TREATMENT OF WASTE WHEY IN THE HEBRON DAIRY INDUSTRY

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The Senior Project Entitled:

Treatment of Waste Whey in the Hebron Dairy Industry

Prepeared By:

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In accordance with the recommendation of the project supervisors , and the acceptance of all examining committee members , this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisors **Department Chairman**

الإهداء

إلى شهداءنا الأبرار الذين قدموا **ارواحهم** رخيصة في سبيل الله ثم الوطن

إلى الرجل الرجل إلى الأسود الرابضة خلف القضبان
إلى كل الأسرى

إلى كل من ضحى من اجل دينه وأرضه وعرضه

إلى خنساوات العصر
إليكن أمهات الشهداء و **الأسرى والجرحى**

إليكم جميعا نهدي هذا العمل المتواضع

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Work Team

ABSTRACT

Treatment of Waste Whey in the Hebron Dairy Industry

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Palestine Polytechnic University

The dairy industry consumes large quantity of water. Between 75% and 95% of the water intake volume is discharged as effluent. The dairy factories in the Hebron Governorate received and processed the milk and throw wastewater into public sewerage system. Wastewater from dairy manufacturing and processing industry are characterizes by a very high organic load and a high fat content. The inevitable wastage of milk and milk products contributes greatly to pollution loads discharged by dairies.

While larger dairy factories in the Hebron city dispose of their effluent into municipal sewers, causes of effluent disposal into wastewater stream of the Hebron city running in Wadis. In contrast to this, smaller dairy factories dispose of their effluent by irrigation onto lands or pastures. Surface and ground water pollution is therefore a potential threat posed by these practices.

Efforts to utilize the huge amount of dairy by products have led to the development of various whey treatment methods. Despite of the different possibilities of whey utilization, approximately half of the cheese whey produced worldwide is discarded without treatment.

Liquid whey can be used in whey cheese production, bakery and meat industries, animal feed, and as an agricultural fertilizer. In the Hebron area, some large factories tried to process whey to produce special type of cheese, but most of them disposed whey into the municipal wastewater network.

Over the past decades, several cost-effective treatment technologies comprising anaerobic, aerobic and facultative processes have been developed for the treatment of whey. Aerobic treatment, such as aerated lagoon, activated sludge process, and Sequencing Batch Reactors (SBR) has been commonly used for wastewater from food industry. Recently, anaerobic treatment leading to biogas production has become an effective biological process for the treatment of many industrial organic wastewaters. The UASB anaerobic reactor is one of the chosen innovative bioreactors.

The aim of this study was to firstly survey the Hebron city dairy industry to determine the present situation, requirements and need for effluent treatment; find out the quantity of wastewater from large dairy factories. Secondly, determine the extent of effluent related problems experienced by the dairy industry in the Hebron city. Thirdly, measure the characteristics of wastewater from the dairy large factory. Finally, investigate the use of the anaerobic digestion system for the treatment of dairy waste water, and study the application of the UASB-system into an efficient process for the treatment of waste water produced by dairy factories in Hebron Governorate.

In this study, which focused on the anaerobic treatment of dairy wastewater, UASB reactor will be designed and built inside the laboratory and laboratory batch experiments will be conducted during the research work, in order to evaluate the efficiency of using UASB technology. The anaerobic UASB reservoir could remove above 75% of the BOD and COD all year round.

At the end of work, the feasibility of using the anaerobic hybrid digester for the treatment of dairy factory wastewater has to be determined, and anaerobic treatment technology for large and medium size dairy factories in the Hebron area that have growing disposal problems and can not offered high investment costs for whey valorization technologies (such as protein and lactose recovery, spray drying, etc.) will be find out.

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ABBREVIATIONS

The following abbreviations were used in this project:

B	Born
BOD	Biochemical Oxygen Demand
Ca^{++}	Calcium
Cl^{-}	Chloride
COD	Chemical Oxygen Demand
CO_3^{--}	Carbonate
DO	Dissolved Oxygen
EC	Electrical Conductivity
FAO	Food and Agriculture Organization
HCO_3^{-}	Bicarbonate
K	Potassium
Mg^{++}	Magnesium
Na+	Sodium
NO_2^{-}	Nitrites
NO_3^{-}	Nitrates
$NH4^{+}$	Ammonia
P	Phosphate
pH	Acidity / Basicity
SAR	Sodium Adsorption Ratio
SO_4^{-2}	Sulfate
SS	Suspended Solid
T	Temperature

TDS	Total Dissolved Solids
TFCC	Total Feacal Coliform Count
TN	Total Nitrogen
TS	Total Solids
TSS	Total Suspended Solids
UASB	Up-flow Anaerobic Sludge Blanket
WHO	World Health Organization

CHAPTER

1 *INTRODUCTION*

1.1 General Background

1.2 Problem Definition

1.3 Technical Objectives

1.4 Work Plan

1.5 Structure of the Report

CHAPTER ONE
INTRODUCTION

1.1 Background

The liquid that residue of cheese and casein production is called whey. It is an important reservoir of food protein still remaining largely outside human consumption. About 80-90% of the total milk volume entering the dairy process will remain as byproduct known as whey which contain about 50% of the nutrients in the original milk like proteins, lactose, vitamins and minerals (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005**)**. There are two kinds of whey, the first is sweet whey produced from the manufacturing of cheese and rennet casein and has a pH of 5.6-6.6. Acid whey is the second kind and is produced from the manufacturing of mineral-acid precipitated casein and from labaneh (dairy product produced in Middle East) and has a pH of 4.3-5.1.

On one hand, it is clear that there is great possibility to invest these huge amounts of whey instead of dumping them to the sewers especially if we know that whey represent a serious environmental problem due to the presence of high concentration of dissolved organic substances which means high Biochemical Oxygen Demand (BOD) that varies from 30000 to 50000 ppm and high value of Chemical Oxygen Demand (COD) about 70000 ppm. Also the expected environmental regulations will force the factories to pay high taxes in order to dispose of whey. On the other hand, whey have high nutrients value as it is considered a good source of amino acids, vitamins, minerals and lactose which means that treatment of whey is more feasible than dumping it (Demirel, B., Yenigun, O., and Onay, T., 2005).

The two major diary factories in west bank (AL-Junidy and Al Jebrini), Produced about 13000 liter per day of sweet whey from white cheese and about 10000 liter per day of acidic whey from labaneh. The two dairy factories dispose of their effluent into municipal sewers. In contrast to this, most smaller dairy factories dispose of their effluent by irrigation onto lands or pastures. Surface and ground water pollution is therefore a potential threat posed by these practices. The environmental impact of these factories can be very high, especially due to the discharge of very large flows of wastewaters with a high content of organic matter and nutrients (N, P). Besides, the use of acid and alkaline cleaning compounds mar cause high pH variability.

The aim of this study was to firstly determine the extent of effluent related problems experienced by the dairy industry in the Hebron Governorate of the West Bank. Secondly, the feasibility of using the anaerobic hybrid digester for the treatment of dairy factory waste water has to be determined.

1.2 Problem Definition

Milk whey is defined as a liquid by-product of the dairy industry, generated after the separation of coagulant casein and fat from the milk. It constitutes 80 to 90% of the total volume of the milk entering the process and contains more than half of the solids of the original milk, including 20% of the protein and most of the lactose (Herbert, H.P., 1990). Because of its high levels of protein and lactose, discharging whey directly into the waterway could cause a severe pollution problem. Dairy farmers have commonly given whey to other farmers as animal feed or as fertilizer. However, the potential pollution problem still exists should other farmers decide not to haul away the whey. More recently, some dairy farmers have used sophisticated technology to process whey, producing dry protein powder and crystallized lactose. By so doing, they not only alleviate a potential pollution problem but also produce two marketable products (Gonzalez Siso, M.I., 1996).

