Wastewater Treatment of Food Industry/ Processing

Case studies (CAPO Milk Factory - Dal Group and El Moshraf Sweets Factory)

By

Khatab Salah El Bahari Mohamed Ahmed

B.Sc. (Honour) water resources engineering

A Thesis Submitted to Sudan University of Science and Technology in fulfillment of the requirements for the degree of M.Sc.in Environmental Engineering

Supervisor:

Dr. Bashier Mohamed El Hassan

Department of Environmental Engineering

College of Water and Environmental Engineering

Jan 2021

Dedication

To my Mother

Soul of my Father

My wife

Sister and Brother

My son

Acknowledgments

I would like to express my great thanks to my supervisor, Dr. Bashir Mohamed El Hassan for his great help and professional encouragement.

My gratitude and thanks extend to EL Mosharf and Capo factories personnel for their kind permission and good welcoming to get samples.

Also, I would like to express my gratitude to all people who contributed directly or indirectly to complete this research work.

Abstract

The objective of this study is to determine the pollution loads (both hydraulic and organic) emanating from the factories under the study (food processing factories). Field observation, interviews of the concerned personnel, and laboratories analysis as study tools. The determined loads are relatively high (hydraulic load, organic load) for each of the two factories and don’t agree with the recommended Khartoum north local order (1970) and SSMO (173/2008) standards. The results of samples analyzed for CAPO factory: were:

pH =6.89, TSS = 1000 mg/l, BOD = 4500 mg/l ,COD = 5650 mg/l and oil and grease = 150.100 mg/l. Wastewater flow = 5000 m^3/day.

Results for EL mosharf factory: were:

pH = 6.55, BOD = 5516 mg/l, COD = 6825 mg/l, TSS = 350 mg/l.

Wastewater flow = 74 m^3/day.

Neither of the two factories is having pretreatment facilities in spite of the need for it.

There is neither inspection nor flow measurement by KSSC for quantity and composition of the industrial wastewater generated.

It is recommended to install pretreatment facilities for the factories industrial wastewater in this plant, so as to be in line with the regulations

The proposed pretreatment unit designed for CAPO Plant as follows:

Q design = 208.33 m^3/d, BOD design load = 124 kg/d, design TSS load= 144 kg/d.

Volume of lift station = 1000 m^3, manual bar screen length =1.2m, width = 0.5 m, height = 0.5 m.

Volume of aeration tank = 6944.44m^3.

مستخلص

هدفت الدراسة لتحديد (التلوث التصريف، أو الحمل العضوي) الظاهر لمصانع المواد الغذائية تحت الدراسة، القياسات الحقلية، المقابلات مع الاشخاص ذات الصلة، معدات المعامل المستخدمة للتحليل تم تحديد احمال التصريف والاحمال العضوية للمصنعين ولم تطابق لقانون الخرطوم بحري المحلي للعام 1970، الموصى به ومعايير الهيئة السودانية للمواصفات والمقاييس 2008/173 م، وكانت نتائج تحليل العينات لمصنع كابو:

الرقم الهيدروجيني 6.89 بالمواد الكلية العالقة 1000 ملم لكل لتر والاكسجين الحيوي المطلوب 4500 ملم لكل لتر والاكسجين الكيموحيوي المطلوب 5650 لكل ملم والزيوت والشحوم 150.100 ومعد التصريف المقدر 5000متر مكعب في اليوم.

نتائج تحليل المشرف للمواد الغذائية:

الرقم الهيدروجيني 6.55 والاكسجين الحيوي المطلوب 5516 ملم لكل لتر والاكسجين الكيموحيوي المطلوب 6825 ملم لكل لتر والمواد العالقة الكلية 350ملم لكل لتر والتصريف 74 متر مكعب في اليوم وتحتاج تلك المصانع للمعالجة الاولية ولا يوجد تفتيش من هيئة الصرف الصحي ولاية الخرطوم لنوعية وتركيبة المخلفات الصناعية السائلة المنتحة.

تصميم الوحدات الاولية: التصميم والتصريف 208.33 متر مكعب في اليوم والحمل العضوي التصميمي 124كيلوجرام في اليوم والمواد الكلية العالقة 144 كيلوجرام ، حجم حوض محطة الرفع 1000 متر مكعب وابعاد المصفى الطول 1.5 متر والعرض 0.5 متر والطول 0.5 متر وحجم حوض التهوية 6944.44 متر

List of Contents

List of Tables

List of figures

Appendixes

CHABTEAPTR ONE

Introduction

1.1 General:

The wastewater from industries varies so greatly in both flow and pollution strength. So, it is impossible to assign fixed values to their constituents. In general, industrial wastewaters may contain suspended, colloidal and dissolved (mineral and organic) solids. In addition, they may be either excessively acidic or alkaline and may contain high or low concentrations of colored matter. These wastes may contain inert, organic or toxic materials and possibly pathogenic bacteria. These wastes may be discharged into the sewer system provided they have no adverse effect on treatment efficiency or undesirable effects on the sewer system. It may be necessary to pre treat the wastes prior to release to the municipal system or it is necessary to a full treatment when the wastes will be discharged directly to surface or ground waters.

The development of industries and extensive urbanization means increased water consumption and pollution resulting from problems of waste disposal. Unfortunately, in most developing countries, effluent quality standards imposed by legislation (where they exist) are sometimes easily flouted. Industrial effluents are liquid wastes which are produced in the course of industrial activities. Over the years, the improper disposal of industrial effluents has been a major problem and a source of concern to both government and industrialist. In most cases the disposal or discharges of effluents, even when these are technologically and economically achievable for particular standards, do not always comply with pretreatment requirement and with applicable tonic pollutant effluent limitations or prohibitions. The consequence of these anomalies is a high degree of environmental pollution leading to serious health hazards **[1]**.

Whereas the nature of domestic wastewater is relatively constant, the extreme diversity of industrial effluents calls for an individual investigation for each type of industry and often entails the use of specific treatment processes. Therefore, a thorough understanding of the production processes and the system organization is fundamental. A long-term detailed survey' are usually necessary before a conclusion on the pollution impact from an industry can be reached. Typical pollutants and BOD range for a variety of industrial wastes are given in Table-1. The values of typical concentration parameters (BOD5, COD, suspended solids and pH). Industrial wastewaters are considerably diverse in their nature, toxicity and treatability, and normally require pre-treatment before being discharged to sewer. Food processing in particular is very dissimilar to other types of industrial wastewater, being readily degradable and largely free from toxicity. However, it usually has high concentrations of biological oxygen demand (BOD) and suspended solids **[3].**Compared to other industrial sectors, the food industry uses a much greater amount of water for each ton of product **[4].** Industrial wastewater characteristics vary not only between the industries that generate them, but also within each industry. These characteristics are also much more diverse than domestic wastewater, which is usually qualitatively and quantitatively similar in its composition. On the contrary, industry produces large quantities of highly polluted wastewater containing toxic substances, organic and inorganic compounds such as: heavy metals, pesticides, phenols and derivatives thereof, aromatic and aliphatic hydrocarbons, halogenated compounds, etc., which are generally resistant to destruction by biological treatment methods. Food industry uses large amounts of water for many different purposes including cooling and cleaning, as a raw material, as sanitary water for food processing, for transportation, cooking and dissolving, as auxiliary water etc. In principle, the water used in the food industry may be used as process and cooling water or boiler feed water. As a consequence of diverse consumption, the amount and composition of food industry wastewaters varies considerably. Characteristics of the effluent consist of large amounts of suspended solids, nitrogen in several chemical forms, fats and oils, phosphorus, chlorides and organic matter **[5].** Food and beverage industry is one of the major contributors to growth of all economies. In EU it constitutes the largest manufacturing sector in terms of turnover, value added and employment. However, the sector has been associated with various environmental issues including water usage and wastewater treatment. Food processing industry wastewater poses pollution problems due to its high COD (Chemical Oxygen Demand) and BOD (Biochemical Oxygen Demand).Compared to other industrial sectors, food industry requires great amounts of water, since it is used throughout most of plant operations, such as production, cleaning, sanitizing, cooling and materials transport, among others. The wastewater streams with different levels of pollution load (low, medium and high contamination) are collected and treated in an on-site installation or in a municipal sewage treatment plant. Increasing food production will increase the volume of sewage and the cost of disposal for food processing plants and present difficult challenges for municipal wastewater treatment plant operators **[6, 7].** Currently, in accordance with the legislation of the European Union introduced more stringent controls and rules concerning pollution of industrial wastewater **[8, 9].** Increasing industrialization trend in the worldwide has resulted in the generation of industrial effluents in large quantities with high organic content, which if treated appropriately, can result in a significant source of energy. Food industry wastewater treatment by physicochemical method using Zinc Sulphate, Ferrous Sulphate and Ferric chloride has been reported. Where the reduction in COD has been obtained 60% with alum dose of 200 mg/L **[10].** The food processing wastewater shows large variation in BOD, COD, total solids and suspended solids, oil and grease, starch, sugar, color, preservatives, total nitrogen, total phosphates, chloride and sodium etc. This is due to the different additives used for different food products. Wastewater depicted COD/BOD and SS of 11220 mg/l, 6860 mg/L and 2210 mg/L respectively. From the studies it can be concluded that the food processing wastewater is easily amenable to physico-chemical treatment. The results obtained show that all the coagulants used individually or in combination with polyelectrolyte can remove moderate to high degree of chemical oxygen demand, biochemical oxygen demand and suspended solids from the food processing wastewater. Lime individually also acts as an efficient coagulant and moreover it is very cost effective. Addition 0.3 mg/L of anionic polyelectrolyte magna floc to 200 mg/L of lime resulted in good SS, COD and BOD removals **[11].** Anaerobic digestion seems to Bethe most suitable option for the treatment of high strength organic effluents. Anaerobic technology has improved significantly in the last few decades with the applications of differently configured high rate treatment processes, especially for the treatment of industrial wastewaters. High organic loading rates can be achieved at smaller footprints by using high rate anaerobic reactors for the treatment of industrial effluents **[12].**A novel anaerobic–aerobic integrative baffled bioreactor supplied with porous burnt-coke particles was developed for the treatment of potato starch wastewater .This bioreactor was found to be effective for the removal of COD (88,4–98,7%) and NH3–N(50,4 to 82,3%), in high-strength starch wastewater**[13].**

Chocolate industry is among the most polluting of the food industries in regard to its large water consumption. Chocolate is one of the major industries causing water pollution. Considering the above stated implications an attempt has been made in the present project (capo and masharf factory) to evaluate one of the Effluent Treatment Plant (ETP) for Chocolate waste. Samples were collected from three points; Collection tank (CT),outflow of Anaerobic Contact Filter (ACF) and Secondary clarifier (SC) to evaluate the performance of the considered Effluent Treatment Plant. Parameters analyzed for evaluation of performance of Effluent Treatment Plant were pH, COD, and BOD. The COD and BOD removal efficiency of Effluent Treatment Plant were 98.7 and 99.4 % respectively **[14].** The main course of water pollution in the river is the direct discharge of food and beverages processing effluents. The impact of such effluents on the water quality was studied in detail by monitoring selected physicochemical parameters monthly between January 2003 and December 2007. The combined effluent was equally monitored.

This study provided a detailed data on the quality of the effluent at the designated discharge point, upstream and downstream locations. The river is a recipient of effluents of poor quality. Some identified pollutants in the combined effluent are organic load, suspended solids, phosphate, nitrate and chloride which led to significant pollution of the river water. The receipt of the combined effluent has rendered the river unwholesome for certain beneficial purposes such as cooking, drinking, irrigation and aquatic life support. Thus the effluent has a profound impact on the physicochemical structure of the river and also affects the consumers of the river water. It is suggested that discharges from these industries should be given very high degree of treatment before final exist to the river **[15].** Water usage in the food and drink industry is expressed either in volume of water consumed per finished product or per raw material processed. For slaughter houses great variations in water usage per end-product were observed depending on the animal been slaughtered. During the production of potato chips approximately 5 m3 of water are consumed for each tone of raw potatoes processed. For olive oil production, less water is consumed if the two-phase centrifuge process is employed instead of the three-phase. Indicative values are 0.25 and 1.24 m3/t of olive oils. The manufacturing of cheese demands 1.05 – 3.6 m3 of water per m3 of milk processed while for the manufacturing of beer 2,5 – 6,4 m^3 of water are consumed for each of produced beer. Used water is eventually end up as wastewater except for the proportion which is used as a raw material e.g. for beer production. Although the pollution load depends on the type of industry, a common characteristic of all food and beverage sectors studied was the high values of organic content of wastewater. The highest values in terms of COD were observed for the wastewater occurring from the olive oil production process (400g/L) and from the cheese production process (77g/L) while high values were also observed for slaughterhouses (2-10g/L), considering blood is gathered separately), chip production process (4.3-9.3g/L) and beer industry (2-6g/L). Due to the high organic content, the biological processes are commonly applied for the treatment of wastewater of those industries. In particular, the application of anaerobic process is the predominant treatment process using UASB reactors **[16].**

II. Description of the Food Industry Process

The industry is a global leader in branded foods and beverages production in Sudan. The food processing plant is operated in three shifts per day. The first shift from 8:00 am to 4:00 pm, the second shift from 4:00 pm to 12:00 pm, while the third shift from 12:00 am to 8:00 am. The production process includes five production lines chocolate cake line, three lines of different biscuits type, and ketchup line.

III. Statement of the Environmental Problem:

The food industry is committed to reducing environmental impacts of its activities, and to continuously improve its environmental performance and to meeting or exceeding the requirements of all applicable environmental laws and regulation. As conclusion of the lab analysis of the industrial wastewater effluent, the average values of pH, settle able solids, BOD, COD and oil and grease are above the limits of the Sudan Environmental Regulations (2009), while values of TSS, settle-able solids, phosphorous and total nitrogen are within the limits. Accordingly, the industry has to treat the wastewater prior to its discharge to the wastewater sanitary network.

IV. a General Objective: is to:

Manage and control the liquid wastewater from diary processing and sweets industries in view in the present environment regulation and legislations (Khartoum North local order (1971) and SSMO standard 174/2008).

IV. b Specific objectives are to:

1. To identify the specific flow processing lines for each factories under studied.
2. To identify analyses the liquid waste generated from food industry (quantity and quality).
3. Design pretreatment factories, so that the generated liquid waste within the requirement of discharge in mainsable sewer.

Chapter Two
Literature review

2.1 Introduction:

The dairy industry is generally considered to be the largest source of food processing wastewater in many countries. As awareness of the importance of improved standards of wastewater treatment grows, process requirements have become increasingly stringent. Although the dairy industry is not commonly associated with severe environmental problems, it must continually consider its environmental impact—particularly as dairy pollutants are mainly of organic origin. For dairy companies with good effluent management systems in place [16], treatment is not a major problem, but when accidents happen, the resulting publicity can be embarrassing and very costly. All steps in the dairy chain, including production, processing, packaging, transportation, storage, distribution, and marketing, impact the environment. Owing to the highly diversified nature of this industry, various product processing, handling, and packaging operations create wastes of different quality and quantity, which, if not treated, could lead to increased disposal and severe pollution problems. In general, wastes from the dairy processing industry contain high concentrations of organic material such as proteins, carbohydrates, and lipids, high concentrations of suspended solids, high biological oxygen demand (BOD) and chemical oxygen demand (COD), high nitrogen concentrations, high oil and/or grease contents, and large variations in pH, which necessitates "special" treatment so as to prevent or minimize environmental problems. The dairy waste streams are also characterized by wide fluctuations in flow rates, which are related to discontinuity in the production cycles of the different products. All these aspects work to increase the complexity of wastewater treatment. The problem for most dairy plants is that waste treatment is perceived to be a necessary it ties up valuable capital, which could be better utilized for core business activity. Dairy wastewater disposal usually results in one of three problems: (a) high treatment levies being charged by local authorities for industrial wastewater; (b) pollution might be caused when untreated wastewater is either discharged into the environment or used directly as irrigation water; and (c) dairy plants that have already installed anaerobic or aerobic biological system are faced with the problem of sludge disposal. To enable the dairy industry to contribute to water conservation, an efficient and cost-effective wastewater treatment technology is critical. Presently, plant managers may choose from a wide variety of technologies to treat their wastes. More stringent environmental legislations as well as escalating costs for the purchase of fresh water and effluent treatment has increased the quality to improve waste control. The level of treatment is normally dictated by environmental regulations applicable to the specific area. While most larger dairy factories have installed treatment plants or, if available, dispose of their wastewater into municipal sewers, cases of wastewater disposal into the sea or disposal by means of land irrigation do occur. In contrast, most smaller dairy factories dispose of their wastewater by irrigation onto lands or pastures. Surface and groundwater pollution is, therefore, a potential threat posed by these practices. Because the dairy industry is a major user and generator of water, it is a candidate for wastewater reuse. Even if the purified wastewater is initially not reused, the dairy industry will still benefit from in-house wastewater treatment management, because reducing waste at the source can only help in reducing costs or improving the performance of any downstream treatment facility.

