemically oxidizable carbonaceous matter which may be quite useful in the control of treatment processes. COD values cannot be corresponded with that of BOD values. In general, COD is more than BOD values for most of the industrial wastes because of the fact that more compounds can be oxidized chemically than by biologically. COD values are taken as basis for calculation of the efficiency of the treatment plants and also figure in the standards for discharging industrial/domestic effluents in various kinds of waters. For many types of wastes it is possible to establish a relation between COD and BOD. For typical COD: BOD ratio ranges from 1.47 to 1.65. If COD value is greater than 3, the waste is considered difficult to biodegrade (Trivedy and Goel, 1986; APHA, 1998).

2.11 Quality control in dairy industry

United States Public Health Service defines pasteurization for milk and milk products as the process of heating every particle of the product to 145°, and holding it continuously at that temperature for at least 30 minutes; or to at least 161°F, and holding at that temperature for at least 15 seconds. (Mitten, 1963) Pasteurization is usually done at temperatures lower than 80-100°C [176°- 212°F]. (Anon, 2003) (Anon) 2003 Pasteurization- Heat treatment parameters. Available at:

http:/vency.com/webPASTEURIZATION.html [Accessed on 2/8/2008]

The HTST process for milk involves heating it to 72-75°C with a hold of 15-20 seconds before it is cooled. (Dairy processing handbook, Tetrapak; Ahmad, 1997)

Intensive heat treatment of milk is desirable from the microbiological point of view. But such treatment also involves a risk of adverse effects on the appearance, taste and nutritional value of milk. Milk is very sensitive to intensive heat treatment which can cause burnings on the heat exchange plates if the rate of heat transfer is too high. The temperature difference between the product and the heating medium must therefore be kept as small as possible in all parts of the heat exchanger (Ahmed, 1979).

According to Food Act 2026, Article 7, the specification for raw cow and buffalo milk is stated below in table 2.1.

Table 2.1 Specification of raw cow and buffalo milk as per Food Act 2026

Composition	**Cow milk**	**Buffalo milk**
Fat%	not less than 3.5%	Fat% - not less than 5%
SNF%	not less than 7.5%	SNF% - not less than 8%

According to Model Weights and Measures ordinance (Anon, 1971), variation from the declared net weight, measure, or count is permitted when caused by unavailable deviations in weighing, or counting the contents of individual packages that occur in good packaging practice. However, variations are not permitted to such extend that the average of the quantities in the packages of a particular commodity, or a lot of the commodity, that is kept, offered , or exposed for sale, or sold, is below the quantity stated. With regard to the tolerance value in general, the tolerances are accepted as four percent (4%) per indicated unit on under registration and two (2%) percent per indicated unit on over registration (Lin, 1981).

2.12 Wastewater treatment

Primary treatment of wastewater will be to remove most of the particulate material and about 60% of the suspended solids. This will cause a drop of about 30% in the BOD. Dissolved substances are not removed in primary treatment facilities. Primary treatment involves simple processes such as screening and perhaps centrifugation. Secondary treatment will address the total BOD issue. In this case, the suspended solids and BOD will be reduced by about 85%. A minimum level of secondary treatment is required before wastewater can be released into the natural water system.

Water conservation saves costs at both ends of the equation — paying for less water as a commodity and having a smaller volume of water to dispose of.

In trickling filters, use is made of bacteria that grow on some medium over which the water is percolated until the desired breakdown of material occurs. The wastewater is first placed in settling tanks to remove suspended solids. The water is then pumped to the trickling filters, where it is distributed over the medium with spray nozzles. The bacteria are exposed to the medium and air, so a strongly aerobic system exists. Tricking filters are used to treat wastewaters with poor settling characteristics.

Waste Treatment

Since the BOD of the wastewater coming from the industry is very high, the waste must not be disposed to the river directly without any pre-treatment.

The BOD load of the effluent from the final discharge is found to be 1359mg/l and the flow rate of the wastewater is found to be $28m^3$. The maximum BOD in the effluent, according to the generic standard for the effluent disposal is 100mg/l. The BOD can be removed by treating the waste by trickling filter.

The design of the two stage trickling filter plant for the flow of $28m^3$/day of BOD 1359mg/l is calculated using the NRC equation.

Primary settling tank.

The overflow rate is assumed to be 11m^3/d.

Dimension: Area= 3.8m^2

Diameter of the filter =2.2m

Depth of the tank=1.5m

BOD removal is assumed as 30%. Therefore, 407.7mg/l of BOD is removed in the primary settling tank.

Trickling filter

BOD loading rate is assumed to be 750mg/d/m^3 and hydraulic loading rate between 10-30m^3/d/m^2.

Assuming depth of the filter as 2.8m for the first stage filter, Dimension: Volume of each filter= 17.8m^3

Area of the first stage filter=6.35m^2

Intermediate settling tank

Taking overflow rate as 14m^3/d and depth of the tank as 2.1m,

Dimension: Area required=3m^2

Diameter of the filter=2m

Final sedimentation tank

The over flow rate is assumed as 14m^3/d and depth as 2.1m,

Dimension: Area required=2.5m^2

Diameter of the filter=1.78m

The overall plant efficiency is calculated as 91% hence the estimated BOD of the final effluent is 121mg/l, which is near the standard for the effluent disposal. Thus, after treating in the trickling filter, the wastewater can be directly discharged in the river water.

Part III

3. Materials and Methods

3.1 Data collection procedure

Both primary and secondary data were used in the research. They were then processed and analyzed using suitable statistical tools to get the results.

3.1.1 Primary data collection

The primary data and information required for the research were collected by direct observation and analysis. The data for Fat% and SNF% of the raw milk from all the 25 milk collection centers were collected from the factory. Water consumption for each section was determined by bucket and stopwatch method. The data for pasteurization was obtained by monitoring the pasteurization temperature over a 30 day period, with 5 observations per day, in a random manner. The volume of the pasteurized milk in the filling section was also recorded. The milk pouch samples were taken at random from both the filling machines over a 20 day period, taking 10 samples per day from each machine at frequent intervals. The defective packets from the filling operation were also calculated for 20 days.

3.1.2 Secondary data collection

The secondary data and information required for the study was collected by personal communication from the dairy industry under study.

3.2 Sampling

The significance of analysis depends on large extent on the program. An ideal sample should be one, which is both valid and truly representative of the water quality from which it is collected and the sample should be small enough in volume to be transported conveniently and handle in the laboratory.

As industrial samples are subjected to rapid change within a few minutes due to breakdowns, spill over, floor washing etc. Hence it is necessary to collect individual samples at uniform intervals, say 10 or 20 minutes. In fact the degree of variation in rate of flow will determine the time interval for sampling (Kudesia and Kudesia, 1998). The sampling program for the research work was performed as per guidelines given by APHA (1998) and Trivedy and Goel (1986).