Surplus milk whey continues to be one of the most critical waste disposal problems challenging the dairy industry. Typical Chemical Oxygen Demand (COD) concentrations of milk whey is in the range of 3000-5000 mg/l, considered as a very polluting stream which traditionally comes in an overall huge amount from many small and from some large cheese manufacturing plants. Currently, the majority of milk whey produced in Palestine is discharged directly without a proper treatment into municipal sewer systems or disposed into water streams, lands or pastures. Uncontrolled release of such highly concentrated wastewater poses serious health as well as environmental problems. Considering the shortage in global water resources in general, and specifically in the Palestine, an appropriate treatment method for recycling milk whey could lower the effluent volume and the total water consumption of the dairy products manufacturers.

In Palestine, where water has been identified as the country's most important natural resource, the dairy industry is significant, both from a water intake and discharge point of view. Current research work deals with the treatment of wastewater from diary industry in the Hebron Governorate of the West Bank. The primary aim of this project is to develop a simple biological process to reduce the BOD and COD concentrations of the wastewater from dairy factories, so that the effluent could be discharged to the municipal sewage. The feasibility of using anaerobic wastewater treatment will be also determined.

Aerobic treatment, such as activated sludge process, has been commonly used for wastewater from food industry. However, only in recent years has anaerobic treatment emerged as a viable means for wastewaters containing high levels of organics; some have applied it to the treatment of dairy wastewater with certain degrees of success. In this study, anaerobic processes will be tested for the treatment of wastewater from the whey processing plant (Herbert, H.P. 1990).

1.3 Technical Objectives

Today, the development of technology leads to high growth in industry in several areas, such as dairy industry which is important all over the world because the number of consumers for its products increase continuously. Therefore, the main objective of this project is to investigate the problem of milk whey effluent in the Hebron Governorate of the West Bank and make a feasibility study of treating this strong and special effluent as well as renovating this effluent from a wastewater definition to a valuable product for beneficial reuse in the food industry.

The specific technical objectives are:

1. Development of a solution for dairy whey from the Palestinian dairy industry which is currently being disposed of into public sewage systems without treatment.

2. Survey the Hebron Governorate dairy industry to determine the present situation, requirements and need for effluent treatment.

3. Find out the quantity and characteristics of wastewater from large and medium dairy factories in the Hebron area, in order to determine the appropriate treatment method.

4. Investigate the use of the anaerobic digestion system for the treatment of dairy waste water, and study the application of the UASB-system into an efficient process for the treatment of waste water produced by dairy factories in Hebron District.

5. Develop a technology for large and medium size dairy factories in the Hebron area that have growing disposal problems and can not offered high investment costs for why valorization technologies (such as protein and lactose recovery, spray drying ,etc.).

1.4 Work Plan

This proposed project was divided into five phases.

Phase 1: Review of literature: During this phase, all the information and previous studies related to the subject were collected and reviewed. At the same time site visit were made to number of dairy factories in the Hebron area in order to understand the environmental impact of wastewater effluent from these factories and collecting wastewater samples .

Phase 2: Sampling and Analytical: A program will be initiated to collect samples of dairy wastewater from three large factories, namely, AL-Junidy, Al Jebrini and Al Safi, and analysis its characteristics in Renewable Energy and Environment Research Unit (REERU) Laboratories at Palestine Polytechnic University. Wastewater characteristics such as BOD, COD, Total Kjeldahl, and Total Suspended Solid (TSS) will be analyzed following the standard procedures.

Phase 3: Bach Experiments: In this study, which focused on the anaerobic wastewater treatment and based on some previous works, a Bach UASB reactor will be designed and installed and the laboratory Bach experiments will be carried out in order to test the UASB reactor output and performance for the treatment of wastewater from the dairy industry.

Phase 4: Analysis and Discussion of Results: The data obtained from the experiments on whey characteristics and the laboratory Bach experiments will be analyzed and the results will be then discussed.

Phase 5: Writing the Report: Upon the completion of the work, one final report was written and submitted to the Department of Civil and Architectural Engineering.

1.5 Structure of the Report

The project report has been prepared in accordance with the objectives and scope of work. The report consists of five chapters.

The title of ***Chapter One "Introduction"*** outlines the general background, problem definition, technical objectives, work plan and structure of the report.

Chapter Two entitled ***"Review of Literature"*** describes the concepts of whey, utilization of whey, and treatment of dairy wastewater.

Chapter Three entitled ***"Dairy Industry in Palestine"*** presents whey production, properties of Palestinian whey, environmental problems facing dairy industry, and dairy and food industry in the Hebron area.

The overall “***Conclusions"*** are given in ***Chapter Four***.

CHAPTER

2 *REVIEW OF LITERATURE*

2.1 General

2.2 Concepts of Whey

2.2.1 What is Whey
2.2.2 Types of Whey
2.2.3 Compositions and Properties

2.3 Utilization of Whey

2.3.1 Introduction
2.3.2 Global Uses
2.3.3 Whey Utilization in Arab Countries

2.4 Treatment of Dairy wastewater

2.4.1 Introduction
2.4.2 Treatment Options
2.4.3 Aerobic Treatment of Dairy Wastewater
2.4.4 Anaerobic Treatment of Dairy Effluent

CHAPTER TWO
REVIEW OF LITERATURE

2.1 General

Milk whey and wastewater from dairy industry has become a controversial topic in recent years. Milk whey, which is generally considered as being one of the best sources of protein available, is processed into a wide range of nutritional ingredients in many countries in the world. Whey can be used in ice cream, bakery products, beverages, yeast products, and in animal feed. Without any treatment cheese whey surplus can be supplied into drinking water for farm animals or used as an agricultural fertilizer.

At the same time, wastewater from dairy industries which is characterized by their high BOD and COD contents is treated in many places using aerobic and anaerobic wastewater treatment technologies. Most of the dairy industries in the world use the typical activated sludge for their effluent treatment. The typical activated sludge treatment is characterized by the relatively high energy consumption and biomass production, leading to a relatively high operation costs and problem with the disposal of large amounts of sludge. Although the aerobic treatments have used in most of the dairy factories, it has been known that wastewater of many dairy factories in the world is treated using UASB and other anaerobic wastewater treatment technologies.

Research efforts in countries of developed markets like Palestine on the nutritional benefits of whey protein and sugar derivatives continue to become available as researchers discover additional applications for whey valuable ingredients. This chapter discusses the previous works on milk whey recovery and the treatment of wastewater from dairy factories.

2.2 Concepts of Whey

Milk whey is defined as a liquid by-product of the dairy industry, generated after the separation of coagulant casein and fat from the milk. More details about what is whey? types of whey, and composition and properties of whey are explained in the following paragraphs.

2.2.1 What is Whey?

Whey or milk plasma is the liquid remaining after milk has been curdled and strained; it is a by-product of the manufacture of cheese or casein and has several commercial uses. Approximately 9 L of whey will be obtained from 10 L of milk for every kg of cheese produced; this general ratio will vary somewhat depending on the type of cheese, fat content of the raw milk used, and other factors. Sweet whey is manufactured during the making of rennet types of hard cheese like cheddar or Swiss cheese. Acid whey (or sour whey) is obtained during the making of acid types of cheese such as cottage cheese.

Whey is used to produce ricotta and brown cheeses and many other products for human consumption. It is also an additive in many processed foods, including breads, crackers and commercial pastry, and in animal feed. Liquid whey contains lactose, vitamins, and minerals along with traces of fat. On the other hand, the fast growing food industry in general, and specifically the dairy industry in the region of the Middle East, has a positive driving force for using whey end-use products, such as ice-creams, biscuits, chocolates, and processed meat (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

2.2.2 Types of Whey

Whey is classified according to the method of precipitation into two types as:

1) **Sweet whey:** This is also termed cheese whey and is produced during cheese making, when rennet is used. Sweet whey forms a very large family of products. Their composition may vary only slightly but their properties are very different. The pH value of sweet whey can range between 5.2 and 6.7. Sweet whey is produced during the manufacturing of hard, semi hard or soft cheeses like Cheddar, Swiss and Mozzarella.