2.2 DAIRY PROCESSES AND COMPOSITION OF DAIRY PRODUCTS:
2 OVERVIEW OF DAIRY PROCESSING

Primary production and dairy processing

- The dairy industry is divided into two main production areas:

The primary production of milk on farms—the keeping of cows (and other animals such as goats, sheep etc.) for the production of milk for human consumption;

- The processing of milk—with the objective of extending its saleable life. This objective is typically achieved by (a) heat treatment to ensure that milk is safe for human consumption and has an extended keeping quality, and (b) preparing a variety of dairy products in a semi-dehydrated or dehydrated form (butter, hard cheese and milk powders), which can be stored.

Focus of this guide

The focus of this document is on the processing of milk and the production of milk-derived products—butter, cheese and milk powder at dairy processing plants. The upstream process of primary milk production on dairy farms is not covered, since this activity is more related to the agricultural sector. Similarly, downstream processes of distribution and retail are not covered.

Industry structure an trends

Dairy processing occurs world-wide; however the structure of the industry varies from country to country. In less developed countries, milk is generally sold directly to the public, but in major milk producing countries most milk is sold on a wholesale basis. Many of the large-scale processors are owned by the farmers as co-operatives, while in the individual contracts are agreed between farmers and processors.

Dairy processing industries in the major dairy producing countries have undergone rationalization, with a trend towards fewer but larger plants operated by fewer people. Most dairy processing plants are quite large. Plants producing market milk and products with short shelf life, such as yoghurts, creams and soft cheeses, tend to be located on the fringe of urban centers close to consumer markets. Plants manufacturing items with longer shelf life, such as butter, milk powders, cheese and whey powders, tend to be located in rural areas closer to the milk supply.

The general tendency world-wide, is towards large processing plants specializing in a limited range of products. There are exceptions, however. In eastern Europe for example, due to the former supply-driven concept of the market, it is still very common for 'city' processing plants to be large multi-product plants producing a wide range of products.

The general trend towards large processing plants has provided companies with the opportunity to acquire bigger, more automated and more efficient equipment. This technological development has, however, tended to increase environmental loadings in some areas due to the requirement for long-distance distribution.

Basic dairy processes have changed little in the past decade. Specialized processes such as ultra filtration (UF), and modern drying processes, have increased the opportunity for the recovery of milk solids that were formerly discharged. In addition, all processes have become much more energy efficient and the use of electronic control systems has allowed improved processing effectiveness and cost savings.

2.3 Process overview

2.3.1 Milk production

The processes taking place at a typical milk plant include:

- receipt and filtration/clarification of the raw milk;
- separation of all or part of the milk fat (for standardization of market milk, production of cream and butter and other fat-based products, and production of milk powders);
- pasteurization;
- homogenization (if required);
- deodorization (if required);
- further product-specific processing;

packaging and storage, including cold storage for perishable products;

- Distribution of final products.

Figure 2–1 is a flow diagram outlining the basic steps in the production of whole milk, semi-skimmed milk and skimmed milk, cream, butter and buttermilk. In such plants, yogurts and other cultured products may also be produced from whole milk and skimmed milk.

2.3.2 Butter production

The butter-making process, whether by batch or continuous methods, consists of the following steps:

- Preparation of the cream;
- Destabilization and breakdown of the fat and water emulsion;
- Aggregation and concentration of the fat particles;
- Formation of a stable emulsion;
- Packaging and storage;
- Distribution.

Figure 2–1 is a flow diagram outlining the basic processing system for a butter-making plant. The initial steps, (filtration/clarification, separation and pasteurization of the milk) are the same as described in the previous section. Milk destined for butter making must not be homogenized, because the cream must remain in a separate phase.

After separation, cream to be used for butter making is heat treated and cooled under conditions that facilitate good whipping and churning. It may then be ripened with a culture that increases the content of directly, the compound responsible for the flavor of butter.

Alternatively, culture inoculation may take place during churning. Butter which is flavors enhanced using this process is termed lactic ripened or cultured butter. This process is very common in continental European countries. Although the product is claimed to have a superior flavor, the storage life is limited. Butter made without the addition of a culture is called sweet cream butter. Most butter made in the English-speaking world is of this nature.

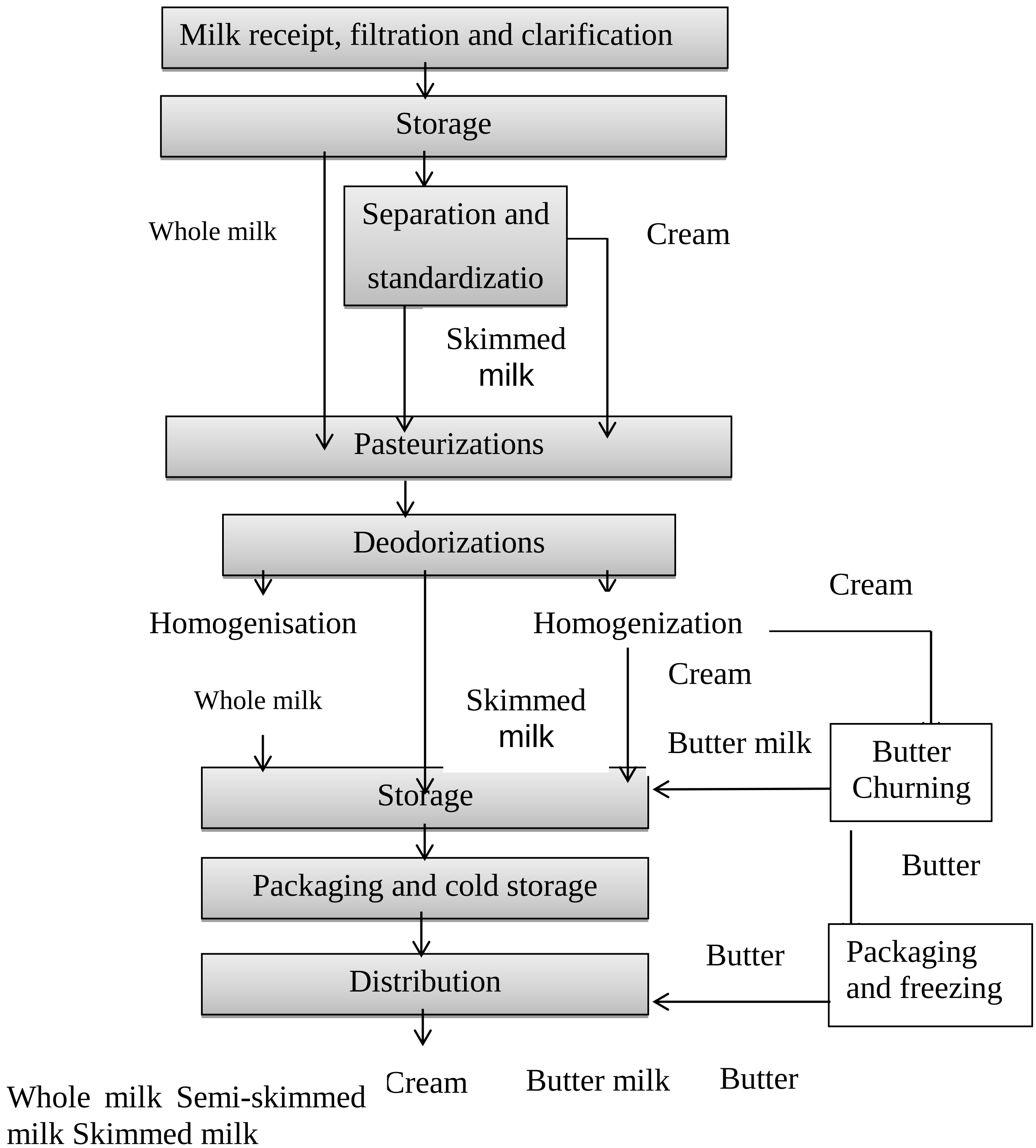

Fig (2-1): Flow diagram for processes occurring at a typical milk plant (personal communication)

Both cultured and sweet cream butter can be produced with or without the addition of salt. The presence of salt affects both the flavor and the keeping quality.

Butter is usually packaged in bulk quantities (25 kg) for long-term storage and then re-packed into marketable portions (usually 250 g or 500 g, and single-serve packs of 10–15 g). Butter may also be packed in internally lacquered cans, for special markets such as the tropics and the Middle East.

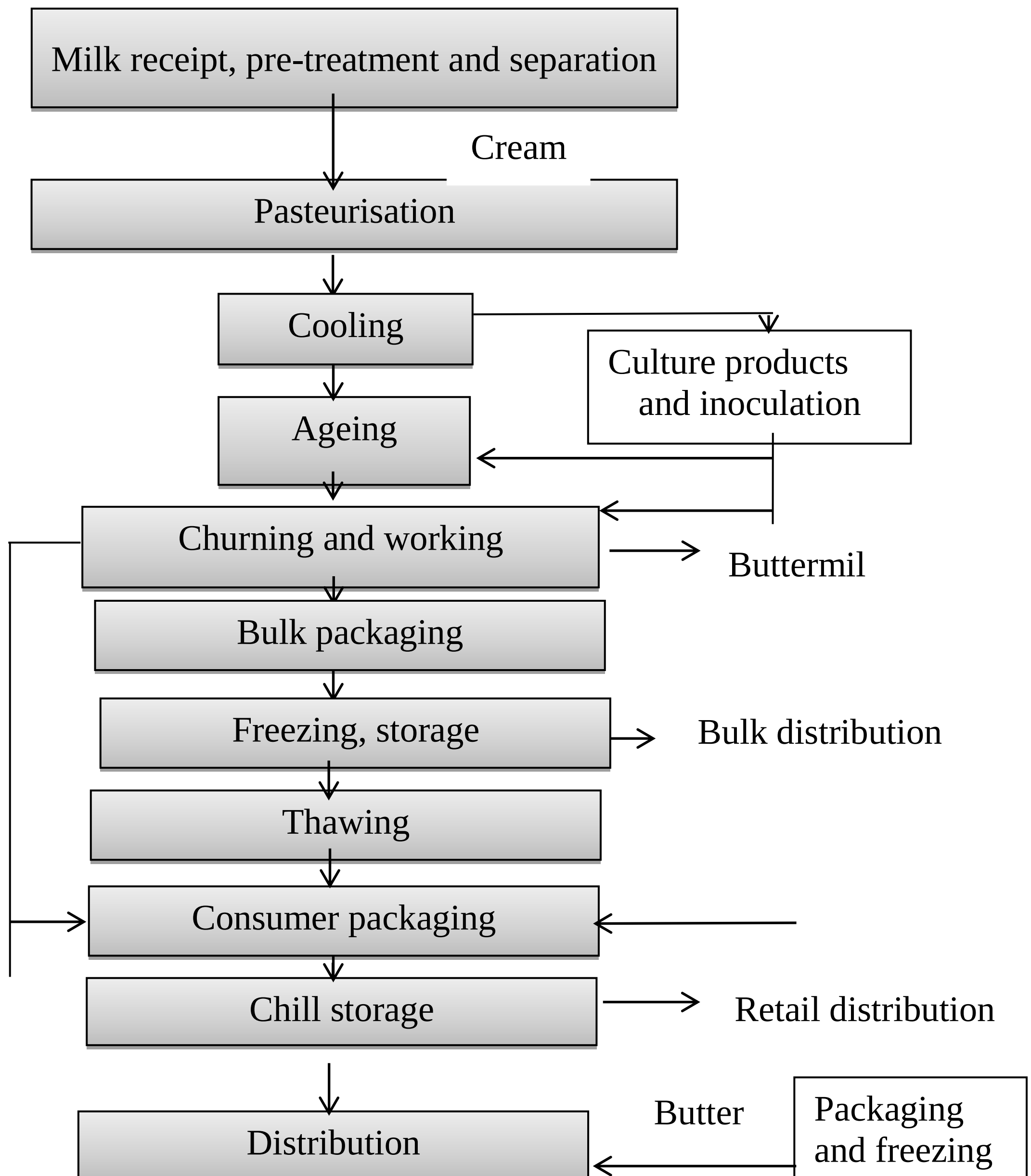

Fig (2–2): Flow diagram for a typical butter-making plant(personal communication)

2.1.3 Cheese production

Virtually all cheese is made by coagulating milk protein (casein) in a manner that traps milk solids and milk fat into a curd matrix. This curd matrix is then consolidated to express the liquid fraction, cheese whey. Cheese whey contains those milk solids which are not held in the curd mass, in particular most of the milk sugar (lactose) and a number of soluble proteins.

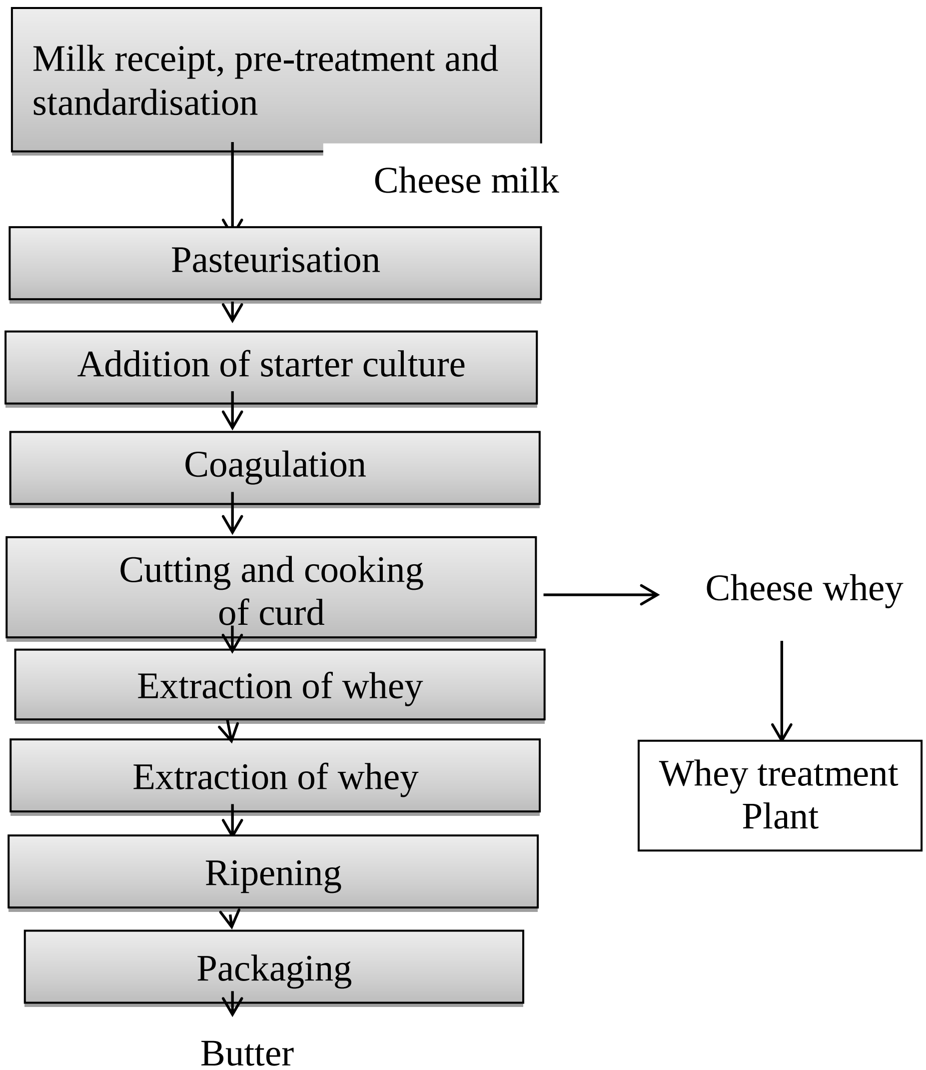

Fig (2–3): Flow diagram for a typical cheese plant (personal communication)

2.1.4 Milk powder production:

Milk used for making milk powder, whether it be whole or skim milk, is not pasteurized before use. The milk is preheated in tubular heat exchangers before being dried. The preheating temperature depends on the season (which affects the stability of the protein in the milk) and on the characteristics desired for the final powder product.