3.3 Sample collection

Samples for wastewater was collected from 5 different section of dairy processing viz; mik receiving, crate washing, pasteurization, packaging and final outlet. The type of sampling was purposive, random, grab sampling. Three samples from each sections were collected in the sampling bottles, at equal time intervals, which were combined together to obtain a representative composite sample. Prior to collection, these containers were thoroughly cleaned with boiling water, 70% ethanol and then washed with acetone and dried well. Separate BOD bottles were used for the collection of the wastewater sample for BOD determination (Trivedy and Goel, 1986; APHA, 1998).

The record of each sample collected was defined with label and coded carefully. The samples were coded as milk receiving section (75A), crate washing section (75B), pasteurization section (75C), packaging section (81B) and final outlet (81A).

3.4 Sample handling and preservation

The collected samples were taken to SEAM-N-MMA laboratory, Biratnagar within 2 hour. The samples were transported in refrigerated condition and protected from direct sunlight and other contaminants. These samples were preserved under refrigeration in the laboratory. Preservation techniques of the water and wastewater samples for chemical analysis are given in Appendix VI.

3.5 Methods of analysis

The samples, thus collected, were analyzed for physical and chemical parameters at SEAM-N-MMA environmental laboratory according to "Standard Methods for the Examination of Water and Waste Water" (APHA, 1998) and "Chemical and Biological Methods for Water Pollution Studies" (Trivedy and Goel, 1986). A summary of parameters determined and methods followed is given in Table 3.2 and subsequent sections.

3.6 Data analysis

The data generated were compared with guideline values given by WHO, 1998 (Appendix VII). In order to find out the contribution of each of the sections for the waste or pollution load, the data of the wastewater quality parameters were analyzed using one way ANOVA-with no blocking and with replication using Genstat Discovery Edition.

The primary data of the milk processing parameters like fat% and SNF% of the incoming raw milk were presented by histogram. The defective % of the milk pouch was presented by p-chart.

Table 3.1 Wastewater parameters determined and the method followed

Test parameters	Analytical Methods
pH	pH meter (0.01 unit sensitivity)
Temperature	Mercury in glass thermometer (0.2°C sensitivity)
Conductivity	Conductivity meter
TSS	Gravimetric method (Trivedy and Goel, 1986)
Oil and grease	Gravimetric method (Trivedy and Goel, 1986)
BOD	Azide Modification
COD	Open reflux

Part IV

4. Process review and observations

4.1 Main Raw Materials

The main raw material used for the production of milk products is raw milk and Skim milk powder where as auxiliary raw materials required are poly pouch, nitric acid, caustic soda, detergents and water respectively.

4.2 Processing units

The existing number of processing units and their capacity is as follows:

Table 4.1 Milk processing units and their capacity

S.N.	Particulars	No.	Capacity	Remarks
1	Milk Receiving Weighing Scale	1	500 litre	-
2	Pasteurizer	1	1800 lit/hr	-
3	Milk Storage Tank	4	20,000 liter	Each of 5000 l
4	Milk Packing Unit	2	1740 lit/hr	Each of 900 and 840 l
5	Ghee Making Pan	1	50 lit/hr	-
6	Cream Separator	1	27 lit/hr	-
9	Hot water generator	1	5000 Kcal/hr	Kerosene based

Source: Kamadhenu Dairy Development Cooperatives Ltd.

Process for Pasteurized milk is summarized in the following flow chart.

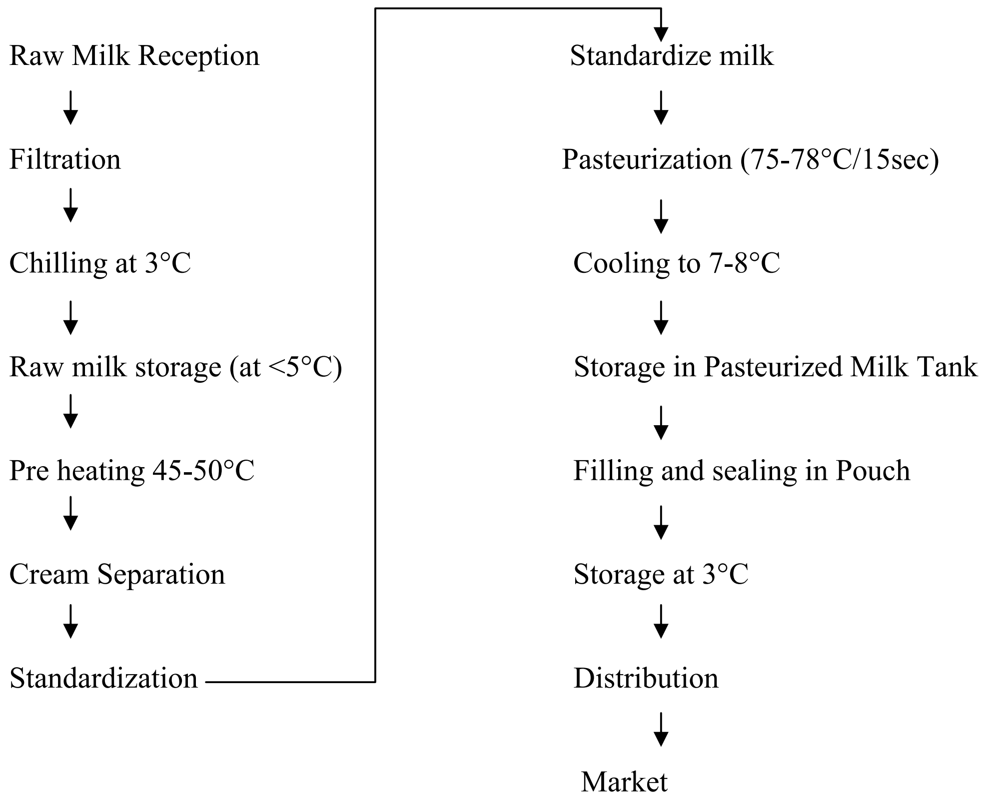


Fig. 4.1 Process flow chart for milk pasteurization.