2) **Sour whey:** This can be acid whey, quark or cottage cheese whey and sour sweet whey. Acid whey, also known as casein whey, originates from the manufacture of casein by means of lactic acid and hydrochloric acid. The origin of quark or cottage cheese whey is self-explanatory. Lactic acid created through natural fermentation gives the whey a high acidity. The pH values of these types of whey range from 3.8 to 4.6. If insufficient care is given to the cheese whey, it becomes sourer by continued natural fermentation. Such a process is of course undesirable so that soured (not sour) whey cannot be considered a natural product (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

2.2.3 Composition and Properties

The main components of whey are lactose, protein, fat and minerals. The portions of the above components vary depending on the cheese making process. Lactose is the primary part of total solid of whey (between 63-75% of total whey solid). This ratio differs depending on the type of whey; acid whey appears to have low lactose content due to the fermentation of lactose into lactic acid. Protein is the most important whey component. It is between 9-11% of dry matter. The importance of proteins resulting from their high nutrients value. Table (1) shows the composition of whey protein fractions in both type of whey (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

Table (2.1): Composition of Whey Protein

Protein	Approximate content (g/L whey)	Total whey protein (%)
α-Lactalbumin	0.6-1.7	20
β-Lactoglobulin	2.0-4.0	55
Serum albumin	0.2-0.4	5
Immunoglobulins	0.5-1.0	8
Protoese-peptones	0.2-0.4	12
Other	0.1	1

On the other hand, the two types of whey show variations in the minerals content. In general, acid whey has higher contents of minerals than sweet whey, especially in calcium and phosphorus. The average compositions for sweet and acid whey are listed in Table (2).

The traditional whey have greenish color due to presence of riboflavin which is sensitive to light and ionizing radiation treatments, and whey exposed to these conditions will appear in green color. Whey may also appear in yellow color due to prolonged heating or by the use of water soluble annatto in the cheese making process. Most of the produced whey shows turbidity as a result of casein fines.

The physicochemical properties of acid and sweet whey show variations that result from different acidity and contents of both types. Calcium and acidity are important in whey protein heat stability while potassium is the reason of saltiness and, together with lactose, for the osmolality of whey. Some of the physicochemical properties of whey are listed in Table (3).

Table (2.2): Average Composition of Sweet and Acid Whey

Component	Sweet whey (g/L)	Acid whey (g/L)
Total solids	63-70	63-70
Protein	6.0-8.0	6.0-7.0
Lactose	46.0-52.0	44.0-46.0
Fat	0.2-1.0	0.1-0.5
Calcium	0.4-0.6	1.2-1.6
Magnesium	0.08	0.11
Phosphate	1.0-3.0	2.0-4.5
Citrate	1.2-1.7	0.2-1.0
Lactate	2.0	6.4
Sodium	0.4-0.5	0.4-0.5
Potassium	1.4-1.6	1.4-1.6
Chloride	1.0-1.2	1.0-1.2

Table (2.3): Properties of Whey

Property	Whey
Viscosity (m Pa s)	1.2
Surface tension (dyne/cm)	42
Freezing point(C)	-0.5
Stability against heat coagulation (standard pH)	unstable
Stability against acid Coagulation (no heat)	stable

Table (3) show properties of whey in general which differ depending on kind. Heat stability is one of the important properties of whey. The acidity, temperature, calcium content and heating time are main factors that affect heat stability of whey. Whey which contains little content of calcium (sweet, decalcified acid whey or solution of whey protein isolate) will show turbidity but no precipitation upon heating .Protein will not precipitate even under sever heating above 90 ˚C for 20 minutes or more if pH is lower than 3.9. Protein will precipitate if heating above 70˚C and pH over than 3.9 with good calcium content.

2.3 Utilization of Whey

2.3.1 Introduction

About 50% of total world cheese-whey production is now treated and transformed into various food products, of which, in the European Economic Community (EEC), about 45% has been reported to be used directly in liquid form, 30%in the form of powdered cheese whey, 15% as lactose and delactosed byproducts, and the rest as cheese-whey-protein concentrates. As research in the field of whey utilization continuous, a variety of new whey products are currently being developed. Some possibilities for whey utilization will be briefly described below (Gonzalez Siso, M.I., 1996).

2.3.2 Global Uses

Whey, the liquid residue of cheese and casein production, is one of the biggest reservoirs of food protein still remaining largely outside human consumption channel. Without any treatment cheese whey surplus can be supplied into drinking water for farm animals. Whey used as a skim milk replacer in ice cream. Whey has also been used as an agricultural fertilizer but with the draw back that it leaches high saline deposits. Liquid whey can be used in bakery products, beverages, yeast products, and in animal feed, which include milk replaces for calves, feeds for cattle, swine, poultry, and finally pet foods. The reported uses for whey products in some countries are summarized in Table (4). (Pilippopoulos, C.D., and Papadakis, M.T., 2001).

2.3.3 Whey Utilization in Arab Countries

Saudi Arabia and Egypt have very developed food industries in the context of the rest of the region and large domestic markets to drive demand for important whey end use products such as ice cream, processed cheese, biscuits, chocolate and processed meat. While first generation whey products such as sweet whey powder and lactose remain the most popular type of whey used by the food processing and animal feed sectors, second generation products such as whey protein concentrate have come on in the past few years and there is even increasing interest at third generation further factionalized products (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

Saudi Arabia and Egypt remain relatively high demand markets, where there is no tradition of hard, and yellow ripened cheese production and as a consequence there has never been

Table (4) Reported Industrial Uses of Whey Powders

Product Reported Industrial Use	Product Reported Industrial Use
Whey powder	Whey cheese production when liquid is not sufficient or absent
	Bakery industry
	Meat industry
	Confectionery
	Processed cheese
	Animal feed
Whey protein concentrates	Whey cheese production
	Yoghurt desserts
	Milk desserts: spreads
	Cream desserts: milk cream analogues
	Ice cream formulation
	Meat industry: sausages
	Skimmed milk replacement
	Animal feed
Permeate powder	Bulk chocolate paste filler
	Animal feed
Cooked whey powder	Processed cheese
	Animal feed

Any processing of whey, nor is there likely to be in the future. The Middle East is now here Near the usage of what one might expect from say Western European markets and even lags behind the Far East in terms of volume used. However, the food processing industries in the region, and in Saudi particular, are becoming increasingly sophisticated and looking more and more for functional ingredients. Dutch, French and Australasian suppliers still have a strong hold on supplying Saudi Arabia and Egypt, although in recent years exports from Poland, the Czech Republic and even as far as Canada and Uruguay have been increasing.

It appears certain that the future for whey products will see continued development and consumption increase further. “More functional food products are going to become a factor in markets such as Saudi Arabia, and compared to even five years ago, the awareness of whey as a food ingredient has increased considerably.

2.4 Treatment of Dairy Wastewater

2.4.1 Introduction

Dairy wastewater contains high levels of fat, proteins and carbohydrates. Because of its high levels of protein and lactose, discharging whey directly into the waterway could cause a severe pollution problem. Commonly whey is used as animal feed or as fertilizer free of charge; however, the potential pollution problem still exists. As mentioned earlier, in the last years dairy farmers and factories have used sophisticated technology to process whey, producing dry protein powder and crystallized lactose. By so doing, they not only alleviate a potential pollution problem but also produce marketable products. On the other hand, many dairy factories built wastewater treatment facility in order to treat dairy wastewater (whey) and reuse for different purposes (Francisco, O., Garrido, B. and Ramon M., 2003).

It has been known that the strength and nature of the wastewater vary quite substantially, depending not only on the process but also on the operation. Different treatment processes are used to treat wastewater from dairy industry, mainly aerobic processes, although in the last two decades anaerobic reactors have been applied increasingly. This section discusses the treatment options as well as aerobic and anaerobic treatment of dairy effluent.

2.4.2 Treatment Option

Dairies factories have two basic choices for wastewater disposal; surface water discharge or land application and discharge there wastewater to the municipal sewer. Dairies with larger flow volumes tend to prefer treatment and discharge to public wastewater system if there is a receiving sewer available. Aerobic treatment, such as aerated lagoon, activated sludge process, and Sequencing Batch Reactors (SBR) has been commonly used for wastewater from food industry**.** However, only in recent years has anaerobic treatment emerged as a viable means for wastewaters containing high levels of organics**;** some have applied it to the treatment of dairy**.** In this section, a brief discussion to the most aerobic and aerobic treatment option is given as follows (Thompson,T. G., and Meyer, G.E.,1998):

1. Aerated Lagoons: Aerated lagoons are having been a commonly used method of wastewater treatment for dairies factories. Generally these systems are several large ponds connected in series with floating surface aerators or submerged air diffusers.