The preheated milk is fed to an evaporator to increase the concentration of total solids. The solids concentration that can be reached depends on the efficiency of the equipment and the amount of heat that can be applied without unduly degrading the milk protein.

The milk concentrate is then pumped to the atomizer of a drying chamber. In the drying chamber the milk is dispersed as a fine fog-like mist into a rapidly moving hot air stream, which causes the individual mist droplets to instantly evaporate.

Milk powder falls to the bottom of the chamber, from where it is removed. Finer milk powder particles are carried out of the chamber along with the hot air stream and collected in cyclone separators.

Milk powders are normally packed and distributed in bulk containers or in 25 kg paper packaging systems. Products sold to the consumer market are normally packaged in cans under nitrogen. This packaging system improves the keeping quality, especially for products with high fat content.

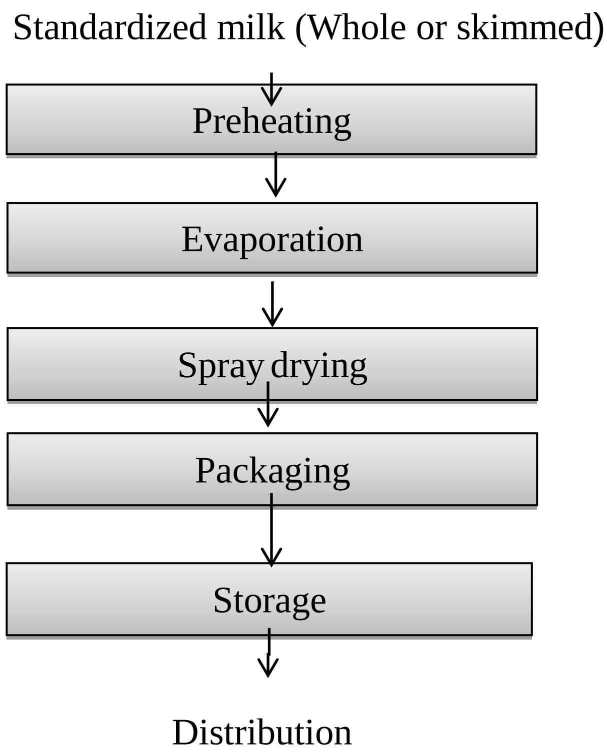

Fig (2–4): outlines the basic processes for the production of milk powder (personal communication).

2.2 Environmental impacts

This section briefly describes some of the environmental impacts associated with the primary production of milk and the subsequent processing of dairy products. While it is recognized that the primary production of milk has some significant environmental impacts, this document is predominantly concerned with the processing of dairy products.

2.2.1 Impacts of primary production

The main environmental issues associated with dairy farming are:

- the generation of solid manure and manure slurries, which may pollute surface water and groundwater;
- the use of chemical fertilizers and pesticides in the production of pastures and fodder crops, which may pollute surface water and groundwater;
- The contamination of milk with pesticides, antibiotics and other chemical residues.

Manure wastes

In most cases, solid manure is applied to pastures and cultivated land. The extent of application, however, may be restricted in some regions. Dairy effluent and slurries are generally held in some form of lagoon to allow sedimentation and biological degradation before they are irrigated onto land. Sludge generated from biological treatment of the dairy effluent can also be applied to pastures, as long as it is within the allowable concentrations for specified pollutants, as prescribed by regulations. Sludge can also be used in the production of methane-rich biogas, which can then be used to supplement energy supplies.

Manure waste represents a valuable source of nutrients. However improper storage and land application of manure and slurries can result in serious pollution of surface waters and groundwater, potentially contaminating drinking water supplies.

Chemical fertilizers

The extensive use of chemical fertilizers containing high levels of nitrogen has resulted in pollution of the groundwater and surface waters in many countries. Nitrite in drinking water is known to be carcinogenic, and nitrite levels in drinking water that exceed 25–50 mg/L have been linked to cyanosis in newborn infants (‘blue babies’). Compounds containing nitrogen and phosphorus, if discharged to surface water, can lead to excessive algal growth (eutrophication). This results in depleted dissolved oxygen levels in the water, thereby causing the death of fish and other aquatic species. In sensitive areas, therefore, the rate and manner of application of chemical fertilizers are critical.

Pesticides

The use of pesticides has been recognized as an environmental concern for many agricultural activities. Toxic pesticides, some of which biodegrade very slowly, can accumulate in body tissues and are harmful to ecosystems and to human health. Pesticides can end up in agricultural products, groundwater and surface waters, and in extreme cases can enter the human food chain through milk.

Milk contamination

For the past few decades, the contamination of milk with antibiotics has been an issue of concern. This is due to the overuse of antibiotics for treatment of cattle diseases, particularly mastitis. It has been brought under control in most countries with developed dairy industries, through strict limitations on the use of antibiotics, regular testing of milk for antibiotic residues, rigorous enforcement of regulations, and education.

In some countries, considerable attention has also been paid to the screening of milk supplies for traces of radioactivity, and most countries now apply acceptance limits for raw and imported milk products. Even the slightest levels of contamination in milk can be serious, because pollutants are concentrated in the processing process.

2.2.2 Impacts of dairy processing

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. Noise, odors and solid wastes may also be concerns for some plants.

Water consumption:

Dairy processing characteristically requires very large quantities of fresh water. Water is used primarily for cleaning process equipment and work areas to maintain hygiene standards.

Effluent discharge:

The dominant environmental problem caused by dairy processing is the discharge of large quantities of liquid effluent. Dairy processing effluents generally exhibit the following properties:

- high organic load due to the presence of milk components;
- fluctuations in pH due to the presence of caustic and acidic cleaning agents and other chemicals;
- high levels of nitrogen and phosphorus;
- fluctuations in temperature.

If whey from the cheese-making process is not used as a by-product and discharged along with other wastewaters, the organic load of the resulting effluent is further increased, exacerbating the environmental problems that can result.

In order to understand the environmental impact of dairy processing effluent, it is useful to briefly consider the nature of milk. Milk is a complex biological fluid that consists of water, milk fat, a number of proteins (both in suspension and in solution), milk sugar (lactose) and mineral salts.

Dairy products contain all or some of the milk constituents and, depending on the nature and type of product and the method of manufacturing, may also contain sugar, salts (e.g. sodium chloride), flavours, emulsifiers and stabilisers.

For plants located near urban areas, effluent is often discharged to municipal sewage treatment systems. For some municipalities, the effluent from local dairy processing plants can represent a significant load on sewage treatment plants. In extreme cases, the organic load of waste milk solids entering a sewage system may well exceed that of the township's domestic waste, overloading the system.

In rural areas, dairy processing effluent may also be irrigated to land. If not managed correctly, dissolved salts contained in the effluent can adversely affect soil structure and cause salinity. Contaminants in the effluent can also leach into underlying groundwater and affect its quality.

In some locations, effluent may be discharged directly into water bodies. However this is generally discouraged as it can have a very negative impact on water quality due to the high levels of organic matter and resultant depletion of oxygen levels.

Energy consumption:

Electricity is used for the operation of machinery, refrigeration, ventilation, lighting and the production of compressed air. Like water consumption, the use of energy for cooling and refrigeration is important for ensuring good keeping quality of dairy products and storage temperatures are often specified by regulation. Thermal energy, in the form of steam, is used for heating and cleaning.

As well as depleting fossil fuel resources, the consumption of energy causes air pollution and greenhouse gas emissions, which have been linked to global warming.

Solid wastes:

Dairy products such as milk, cream and yogurt are typically packed in plastic-lined paperboard cartons, plastic bottles and cups, plastic bags or

reusable glass bottles. Other products, such as butter and cheese, are wrapped in foil, plastic film or small plastic containers. Milk powders are commonly packaged in multi-layer kraft paper sacs or tinned steel cans, and some other products, such as condensed milks, are commonly packed in cans.

Breakages and packaging mistakes cannot be totally avoided. Improperly packaged dairy product can often be returned for reprocessing; however the packaging material is generally discarded.

Emissions to air:

Emissions to air from dairy processing plants are caused by the high levels of energy consumption necessary for production. Steam, which is used for heat treatment processes (pasteurisation, sterilisation, drying etc.) is generally produced in on-site boilers, and electricity used for cooling and equipment operation is purchased from the grid. Air pollutants, including oxides of nitrogen and sulphur and suspended particulate matter, are formed from the combustion of fossil fuels, which are used to produce both these energy sources.

In addition, discharges of milk powder from the exhausts of spray drying equipment can be deposited on surrounding surfaces. When wet these deposits become acidic and can, in extreme cases, cause corrosion.

Refrigerants:

For operations that use refrigeration systems based on chlorofluorocarbons (CFCs), the fugitive loss of these gases to the atmosphere is an important environmental consideration, since CFCs are recognized to be a cause of ozone depletion in the atmosphere. For such operations, the replacement of CFC-based systems with non- or reduced-CFC systems is thus an important issue.

Noise:

Some processes, such as the production of dried casein, require the use of hammer mills to grind the product. The constant noise generated by this equipment has been known to be a nuisance in surrounding residential areas. The use of steam injection for heat treatment of milk and for the creation of reduced pressure in evaporation processes also causes high noise levels.

A substantial traffic load in the immediate vicinity of a dairy plant is generally unavoidable due to the regular delivery of milk (which may be on a 24-hour basis), deliveries of packaging and the regular shipment of products.

Noise problems should be taken into consideration when determining plant location.

Hazardous wastes:

Hazardous wastes consist of oily sludge from gearboxes of moving machines, laboratory waste, cooling agents, oily paper filters, batteries, paint cans etc. At present, in western Europe some of these materials are collected by waste companies. While some waste is incinerated, much is simply dumped.

2.3 Environmental indicators

Environmental indicators are important for assessing Cleaner Production opportunities and for assessing the environmental performance of one dairy processing operation relative to another. They provide an indication of resource consumption and waste generation per unit of production.

Figure 2–5 is a generic flowchart of the overall process including resource inputs and waste outputs. The sections that follow provide a discussion of the key inputs and outputs. Where available, quantitative data are provided.

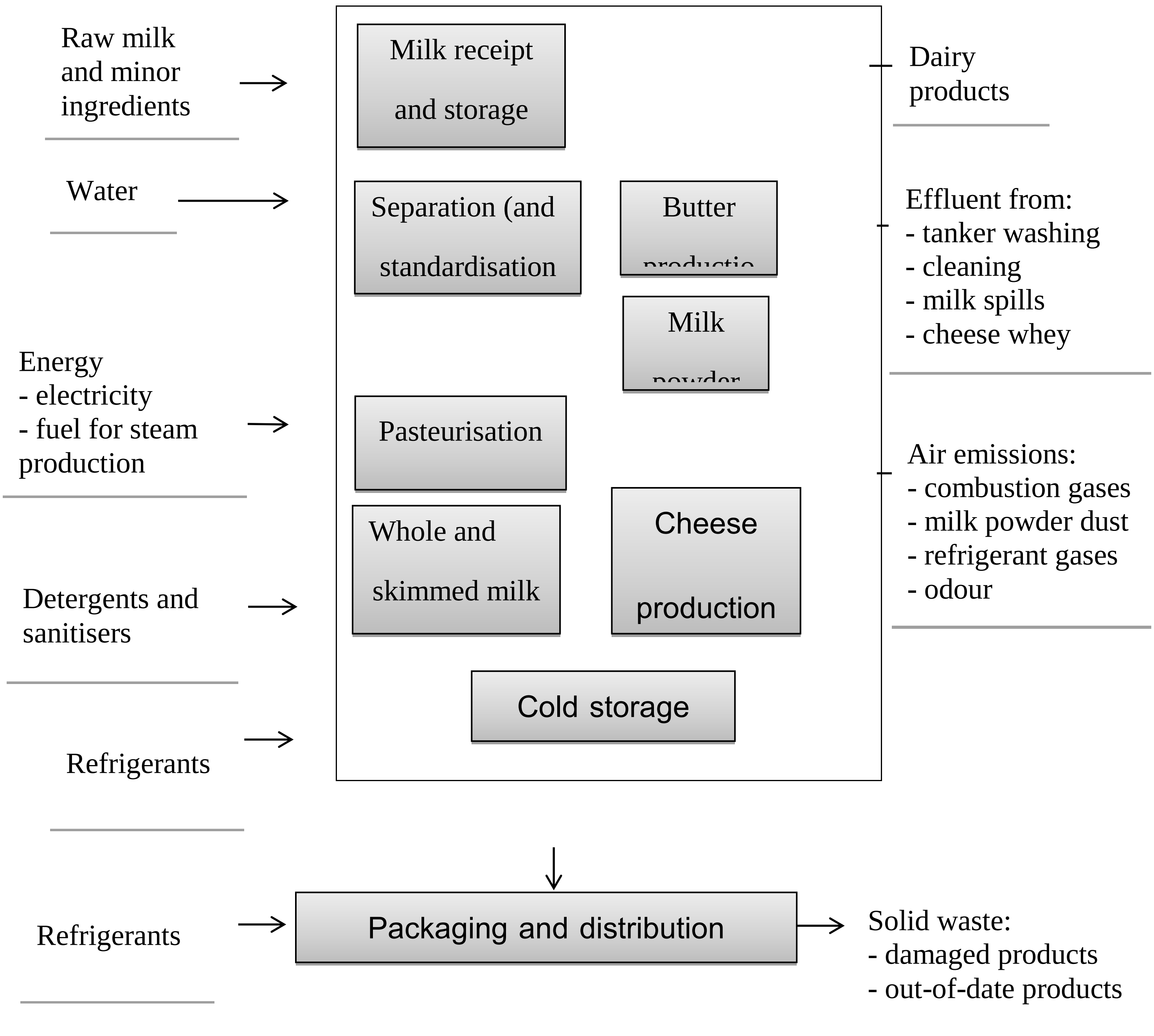

Fig (2–5): Inputs and outputs of a dairy source from field survey

2.3.1 Water consumption

As with most food processing operations, water is used extensively for cleaning and sanitising plant and equipment to maintain food hygiene standards. Table 2–1 shows the areas of water consumption within a dairy processing plant, and gives an indication of the extent to which each area contributes to overall water use.

Due to the higher costs of water and effluent disposal that have now been imposed in some countries to reflect environmental costs, considerable reduction in water consumption has been achieved over the past few decades in the dairy processing industry. Table 2–1 shows the reductions in water consumption per kilogram of product that have been achieved over this period. These improvements are attributed to developments in process control and cleaning practices.

At modern dairy processing plants, a water consumption rate of 1.3–2.5 liters water/kg of milk intake is typical; however 0.8–1.0 liters water/kg of milk intake is possible .To achieve such low consumption requires not only advanced equipment, but also very good housekeeping and awareness among both employees and management.

Table 2.1 Areas of water consumption at dairy processing plants (from factory record).

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**%

2.3.2 Effluent discharge

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. The constituents present in dairy effluent are milk fat, protein, lactose and lactic acid, as well as sodium, potassium, calcium and chloride. 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%.

A major contributing factor to a dairy plant's effluent load is the cumulative effect of minor and, on occasions, major losses of milk. These losses can occur, for example, when pipework is uncoupled during tank transfers or equipment is being rinsed. Table 2–3 provides a list of the sources of milk losses to the effluent stream.

The organic pollutant content of dairy effluent is commonly expressed as the 5-day biochemical oxygen demand (BOD5) or as chemical oxygen demand (COD). One litre of whole milk is equivalent to approximately 110,000 mg BOD5 or 210,000 mg COD.

Concentrations of COD in dairy processing effluents vary widely, from 180 to 23,000 mg/L. Low values are associated with milk receipt operations and high values reflect the presence of whey from the production of cheese. A typical COD concentration for effluent from a dairy plant is about 4000 mg/L. This implies that 4% of the milk solids received into the plant is lost to the effluent stream, given that the COD of whole milk is 210,000 mg/L and that effluent COD loads have been estimated to be approximately 8.4 kg/m3 milk intake (Marshall and Harper, 1984).

A Danish survey found that effluent loads from dairy processing plants depend, to some extent, on the type of product being produced. The scale of the operation and whether a plant uses batch or continuous processes also have a major influence, particularly for cleaning. This is because small batch processes requires more frequent cleaning. The tendency within the industry towards larger plants is thus favorable in terms of pollutant loading per unit of production.