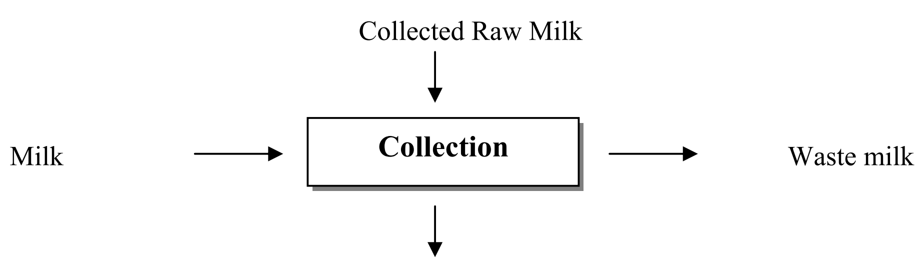
4.3 Process Description

A detailed process description including inputs, outputs and wastes is as follows:

4.3.1 Milk Processing

4.3.1.1 Raw Milk Collection

Raw milk is collected from 25 different milk co-operatives at the chilling centre. The collected milk is chilled at 4^0C and stored in the chilling vat measuring its quality and quantity.



The overall view of the milk processing in Kamadhenu Dairy is presented below in fig. 2.1.

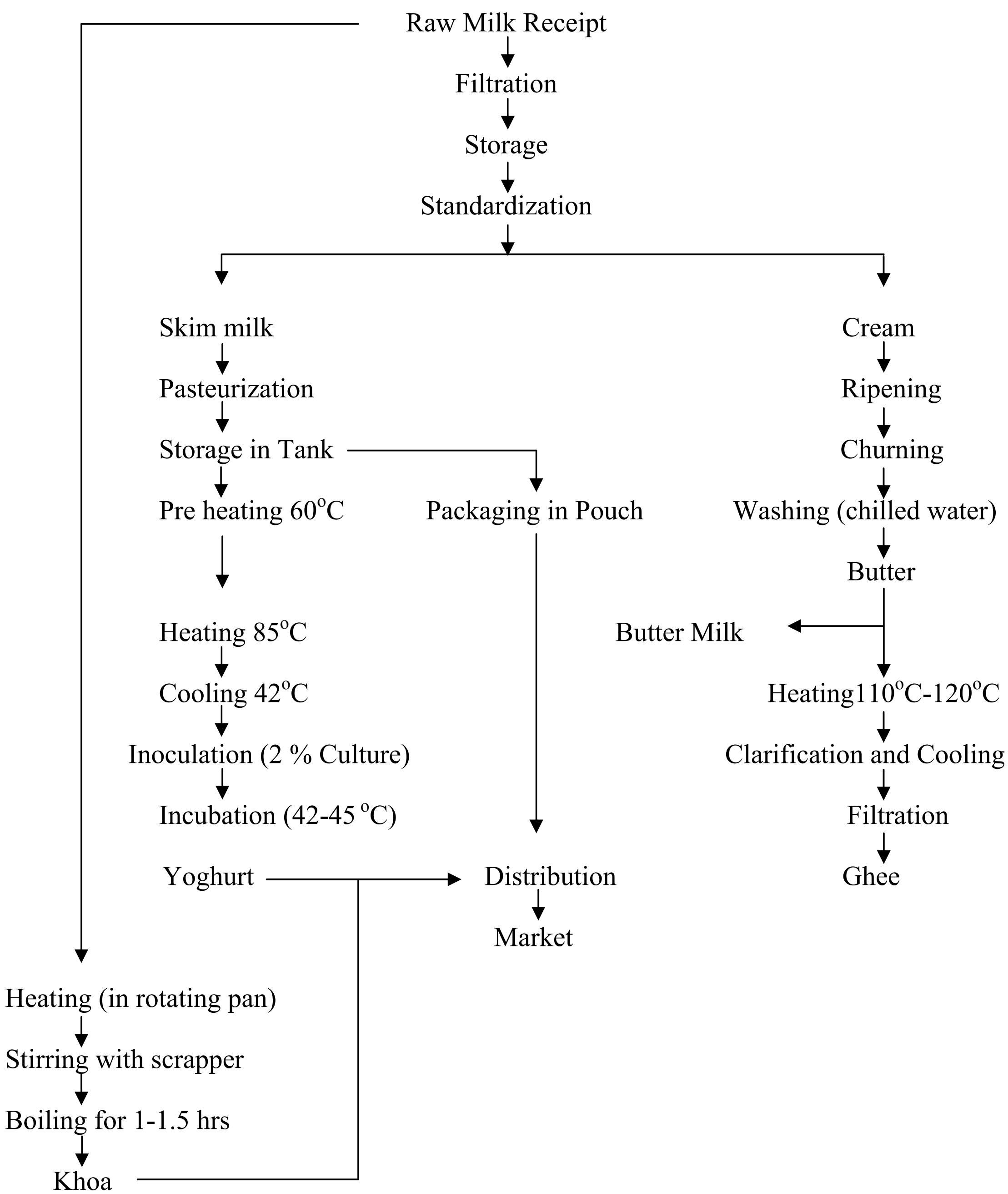
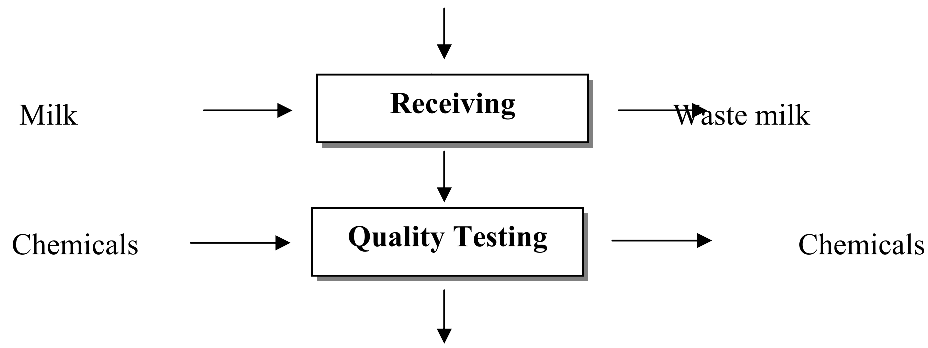