The advantages of these treatment systems are: (a) the long retention times of 30 days provide enough wastewater volume to absorb shock loads. (b) Lagoons are economical to construct and easy to operate. (c) Lagoons generate small volumes of sludge, and therefore can allow sludge to accumulate for years before it has to be dredged out.

The disadvantages of the system are as follows: (a) Because of their large surface area, and cold winter, the wastewater in the lagoons may have a low temperature which causes a decrease in biological activity and treatment efficiency. (b) Algae grow readily in these large lagoons, and algae growth in summer causes violation of effluent suspended solids limits. (c) Earthen lagoons are required to be constructed and maintained correctly to prevent leakage and possible contamination of groundwater. (d) It is difficult to meet the effluent phosphorus limitations with phosphorus removal processes available in a lagoon.

2. Activated Sludge: The conventional activated sludge process is effective for dairy wastewater, but it does require higher operator skills. A sludge management system is also required. The activated sludge process does overcome some of the primary disadvantages of the aerated lagoons such as low waste temperatures and algae growth.

3. Sequencing Batch Reactors (SBR): A relatively new technology that is used in a few dairies is sequencing batch reactors. This is essentially an activated sludge batch process which operates in cycles. One cycle involves shutting off aeration to the wastewater treatment vessel long enough for the sludge to settle. The clean treated effluent is then decanted off and if necessary, sludge is wasted before the aeration system is restarted.

4. Up flow Anaerobic Sludge Blanket (UASB): The UASB reactor is the world's most widely applied anaerobic technology after lagoons, with hundreds of systems having been installed over the last 20 years. UASB reactors are commonly anaerobic method used of wastewater treatment for dairies factories. In the UASB process wastewater is introduced at the bottom of the reactor, where it then flows through a blanket of active anaerobic sludge. Treatment occurs as a result of proper contact of the wastewater with the active sludge. The biogas produced in the sludge blanket becomes partially entrapped in the sludge, and the free gas bubbles gas particles with the attached gas tend to rise to the top of the reactor. Particles buoying to the surface of the degassing baffles on there way upwards, which may cause attached gas bubbles to be released. The degassed sludge particles then drop back to the top of the sludge blanket.

2.4.3 Aerobic Treatment of Dairy Wastewater

Wastewater from a dairy plant was treated aerobically using Activated Sludge Reactors, Aerated Lagoons, Sequencing Batch Reactors (SBR), etc. in many places in the world. In each study an aerobic pilot plants were constructed and examined. Samples from dairy factories were collected and analyzed. Wastewater characteristics such as BODS, chemical oxygen demand (COD), total Kjeldahl N, N, Total Suspended Solids (TSS), and Volatile Suspended Solids (VSS) were analyzed following the standard procedures.

Table (5) summarizes the average characteristics of wastewater from the whey processing plant, which had a neutral pH of 7.0, BOD5 of about 900 mg/L and total Kjeldahl N of 109 mg/L (Monroy, H.O., Vhquez, F. M., Derramadero, J.*C.* and Guyot, J. P., 1995).

Table (2.5) Characteristics of Wastewater from the Whey Processing Plant

Parameter	Unit	Average Value	Range
Temperature	^{o}C	25	20-30
pH	-	7.5	5.5-9.5
BOD_5	Mg/L	1250	500-2000
COD	Mg/L	2500	1000-5000
TOC	Mg/L	750	300-1200
TKN	Mg/L	215	120-480
NH_4 N	Mg/L	18	10-40
TSS	Mg/L	350	200-500
VSS	Mg/L	250	200-300
BOD_5: COD	-	0.52	0.3-0.9
BOD_5: TOC	-	1.69	1.4-2.0
COD: TOC	-	3.02	2-4
NH_4 N: TKN	-	0.084	0.07-0.9
VSS:TSS	-	0.72	0.6-0.8

BOD_5: 5-day Biological Oxygen Demand; COD: Chemical Oxygen Demand; TOC: Total Organic Carbon; TKN: Total Kjeldahl Nitrogen; TSS: total Dissolved Solid; VSS: Volatile Suspended Solids.

The average characteristics of the influent and effluent samples at final stages of treatment are presented in Table (6). The overall reductions for the treatment were 97% for BOD_5, 93% for COD, 92% for TOC, and 91% for TKN (Herbert, H.P., 1990).

Table (2.6) Characteristics of the Influent and Effluent Samples

Parameter	**Unit**	**Influent Average Value**	**Effluent Average Value**	**Reduction (%)**
Temperature	^oC	25	22	-
pH	-	7.5	7.0	-
BOD_5	Mg/L	1250	39	97
COD	Mg/L	2500	175	93
TOC	Mg/L	750	60	92
TKN	Mg/L	215	19.5	91
NH_4 N	Mg/L	18	1.8	92
TSS	Mg/L	350	45	87
VSS	Mg/L	250	699	-

BOD_5: 5-day Biological Oxygen Demand; COD: Chemical Oxygen Demand; TOC: Total Organic Carbon; TKN: Total Kjeldahl Nitrogen; TSS: total Dissolved Solid; VSS: Volatile Suspended Solids.

2.4.4 Anaerobic Treatment of Dairy Effluent

Over the past decades, several cost-effective treatment technologies comprising anaerobic, aerobic and facultative processes have been developed for the treatment of whey. Recently, anaerobic treatment leading to biogas production has become an effective biological process for the treatment of many industrial organic wastewaters. In anaerobic processes, the major produced gas is methane, which is a valuable and renewable energy source used for heating and production of electrical energy. Great interests in anaerobic treatment process have been developed for removal of organic waste and improve the treatment efficiency. The UASB reactor is one of the chosen innovative bioreactors. However, the performance of UASB systems has been examined by many studies.

The results achieved in several high-rate anaerobic reactors treating different dairy wastewaters show that high COD removal efficiencies could be achieved even with extremely high COD contents, such as those present in the effluents generated during cheese making processes. On the other hand, the anaerobic reservoir could remove above 75% of the BOD and COD all year round (Francisco, O., Garrido, B. and Ramon M., 2003).

CHAPTER

2 *REVIEW OF LITERATURE*

2.1 General

2.2 Concepts of Whey

2.2.1 What is Whey
2.2.2 Types of Whey
2.2.3 Compositions and Properties

2.3 Utilization of Whey

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CHAPTER TWO

REVIEW OF LITERATURE

2.1 General

Milk whey and wastewater from dairy industry has become a controversial topic in recent years. Milk whey, which is generally considered as being one of the best sources of protein available, is processed into a wide range of nutritional ingredients in many countries in the world. Whey can be used in ice cream, bakery products, beverages, yeast products, and in animal feed. Without any treatment cheese whey surplus can be supplied into drinking water for farm animals or used as an agricultural fertilizer.

At the same time, wastewater from dairy industries which is characterized by their high BOD and COD contents is treated in many places using aerobic and anaerobic wastewater treatment technologies. Most of the dairy industries in the world use the typical activated sludge for their effluent treatment. The typical activated sludge treatment is characterized by the relatively high energy consumption and biomass production, leading to a relatively high operation costs and problem with the disposal of large amounts of sludge. Although the aerobic treatments have used in most of the dairy factories, it has been known that wastewater of many dairy factories in the world is treated using UASB and other anaerobic wastewater treatment technologies.

Research efforts in countries of developed markets like Palestine on the nutritional benefits of whey protein and sugar derivatives continue to become available as researchers discover additional applications for whey valuable ingredients. This chapter discusses the previous works on milk whey recovery and the treatment of wastewater from dairy factories.