Table 2.2: Sources of milk losses to the effluent stream (from factory record)

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
Pasteurizations 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
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

Due to the traditional payment system for raw milk (which is based on the mass or volume delivered plus a separate price or premium for the weight of milk fat), the dairy processing industry has always tried to minimize loss of milk fat. In many countries the payment system now recognizes the value of the non-fat milk components. Systems that control the loss of both fat and protein are now common in the industrialized world, but less so in the developing world.

The disposal of whey produced during cheese production has always been a major problem in the dairy industry. Whey is the liquid remaining after the recovery of the curds formed by the action of enzymes on milk. It comprises 80–90% of the total volume of milk used in the cheese making process and 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. Only in the past two decades have technological advances made it economically possible to recover soluble proteins from cheese whey and, to some extent, to recover value from the lactose.

Most dairies are aware that fat and protein losses increase the organic load of the effluent stream and, even in the developing world; the use of grease traps has been common for some decades. Many companies, however, do not take any action to reduce the organic pollution from other milk components. It is becoming more common for dairy companies to be forced by legal or economic pressures to reduce the amount and concentration of pollutants in their effluent streams.

Therefore, at most sites, wastewater treatment or at least pretreatment is necessary to reduce the organic loading to a level that causes minimal environmental damage and does not constitute a health risk. The minimum pretreatment is usually neutralization of pH, solids sedimentation and fat removal.

2.3.3 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 compressed air. Approximately 80% of a plant's energy needs is met by the combustion of fossil fuel (gas, oil etc.) to generate steam and hot water for evaporative and heating processes. The remaining 20% or so is met by electricity for running electric motors, refrigeration and lighting. The energy consumed depends on the range of products being produced. Processes which involve the concentration and drying of milk, whey or buttermilk for example, are very energy intensive. The production of market milk at the other extreme involves only some heat treatment and packaging, and therefore requires considerably less energy. Consumption of different dairy products.

Table 2.3: Specific energy consumption for various dairy products(from factory design)

Product	Electricity consumption (GJ/tone product)	Fuel consumption (GJ/tone product)
Market milk	0.20	0.46
Cheese	0.76	4.34
Milk powder	1.43	20.60
Butter	0.71	3.53

Energy consumption will also depend on the age and scale of a plant as well as the level of automation. To demonstrate this, Table 2–4 provides examples of energy consumption rates for a selection of Australian plants processing market milk.

Table 2.4: Energy consumption for a selection of milk plants (from factory design)

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 plants	2.00
Range for most plants	0.5–1.2

Plants producing powdered milk exhibit a wide range of energy efficiencies, depending on the type of evaporation and drying processes that are used. Energy consumption depends on the number of evaporation effects (the number of evaporation units that are used in series) and the efficiency of the powder dryer. Table 2–5 provides examples of how different evaporation and drying systems can affect the energy efficiency of the process. Substantial increases in electricity use have resulted from the trend towards automated plant with associated pumping costs and larger evaporators as well as an increase in refrigeration requirements.
High consumption of electricity can also be due to the use of old motors, excessive lighting or possibly a lack of power factor correction.

Table 2.5: Energy consumption for evaporation and drying systems (from electrical design)

Type of evaporation and drying system	**Total energy consumption** (kJ/tone product)
5-effect evaporator and 2-stage drier	13–15
3-effect evaporator and 1-stage drier	22–28
2-effect evaporator and 1-stage drier	40–50

2.2.1 Milk and Whey Powders:

This is basically a two-step process whereby 87% of the water in pasteurized milk is removed by evaporation under vacuum and the remaining water is removed by spray drying. Whey powder can be produced in the same way. The condensate produced during evaporation may be collected and used for boiler feed water.

2.2.2 Cheese:

Because there are a large variety of different cheeses available, only the main processes common to all types will be discussed. The first process is curd manufacturing, where pasteurized milk is mixed with rennet and a suitable starter culture. After coagulum formation and heat and mechanical treatment, whey separates from the curd and is drained. The finished curd is then salted, pressed, and cured, after which the cheese is coated and wrapped. During this process two types of wastewaters may arise: whey, which can either be disposed of or used in the production of whey powder, and wastewater, which can result from a cheese rinse step used during the manufacturing of certain cheeses. Manufacturing and the pollution potential of different dairy products (Table 2.6).

Table 2.6: BOD and COD Values for Typical Dairy Products and Domestic Sewage factory (from factory record)

Product	BOD5 (mg/L)	COD (mg/L)
Whole milk	114,000	183,000
	110,000	190,000
	120,000	
	104,000	
Skim milk	90,000	147,000
	85,000	120,000
	70,000	
	67000	
Buttermilk	61,000	134,000
	75,000	110,000
	68,000	
Cream	400,000	750,000
	400,000	860,000
	400,000	
	399,000	
Evaporated milk	271,000	378,000
	208,000	
Whey	42,000	65,000
	45,000	80,000
	40,000	
	34,000	
Ice cream	292,000	

2.2.3 Butter:

Cream is the main raw material for manufacturing butter. During the churning process it separates into butter and buttermilk. The drained buttermilk can be powdered, cooled, and packed for distribution, or discharged as wastewater.

2.3 Evaporated Milk:

The milk is first standardized in terms of fat and dry solids content after which it is pasteurized, concentrated in an evaporator, and homogenized, then packaged, sterilized, and cooled for storage. In the production of sweetened condensed milk, sugar is added in the evaporation stage and the product is cooled.

2.4 Ice Cream:

Raw materials such as water, cream, butter, milk, and whey powders are mixed, homogenized, pasteurized, and transferred to a vat for ageing, after which flavorings, colorings, and fruit are added prior to freezing. During primary freezing the mixture is partially frozen and air is incorporated to obtain the required texture. Containers are then filled and frozen.

Table 2.1 Reported BOD and COD Values for Typical Dairy Products and Domestic Sewage Product BOD5 (mg/L) COD (mg/L) personal communications.

2.5 Yogurt:

Milk used for yogurt production is standardized in terms of fat content and fortified with milk solids. Sugar and stabilizers are added and the mixture is then heated to 608C, homogenized, and heated again to about 958C for 3–5 minutes [9]. It is then cooled to 30–458C and inoculated with a starter culture. For set yogurts, the milk base is packed directly and the retail containers are incubated for the desired period, after which they are cooled and dispatched. For stirred yogurts, the milk base is incubated in bulk after which it is cooled and packaged, and then distributed.

2.6 Wastewater from Associated Processes:

Most of the water consumed in a dairy processing plant is used in associated processes such as the cleaning and washing of floors, bottles, crates, and vehicles, and the cleaning-in-place (CIP) of factory equipment and tanks as well as the inside of tankers. Most CIP systems consist of three stages

a prerinse step to remove any loose raw material or product remains, a hot caustic wash to clean equipment surfaces, and a cold final rinse to remove any remaining traces of caustic.

2.7 CHARACTERISTICS AND SOURCES OF WASTEWATER FROM DAIRY PROCESSING:

The volume, concentration, and composition of the effluents arising in a dairy plant are dependent on the type of product being processed, the production program, operating methods, design of the processing plant, the degree of water management being applied, and, subsequently, the amount of water being conserved. Dairy wastewater may be divided into three major categories:

1. Processing waters, which include water used in the cooling and heating processes. These effluents are normally free of pollutants and can with minimum treatment be reused or just discharged into the storm water system generally used for rain runoff water.
2. Cleaning wastewaters emanate mainly from the cleaning of equipment that has been in contact with milk or milk products, spillage of milk and milk products, whey, pressings and brines, CIP cleaning options, and waters resulting from equipment malfunctions and even operational errors. This wastewater stream may contain anything from milk, cheese, whey, cream, separator and clarifier dairy waters [10], to dilute yogurt, starter culture, and dilute fruit and stabilizing compounds [9].
3. Sanitary wastewater, which is normally piped directly to a sewage works.

Dairy cleaning waters may also contain a variety of sterilizing agents and various acid and alkaline detergents. Thus, the pH of the wastewaters can vary significantly depending on the cleaning strategy employed. The most commonly used CIP chemicals are caustic soda, nitric acid, phosphoric acid, and sodium hypochloride [10]; these all have a significant impact on wastewater pH. Other concerns related to CIP and sanitizing strategies include the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) contributions (normally ,10% of total BOD concentration in plant wastewater), phosphorus contribution resulting from the use of phosphoric acid and other phosphorus-containing detergents, high water volume usage for cleaning and sanitizing (as high as 30% of total water discharge), as well as general concerns regarding the impact of detergent biodegradability and toxicity on the specific waste treatment facility and the environment in general [11].

Treatment of Dairy Processing Wastewaters fig(fig (2.6),(2.7)and fig(2.8):

Dairy industry wastewaters are generally produced in an intermittent way; thus the flow and characteristics of effluents could differ between factories depending on the kind of products produced and the methods of operation [12]. This also influences the choice of the wastewater treatment option, as specific biological systems have difficulties dealing with wastewater of varying organic loads.

Published information on the chemical composition of dairy wastewater is scarce [10]. BOD content 250 times greater than that of sewage It can, therefore, be expected that dairy wastewaters will have relatively high organic loads, with the main contributors being lactose, fats, and proteins (mainly casein), as well as high levels of nitrogen and phosphorus that are largely associated with milk proteins The COD and BOD for whey have, for instance, been established to be between

35,000–68,000 mg/L and 30,000–60,000 mg/L, respectively, with lactose being responsible for 90% of the COD and BOD contribution.

Treatment of Dairy Processing Wastewaters

Efficient of performance Biological treatment system depend on the pH adjustment and control flow incoming can be achieved by keeping effluent in an equalization or balancing tank for at least 6–12 hours [7]. During this time, residual oxidants can react completely with solid particles, neutralizing cleaning solutions. The stabilized effluent can then be treated using a variety of different options.

According to the IDF balance tanks should be adequately mixed to obtain proper blending of the contents and to prevent solids from settling. This is usually achieved by the use of mechanical aerators. Another critical factor is the size of the balance tank. This should be accurately determined so that it can effectively handle a dairy factory's daily flow pattern at peak season. It is also recommended that a balancing tank should be large enough to allow a few hours extra capacity to handle unforeseen peak loads and not discharge shock loads to public sewers or onsite biological treatment plants.

2.8 TREATMENT MANAGEMENT OPTIONS OF WASTEWATER:

The highly variable nature of dairy wastewaters in terms of volumes and flow rates (which is dependent on the factory size and operation shifts) and in characteristics IN terms of pH and suspended solids (SS) content (mainly the result of the choice of cleaning strategy employed) makes the choice of an effective wastewater treatment regime difficult. Because dairy wastewaters are highly biodegradable, they can be effectively treated with biological wastewater treatment systems, but can also pose a potential environmental hazard if not treated properly. The three main options for the dairy industry are:

A: Discharge to and subsequent treatment of factory wastewater at a nearby sewage treatment plant.

B: Removal of semisolid and special wastes from the site by waste disposal contractors.

C: The treatment of factory wastewater in an onsite wastewater treatment plant. The first two options are continuously impacted by increasing costs, while the control of allowable levels of SS, BOD, and COD in discharged wastewaters are also becoming more stringent. As a result, an increasing number of dairy industries must consider the third option of treating industrial waste onsite. It should be remembered, however, that the treatment chosen should meet the required demands (laws and regulation) and reduce costs associated with long-term industrial wastewater discharge.

2.8.1 Direct Discharge to a Sewage Treatment Works:

Municipal sewage treatment facilities are capable of treating a certain quantity of organic substances and should be able to deal with certain peak loads. However,

certain components found in dairy waste streams may present problems. One such substance is fat, which adheres to the walls of the main system and causes sedimentation problems in the sedimentation tanks. Some form of onsite pretreatment is, therefore, advisable to minimize the fat content of the industrial wastewater that can be mixed with the sanitary wastewater going to the sewage
Treatment facility [6]. Dairy industries are usually subjected to discharge regulations, but these regulations differ significantly depending on discharge practices and capacities of municipal sewage treatment facilities. Sewer charges are based on wastewater flow rate, BOD5 mass, SS, and total discharged per day [10]. Some municipal treatment facilities may demand treatment of high strength
industrial effluents to dilute the BOD load of the water so that it is comparable to that of domestic sewage [7].Treatment of Dairy Processing Wastewaters Some of the more recent information available is summarized in Tables.2.6 Milk has a In a recent survey conducted [10] at 14 milk processing plants in Minnesota, Wisconsin, and South Dakota, it was reported that four facilities directed both their mixed sanitary and industrial wastewater directly to a municipal treatment system, while the rest employed some form of wastewater treatment. Five of the plants that treated their wastewater onsite did not separate their sanitary wastewater from their processing wastewater, which presents a major concern when it comes to the final disposal of the generated sludge after the wastewater treatment, since the sludge may contain pathogenic microorganisms [10]. It would thus be advisable for factories that employ onsite treatment to separate the sanitary and processing wastewaters, and dispose of the sanitary wastewater by piping directly to a sewage treatment facility.