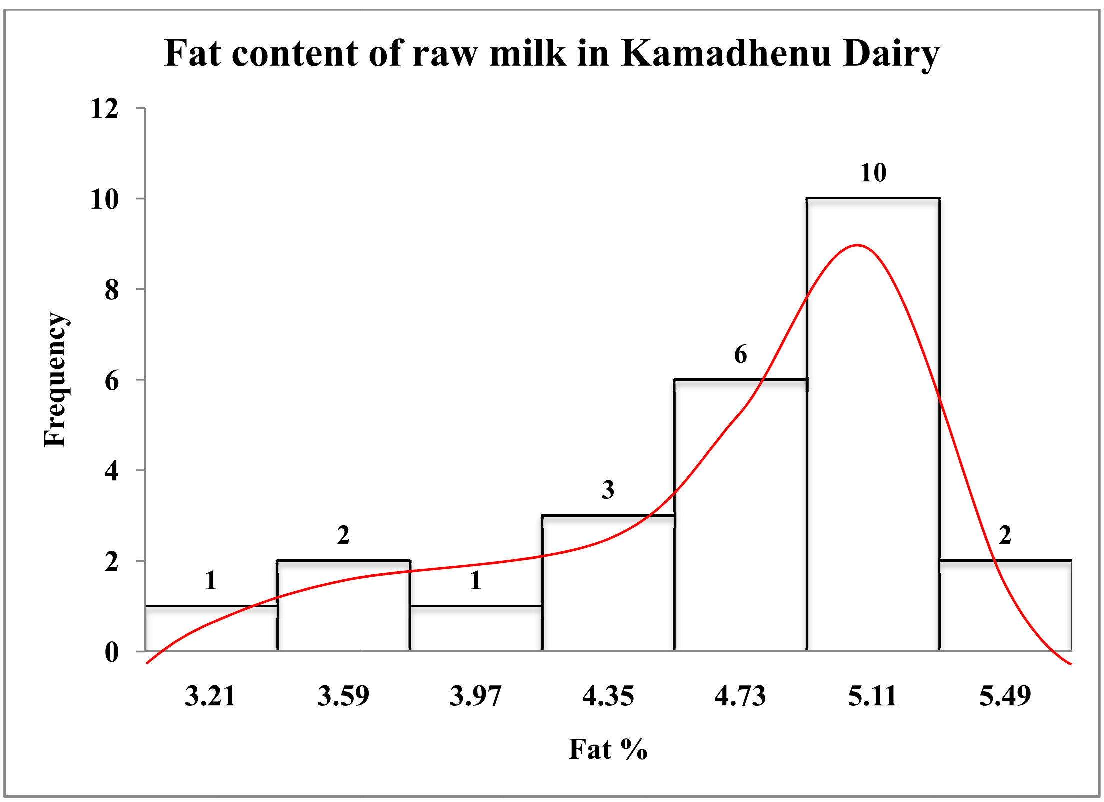
Fig. 4.2 An Overview of Milk Processing in Kamadhenu Dairy

4.3.1.2 Milk Receiving

The chilled milk is loaded in the milk tanker at the chilling centre and then brought to the factory. At the receiving section, quantity and quality content of milk is measured. In the quality testing, fat percentage and SNF percentage is checked.

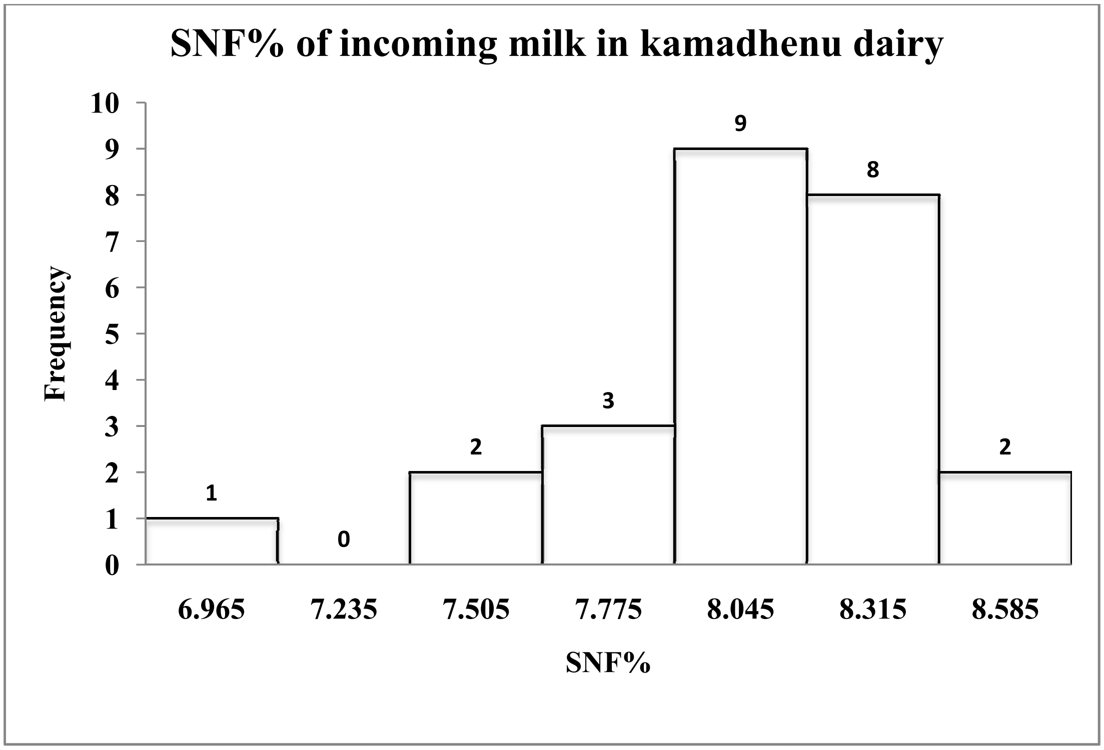


The samples of the incoming raw milk from the entire 25 collection centre were analyzed for fat content in the factory by volumetric Gerber method. Mean value of the fat content were plotted in the histogram shown below.



The true mean of the fat% was found to lie within the range 4.9±0.24 that is from 4.66 to 5.14, at 95% confidence limit. So we may say that the status of the fat% of the incoming raw milk was within the range as specified by Nepal Standard.

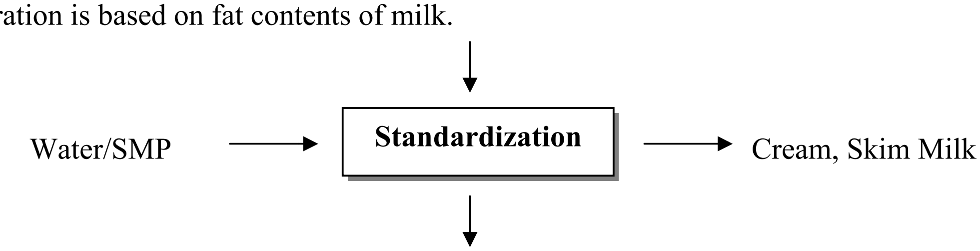
The samples of the incoming raw milk from the entire 25 collection centre were analyzed for SNF content by Lactometer test. Mean value of the SNF content were plotted in the histogram shown below.



The true mean of the SNF% was found to lie within the range 8.2±0.13 that is from 8.06 to 8.34, at 95% confidence limit. So, we may say that the status of the SNF% of the incoming raw milk was within the range as specified by Nepal Standard.