2.2 Concepts of Whey

Milk whey is defined as a liquid by-product of the dairy industry, generated after the separation of coagulant casein and fat from the milk. More details about what is whey? types of whey, and composition and properties of whey are explained in the following paragraphs.

2.2.1 What is Whey?

Whey or milk plasma is the liquid remaining after milk has been curdled and strained; it is a by-product of the manufacture of cheese or casein and has several commercial uses. Approximately 9 L of whey will be obtained from 10 L of milk for every kg of cheese produced; this general ratio will vary somewhat depending on the type of cheese, fat content of the raw milk used, and other factors. Sweet whey is manufactured during the making of rennet types of hard cheese like cheddar or Swiss cheese. Acid whey (or sour whey) is obtained during the making of acid types of cheese such as cottage cheese.

Whey is used to produce ricotta and brown cheeses and many other products for human consumption. It is also an additive in many processed foods, including breads, crackers and commercial pastry, and in animal feed. Liquid whey contains lactose, vitamins, and minerals along with traces of fat. On the other hand, the fast growing food industry in general, and specifically the dairy industry in the region of the Middle East, has a positive driving force for using whey end-use products, such as ice-creams, biscuits, chocolates, and processed meat (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

2.2.2 Types of Whey

Whey is classified according to the method of precipitation into two types as:

1) Sweet whey: This is also termed cheese whey and is produced during cheese making, when rennet is used. Sweet whey forms a very large family of products. Their composition may vary only slightly but their properties are very different. The pH value of sweet whey can range between 5.2 and 6.7. Sweet whey is produced during the manufacturing of hard, semi hard or soft cheeses like Cheddar, Swiss and Mozzarella.

2) Sour whey: This can be acid whey, quark or cottage cheese whey and sour sweet whey. Acid whey, also known as casein whey, originates from the manufacture of casein by means of lactic acid and hydrochloric acid. The origin of quark or cottage cheese whey is self-explanatory. Lactic acid created through natural fermentation gives the whey a high acidity. The pH values of these types of whey range from 3.8 to 4.6. If insufficient care is given to the cheese whey, it becomes sourer by continued natural fermentation. Such a process is of course undesirable so that soured (not sour) whey cannot be considered a natural product (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

2.2.3 Composition and Properties

The main components of whey are lactose, protein, fat and minerals. The portions of the above components vary depending on the cheese making process. Lactose is the primary part of total solid of whey (between 63-75% of total whey solid). This ratio differs depending on the type of whey; acid whey appears to have low lactose content due to the fermentation of lactose into lactic acid. Protein is the most important whey component. It is between 9-11% of dry matter. The importance of proteins resulting from their high nutrients value. Table (1) shows the composition of whey protein fractions in both type of whey (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

Table (2.1): Composition of Whey Protein

Protein	Approximate content (g/L whey)	Total whey protein (%)
α-Lactalbumin	0.6-1.7	20
β-Lactoglobulin	2.0-4.0	55
Serum albumin	0.2-0.4	5
Immunoglobulins	0.5-1.0	8
Protoese-peptones	0.2-0.4	12
Other	0.1	1

On the other hand, the two types of whey show variations in the minerals content. In general, acid whey has higher contents of minerals than sweet whey, especially in calcium and phosphorus. The average compositions for sweet and acid whey are listed in Table (2).

The traditional whey have greenish color due to presence of riboflavin which is sensitive to light and ionizing radiation treatments, and whey exposed to these conditions will appear in green color. Whey may also appear in yellow color due to prolonged heating or by the use of water soluble annatto in the cheese making process. Most of the produced whey shows turbidity as a result of casein fines.

The physicochemical properties of acid and sweet whey show variations that result from different acidity and contents of both types. Calcium and acidity are important in whey protein heat stability while potassium is the reason of saltiness and, together with lactose, for the osmolality of whey. Some of the physicochemical properties of whey are listed in Table (3).

Table (2.2): Average Composition of Sweet and Acid Whey

Component	Sweet whey (g/L)	Acid whey (g/L)
Total solids	63-70	63-70
Protein	6.0-8.0	6.0-7.0
Lactose	46.0-52.0	44.0-46.0
Fat	0.2-1.0	0.1-0.5
Calcium	0.4-0.6	1.2-1.6
Magnesium	0.08	0.11
Phosphate	1.0-3.0	2.0-4.5
Citrate	1.2-1.7	0.2-1.0
Lactate	2.0	6.4
Sodium	0.4-0.5	0.4-0.5
Potassium	1.4-1.6	1.4-1.6
Chloride	1.0-1.2	1.0-1.2

Table (2.3): Properties of Whey

Property	Whey
Viscosity (m Pa s)	1.2
Surface tension (dyne/cm)	42
Freezing point(C)	-0.5
Stability against heat coagulation (standard pH)	unstable
Stability against acid Coagulation (no heat)	stable

Table (3) show properties of whey in general which differ depending on kind. Heat stability is one of the important properties of whey. The acidity, temperature, calcium content and heating time are main factors that affect heat stability of whey. Whey which contains little content of calcium (sweet, decalcified acid whey or solution of whey protein isolate) will show turbidity but no precipitation upon heating .Protein will not precipitate even under sever heating above 90 ˚C for 20 minutes or more if pH is lower than 3.9. Protein will precipitate if heating above 70˚C and pH over than 3.9 with good calcium content.

2.3 Utilization of Whey

2.3.1 Introduction

About 50% of total world cheese-whey production is now treated and transformed into various food products, of which, in the European Economic Community (EEC), about 45% has been reported to be used directly in liquid form, 30%in the form of powdered cheese whey, 15% as lactose and delactosed byproducts, and the rest as cheese-whey-protein concentrates. As research in the field of whey utilization continuous, a variety of new whey products are currently being developed. Some possibilities for whey utilization will be briefly described below (Gonzalez Siso, M.I., 1996).

2.3.2 Global Uses

Whey, the liquid residue of cheese and casein production, is one of the biggest reservoirs of food protein still remaining largely outside human consumption channel. Without any treatment cheese whey surplus can be supplied into drinking water for farm animals. Whey used as a skim milk replacer in ice cream. Whey has also been used as an agricultural fertilizer but with the draw back that it leaches high saline deposits. Liquid whey can be used in bakery products, beverages, yeast products, and in animal feed, which include milk replaces for calves, feeds for cattle, swine, poultry, and finally pet foods. The reported uses for whey products in some countries are summarized in Table (4). (Pilippopoulos, C.D., and Papadakis, M.T., 2001).

2.3.3 Whey Utilization in Arab Countries

Saudi Arabia and Egypt have very developed food industries in the context of the rest of the region and large domestic markets to drive demand for important whey end use products such as ice cream, processed cheese, biscuits, chocolate and processed meat. While first generation whey products such as sweet whey powder and lactose remain the most popular type of whey used by the food processing and animal feed sectors, second generation products such as whey protein concentrate have come on in the past few years and there is even increasing interest at third generation further factionalized products (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

Saudi Arabia and Egypt remain relatively high demand markets, where there is no tradition of hard, and yellow ripened cheese production and as a consequence there has never been

Table (4) Reported Industrial Uses of Whey Powders

Product Reported Industrial Use	Product Reported Industrial Use
Whey powder	Whey cheese production when liquid is not sufficient or absent
	Bakery industry
	Meat industry
	Confectionery
	Processed cheese
	Animal feed
Whey protein concentrates	Whey cheese production
	Yoghurt desserts
	Milk desserts: spreads
	Cream desserts: milk cream analogues
	Ice cream formulation
	Meat industry: sausages
	Skimmed milk replacement
	Animal feed
Permeate powder	Bulk chocolate paste filler
	Animal feed
Cooked whey powder	Processed cheese
	Animal feed

Any processing of whey, nor is there likely to be in the future. The Middle East is now here Near the usage of what one might expect from say Western European markets and even lags behind the Far East in terms of volume used. However, the food processing industries in the region, and in Saudi particular, are becoming increasingly sophisticated and looking more and more for functional ingredients. Dutch, French and Australasian suppliers still have a strong hold on supplying Saudi Arabia and Egypt, although in recent years exports from Poland, the Czech Republic and even as far as Canada and Uruguay have been increasing.