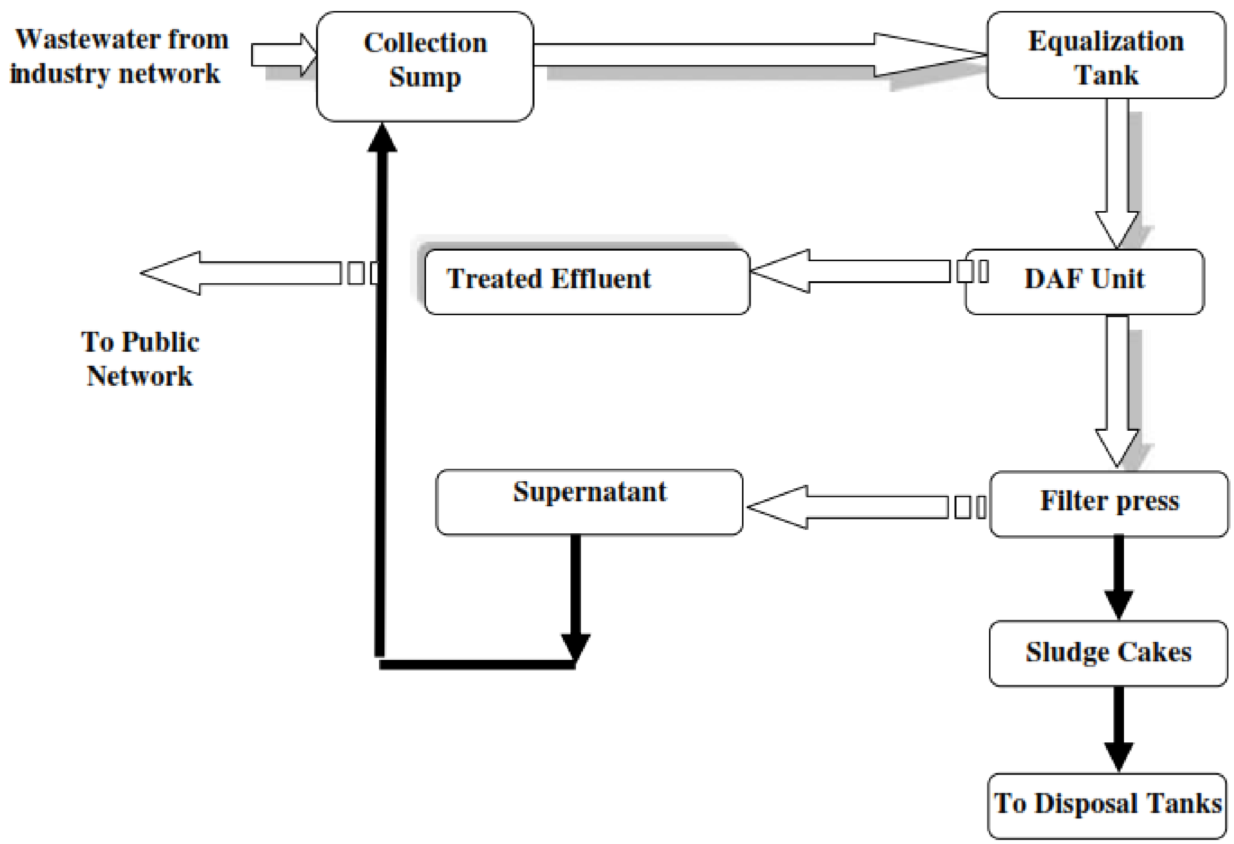

Fig (2.6): Dissolved Air Floatation

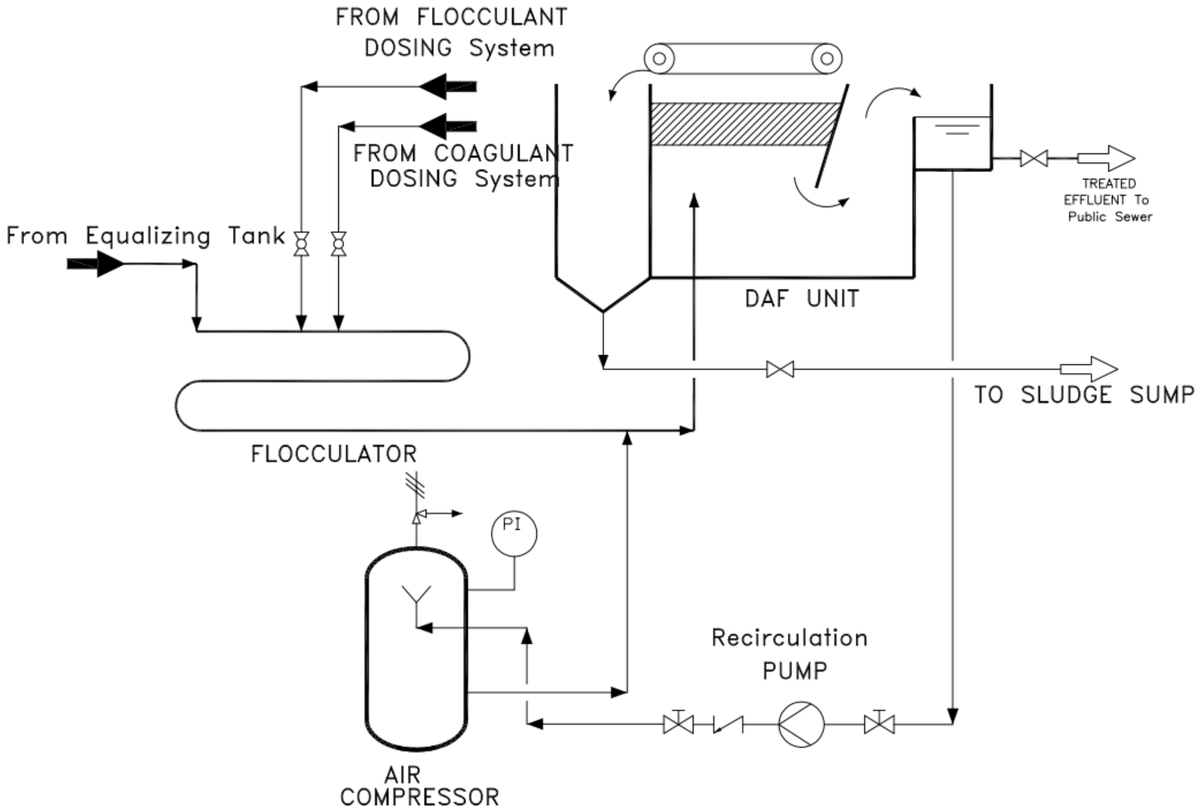

Fig (2.7): The Treatment Process option one

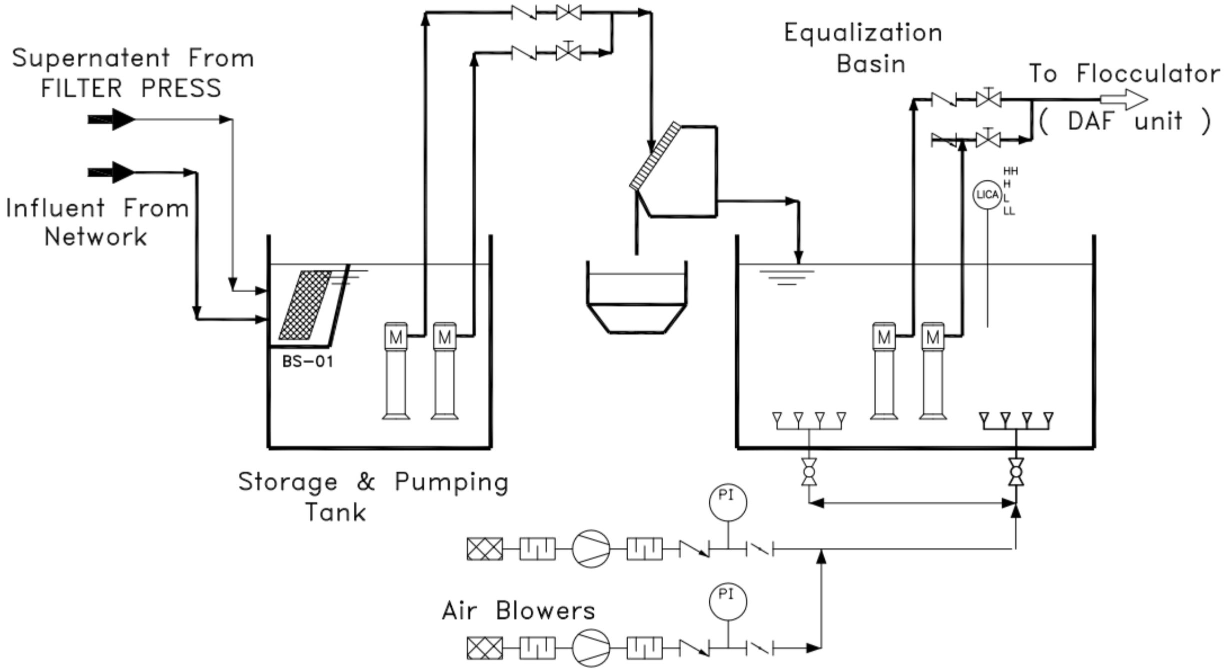

Fig (2.8): The Treatment Process option two

Table 2.7 Chemical Characteristics of Different Dairy Plant Wastewaters

Industry	BOD5 (mg/L)	COD (mg/L)	pH	FOG (g/L)	TS (mg/L)	TSS (mg/L)	Alkalinity (mg/L as CaCO3)
Cheese							
14 Cheese/whey plants	565–5722	785–7619	6.2–11.3	-	837–14,205	326–3560	225–1550
Cheese/whey plant	377–2214	189–6219	5.2	-	-	188–2330	-
Cheese factory	-	5340	5.22	-	4210	-	335
Cheese factory	-	2830	4.99	-		-	-
Cheese processing industry	-	63,300	3.38	2.6	53,200	12,500	-
Cheese/casein product plant	-	5380	6.5	0.32	-	-	-
Cheese/casein product plant	8000	-	4.5–6.0	0.4	-	-	-
Milk							
Milk processing plant	-	713–1410	7.1–8.1	-	900–1470	360–920	-
Milk/yogurt plant		4656	6.92		2750		546
Milk/cream bottling plant	1200–4000	2000–6000	8–11	3–5	-	350–1000	150–300
Butter/milk powder							
Butter/milk powder plant	-	1908	5.8	-	1720	-	532
Butter/milk powder plant	1500	-	10–11	0.4	-	-	-
Butter/Comte´cheese plant	1250	2520	5–7	-	-	-	-
Whey							
Whey wastewater	35,000	-	4.6	0.8	-	-	-
Raw cheese whey		68,814	-	-	3190	1300	-

2.8.2 Onsite Pretreatment Options:

- **Physical Screening:**

The main purpose of screens in wastewater treatment is to remove large particles or debris that may cause damage to pumps and downstream clogging. It is also recommended that the physical screening of dairy wastewater should be carried out as quickly as possible to prevent a further increase in the COD concentration as a result of the solid solubilization [7] recommended the use of a wire screen and grit chamber with a screen aperture size of 9.5 mm, while Hemming recommended the use of even finer spaced mechanically brushed or inclined screens of 40 mesh (about 0.39 mm) for solids reduction. According to certain precautionary measures should be taken to prevent the settling of coarse matter in the wastewater before it is screened. These requirements include the ratio of depth to width of the approach channel to the screen, which should be 1: 2, as well as the velocity of the water, which should not be less than 0.6 m/sec. Screens can be cleaned either manually or mechanically and the screened material disposed of at a landfill site.

- **pH Control.**

This may be directly attributed to the different cleaning strategies employed. Alkaline detergents generally used for the saponification of lipids and the effective removal of proteinacous substances would typically have a pH of 10–14, while a pH of 1.5–6.0 can be encountered with acidic cleaners used for the removal of mineral deposits and acid-based sanitizers [11]. Theoptimum pH range for biological treatment plants is between 6.5 and 8.5. Extreme pH values can be highly detrimental to any biological treatment facility, not only for the negative effect that it will have on the microbial community, but also due to the increased corrosion of pipes that will occur at pH values below 6.5 and above 10 [6]. Therefore, some form of pH adjustment as a pretreatment step is strongly advised before wastewater containing cleaning agents is discharged to the drain or further treated onsite. In most cases, flow balancing and pH adjustment are performed in the same balancing tank. According to the International Dairy Federation (IDF) a near-neutral pH is usually obtained when water used in different production processes is combined. If pH correction needs to be carried out in the balancing tank, the most commonly used chemicals are H2SO4, HNO3, NaOH, CO2, or lime Flow and Composition Balancing Because discharged dairy wastewaters can vary greatly with respect to volume, strength, temperature, pH, and nutrient levels, flow and composition balancing is a prime requirement.

As shown in Table 2.7, large variations exist in wastewater pH from different dairy factories.

- **Fats, Oil, and Grease Removal**

The presence of fats, oil, and grease (FOG) in dairy processing wastewater can cause all kinds of problems in biological wastewater treatment systems onsite and in public sewage treatment facilities. It is, therefore, essential to reduce, if not remove FOG completely, prior to further treatment. According to the IDF, factories processing whole milk, such as milk separation plants as well as cheese and butter plants, whey separation factories, and milk bottling plants, experience the most severe problems with FOG. The processing of skim milk seldom presents Problems in this respect.

As previously mentioned, flow balancing is recommended for dairy processing plants. An important issue, however, is whether the FOG treatment unit should be positioned before or after the balancing tank. If the balancing tank is placed before the FOG unit, large fat globules can accumulate in the tank as the discharged effluent cools down and suspended fats aggregate during the retention period. If the balancing tank is placed after the FOG removal unit, the unit should be large enough to accommodate the maximum anticipated flow from the factory.

According to the IDF it is generally accepted that flow balancing should precede FOG removal.

General FOG removal systems include the following:

Gravity Traps. In this extremely effective, self-operating, and easily constructed system, wastewater flows through a series of cells, and the FOG mass, which usually floats on top, is removed by retention within the cells. Drawbacks include frequent monitoring and cleaning to prevent FOG buildup, and decreased removal efficiency at pH values above eight. Air Flotation and Dissolved Air Flotation. Mechanical removal of FOG with dissolved air flotation (DAF) involves aerating a fraction of recycled wastewater at a pressure of about 400–600 kPa in a pressure chamber, then introducing it into a flotation tank containing untreated dairy processing wastewater. The dissolved air is converted to minute air bubbles under the normal atmospheric pressure in the tank [6]. Heavy solids form sediment while the air bubbles attach to the fat particles and the remaining suspended matter as they are passed through the effluent [6,9]. The resulting scum is removed and will become odorous if stored in an open tank. It is an unstable waste material that should preferably not be mixed with sludge from biological and chemical treatment processes since it is very difficult to dewater. FOG waste should be removed and disposed of according to approved methods. DAF components require regular maintenance and the running costs are usually fairly high. Air flotation is a more economical variation of DAF. Air bubbles are introduced directly into the flotation tank containing the untreated wastewater, by means of a cavitation aerator coupled to a revolving impeller. A variety of different patented air flotation systems are available on the market and have been reviewed by the IDF. These include the "Hydro float," the "Robosep," vacuum flotation, electro flotation, and the "Zeda" systems.

Air flotation has been used for many years in the beneficiation of ores. Its first application in the wastewater-treatment field was in the flotation of suspended solids (SS), fibers, and other low-density solids (2, 3). Flotation also is used for the thickening of activated sludge (4) and flocculated chemical sludges. More recently, air flotation has been applied to the removal of oils and greases from wastewater because it is a practical, reliable, and efficient treatment process (5–8).

Air flotation is widely used to treat wastes from a wide variety of sources: paper making, refineries, ship's bilge and ballast waste, deinking operations, metal plating, meat processing, laundries, iron and steel plants, soap manufacturing, chemical processing and manufacturing plants, barrel and drum cleaning, wash rack and equipment maintenance, glass plants, soybean processing, mill waste, and aluminum forming. The process of flotation consists of four basic steps (9, 10):

1. Bubble generation in the wastewater
2. Contact between the gas bubble and the particle or oil droplet suspended in the water
3. Attachment of the particle or oil droplet to the gas bubble
4. Rise of the air/solids combination to the surface where the floated material are skimmed off Flotation utilizes the differential density between the bubbles to which the small solid particles and oil droplets become attached, and the water, to effect separation. Since the agglomerates have a lower density than the medium in which they are immersed, they rise to the surface where they are removed.

There are essentially five different types of flotation systems, their classification being based on the method of bubble formation:

1. Dissolved air. The gas is released from a supersaturated solution as a result of the reduction of pressure (11–14).
2. Induced (dispersed) air. The gas and liquid are mechanically mixed to induce bubble formation in the liquid (15, 16).
3. Froth. The gas is directly injected into the fluid by means of a sparger (17).
4. Electrolytic. The bubbles are generated by electrolysis of the water.
5. Vacuum. The air is released from a saturated solution by a negative pressure.

Only the first four are utilized industrially to any extent for wastewater treatment.

The two major commercial types of gas flotation systems currently used industrially are (1) dispersed or induced gas (normally air) flotation (IAF) in which air bubbles are introduced into the waste stream mechanically using high-speed impellers, or by a venturi nozzle, in which bubbles are formed at the throat of the nozzle, and (2) dissolved gas (air) flotation (DAF) in which air is dissolved in the wastewater under pressure and comes out of solution when the pressure is released.

As a result of this pressurization–depressurization, very small gas bubbles are formed and rise to the surface with oil and SS attached.

Froth flotation is not commercially utilized because high concentrations of surfactants are needed to enhance the separation. It is also very difficult to separate the surfactant from the water.

The older process of vacuum flotation is described in the following stepwise manner:

1. Preaeration to saturate the wastewater at atmospheric pressure
2. Release of large bubbles
3. Application of vacuum to the wastewater

Depending on the vacuum applied, the air bubbles have sizes approximating those in DAF systems; however, the desorption process may require more energy than conventional DAF. Even within a plant, industrial wastewaters fluctuate in quality and quantity with time depending on the process and production cycle. Most water treatment processes are sensitive to changes in flow rate, contaminant concentration, pH, and temperature. The fluctuations in these parameters can be reduced by equalization, which may be the single most important pretreatment feature in a wastewater-treatment facility.

have demonstrated the need for smoothing out the variations in flow and concentration as well as the need for removal of free oil. Installing an equalization tank reduced fluctuations in loading and allowed operation at a constant polymer dosage.

2. THEORY OF FLOTATION

Separation of particles by flotation adheres to the same laws as sedimentation but in a "reverse field of force." The governing equation in air flotation separation, as in all gravity controlled processes, is Stoke's Law (at least in laminar flow), which is used to compute the rise rate of bubble flocs, agglomerates, and bubble-oil aggregation (2, 11):

$$\mathbf{Vt} = \frac{gd(\rho-\rho)}{18\mu} \longrightarrow \mathbf{(1)}$$

where Vt is the terminal rise velocity of the agglomerate, cm/s; g is the gravitational constant, 980 cm/s2; D is the effective diameter of the agglomerate, cm;

ρ = is the density .

The key to an increase in rise rate of bubble/solid or bubble/oil agglomerates over the rise in unaerated systems is a reduction in the effective density of the oil (or solid) particle (or agglomerate) that is accomplished by the attachment or encapsulation of an air bubble onto or into flocs, bubbles, or solid particles. process follows these steps (11):

1. Introduction of gas bubbles into the wastewater
2. Collision between the gas bubble and suspended matter (suspended particulates as well as oil droplets)
3. Attachment of fine bubbles to the surface of the suspended matter
4. Collision between gas-attached suspended particles with the formation of agglomerates.
5. Entrapment of more gas bubbles in the agglomerates
6. Upward rise of floc structures in a sweeping action, which is termed “sweep flocculation” Key design variables in the system controlling efficiency of removal are (2, 9, 11,) as follows:

1. Gas input rate and volume of gas entrained per unit volume of liquid
2. Bubble-size distribution and degree of dispersion
3. Surface properties of the suspended matter
4. Hydraulic design of the flotation chamber
5. Concentration and type of dissolved materials
6. Concentration and type of suspended matter and oils
7. Chemicals added
8. Temperature
9. Residence time
10. Recycle ratio
11. pH

However, there is still much that is unknown about parameters and rate-controlling mechanisms concluded that the performance of DAF systems (in the concentration of suspended solids) cannot be reliably predicted from conventional design parameters based on hydraulic loadings, solids loadings, and amount of air available. It is recommended to test the actual wastewater to be treated on a pilot-scale before embarking on the design of a full-scale DAF unit (2, 9, 11).