4.3.1.3 Milk Standardization

The objective of standardization of milk is to meet with standard i.e. 3% fat and 8% SNF for standard milk and 5% fat and 8% SNF content for whole milk. During standardization, either cream is separated from milk or water and SMP is added into it. The addition or separation is based on fat contents of milk.



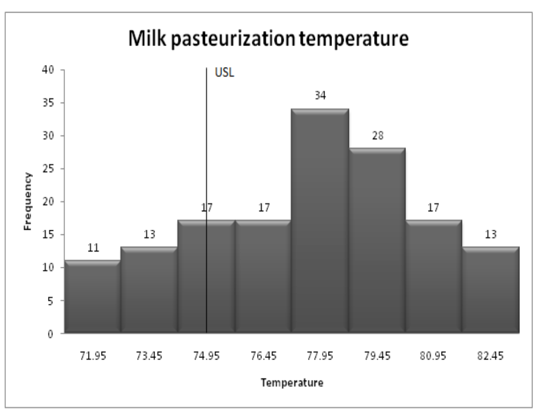
4.3.1.4 Pasteurization

After standardization process it is pasteurized at 72^0C for 15 seconds. The main objective of pasteurization is to kill all pathogenic micro-organisms present in milk.

In the pasteurization process, first of all, the received milk is pre-heated at 40-45^0C in the pre-heating section of pasteurizer. It is then passed to the regeneration section where the milk is heated up to 60^0C. In the heating section the milk is heated up to 72.7-83°C. From heating section, it is passed into holding tanks where it is cooled for 15 sec. and then through regeneration and pre-heating section, it is passed into chilling section where the milk is chilled up to 4^0C.

Raw Milk, Skim milk → **Pasteurization** → Milk, Water

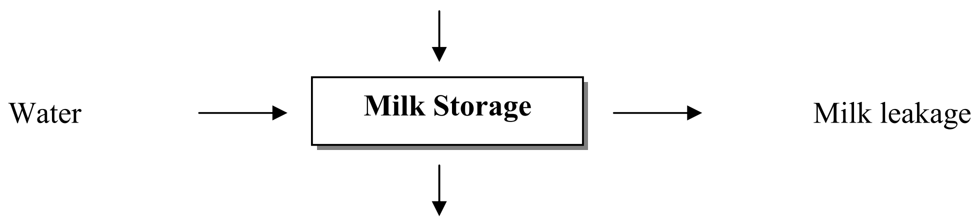
The data for milk pasteurization temperature were collected over a 30-day period, with five observations per day, at regular time interval. Then the frequency distribution of the data was made ranging from the lowest to the highest value. The data were placed in class intervals. The data were presented in the histogram as shown in the figure below. The Upper specification limit for pasteurization temperature is 75°C which is shown by USL line in the histogram.



From the figure it is clear that most of the data were above the upper specification limit for pasteurization temperature. The loss of energy was calculated. Hence, it was found that at 95% confidence limit, loss in energy amounts to 9.69 to 12.39 KW energy per/ day.

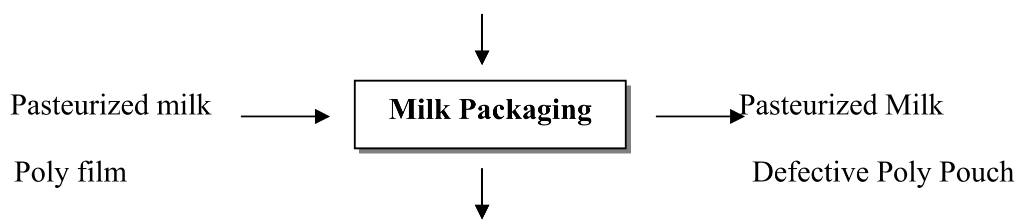
4.3.1.5 Milk Storage

In this stage the pasteurized milk is chilled below 4^0C in the chilling section of the pasteurizer and then stored in storage tank. The storage tank is insulated so the milk temperature is maintained constant.

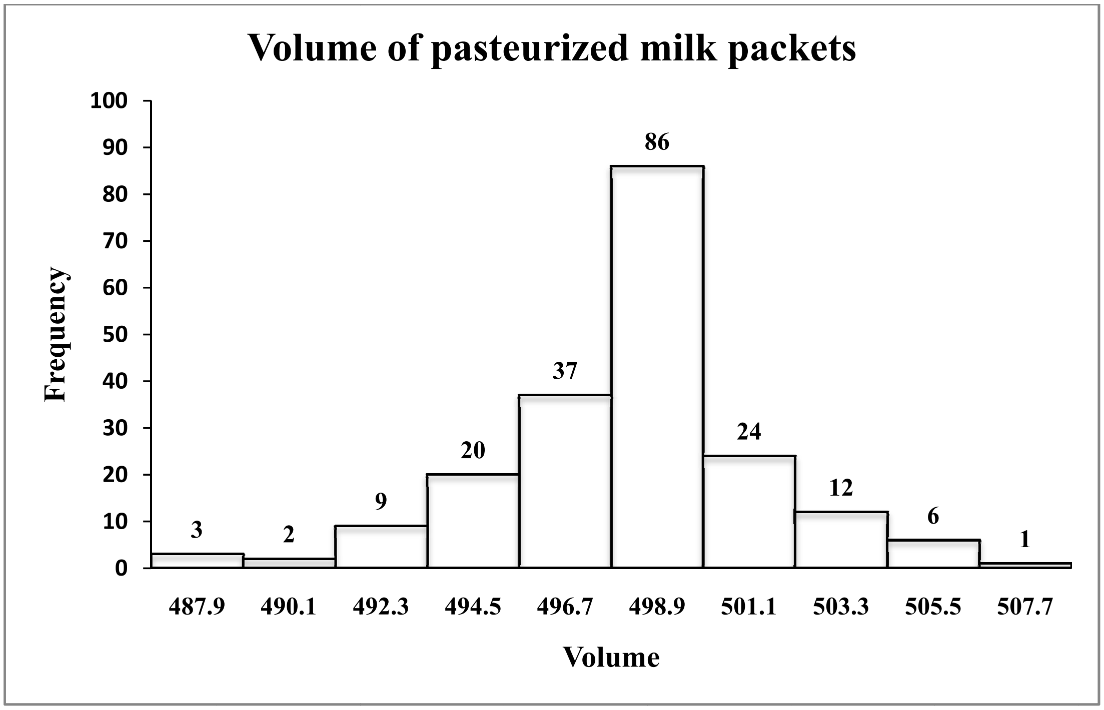


4.3.1.6 Milk Packing

The stored milk kept in storage tank is pumped into the filling section for packing. The milk is packed into a 500 ml LDPE pouch. The packing is done by two packing machines.