It appears certain that the future for whey products will see continued development and consumption increase further. “More functional food products are going to become a factor in markets such as Saudi Arabia, and compared to even five years ago, the awareness of whey as a food ingredient has increased considerably.

2.4 Treatment of Dairy Wastewater

2.4.1 Introduction

Dairy wastewater contains high levels of fat, proteins and carbohydrates. Because of its high levels of protein and lactose, discharging whey directly into the waterway could cause a severe pollution problem. Commonly whey is used as animal feed or as fertilizer free of charge; however, the potential pollution problem still exists. As mentioned earlier, in the last years dairy farmers and factories have used sophisticated technology to process whey, producing dry protein powder and crystallized lactose. By so doing, they not only alleviate a potential pollution problem but also produce marketable products. On the other hand, many dairy factories built wastewater treatment facility in order to treat dairy wastewater (whey) and reuse for different purposes (Francisco, O., Garrido, B. and Ramon M., 2003).

It has been known that the strength and nature of the wastewater vary quite substantially, depending not only on the process but also on the operation. Different treatment processes are used to treat wastewater from dairy industry, mainly aerobic processes, although in the last two decades anaerobic reactors have been applied increasingly. This section discusses the treatment options as well as aerobic and anaerobic treatment of dairy effluent.

2.4.2 Treatment Option

Dairies factories have two basic choices for wastewater disposal; surface water discharge or land application and discharge there wastewater to the municipal sewer. Dairies with larger flow volumes tend to prefer treatment and discharge to public wastewater system if there is a receiving sewer available. Aerobic treatment, such as aerated lagoon, activated sludge process, and Sequencing Batch Reactors (SBR) has been commonly used for wastewater from food industry**.** However, only in recent years has anaerobic treatment emerged as a viable means for wastewaters containing high levels of organics**;** some have applied it to the treatment of dairy**.** In this section, a brief discussion to the most aerobic and aerobic treatment option is given as follows (Thompson,T. G., and Meyer, G.E.,1998):

1. Aerated Lagoons: Aerated lagoons are having been a commonly used method of wastewater treatment for dairies factories. Generally these systems are several large ponds connected in series with floating surface aerators or submerged air diffusers.

The advantages of these treatment systems are: (a) the long retention times of 30 days provide enough wastewater volume to absorb shock loads. (b) Lagoons are economical to construct and easy to operate. (c) Lagoons generate small volumes of sludge, and therefore can allow sludge to accumulate for years before it has to be dredged out.

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2. Activated Sludge: The conventional activated sludge process is effective for dairy wastewater, but it does require higher operator skills. A sludge management system is also required. The activated sludge process does overcome some of the primary disadvantages of the aerated lagoons such as low waste temperatures and algae growth.

3. Sequencing Batch Reactors (SBR): A relatively new technology that is used in a few dairies is sequencing batch reactors. This is essentially an activated sludge batch process which operates in cycles. One cycle involves shutting off aeration to the wastewater treatment vessel long enough for the sludge to settle. The clean treated effluent is then decanted off and if necessary, sludge is wasted before the aeration system is restarted.

4. Up flow Anaerobic Sludge Blanket (UASB): The UASB reactor is the world's most widely applied anaerobic technology after lagoons, with hundreds of systems having been installed over the last 20 years. UASB reactors are commonly anaerobic method used of wastewater treatment for dairies factories. In the UASB process wastewater is introduced at the bottom of the reactor, where it then flows through a blanket of active anaerobic sludge. Treatment occurs as a result of proper contact of the wastewater with the active sludge. The biogas produced in the sludge blanket becomes partially entrapped in the sludge, and the free gas bubbles gas particles with the attached gas tend to rise to the top of the reactor. Particles buoying to the surface of the degassing baffles on there way upwards, which may cause attached gas bubbles to be released. The degassed sludge particles then drop back to the top of the sludge blanket.

2.4.3 Aerobic Treatment of Dairy Wastewater

Wastewater from a dairy plant was treated aerobically using Activated Sludge Reactors, Aerated Lagoons, Sequencing Batch Reactors (SBR), etc. in many places in the world. In each study an aerobic pilot plants were constructed and examined. Samples from dairy factories were collected and analyzed. Wastewater characteristics such as BODS, chemical oxygen demand (COD), total Kjeldahl N, N, Total Suspended Solids (TSS), and Volatile Suspended Solids (VSS) were analyzed following the standard procedures.

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TKN	Mg/L	215	120-480
NH_4 N	Mg/L	18	10-40
TSS	Mg/L	350	200-500
VSS	Mg/L	250	200-300
BOD_5: COD	-	0.52	0.3-0.9
BOD_5: TOC	-	1.69	1.4-2.0
COD: TOC	-	3.02	2-4
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BOD_5: 5-day Biological Oxygen Demand; COD: Chemical Oxygen Demand; TOC: Total Organic Carbon; TKN: Total Kjeldahl Nitrogen; TSS: total Dissolved Solid; VSS: Volatile Suspended Solids.

The average characteristics of the influent and effluent samples at final stages of treatment are presented in Table (6). The overall reductions for the treatment were 97% for BOD_5, 93% for COD, 92% for TOC, and 91% for TKN (Herbert, H.P., 1990).

Table (2.6) Characteristics of the Influent and Effluent Samples

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BOD_5: 5-day Biological Oxygen Demand; COD: Chemical Oxygen Demand; TOC: Total Organic Carbon; TKN: Total Kjeldahl Nitrogen; TSS: total Dissolved Solid; VSS: Volatile Suspended Solids.

2.4.4 Anaerobic Treatment of Dairy Effluent

Over the past decades, several cost-effective treatment technologies comprising anaerobic, aerobic and facultative processes have been developed for the treatment of whey. Recently, anaerobic treatment leading to biogas production has become an effective biological process for the treatment of many industrial organic wastewaters. In anaerobic processes, the major produced gas is methane, which is a valuable and renewable energy source used for heating and production of electrical energy. Great interests in anaerobic treatment process have been developed for removal of organic waste and improve the treatment efficiency. The UASB reactor is one of the chosen innovative bioreactors. However, the performance of UASB systems has been examined by many studies.

The results achieved in several high-rate anaerobic reactors treating different dairy wastewaters show that high COD removal efficiencies could be achieved even with extremely high COD contents, such as those present in the effluents generated during cheese making processes. On the other hand, the anaerobic reservoir could remove above 75% of the BOD and COD all year round (Francisco, O., Garrido, B. and Ramon M., 2003).

CHAPTER

3 *Dairy Industry in Palestine*

3.1 Introduction

3.2 Whey Production

3.3 Properties of Palestine Whey

3.4 Environmental Problem facing Dairy Industry

3.5 Dairy and Food Industry in Hebron Area

CHAPTER THREE
DAIRY INDUSTRY IN PALESTINE

3.1 Introduction

Dairy industry is one of the important industries in Palestine, such that large amount of the raw milk are used to this industry and many farmers sell the milk to the dairy factories, and many workers are employed in this industry, so that it is considered as improvement of economy.

In Palestine there are many dairy factories, but the major factories are: -

1. AL- Junidi in Hebron.
2. AL- Gibreeni in Hebron.
3. Al-Safa in Nablus.
4. AL- Rayyan in Ramallah.
5. AL- Binar in Ramallah.
6. Hamoda in Jerusalem.
7. AL- Qaysi in Talkarm.
8. Alban Altaawonia in Tulkarm.

3.2 Whey Production

In Palestine the white cheese and labaneh are considered the main sources for whey production, most factories produced large amount of whey, but these amount are disposed into wastewater without utilization, a very small amount of this whey used as irrigation on to lands or pastures. But this amount of utilized is negligible compared to total amount of whey produced.