2.1. Gas Solubility

The key to DAF is the dissolution of air (or other suitable gas) under pressure and the reduction of this pressure to form bubbles. The amount of gas going into solution generally obeys Henry’s Law:

p ¼ kC; (2)

where p is the partial pressure of the gas, C is the concentration of the gas dissolved in the solution, and k is the Henry’s Law constant.

Thus, the amount of gas dissolved in solution and consequently the amount of gas released upon reduction of the pressure are both direct functions of the initial air pressure. The solubility of gases is also a function of temperature and dissolved solids concentration

(Tables 2.6 and 2.7). The solubility of air in distilled water, for example, is reduced 45% as the temperature is raised from 0 to 30_C. Also, the solubility of oxygen decreases 19% as its salinity increases from 0 to 20,000 mg/L. Following pressurization, the water proceeds from the saturator, through the pressure-reducing valve, into the flotation basin; there the bubbles will first nucleate on any available low-energy sites on solid particles. If no sites are available, bubbles will nucleate homogeneously in the liquid phase .The bubbles will then grow until their growth is diffusion limited.

Chapter Three

Chapter Three

MATERIALS AND METHODS

3.1 The study area:

Khartoum North city is located on the north bank of the blue Nile and the east bank of the River Nile, near the confluence of the Blue Nile with the White Nile, and bridges connect it with both.

It has a population of 1012211 at the last Sudanese census in 2008.

Two food processing factories were chosen as study cases. Case one CAPO and case two EL Mosharf.

Case study number one: CAPO Milk factory Dal group Khartoum north industrial area.

CAPO is Sudan favorite dairy brand producing a wide range of tasty and nutritious products, such as yoghurt, fresh milk and long life milk, cream, and mish. We believe that food derived from natural sources is fresher and of more nutrients.

CAPO has been a pioneer in the diary sector, producing the first ever packed yoghourt in the country, following that with a series of first in fresh milk pro-biotic yoghurt and low fat yoghurt. CAPO is striving to lead the market and bring new exciting experiences to Sudanese consumer.

In September 2010, moved into new world – class manufacturing facilities which includes state of the art processing equipment which will allow sustaining and enhancing their reputation as the leading dairy brand in the Sudan.

In 2011 CAPO look forward to maintaining the standard have made them famous and introducing some exciting new products to please and surprise their valued customers.

Industries food production.

501 – 1000 employees.

Headquarter Khartoum North

Type privately wonted forward.

Founded, 1997.

Specialties, dairy products.

Location: NO 15, block 4, east industrial area Khartoum north sudan

Case study number two: El mosharf sweets factory Khartoum north industrial area.

El mosharf sweets factory in Khartoum north, block 8, Khartoum north industrial area.

Products to day biscuitis and tahnia sweets.

Founded in 1986as part of Kambal group in Khartoum north specializing in sweets and biscuits, production starting in 1992 to produce tahnia sweet 600 ton / month used old traditions lines and biscuit capacity of 6 gram of 200000 per month packages.

In 2000 ELmosharf company has introduced new technology in the production lines and sales points.

In 2006 additional el mosharf Amdro part of el mosharf company under brand sweets lights. Adding new 3 lines.

In 2015 started kambal muliti activities rehabilitation production lines, machines, building…etc.

Turkey technologies were introduced in new lines.

In 2017 new products and high quality products and trucks with different loads (3-15 tons).were introduced.

3.2 **Materials**:- samples were taken for BOD, COD, pH, TSS.

3.3. Methodology:

Because of the great variation in the quality and quantity of wastewater produced, a continuous monitoring program was carried out to identify the quality and quantity of wastewater discharged. Samples were taken from the process and end-of-pipe industrial wastewater and from other points of industrial wastewaters discharged during the process activities to perform a preliminary assessment of the environmental status of the facility. To achieve the stated objectives, the study is conducted following some steps and approaches as evaluate the current environmental conditions in the production and service units to determine the industry required to upgrade these units in order to reduce pollution load in the final effluent, data collection including the collection of information relevant to the different activities in the industry including qualitative and quantitative estimation of solid and liquid wastes, collecting composite wastewater samples from the end-of-pipe industrial effluent (the samples were analyzed by specialized laboratory(Electricity laboratory) and the results are used for selection of the most appropriate alternative schemes), check on the compliance with national environmental regulation and legislation and description of the existing environmental situation in the industry.

3.3.1 Primary data:-

Formal and informal interviews were conducted with officials involved in the system. Interviews were made with Factories site operators and engineers.

The engineers given data about water consumption for production lines and operators were gave data of treble shooting and solutions for it

3.3.2 Observation:

Data on the various aspects of the industrial waste management system were collected in order to analyze the system performance. Such data and information cover point of pollution, grab samples collected because the pollution was point source, collected samples in last manholes to assess the degree of pollution in the disposal site. The determination of BOD is used to measure the self-purification capacity of mixed and serves regulatory authorities as a means of checking on the quality of effluents discharged to main sable sewer.

3.3.3 Analysis of samples:

Samples were analysis to determine chemical oxygen demand for Water and Wastewater, Biological oxygen demand and total suspended solids. Test procedure is in accordance with IS: 3025 (Part 44) -Reaffirmed 2003.In addition to the Indian Standards, and the procedures Stated in:

(1) APHA Standard Methods for the Examination of Water and Wastewater – 20th Edition. Method 5210 B.

(2) Methods for Chemical Analysis of Water and Wastes, EPA - 600/4 – 79 - 020, USEPA, Method 405.1. The determination of the BOD of wastes is useful in the design of treatment facilities. It is the only parameter, that give an idea of the biodegradability of sample and self-purification capacity of rivers and streams. The BOD test is among the most important method in sanitary analysis to determine the polluting power, or strength of sewage, industrial wastes or polluted water. It serves as a measure of the amount of clean diluting water required for the successful disposal of sewage by dilution.

Table:3.1 Results of samples were taken for manhole CAPO

Parameter	Units	Results	Remark
pH		6.89	
TSS	Mg/l	1000	
BOD	Mg/l	4500	
COD	Mg/l	5650	
OIL and grease		150.100	

3.4 Materials And Methods for case study two

There are two wastewater drainage networks and two end-of-pipe discharge points in the industry (collected in two manhole) one for industrial wastewater and the other for the domestic wastewater. The industrial wastewater end-of pipe discharge points include wastewater discharges from cleaning of equipment and production units, boiler blowdown, and the chiller open cycle discharged water, they all discharge at one manhole within the premises of the plant. The domestic wastewater discharge points include wastewater discharges from the wastewater generated from the washing of equipment at the end of the shifts, and wastewater discharges from all domestic sources within the industry, including toilets, restaurant, irrigation, cleaning, etc.As for the domestic wastewater, it is mixed with the industrial wastewater outside the premises of the plant prior to its discharge to the public sewer system. Due to the great variation in the quality and quantity of wastewater produced, a continuous monitoring program was carried out to identify the quality and quantity of wastewater discharged. Samples were taken from the process and end-of-pipe industrial wastewater and other point of industrial wastewaters discharge during the process activities to perform a preliminary assessment of the environmental status of the facility. To achieve the required objectives, the study is conducted following some steps and approaches as evaluate the current environmental conditions in the production and service units to determine the industry required to upgrade these units in order to reduce pollution load in the final effluent, data collection including the collection of information relevant to the different activities in the industry including qualitative and quantitative estimation of solid and liquid wastes, collecting composite wastewater samples from the end-of-pipe industrial effluent (the samples were analyzed by specialized laboratory and the results are used for selection of the most appropriate alternative schemes), check on the compliance with national environmental regulation and legislation and description of the existing environmental situation in the industry, and studying the different approaches for pollution prevention and suggesting possible end-of-pipe treatment modules.

Water balance and Wastewater Discharge of the industry process:

The production process includes five operating production lines were chocolate cake line, three li

nes of different biscuits type, and ketchup line. The industry consumes about 150 m3/day for domestic water activities while the overall total wastewater production equal 120 m3/day and 70 m3/day for domestic wastewater and industrial wastewater respectively.There are two wastewater drainage networks and two end-of-pipe discharge points in the industry, one for industrial wastewater and the other for the domestic wastewater. The industrial wastewater end-of pipe discharge points include wastewater discharges from cleaning of equipment and production units, boiler blow down, and the chiller open cycle discharged water, they all discharge at one manhole within the premises of the plant. The domestic wastewater discharge points include wastewater discharges from the wastewater generated from the washing of equipment at the end of the shifts, and wastewater discharges from all domestic sources within the industry, including toilets, restaurant, irrigation, cleaning, etc. Based on the data provided by the plant on domestic water consumption the domestic wastewater flow rate is calculated assuming that 85% of the domestic water is discharged as wastewater. The following table illustrates the industrial wastewater discharges of the process.

Table 3.2: Industrial Wastewater Discharges of the Process

Wastewater Discharge Sources	**Wastewater discharge m3/day**
Washing of equipment and production units	**20**
Chiller water	**50**
Boiler blow down	**4**
Total	**74**

Table 3.3: **Domestic Water Consumptions and Discharges**

Domestic Water Consumption (m3)		
1st shift	2ndshift	3rd shift
60	50	40
Total :150 m3/day		
Domestic Wastewater discharge (m3)		
1st shift	2ndshift	3rd shift

50	40	30
Total 120 m3/day		

Sampling and characterization of wastewater The main objective of the analysis is to investigate the compliance of the wastewater with limits for discharge to the public sewer system, and in case of noncompliance identified and evaluate alternatives for management of the wastewater to reach compliance. For investigating the compliance of the discharged wastewater and identifying possible alternatives for its management, the sampling and analysis carried out for the wastewater in the industrywas conducted as composite samples and analysis of the compiled industrial wastewater for each of the three operating shifts as well as grab samples and analysis of the mixed industrial and domestic wastewater in each of the three operating shifts.In addition, filtrations of the samples were carried out and the BOD and COD were analyzed before and after filtration.The analyses were carried out according to the Standard Methods for Examination of Water and Wastewater **[17]** and covered Temperature, pH, Chemical and Biological Oxygen Demand (COD and BOD), Total Dissolved and suspended solids (TDS and TSS), settle-able solids, and Oil & Grease. Moreover, in order to investigate the effect of removing the suspended solids in the wastewater, through physical treatment, on the BOD and COD, filtration was carried out, and the BOD and COD were analyzed before and after filtration.

Chapter Four

ur

Res ıssion

4.1 Introduction:

This design calculation for CAPO dairy factory dal group is wastewater pretreatment plant. With estimated over all discharge of dairy processing wastewater for three shift, 5000 m^3/day .the wastewater flow is divided to different categories: dairy, processing, domestic and boiler/steam. The design adopted the Sequential flotation technology system instead of conventional activated sludge for the major advantages of the SBR such as the minimal footprint and potential capital cost savings by elimination of the load of sewer and the flexibility in operation and control. Indicates raw wastewater characteristics for the study area.

Table: 4.1 results of raw wastewater characteristics CAPO

parameter	units	Results	remark
pH		6.89	
TSS	Mg/l	800	
BOD	Mg/l	4500	
COD	Mg/l	5650	
OIL and grease		150.100	

The analysis the raw wastewater with compare with Khartoum local (1970) high BOD and COD, need pretreatment before the discharge wastewater in mainsable sewer, flow estimated by operators engineer greater than **5000 m^3/ day**

The pretreatment plant as follows:

4.2 DESIGN PHILOSOPHY

4.3 PROCESS DESIGN CALCULATIONS

4.4 EQUIPMENT SPECIFICATION

4.2 DESIGN PHILOSOPHY
SEWAGE TREATMENT PLANT – 5000 m^3/ day

4.2.1 Process Description

The raw sewage is normally conveyed via a trunk sewer and discharges freely into the raw sewage wet well ahead of the treatment plant. The working capacity of the wet well should be sufficient to contain any excess sewage during periods when the flow from the sewer exceeds the maximum design flow to the sewage treatment plant. The volume of the wet well is expected to be small since the already existing tanks can be used for storage. The air blowers will aerate this wet well and it will incorporate an odour control unit. The unit comprises a dosing pump and a chemical dosing tank.

Level switches actuate submersible sewage pumps in the wet well and pumps lift the sewage to the Extended Aeration Plant, which is located above ground.

The pumped flow of raw sewage arrives at the Extended Aeration Plant through the bar screen arrangement which holds debris that otherwise may cause blockages. The screen requires to be manually raked periodically for cleaning if necessary. The Bar Screen is installed in the Bar Screen Box.

The screened sewage discharges into the aeration chamber where it is mixed with recycled activated sludge (a mixture of natural aerobic microorganisms). For the purification to proceed, the mixture must be agitated to prevent settlement and aerated to supply oxygen for the respiration of the microorganisms. Both agitation and oxygen supply are provided by the air blowers.

The microorganisms remove the organic material from the sewage and multiply to greater numbers. This increase in number of microorganisms results in excess activated sludge, which requires occasional disposal. The frequency and volume of sludge wastage is best determined from individual plant operation.

In general, it can be assumed that 0.5 to 1.0 kg (from tables of extended aeration) of sludge will be wasted for every 1.0 kg of BOD removed by the plant. A sludge concentration of 0.5 to 1.0% is usual for wastage of excess sludge.

When the biological reaction is complete, the mixed liquor flows to the settlement chamber where the velocity is reduced in a diffusion drum and the activated sludge separated from the secondary effluent during a period of quiescent settlement. The secondary effluent discharges from the plant via an overflow weir, and part of the settled sludge is pumped back to the aeration chamber to treat more sewage, where the surplus is wasted.

The overflow of secondary effluent from the extended aeration plant discharges into the Chlorine Contact/Break Tank where it meets a controlled dose of sodium hypochlorite solution. The sodium hypochlorite solution is drawn from the hypochlorite storage tank by hypochlorite dosing pump of adjustable delivery rate.

Level switches in the Chlorine Contact Tank actuate Filter Feed Pumps, which deliver the disinfected secondary effluent to the Tertiary Filters through graded sand media. The tertiary effluent from the filters passes on to the treated effluent tank.

As solids accumulate in the sand bed the pressure loss through the media rises and periodically reaches a value above which the plant will not function as designed. At this time, the filter requires to be washed and cleaned from the accumulated solids. The media is backwashed by a controlled flow of tertiary effluent delivered from the client's treated effluent tank by the filter feed pumps. The backwash water passes up through the sand media, flushing out the accumulated solids and the resulting spent backwash water is returned to the wet well. Backwashing is manually controlled.

The wasted sludge from the settlement tank will be collected in a sludge-holding tank in which further digestion of the sludge takes place by means of air supplied by the same air blowers used for aeration. The client's tankers will then dispose the sludge off-site.

4.2.2 Design Data

The present data is for a Sewage Treatment Plant having 5000 m^3/day average daily flow. The treatment plant is designed for sewage purification and utilities the extended aeration modification of the activated sludge process.

Average sewage flow = 5000 m^3/day

Peak flow = 1000 m^3/h (for up to 3 hr period)

Influent quality = 350 mg/l BOD_5, but expected less

400 mg/l S.S., but expected less

Average secondary effluent quality (con) = 20 mg/l BOD, 30 mg/l S.S.

Average tertiary effluent quality = 10 mg/l BOD_5

10 mg/l S.S., better than required

4.2.3 STP Treatment Units Considered

The Sewage Treatment Plant Units comprise the following:

One (1) Odor control dosing system.

Three (3) Lift station pumps.

One (1) Bar screen.

One (1) Aeration tank.

One (1) Lot of air diffusers (in aeration tank).

Two (2) Air blowers.

One (1) Settlement tank.

One (1) Sludge air lift system.

One (1) Sludge scraper.

One (1) Work bridge for aeration tank.

One (1) Chlorine contact tank.

One (1) Disinfection dosing system.

One (1) Sludge holding tank.

One (1) of air diffusers (in sludge holding tank).

One (1) Work bridge (for sludge holding tank).

Two (2) Filter feed / backwash pumps.

One (1) Manual pressure sand filter.

One (1) Lot of electrical items.

One (1) Lot of interconnecting pipe work.