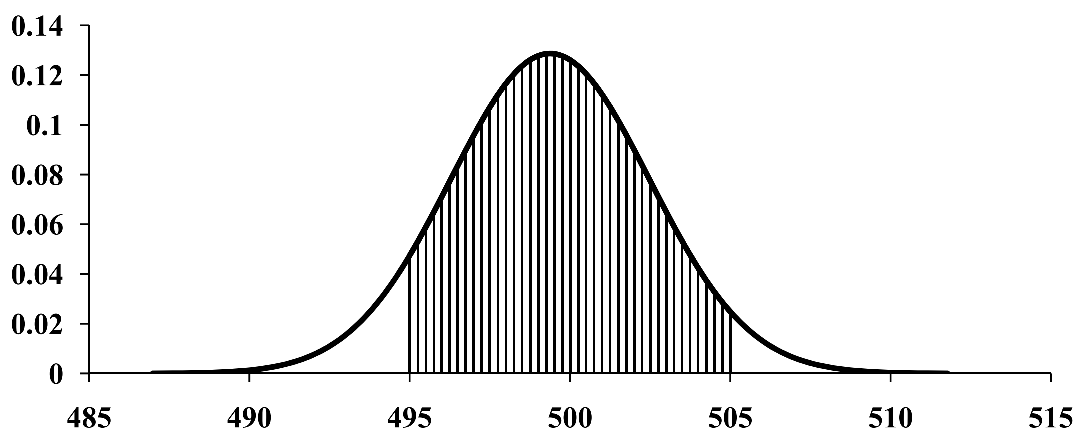
The milk packaging efficiency of the filling machines at Kamadhenu Dairy was also studied. The histogram below represents the data regarding volume of pasteurized milk taken during milk filling operation. The data were collected over a 10days period, with 20 observations, taking 10 samples from each machine. Variability in the volume of milk can be observed. The histogram shows the shape of the distribution, its central tendency, and the variation or scatter of the measurement. (Banks, 1989)



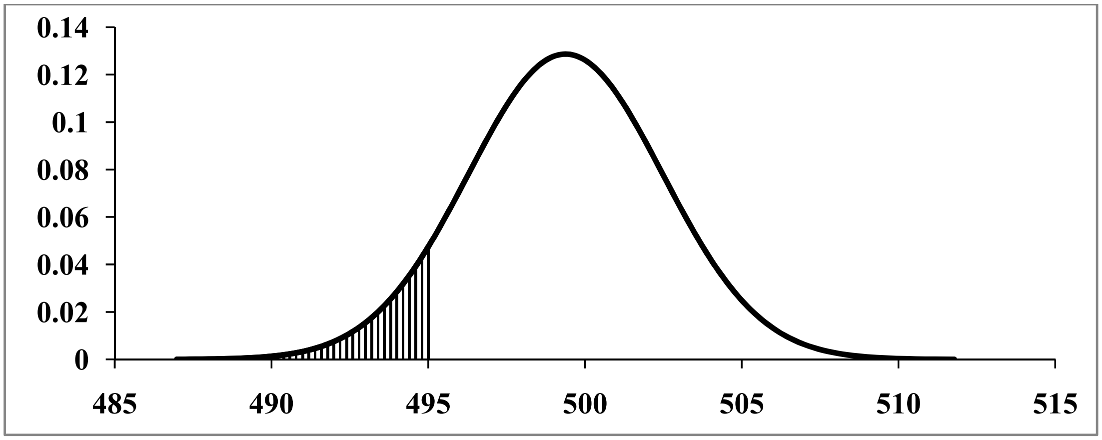
The no. of milk packets weighing between 495 and 505ml were calculated at 5% level of significance. Volume recorded as being between 495ml and 505ml can actually have any value from 494.5 to 505.5 assuming they are recorded to the nearest ml. The standard normal variate were calculated from the formula given below,

$$Z=\frac{X-\overline{X}}{\sigma} \text{ (at 5\% level of significance)}$$

The number of milk packets weighing between 495 and 505ml was found to be 88.63% and the area covered is shown in the figure below.



Similarly, the number of milk packets below 495ml was found to be 7.88%. The area covered is given in the figure below.



The table below presents the percentage defective in pasteurized milk package. The values for the control limits for 20 days are shown in the last two columns of the table and the *p* chart is shown in Figure….

Table 2. Percentage defective in milk packaging

SN	No. of Pkg Inspected (n)	No. of defective Pkg (Pn)	P (%)	UCL(%)	LCL(%)
1	7140	41	0.57	1.58	0.82
2	7540	66	0.88	1.57	0.83
3	8776	90	1.03	1.54	0.85
4	9100	157	1.72	1.53	0.86
5	9500	175	1.84	1.53	0.87
6	6400	60	0.94	1.6	0.8
7	8580	101	1.18	1.55	0.85
8	9640	82	0.85	1.53	0.87
9	9700	185	1.9	1.53	0.87
10	9592	65	0.67	1.53	0.87
11	9220	79	0.86	1.54	0.86
12	3580	45	1.26	1.74	0.66
13	8000	71	0.89	1.56	0.84
14	8400	80	0.95	1.55	0.85
15	7940	70	0.88	1.56	0.84
16	8880	96	1.08	1.54	0.86
17	8640	90	1.04	1.55	0.85
18	9020	111	1.23	1.54	0.86
19	9360	91	0.97	1.53	0.87
20	9160	186	2.03	1.54	0.86