In AL-Junidy factory as an example, the total amount of milk input equals 25 tons per day, where 20% of this quantity are used for manufacturing of Cheese, 25% for producing Labaneh, 15% for manufacturing Yogurt, and the remaining are used for manufacturing of UHT milk, chocco and banana flavored taste. And as mentioned earlier, the large quantity of whey are produce by manufacturing cheese and labaneh. It is estimated that (82-84)% of milk used in white cheese production ends up as whey; while in labaneh this fraction is (60-63)%. Figure (3.1) shows the milk provide to the factory from cow farms, while Figure (3.2) present whey produced from manufacturing of cheese.

Figure (3.1): Milk from Cow farm

Figure (3.2) Whey Produced from Cheese

3.3 Properties of Palestine Whey

The different kinds of whey have the same components such as (protein, lactose, minerals); the variation between these kinds is in the concentration of each component. For example, all types of whey contain protein in their composition, but the percentage of protein differs from each type, these differs due to the two main reasons; the first; source of milk; the second; type of dairy process. So it is important before the choice of the suitable application for whey is to know the accurate composition.

The chemical and biological characteristics of whey produced from manufacturing of cheese and labaneh in Al-Safa dairy factory in Nablus are listed in Tables (3.1) and (3.2). (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005**)**.

Table (3.1): Ingredient of Cheese Whey Sample

Test	Unit	Result
Protein	%	Non detective
Soluble solids	ppm	3700
Total soluble solids	%	6.58
Conductivity	µs/ cm	5500
Sodium	ppm	280
PH	---	4.8
Phosphorus	ppm	144

Table (3.2): Ingredient of Labaneh Whey Sample

Test	Unit	Result
Protein	%	Non detective
Soluble solids	ppm	Non detctive
Total soluble solids	%	3800
Conductivity	µs/ cm	5.0
Sodium	ppm	7700
PH	---	300
Phosphorus	ppm	3.7

3.4 Environmental Problems facing Dairy Industry

Ever since the industrialization of cheese production, whey has in large amounts been dumped into rivers, lakes or similar water reservoirs. However, as the whey contains organic substances, oxygen is required for the decomposition, and dumping of whey will therefore have a great influence on the environment. If the dumping is of such a quantity that the decomposition requires all the oxygen available in the water, then all life will die. It is therefore obvious that the amount of whey which can be dumped per hour depends on the amount of oxygen available which is again determined by the amount of water per hour and its content of oxygen (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

Whey represents a serious environmental problem due to the presence of high concentrations of dissolved organic substances. The Biochemical Oxygen Demand (BOD) of whey varies from 30000 to 50000 ppm depending upon the source of milk and lactose is mainly responsible for his high value, While the (COD) of a whey is 70000 ppm.

In general terms, waste products may occur as wastewater, solid material, and volatile compound. Discharge of wastewater with whey to surface waters affects by: Discharge of biodegradable organic compounds (BOC's) may cause a strong reduction of the amount of dissolved oxygen, which in turn may lead to reduced levels of activity or even death of aquatic life. Problems resulting from the discharge of biodegradable organic compounds may be addressed by means of biological wastewater systems, either of the aerobic or of the anaerobic type. In aerobic systems the organic compounds are oxidized by aerobic micro-organisms (oxygen required) into CO2, H2O and new bacterial biomass. Anaerobic systems are based on the capacity of anaerobic bacteria (no oxygen required) to degrade the organic material into CO_2, CH_4 (Aref, E., Barroq, H., Abuwaza, S. and AL-khalele, K., 2005).

3.5 Dairy and Food Industry in Hebron Area

In Hebron district there are many large and small dairy factories. In this study, the largest two dairy factories in the area, namely, AL-Jounidi and AL-Jibreeni were selected for the purpose of this study. Brief descriptions to these two factories are given in the following sections.

1. AL-Jounidi Dairy and Food Industries:

AL-Jounidi Company is one of the major factories in the Palestinians territories specialized in dairy product and salads. It is established in 1982 in the Hebron city of the West Bank, Palestine. In this company, more than 250 workers and employees from various Palestinian areas are working in this company. However, the absorbed production capacity in the main production lines is (70,000 liters) of fresh milk per day in addition to (10 tons) of fresh salads, and (5 tons) of Tahaineh, all of these products are produced on area of (11,000 m^2) of the modern buildings which includes the administration offices, the company production lines, various support services and quality laboratories, and storage and refrigeration facilities.

AL-Jounidi Company get the most amount of fresh milk every day from three farms, AL-Jounidi Company farm, National Accord farm, and local farms. AL- Jounidi Company farm located in south of the Hebron city in Zeef area, features with flat land, fertility, suitable climate for cattle-breeding farm, designed with area equal to (400 m^2). The farm used accurately methods of conservation, storage, processing and filtering through accurate and rapid cooling to ensure the degree of safety and stored in refrigerated containers so special be transferred to the plant, adopt own rules that applicable to all stages of the work to avoid the critical points that lead to contamination of the final product used for machinery and materials for the operations of hygiene and sterilization, whether indoors or in milking lines (See Figure (3.3)).

AL-Junidi Company receive approximately (35) tons of fresh milk per day from (16) sixteen local farm located in the governorate of Hebron, where the farmers supply of chilled milk and fresh on a daily basis and are required for testing the quality of milk to be in conformity with the specifications.

AL- Jounidi Company manufactures many products; these products can be classified in four groups as shown Figure 3.4, Fresh milk as cheese, Salts as Tahaineh, Sweet milk as fruit milk, and Snack foods as sesame oil.

Figure (3.3) AL-Junidi Company Farms

Figure (3.4) AL-Junidi Products

2. AL-Jebrini Dairy and Food Industries:

AL-Jebrini Company is one of the major factories in the Palestinians territories specialized in dairy product and salads, established since 1993 in Hebron-Palestine, the company market in all Palestine territories, it have 500 employers, 70 refrigerated trucks, builded on 200000 quadrate meter,1000 cows, now the company manufacturing 38 of food product type (See Figure (3.5))