4.3 PROCESS DESIDGN CALCULATIONS

4.3.1 Design Data

Average daily flow (Qav) = 500 (m3/d)

S inf. = 500 mg/l (Influent soluble BOD concentration, mg/l)

S eff. = 20 mg/*1* (Effluent soluble BOD concentration, mg/1)

SS inf. = 360 mg/l (Influent suspended Solids concentration, mg/l)

SS eff. = 12 rng/1 (Effluent suspended Solids concentration, mg/1)

N2 inf. = 15 mg/I (Influent Nitrogen concentration, mg/I)

N2 eff. = 2.0 mg/*1* (Effluent Nitrogen concentration, mg/l)

Qav = 500 m^3/d Design daily flow.

Qav = 208.33 m3/h.

Qdesign = 208.33 m^3/h.

Qpeak = 2* q = 1000 m^3/h Design Hourly Flow m^3/h.

Design BOD load =124 (kg/d)

Design SS Load =144 (kg/d)

4.3.2 Lift Station

Pumps Quantity = 3 Nos (1duty, 1 assist, l standby)

Pump Capacity = 1000 m^3 */h* each

Max pumped out flow = 100 m^3*/h*

Hydraulic retention time = 1 hr

@ peak flow rate

Tank capacity = 1000 m^3

4.3.3 Manual Bar Screen:

Q design = 1000 m^3/h (0.0115 m^3/s)

Vsc = 0.8 m/sec

A opening = 0.0175m^2

Angle of inclination of screen = 60°

LD in screen = 200 mm

Total width of openings = (0.0115 m^3/sec) /(0.8 m/sec) x (sin 60) /(0.15 m)

= 0.1 m

Let no of bars = N+1

No of openings = N

Width of opening = 25 mm

25(N+1) = 100 mm

N=3

Width of channel = 25 x 4 + 5 x 3

= 115 mm

Provide channel width = 500 mm
liquid depth through bar screen = 0.29 m @ Vsc = 0.8 (m/s)

Provide channel size= 1200L mm x 500mmW x500mmH

4.3.4 Aeration Tank

Average Daily Flow = 5000 m^3/d

BOD5 = 500 mg/l

BOD5 Load = (500 x 5000 / 1000)

= 2500 (kg/day)

Consider:

MLSS mg/l = 3500 mg/l - Mixed liquor suspended solids

ML VSS = 3000 mg/I - Mixed liquor volatile suspended solids

Volume of aeration tank required = BOD5 (Kg/d) / (F/M x MLVSS)

F /M range (0.05 – 0.15) for extended aeration

Consider F/M = 0.12

Consider MLVSS = 3000 (mg/l)

Volume of tank = 2500/(0.12 x 3.0) = 6944.44 m^3

Consider Liquid Depth = 3.75 m

Surface Area = 6944.44/3.75 = 1851. 85 m^2

Retention Time = 6944.44/208.33 = 33.33 hours

4.3.5 Secondary Clarifier

Average Flow = 208.33 m^3/h

Surface overflow rate = (12 $m^3/m^2/$ d) at average flow

= 0.5 m^3/m^2 hr

Required surface area =Average flow/surface overflow rate

= 208.33/0.5

= 416.66m^2

Required Diameter = 23.0 m

Provided Diameter = 23.5 m

Provided Area = 433.52 m^2

Liquid Depth = 3.7m

Effective Volume = 1604m³

Retention Time = 1604 /208.33 = 7.699 hours

Provided Tank Size = $A = \pi D^2/4$ **23.5 X 4.273 m H**

Total concentric Tank Surface = 36.65 +91.9= 128.55 m²

Area

Required Concentric Tank Dia = 12.794 m

Provided Diameter = 12.808 m

Provided Tank Size = 12.808 m X 4.273 m H

Check:

A. Aeration Tank

Volume Loading = BOD Load /Volume

= 310 x 5000/1000 / **6944.44**

= 0.3600 Kg BOD/ m^3/d OK this is within (0.1-0.4) Kg/ m^3/d

Hydraulic Retention time = Volume/ Average Flow

= 6944.44/208.33 = 33.33 hrs Ok this is within the range 18 - 36 hrs

B. Settling Tank

Hydraulic Retention time

= 1604.033/ 208.33 = 7.6 hrs Ok this is within the range 6 – 7.5 hrs

4.3.6 Chlorine Contact Tank

Volume of chlorine contact tank= Average flow x retention time

Retention time in chlorine contact tank = 3 h

Volume = 208.33x 3

= 624.99 m^3

Liquid depth in chlorine contact tank = 2.4 (m)

Provided Diameter = 5.152m

Provided Tank Size = 5.152m Dia X 2.873m H

4.3.7 Chlorination

4.3.7.1 Dosing Pump Capacity

Sodium Hypochlorite NaOCI

p = 1.14 kg/l Chemical Density

C = 10% Chemical Concentration

X = 10 mg/1 Chemical Dosing rate

Qd = Q x X / 1000 x P x C

Qd = 208.4 m^3/h

Qd = 208.33 m^3/h x 10 g/m^3 = 2083.3 kg/h

= 2083.3 kg/h I (0.1 x1.14 kg/l) /1000

= 0.23 1ph

Provide dosing pump with capacity 0 - 3.78 litres / hr

4.3.7.2 Dosing Tank Capacity

- Required storage capacity = 2 days
- Daily Required Quantity = 182 liters

Provide tank capacity of 190 litres

4.3.8 Sludge Holding Tank

- consider 0.50 kg sludge produced per 1 kg of BOD Load
- BOD Load= 2500 kg
- Sludge mass= 0.50 x 2500 = 1250 kg/d, Sludge concentration is 0.80 % and sludge density is1030 kg/m^3
- **sludge volume= 8 m^3/d**

Consider sludge retention time = 7 Days

Volume of sludge = Qw x retention time

8 x 7= 56 m^3

Provided Diameter = 4.3 m

Tank Dimensions = 4.3 m Dia x 4.273m

After Digestion

- Secondary Sludge mass= 2500 kg/d, Sludge concentration is 1.2 % and sludge density is 1030 kg/m3
- **Secondary sludge volume = 5 m^3/d**

4.3.8.1 Filter Feed Backwash Pumps and Pressure Sand Filter

4.3. 8.2 Pressure Sand Filter Sizing

Design Flow rate through the filter = 208.33 (m^3/hr)

Filtration = 12 $m^3/h/m^2$

Cross Sectional area =17.36 m^2

Diameter = 4.7 m

Provided Diameter = 4.9 m

Provide filter = 4.9 Dia

For good quality effluent provide 2 filters.

Check:

Filter Area= 17.36 m^2

Filtration rate = 208.33 17.36 = 12.00 m/hr Ok it is within the range of (8 - 12) m/hr

4.3. 8.3 Filter Feed / Backwash Pumps

Consider specific rate of filter backwash = 30 $m^3/m^2/h$ Backwash Flow = 17.36 x 30 = 520 m^3/h

Backwash Volume = (520/60) x 15 =130 m^3

Use Filter Feed Backwash Pumps 2 nos. as follows:

Service: 1 duty/1 standby each of 35 m^3/h @ 4.0 bar Backwash: 2 duty each of 65 m^3/h @ 4.0 bar

4.3.9. Air Blower Calculations

4.3.9.1 Aeration Tank

Air Requirement for Aeration Tank

O= 2.0 mg/l Minimum dissolved oxygen maintained in the aeration tank, mg/l

T = 30°C Temperature

C'sw = 6.5 mg/1 Solubility of Oxygen in tap water at field temperature, mg/I

C'sw = 9.0 mg/1Solubility of Oxygen in tap water at 20°C, mg/I

A = 0.8 Oxygen transfer correction factor for waste water

β = 0.98 Salinity surface tension factor

f = 0.68 Conversion factor for converting B005 to BOOL

Yobs = 0.4 Observed yield, g/g

O2 kg/day= { Qa (S inf - S eff.)/ f 1000} - 1.42*Px + 4.6Qa (Ninf - Neff)/1000

Qa(Sinf - Seff)/1000 =5000 (500-20) /(0.68 x 1000) = 3529.11 kg/dayf

Px kg/day =YobsQa(Sinf - Seff)/1000 = 0.4 x5000x(500-20)/l000=960kg/day

O2 kg/day == 3529.11 - (1.42 x 960) + (4.6x5000 (15-2)/1000)

=2487.91 kg/day

$$\text{SOR kg/day} = \frac{\text{O2 kg/d}}{[(C'sw\ \beta\ Fa - C)/C\ sw](1.024)^{t-20}\ \alpha} = \frac{2487.91}{0.46 \times 1.268 \times .80}$$

= 5331.99 kg/day (222.166 kg/h)

Consider Diffuser Efficiency is 6 %

Air Required = 222.166 kg/h / 0.21/1.2 /0. 06kg/m³ = 14693.55 m³/hr @ 30° C

Consider 10% safety = 1.1 x 14693.55 = 16162.911 m³/hr @ 30°C

= 1.1 x 709 = 780 N m³/hr @ 0°C

No Of Air Diffusers required = 16162.911 m³/hr/ 100 m³/hr each diffuser = 161.9 Provided 10 air drop pipes of 6 diffusers each

10.2 Sludge Holding Tank

Consider Air req is 2N m³ air / m³ of produced Sludge

Air requirements = 2 Nm³ air x 56 = 112 N m³/h

Consider 10% safety = 1.1 x 112 =123.2 N m³/r

No Of Air Diffusers required = 123.2 m³/hr I 12 m³/hr each diffuser = 10.3 Provided 3 air drop pipes of 4 diffusers each

10.3 Air Lift

Consider Air req = 2.0 Nm^3 air /1 m^3 recirculated sludge

Qr = (Qa x MLSS in aeration tank)/ (MLSS in RAS - MLSS in aeration tank)

Qr= (16.7x3)/(7-3) = 12.5m^3/hr

Secondary Clarifier Scum Air Lift = 2 Nm^3 air x 12.5 m^3/h = 25 Nm^3 air / hr

Consider 10% safety = I.I x 25 = 27.5N air/hr

Total Air Requirement = 925 N m^3 air/hr

4.3.11 Odor Control system

4.3.11.1 Dosing Pump Capacity

AS - 100

p = 1.10 kg/l Chemical Density

C = 100% Chemical Concentration

X = 4 mg/1 Chemical Dosing rate

Qd = Q x X / 1000 x px C

Qd = 0.061 I/h

Required Qd = 0.09 I/h

Provided Dosing Pump = 0.1 I/h

4.3.11.2 Dosing Tank Capacity:

- **Required storage capacity = 2 days**
- **Daily Required Quantity = 4 8 liters**
- **Odor Dosing Tank Capacity = 51iter**
- **Provide tank capacity of 50 liter**

4.4 EQUIPMENT SPECIFICATION

4.4.1 Odour Control Dosing System

Reagent = AS-100 (commercial)

Quantity = One (1)

Pump type = Positive displacement

Duty = 3.8 l/h at 69 m

Material = PVC

Suction and delivery hoses = Polyethylene

Mode of adjustment = Manual

Solution tank material = Polyethylene

Solution tank capacity = 190 litres

Manufacturer = Options

Country of Origin = USA / Germany

4.4.2 Lift Station Pumps

Quantity = Three (3) (2 duty / 1 standby)

Type = Non-clog, submersible, centrifugal

Duty = 25 m^3/h

Total head = 10 m TDH

Suction = Flooded

Casing material: Cast iron

Shaft material: Stainless steel

Impeller material: Cast iron

Sealing arrangement: Mechanical

Drive arrangement: Close coupled

Motor speed: 1450 rpm

Winding insulation: Class ‘F’

Motor rating: 2.2 kW

Mode of control: Float switches

Starter: DOL

Valves: Delivery and non-return

4.4.3 Bar Screen

Quantity: One (1)

Type: Rectangular, with bar screen

Size: Up to 50 m^3/hr

Material: 5 mm thick all welded steel fabrication

Bar screen: 30 mm deep by 5-mm thick bar with 25-mm spacing

Weirs : 180-mm wide slot, height adjustable

Outlet: Plain end outlet to aeration tank

Finish: Shot blast to Swedish 2.5, painted with epoxy enamel to 320-micron dry finished thickness.

4.4.4 Aeration Tank

Quantity: One (1)

Duty: Nominally 24 hours at average flow.

Type: Vertical, circular steel panel, bolted tank to form outer ring of a concentric arrangement, for erection above ground on a concrete base.

Tank diameter: 13.9 m

Sidewall height: 4.2 m

Free board: 0.3 m

Material: Glass lined carbon steel to BS 1344 impermeable lining 0.18 to 0.26 mm thick on both sides.

Bolts and fittings: Plastic capped galvanized steel.

Fittings

Outlet:150 mm NB

Drain:150 mm NB

Stiffening angles: Top and bottom stiffening ring

Sealant: Mastic

Accessories: Anode packs for cathodic protection

4.4.5 Air Diffusers (in Aeration Tank)

Quantity: 161.3 pcs

Duty: 100 m^3/h each

Air pressure: 0.48 bar at 3.7 m total liquor depth

Type: Medium bubble rubber diaphragm valve

Fluid depth: 3.7m

Material: Plastic body with neoprene rubber diaphragm

Air connection: ¾"NPT

Support: Down comer manifold, two diffusers per down comer

Valves: Globe, one per down comer

4.4.6 Air Blowers

Quantity: Two (2) (1 duty / 1 standby)

Duty: 16162.911 m^3/hr @ 0.45 bars

Type: Rotary-positive displacement, oil free

Filter: at inlet

Silencer: at exhaust

Motor arrangement: Vee belt coupled

Motor speed: 2940 rpm (max.)

Motor enclosure: TEFC-IP 55

Insulation: Class ‘F’

Motor rating: 22 kW

Starter: Star-Delta

Valves: - Isolating valve

- Non-return valve

- Pressure relief valve

Fittings:

- Steel support base

- Belt tensioner

- Flexible connections

- Anti-vibration mounts

Finish: Standard enamel

4.4.7 Settlement Tank

Quantity: One (1)

Duty: Nominally 6 hours at average flow

Type: Vertical, circular steel panel, bolted tank to form inner ring , for erection above ground on a concrete base

Tank diameter: 7.4 m

Sidewall height: 4.2 m

Free board: 0.35 m

Material: Glass lined carbon steel to BS 1344 impermeable lining 0.18 to 0.26 mm thick on both sides

Fittings

Inlet: 150 mm NB

Outlet:150 mm NB

Stiffening angles: Top and bottom stiffening ring

Sealant: Mastic

Accessories:

- Overflow weir and launder

- Diffusion drum

- Anode packs for cathodic protection

4.4.8 Sludge Air Lift System

Quantity: One (1)

Duty: Pumping rate to be adjusted as necessary by means of air valve

Capacity: 21.9 m^3/hr

Diameter: 100 mm NB

Air requirement:15m³/hr at 0.5 bar

Diameter of airline: 25 mm NB

Material: PVC Class 4

Lift: 0.5m

Immersion depth: 3.5m

Clearance: Min. 150 mm (inlet to floor)

4.4.9 Sludge Scraper

Quantity: One (1)

Type: Rotating centre drive, under water floor scraping mechanism.

Duty: To direct settled sludge to the centre of

settling tank.

Diameter: 7.4m

Speed: 2.0 m/min

Drive: Geared motor with torque

Coupling: Solid

Construction: Tubular drive shaft support braced outrigger scraper arms.

Motor gearbox: Flange mounted triple reduction worm drive. Oil lubricated.

Motor power: 0.18 kW

4.4.10 Work Bridge (for Aeration / Settlement Tanks)

Quantity: One (1)

Type: Twin beam welded steel fabrication

Duty: Design loading includes uniform distributed load of 1.5 kN/m² plus a single concentrated load of 1,000 kg.

Width:1100mm

Length: 10.5m for aeration tank

Cross brace: 150 x 75 x 18.7 kg/m

Handrail: 27 mm OD twin rail 1,080 mm H. on 50 mm x 50 mm x 33 mm RSA standard

Flooring: Galvanized open mesh with bars parallel to bridge (suitable for 140 kg/m^2 OD loading)

Bolts: M16 hot dip galvanized to B.S. 4604 - Part 1

Welding: N 70

Finish for handrail and bridge frame: Wire brush and zinc chromate primer and two coats chlorinated rubber paint

Support: From settlement and aeration tank walls

4.4.11 Chlorine Contact Tank

Quantity: One (1)

Duty: Nominally 2 hours at peak flow.

Type: Vertical, circular steel panel, bolted tank, for erection above ground on a concrete base.