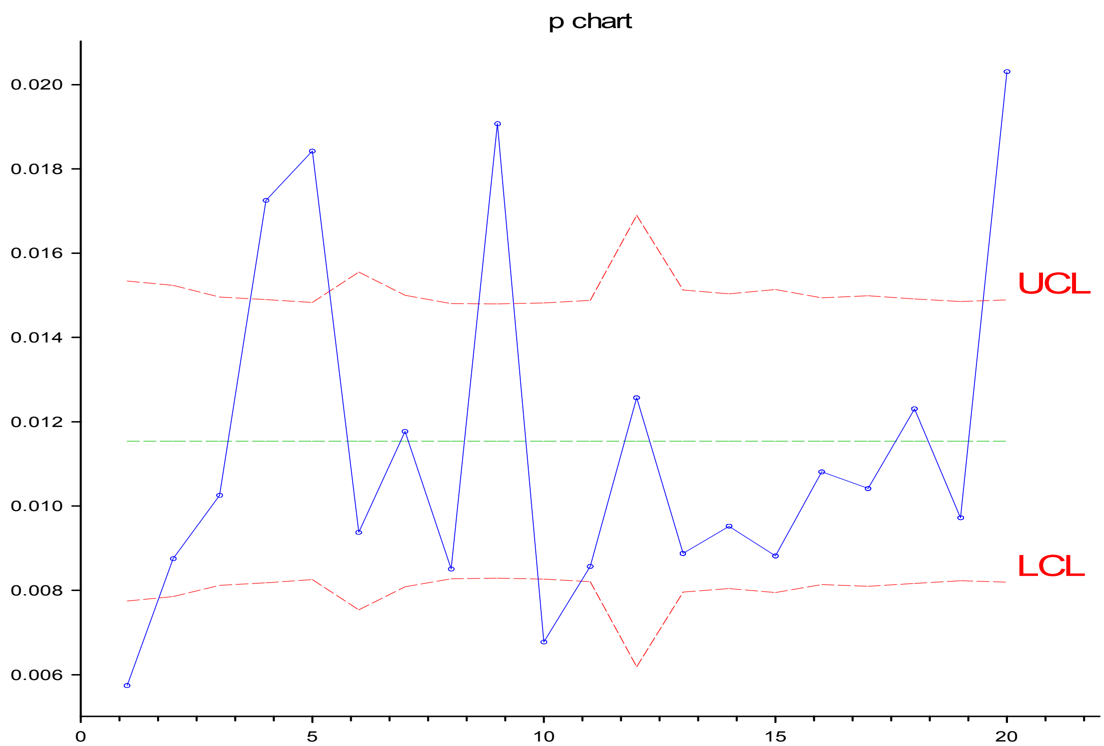
The CL, as computed by the following equation, was found to be 1.2%.

$$\bar{p} = \frac{total defective}{total inspected} = \frac{\sum pn}{\sum n}$$

The control limits are given by,

$$\text{UCL} = \bar{p} + 3\frac{\sqrt{\bar{p}(1-\bar{p})}}{\sqrt{n}} \quad \text{and LCL} = \bar{p} - 3\frac{\sqrt{\bar{p}(1-\bar{p})}}{\sqrt{n}}$$

The corresponding p-chart is presented below showing the defective items as observed during the study.



4.3.1.7 Storing

Packed milk pouches are placed into crates and transferred into the cold store for market dispatched.

Pouch Milk

Milk Packaging

Pouch

Pasteurized Milk

Dispatch

4.3.2 Environmental Issues Related with Processes

The possible environmental issues related with milk processing are as follows.

4.3.2.1 Milk Receiving

The main form of waste generation in this process is wastewater and milk, Water is consumed for rinsing the tankers, cleaning and sanitization of transfer vessels and storage tanks. The effluent resulting from rinsing tankers and cleaning contain milk spilled over the ground. This would contribute to the organic load of the effluent stream.

4.3.2.2 Pasteurization

The main environmental issue associated with this process is water consumed for rinsing and cleaning of process equipments resulting in the generation of wastewater containing milk, sludge and chemicals.

4.3.2.3 Milk storage

Milk spillage through leakages of piping and valves, spillage resulting in milk product lost to the wastewater stream is responsible for high organic pollution load generation in wastewater stream.

4.3.2.4 Packing

Milk loss due to voltage fluctuation in sealing of poly pouch is the major issue in terms of organic pollution and solid waste generation. However, incorrectly filled milk poly pouches are emptied and milk returned to the milk receiving section for reprocessing still has contributed to the pollution load.

4.4 Nature of Waste Generation

The natures of waste generation from milk processing are as follows:

- **Waste Water**- Waste Water containing milk product loss, milk and whey spillage, chemicals used in CIP, crate washing and shop floor washing are the main sources of waste water effluent coming out from the industry.
- **Solid Waste**- Poly pouch rejected during the milk filling and sludge generation from the cream separation, are the major source of solid waste.

Part V

5. Results and Discussions

5.1 Areas of Water Consumption

The ground water is a main source of water to be used in overall activity of milk processing. The annual water consumption is 7182.03 m^3. A section wise water use and duration is given as below:

Table 5.1 Section wise water consumption record

S.N.	Section	Purpose	Consumption		Annual (m^3)
			Duration	Lit/d	Consumption
1.	Milk reception section	Cleaning	30 min	642.85	234.64
2.	Crates/cans	Cleaning	5 hr	4864.86	1775.67
3.	Yoghurt making section	Cleaning	30 min	720	262.8
7.	Milk holding Tanks (4 number)	CIP	20 min/tank	3000 x 2	2190
8.	Pasteurizer	CIP	1.5hr	2500	912.5
9.	Packaging section	CIP	30 min	920	336
9.	Shop floor	Cleaning	1.5 hrs/d	1928.57	703.92
10	Others	Drinking, vehicle washing and Sanitation	Daily	2000	730
11.	Ghee making section	Cleaning	-	100	36.5
		Total			7182.03

Source: Kamadhenu Dairy Development Cooperatives Ltd.

5.2 Unit water use

The annual water consumption was found to be $7182.03m^3$ and the total amount of raw milk received for the year 2065/66 was $1269294l$.

The unit of liters of water per liter of raw milk is calculated as follows:

$$\text{Unit water use} = \frac{\text{Total m3 of water used over 12 month period}}{\text{Total liters of raw milk received over same 12 month period}} \text{ X } 1000\ l/m^3$$

Hence from the above formula the unit water use was found to be 5.65litre per liter of raw milk.

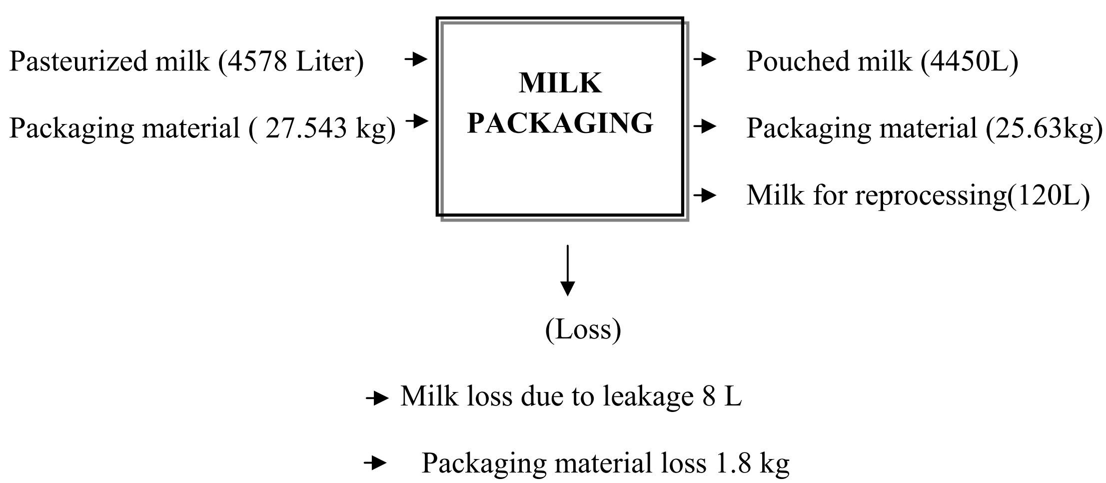
5.3 Material Balance and cost of waste

The purpose of conducting material balance in the industry is to identify and quantify the waste generation in the processes.

5.3.1 Material balance of the packaging section

Material and energy balances give a detailed account of all inputs and outputs, so that problem areas can be identified and losses quantified. They will also clearly identify and quantify previously unknown losses or emissions. (SEAM+CP) reference

The material balance about the packaging section of the dairy based on direct observation and measurement is presented below.



5.4 Wastewater analysis

The data from waste water analysis of three different section of the dairy processing plant are presented in the table below.

Table. Section wise dairy wastewater quality parameters

S.N.	Parameters	Section A	Section B	Section C
1	pH	7.9±0.01 [a]	3.82±0.01 [b]	6.73±0.02 [c]
2	TSS (mg/L)	276±1 [a]	674±1 [b]	868±1 [c]
3	Oil and grease (mg/L)	108±1 [a]	1809±1 [b]	320±1 [c]
4	BOD (mg/L)	514±3 [a]	832±2 [b]	944±1 [c]
5	COD(mg/L)	936±2 [a]	2017±5 [b]	1892±2 [c]

The data in the above tables are in the form of (mean ± s. d.) and the figures with different superscript are significantly different at 5% level of significance from each other otherwise not.

From the above table it can be concluded that the effluent sample from each of the three sections were found to be significantly different from each other at 5% level of significance.

The detailed results and discussion about the water quality parameters is given in the following paragraphs.

5.4.1 pH

The pH of the effluent coming from section B is not within the range as stated in the generic standard for industrial effluent disposal given by HMG/N. The use of highly concentrated nitric acid for cleaning purpose may be the cause of low pH in the wastewater generated in that section.

5.4.2 TSS

The TSS of the samples of wastewater coming from all the three sections exceeds the generic standard for effluent disposal given by HMG/N. Section c has the highest value of 864 mg/l. This shows that

5.4.3 Oil and grease

The value for oil and grease of the samples from all the three sections exceeds the generic standard and it is maximum for the samples from section B that is from the pasteurization unit. The high value of oil and grease may be due to the presence of milk residue during HTST startup and shutdown or from

5.4.4 BOD

The BOD of all the samples exceeds the generic standard. The maximum BOD was from section C. The high value of BOD from the packaging section may be due to spillage of milk during filling operation, milk residue remaining in the overhead tank before cleaning due to improper emptying of the tank.

5.4.5 COD

The value for COD of the samples from all the three sections exceeds the generic standard and it is maximum for the samples from section B that is from the pasteurization unit. The ratio of COD to BOD is less than three so it can be concluded that the waste is biodegradable. So, biological methods can be applied to treat the waste.

Water Conservation Tips

- Think of water as a raw material with a cost.
- Set specific water conservation goals for your plant.
- Make water conservation a management priority.
- Install water meters and read the each shift.
- Train employees how to use water efficiently.
- Use automatic shut-off nozzles on all water hoses.
- Use high-pressure, low-volume cleaning systems.
- Avoid using water hoses as brooms.
- Reuse water where possible.
- Prevent spills of ingredients and of raw and finished product.
- Always clean up spills before washing.
- Establish a recognition and reward program for employees and teams who do an outstanding job.

Part VI

6. Conclusions and recommendations

6.1 Conclusions

Appendix A. Quality parameters of the dairy effluent sample

SN.	Parameters	Units	Methods	Generic standard of effluent disposal	Results
1	pH	-	pH metric	5.5-8.5	
2	Temperature	°C	Electrometric	Not exceed 40°C	
3	Conductivity	mS/cm	APHA 2510	-	
4	Total suspended solids	mg/L	APHA 2540D	150	
5	Oil and Grease	mg/L	APHA 5520	10	
6	Dissolved Oxygen	mg/L	APHA 4500	-	
7	Biochemical Oxygen Demand	mg/L	APHA 5210	100	
8	Chemical Oxygen Demand	mg/L	APHA 5220	250	
9	Flow rate	m^3/Day	Bucket and stopwatch method	-	

Appendix B Preservation techniques of the water sample for chemical analysis

Parameter	Recommended sample vol. (ml)	Type of container	Preservation	Allowable holding time
Acidity	100	P, G	Refrigerate at – 4°C	24hr
Alkalinity	100	P, G	Refrigerate at – 4°C	24hr
BOD	1000	P, G	Refrigerate at – 4°C	6hr
COD	50	P, G	H_2SO_4 to pH < 2	7 days
Chlorine, residual	500	P, G	Analyze immediately	–
Chloride	50	P, G	Not required	7 days
Color	50	P, G	Refrigerate at – 4°C	24hr
Cyanide	500	P, G	Refrigerate at – 4°C; NaOH to pH 12	24 hr
Dissolved oxygen:				
Probe	300	G	Determine on site	–
Winkler	300	G	Fix on site	6hr
Hardness	100	P, G	Refrigerate at – 4°C	7 days
Metals	200	P, G	HNO_3 to pH < 2	6 months
Ammonia	500	P, G	Refrigerate at – 4°C;	24 hr
			H2SO4 to pH < 2	
Kjeldahl-N	500	P, G	Refrigerate at – 4°C;	7 days
			H2SO4 to pH < 2	
Nitrate	100	P, G	Refrigerate at – 4°C;	24 hr
			H_2SO_4 to pH < 2	
Nitrite	100	P, G	Refrigerate at – 4°C	24 hr
Oil and grease	1000	G	HCl to pH < 2	24 hr
Organic carbon	50	P, G	Refrigerate at -4°C;	24 hr

			H_2SO_4 to pH < 2	
pH	100	P, G	Determine on site	–
Phenol	500	G	Refrigerate at – 4°C	24 hr
Phosphate	50	P, G	Refrigerate at – 4°C	24 hr
Specific conductance	100	P, G	Refrigerate at – 4°C	24 hr
Solids (total, dissolved)	100	P, G	Refrigerate at – 4°C	7 days
Sulfate	50	P, G	Refrigerate at -4°C	7days
Sulfide	100	P, G	Analyze immediately	–
Temperature	1000	P, G	Determine on site	–
Turbidity	100	P, G	Refrigerate at -4°C	No holding
Radioactivity	1000	P, G	Not required	24 hr

P – plastics; G – borosilicate glass

(Trivedy and Goel, 1986)