Tank diameter: 6.83m

Sidewall height: 2.36 m

Free board: 0.3m

Material	:	Glass lined carbon steel to BS 1344 impermeable lining 0.18 to 0.26 mm thick on both sides.
Bolts and fittings	:	Plastic capped galvanised steel.

<u>Fittings</u>

Outlet	:	100 mm NB

Drain	:	100 mm NB
Stiffening angles	:	Top and bottom stiffening ring
Sealant	:	Mastic
Accessories	:	Anode packs for cathodic protection

4.4.12 Disinfection Dosing System

Reagent	:	Sodium hypochlorite
Quantity	:	One (1)
Pump type	:	Positive displacement
Duty	:	6.3 l/h @ 69m
material	:	PVC
Suction and delivery hoses	:	Polyethylene
Mode of adjustment	:	Manual
Solution tank material	:	Polyethylene
Solution tank capacity	:	200 litres

4.4.13 Sludge Holding Tank

Quantity	:	One (1)
Construction	:	Above ground
Capacity	:	Nominally 7 days
Tank diameter	:	4.7 m
Freeboard	:	0.3 m
Sidewall height	:	4.256 m

Material plates	:	Glass lined carbon steel to BS 1344 impermeable lining 0.18 to 0.26 mm thick on both sides.
Stiffening rings	:	Top and bottom stiffening in galvanized steel.
Bolts and fixing	:	Vinyl capped galvanized tensile steel

<u>Fittings</u>

Outlet:		65 mm NB
Drain :		65 mm NB
Overflow	:	65 mm NB
Decanting	:	65 mm NB (three numbers)
Sealant	:	Mastic
Accessories	:	Anode packs for cathodic protection

4.4.14 Air Diffusers (in Sludge Holding Tank)

Quantity	:	6 pcs
Duty	:	15 m^3/h each
Air pressure	:	0.48 bar at 3.7 m total liquor depth
Type	:	Medium bubble rubber diaphragm valve
Fluid depth	:	3.7 m
Material	:	Plastic body with neoprene rubber diaphragm
Air connection	:	¾” NPT
Support	:	Down comer manifold, two diffusers per down comer

Valves	:	Globe, one per down comer

4.4.15 Work Bridge (for Sludge Holding Tank)

Quantity	:	One (1)
Type	:	Twin beam welded steel fabrication
Duty	:	Design loading includes uniform distributed load of 1.5 kN/m^2 plus a single concentrated load of 1,000 kg.
Width	:	1100 mm
Overall length	:	4.7 m
Cross brace	:	150 x 75 x 18.7 kg/m
Handrail	:	27 mm OD twin rail 1,080 mm H. on 50 mm x 50 mm x 33 mm RSA standard
Flooring	:	Galvanized open mesh with bars parallel to bridge (suitable for 140 kg/m^2 OD loading)
Bolts	:	M16 hot dip galvanized to B.S. 4604 - Part 1
Welding	:	To B.S. 5135
Finish for handrail and bridge frame	:	Wire brush and zinc chromate primer and two coats chlorinated rubber paint
Support	:	From sludge holding tank walls

4.4.16 Filter Feed / Backwash Pumps

Quantity	:	Two (2) (1 duty/ 1 standby)
Type	:	Centrifugal, end suction, horizontal
Duty	:	20 m^3/h

Total head	:	2.0 Bar
Suction	:	Flooded
Casing material	:	Cast Iron
Shaft material	:	Stainless steel
Impeller material	:	Stainless steel
Sealing arrangement	:	Mechanical
Drive arrangement	:	Close coupled
Motor speed	:	2900 rpm (nominal)
Motor wining	:	TEFC - IP 55
Winding insulation	:	Class F
Motor rating	:	10 kW
Mode of control	:	Low level (dry running) protection.
Starter	:	DOL
Valves	:	Suction, delivery, non-return

4.4.17 Manual Pressure Sand Filter

Quantity	:	One (1)
Diameter	:	1400 mm
Height of straight	:	1500 mm
Operating pressure	:	2.0 bar
Standard	:	Good commercial practice
Material of construction	:	Welded Carbon Steel
Coating	:	Grit blasted internally, one coat of epoxy primer 2 coats of high build epoxy, and externally one coat of primer and one coat of paint.
Service flow	:	14.58 m³/h
Filtration rate	:	9.47m³/h/m²
Media type	:	Graded silica sand Anthracite
Media depth	:	600 mm 200 mm
Graded gravel supporting bed	:	400 mm
Operation	:	Manual
Pipe work	:	HDPE filter frontal pipe work
Valves	:	250 mm PN 16 bar Inlet, outlet 150 mm PN16 bar Backwash (in and out) 50 mm Vent 100 mm Drain 50 mm Air scour

Manhole	:	One 450 mm dia. Pin stock gate.

4.4.18 Electrical Items

The scope of electrical items included in this offer consists of the following:

- Main control panel.
- Raceways.
- Power, control and earthing cables.
- Main Control Panel

One (1) control panel protected to IP 54, floor mounted type will be provided in the plant room, and shall house the following starters:

Three (3)	Lift station pumps	15 kW
Two (2)	Air blowers	25 kW
One (1)	Scraper drive	10 kW
Two (2)	Filter feed/backwash pumps	5 kW

- Raceways

In and under slab conduits will be in PVC. Above ground and outside building conduits will be rigid steel conduit.

- Power , Control and Earthing Cables

The minimum size of wires will be insulated type for motors, and for controls and dosing pump. Quantity and size will be in accordance with manfacure code of practice.

Power cables to motors will be PVC / XLPE / Cu in conduits, and Armoured for direct buried type.

Control cables will be UPVC / PVC / Cu in conduits, and Armoured for direct buried type.

Earthling cable shall be PVC insulated, green color, and base copper type as per site requirements (rote pit).

4.4.19 Piping work

The process and interconnecting pipe work for the Sewage Treatment Plant will generally be HDPE.

The air blowers' discharge pipelines immediately adjacent to the blower will be galvanized steel and PPR in the end of tank..

4.4.20 Drawings

The drawings included in the scope include the followings:

- Plant room general arrangement.
- Civil outline drawings.
- General arrangement of the overall plant.
- Schematic process flow diagram.
- Schematic panel wiring diagram.
- Funes of plant.
- Layout of plant.

4.4.21 Operation and Maintenance Manuals

Two (2) Comprehensive operation and maintenance manuals describing the plant in detail and complete with drawings and equipment schedules, operation and lubrication schedules, equipment manuals, will all be provided in the English language format.

4.5. Results of case study two EL moshraf sweets factory

Characterization of Liquid Wastewater and Assessment of Compliance of Industrial Wastewater For investigating the compliance of the discharged wastewater, the sampling and analysis carried out for the wastewater in the industry was conducted as composite samples and analysis of the industrial wastewater with and without the Presence of the chiller water. Composite sampling and analysis for the industrial wastewater was carried out for the production process includes five production lines were operating, chocolate cake line, three lines of different biscuits type, and ketchup line. The samples were taken for the collective industrial wastewater stream, which includes wastewater from cleaning of equipment and production lines, boilers blow down, and the chillers recycling water. The results of the analysis for the industrial wastewater for the three shifts are summarized in the following table

Analysis of Industrial Wastewater Characterizations with the Presence of the Chiller Water:

Table 4.1 Characteristics of the Industrial Wastewater Characterizations with the Presence of the Chiller Water

Parameter	**Units**	**1st shift**	**2nd shift**	**3rd shift**	limits
pH		6.5	6.55	5.55	6 – 9.5
TSS	mg/l	580	200	350	800
Total Nitrogen	mg/l	15.1	11.6	11.1	100
Orthophosphorous	mg/l	0.5	0.252	0.32	25
Settleable solids	mg/l				
after 10 min		15	5	4	8
after 30 min		16.1	6	4.5	15
BOD		2000	618	1990	600
COD		2600	664	2450	1100
Oil and grease		5	99.6	100.1	100

As a results from the above analysis, is concluded that for pH analysis of the first two shifts is within the allowable limits, as for the third shift the pH is lower than the allowable limits. For the samples of the three shifts the pH is more towards the acidic range on the pH scale, for the settleable solids, samples from the second and third shift is complying with law limits, as for the first shift both the setlleable solids after 10 min and 30 min are above the limits, for the BOD, the second shift is within the limits, while the first and third shifts are above the stipulated limits. Similarly for the COD, the second shift sample is within the limits while samples of the other two shifts are not complying, fFor oil and grease, samples of the first two shifts are within the stipulated limits, while sample for the third shift is not complying. As a conclusion, the above results obtained from the analysis indicated that the average values of the pH, settleable solids, BOD, COD and oil and grease are above the limits, while the values of the other parameters are within the limits, and accordingly cannot be discharged directly to the sewer network

Analysis of Industrial Wastewater Characterizations without the Presence of the Chiller Water: In case the chiller water cycle is fixed and converted to a close loop cycle, water will not be discharged from the chiller. The following table presents the results for analysis of BOD and COD concentrations of the industrial wastewater after the removal of the chiller water.

Table 4.2: Industrial Wastewater determined BOD&COD after Chiller Water Removal

Parameter	**Units**	**1st shift**	**2nd shift**	**3rd shift**	Limits
BOD	Mg/l	7264	1554	5516	600
COD	Mg/l	9822	1992	6825	1100

From the table above, it is clear that the concentration of the pollutants has increased in the industrial wastewater after the removal of the chiller water, and accordingly it is not complying with the limits and cannot be discharged directly to the sewer system

Treatability Study and Identification of Possible Treatment scenario Alternatives for management and treatment of the discharged industrial wastewater to the limits of Environmental Regulation will be identified and assessed to investigate their feasibility from environmental and technical perspectives. Special attention will be given to low cost alternatives due to the limited budget allocated by industry for the wastewater management. Pollutants in the domestic wastewater are expected to be lower than that of the industrial wastewater, accordingly mixing of the industrial and domestic wastewater is expected to dilute the pollutants discharged from the industrial wastewater. According to the laboratory analysis carried out for the mixed wastewater stream, it is clear that the pollutants concentration has decreased but it is still not complying with the regulatory discharge limits. As stated above, the non-complying parameters for the industrial wastewater are the pH, settleable solids, BOD, COD and oil and grease. After mixing with the domestic wastewater, the same parameters remained non-complying except for the oil and grease.

Table 4.3: Analysis of Grab Samples from Mixed Industrial and Domestic Wastewater

Parameter	**Units**	**1st shift**	**2nd shift**	**3rd shift**	limits
pH		6.2	6.5	5.88	6 – 9.5
TSS	mg/l	580	300	750	800
Total Nitrogen	mg/l	33.9	12.8	25.5	100
Orthophosphorous	mg/l	0.625	0.232	0.535	25
Settleable solids	mg/l				
after 10 min		80.6	6.0	8.3	8
after 30 min		80.6	8	12	15
BOD		1152	462	1851	600
COD		1519	517	2200	1100
Oil and grease		20.8	10.4	54.8	100

As a results from the above analysis, it is concluded that for pH, as with the industrial wastewater, the pH in the third shift was still not complying, for settleable solids, noncompliance has been witnessed in the first shift for the industrial wastewater, and the noncompliance of the same shift remained after mixing with the domestic wastewater, for both the BOD and COD, the second shiftwas within the limits, while the first and third shifts were above the stipulated limits, for the industrial wastewater before mixing with the domestic wastewater. After mixing, the noncompliance of the two shifts remained. But as for the oil and grease, it was the only noncomply parameter that has reached compliance after mixing with the domestic wastewater. Accordingly, it is clear that the direct mixing of the domestic wastewater with the industrial wastewater would not be considered a feasible alternative as the mixed wastewater did not complying with the discharge limits. There are two treatment scenario identified based on the characteristics of the wastewater. The first scheme is physico-chemical treatment, while the second is by physico-chemical treatment followed bybiological treatment.

Chapter Five

Chapter Five

Conclusions and Recommendation

5.1 Conclusion:

Based on the findings of this research the followings are concluded:

1. The quantity of generated wastewater from both of the studied production facilities is excessive and uncontrolled.
2. The characteristics of generated wastewater in terms of (BOD, COD, and TSS) exceed the recommended in the Khartoum North (local order 1970, SSMO standard 173/2008), neither of the two factories is having pretreatment facilities as recommended by standards.
3. The oil and grease from these factories are adversely affecting the municipal treatment plant.
4. Nobody seems to follow the quantity of the generated wastewater this presents over loads to the municipal wastewater treatment plant.

5.2 Recommendation:

Based on findings and conclusion of this study the followings are recommended:

1. The Khartoum state sanitary cooperation (KSSC) should regularly monitor the hydraulic and organic load emanating from factories according to Khartoum North local order (1970).
2. The KSSC should in force the local order and standards so as to insure efficiency and safety of wastewater treatment plant.
3. It is recommended to install pretreatment / treatment units to control the quality of generated wastewater from both factories.
4. Implement the designed pretreatment facilities for both factories.

References

[1]. Emmanuel A. Echiegu* Jacob T. Liberty(2013)., “Effluents Characteristics of Some Selected Food ProcessingIndustries in Enugu and Anambra States of Nigeria”. Journal of Environment and Earth Science.Vol. 3, No.9.

[2]. Wang & Howard(2004)."Handbook of Industrial and Hazardous Wastes Treatment".USA.

[3]. Gray, N. F.(2005). “Water Technology: An Introduction for Environmental Scientists and Engineers”.Oxford : Elsevier Butterworth-Heinemann.

[4]. Mavrov, V., and Beleires, E. (2000). “Reduction of Water Consumption and Wastewater Quantities in The Food Industry by Water Recycling using Membrane Processes”. Desalination; 131, 75-86.

[5]. DorotaKrzemińska, Ewa Neczaj1, Gabriel Borowski (2005). “Advanced Oxidation Processes For Food Industrial Wastewater Decontamination”.Journal of Ecological Engineering.Volume 16, Issue 2, Apr. 2015, pages 61–71. DOI: 10.12911/22998993/1858.

[6]. U.S. EPA (2001) Environmental Management System (EMS) guide, meat processing, U.S.
Environmental Protection Agency, Washington, DC.

[7]. Cicek N. (2003). “A review of membrane bioreactors and their potential application in the treatment of agricultural wastewater”. CSBE, 43, 37–49.

[8]. Marcucci M., Ciardelli G., Matteucci A., Ranieri L., Russo M. (2002). Experimental campaigns on textile wastewater for reuse by means of different membrane processes. Desalination, 149 (1-3), 137–143.

[9]. Mason T.J. (2000). Large scale sonochemical processing: aspiration and actuality. Ultrason.Sonochem., 7(4), 145–149.

[10]. R. Mehrotra, B. K. Srivastava, and S. Prasad (1995).“Third International Conference on Appropriate wastemanagement technologies for developing countries, Nagpur. 25-26, 607-612.

[11]. Vanerkar A. P., Sanjeev Satyanarayan (2013). “Treatment of Food Processing Industry Wastewaterby a Coagulation/ Flocculation Process”.International Journal of Chemical and Physical Sciences. ISSN:2319-6602. Vol. 2,63-72.

[12]. Dereli, R.K.; Ersahin, M.E.; Ozgun, H.; Ozturk, I. & Aydin, A.F. (2010). Applicability ofAnaerobic Digestion Model No.1 (ADM1) for a Specific Industrial Wastewater:Opium alkaloid effluents. Chemical Engineering Journal, 165, 1, 89-94

[13]. Wang, R.; Wang, Y.; Ma, G.; He, Y. & Zhao, Y. (2009). "Efficiency of porous burnt-coke carrieron treatment of potato starch wastewater with an anaerobic–aerobic bioreactor".Chemical Engineering Journal, 148, 35–40.
[14]. Akhilesh Kumar Patel, Shraddha Patel, AasfaTabassum and Nikhil RanjanJha (2016).""Effluent Treatment Plant of Chocolate Industry- A Case Study".International Journal of Scientific Engineering and Applied Science. Volume-2, Issue-3, 181-186.
[15]. AyodeleRotimiIpeaiyeda* and Percy ChuksOnianwa (2011). "Pollution Effect Of Food And Beverages Effluents On The Alaro River In Ibadan City, Nigeria". Bull. Chemical Society of Ethiopia.ISSN 1011-3924. 25(3), 347-360.
[16]. Katerina Valta, TatjanaKosanovic, Dimitris Malamis, Konstantinos Moustakas,Maria Loizidou (2015). "Overview of water usage and wastewater management in the food andbeverage industry".Desalination and Water Treatment.Volume 53, Issue 12,3335–3347.
[17]. APHA, AWWA, WEF (2012). "Standard Methods for the Examination of Water and Wastewater". (22nd edition) Washington