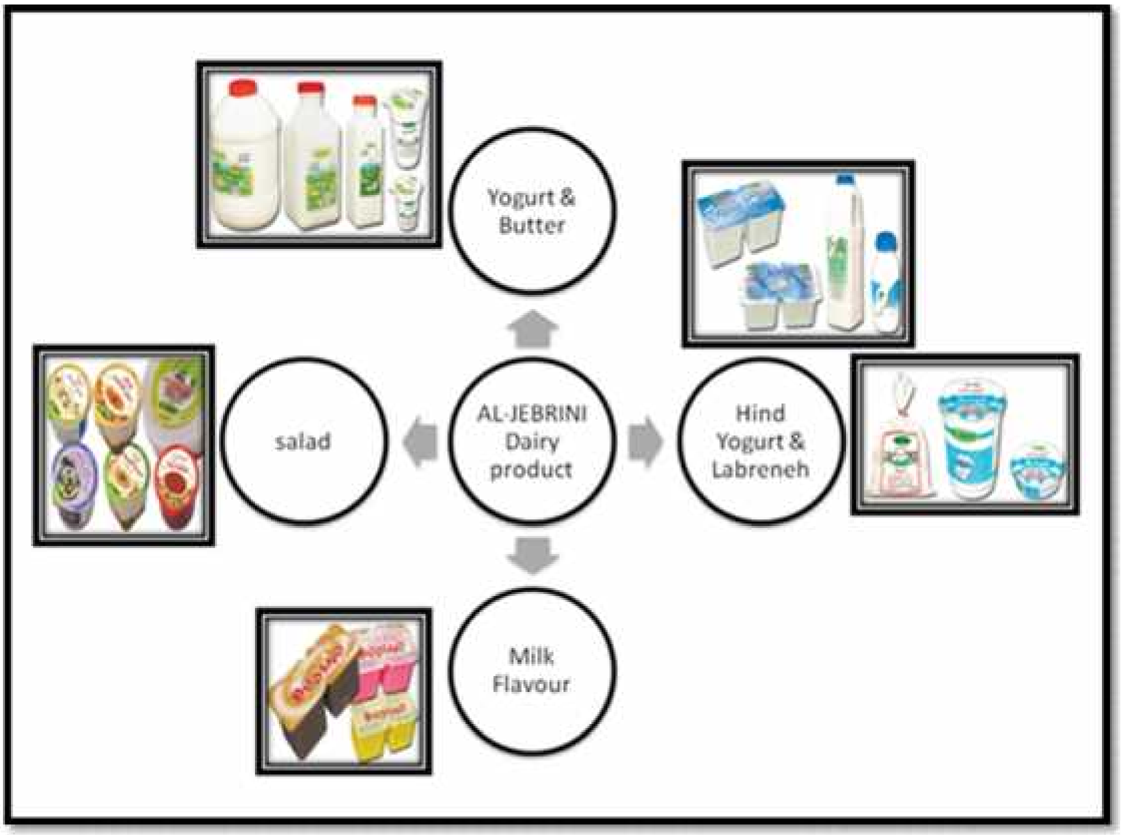

Figure 3.5 AL-Jebrini Products

CHAPTER

4 SURVEY AND ANALYSIS OF WASTEWATER QUALITY

4.1 Introduction

4.2 Discussion of Parameters Tested.

4.3 Diary wastewater Sampling.

4.4 Diary waewater Quality Analysis.

4.5 Discussion of Results.

CHAPTER FOUR

SURVEY AND ANALYSIS OF WASTEWATER QUALITY

4.1 Introduction :

The study of the characteristics of Dairy wastewater is important in treatment of Dairy wastewater and in the study of suitability of Diary wastewater for irrigation use. This chapter will covers the survey and analysis of diary wastewater quality of the study area(Dairy Factory in Hebron city) . The main objective of this chapter is to find out the characteristics of raw wastewater before the treatment, in order to determine the treatment method and evalute it is sutability for irrigation purposes.

4.2 Discussion of Parameters Tested :

1. pH: The hydrogen-ion concentration is an important quality parameter of both natural water and wastewater. The usual means of expressing the hydrogen-ion concentration is as pH, which is defined as the negative logarithm of the hydrogen-ion concentration.

The concentration range suitable for the existence of most biological life is quite narrow and critical (typically 6-9). Wastewater with an extreme concentration of hydrogen-ion is difficult to treat by biological means, and if the concentration is not altered before discharge, the wastewater effluent may alter the concentration in the natural water. For treated effluent discharged to the environment the allowable range usually varies from 8 to 11.

2. Electrical Conductivity (EC): The Electrical Conductivity (EC) of a water is a measure of the ability of a solution to conduct an electrical current; because the electrical current is transported by the ions in solution, the conductivity increases as the concentration of ions increases. In effect, the measured EC value is used as a surrogate measure of Total Dissolved Solids (TDS) concentration. At present, the EC of water is one of the important parameters used to determine the suitability of water for irrigation. The salinity of treated wastewater to be used for irrigation is estimated by measuring its electrical conductivity. The electrical conductivity is expressed as millisiemens per meter (mS/m) or micromhos per centimeter (μmho/cm). It should be noted that 1 mS/m is equivalent to 10 μmho/cm.

3. Total Dissolved Solids (TDS): Total dissolved solid can be defined as the solids that pass through a filter with nominal pore size of 2 microns or less. Yet it is known that wastewater contains a high fraction of colloidal solids. The size of colloidal particles in wastewater is typically in the range from 0.01 to 1.0 μm. The number of colloidal particles in untreated wastewater and after primary sedimentation is typically in the range from 10^8 to 10^{12} per milliter.

4. Chemical Oxygen Demand (COD): The COD test is used to measure the oxygen equivalent of the organic material in wastewater that can be oxidized chemically using dichromate in an acid solution. It is a chemical test using a strong oxidizing agent (potassium dichromate), sulfuric acid and heat. The results of the COD test can be available in just two hours, a definite advantage over the 5 days reqired for the standard BOD test. COD values are always high than BOD values for the same sample, but there is generally no consistent correlation between the two tests for different wastewaters.

5. Total Salt Concentration: Total salt concentration is one of the most important agricultural water quality parameters. This is because the salinity of the soil water is related to, and often determined by; the salinity of the irrigation water. According to, plant growth, crop yeild and quality of produce are effected by the total dissolved salts in the irrigation water. Equally, the rate of accumulation of salts in the soil, or soil salinization, is also directly affected by the salinity of the irrigation water. Total salt concentration is expressed in milligrams per liter (mg/l) or parts per million (ppm).

6. Total Solids (TS): The most important physical characteristic of wastewater is its total solids content, which is composed of floating matter, settleable matter, colloidal, and matter in solution. Total Solid (TS) are obtained by evaporating a sample of wastewater to dryness and measuring the mass of the residue.

7. Total Suspended Solids (TSS): Total suspended solids in wastewater may be due to sand, silt, clay, and organic matter. The typical total suspended solids concentration in diary wastewater is 979 mg/l. The suspended solids when discharged into the natural water may increase turbidity of the water and when they settle to the bottom may ruin the spawing and breeding grounds of a quatic animals.

8. Biochemical Oxygen Demand (BOD): Biochemical Oxygen Demand (BOD) is defined as the amount of oxygen utilized by a mixed population of microorganisms under aerobic condition to stabilize the organic matter (or is a measure of organic material in wastewater). Oxygen is required to break down large organic molecules into smaller molecules and eventually into carbon dioxide and water.

5-day Biochemical Oxygen Demand (BOD_5) is the most commonly used parameter to express the strength of municipal and industrial wastewaters. The BOD_5 test is important for the design of biological treatment facilities, determining organic loadings to treatment plants, and evaluating the efficiencey of treatment systems.

4.3 Wastewater Sampling:

In order to study the characteristics of raw wastewater, one sample were collected from each factory, tested, and analyzed. The samples are then tested and analyzed in the Palestinian Hydrology Group (PHG) labratories and the results were obtained.

In the sampling dairy wastewater for quality analysis, plastic bottels 2 litter volume was used, Samples were stored at 4ºC in iceboxes and brought back immediately to the laboratory for analysis. Sampling was performed in accordance with the standard sampling procedure of American Society for Testing and Materials (ASTM).

4.4 Wastewater Quality Analysis:

The laboratory analysis included the following tests which were performed:

1. pH value (pH).
2. Electric Conductivity (EC).
3. Total Dissolved Solids (TDS).
4. Chemical Oxygen Demand (COD).
5. Salinity (S).
6. Total Solids (TS).
7. Total Suspended Solids (TSS).
8. Biochemical Oxygen Demand (BOD).

The procedures for the the test are given in Appendix B.

4.5 Discussion of Results:

The characteristics of dairy wastewater are impacted by the type of whey (acide or sweet) and water consumption rates. Dairy wastewater contains over 90 percent water. The remaining materials include suspended and dissolved organic and inorganic matter as well as microorganisms. These materials given physical, chemical, and biological qualities that are characteristic of wastewater. In this section, chemical, and variaties in contituents and loading in raw wastewater are discussed for the study area (Hebron city).

As mentioned earlier, the analysis of Dairy wastewater characteristics includes measurement of pH, EC, TDS, COD, and Salinity. The analysis results of two sample (AL- Junidi & AL- Gibreeni) are presented in Table (4.1). The averages values of each contituents are given in the table beside the typical quality of raw domestic wastewater for some parameters.

Table (4.1) : Results of the Analysis of Raw Dairy Wastewater Samples.

#	Parameters	Unit	Average Value		Typical Value
			Sampl# 1	Sampl# 2	
1	**pH value (pH)**	-	6.38	3.69	6.5-7.5
2	**Electric Conductivity (EC)**	ms/cm	9.88	9.97	-
3	**Total Dissolved Solid (TDS)**	g/l	5.39	5.44	0.25-0.8
4	**Chemical Oxygen Demand (COD)**	mg/l	52000	24953	283-7312
5	**Salinity (S)**	%	5.60	5.70	-
6	**Total Suspended Solid (TSS)**	mg/l	795	742	105-551
7	**Total Solid (TS)**	mg/l	3040	3038	1329-5262
8	**Biochemical Oxygen Demand (BOD)**	mg/l	2030	3020	220-4880

From the data presented in Table (4.1), one can conclude the following about dairy wastewater experimental parameters:

1. pH value: pH is indication of acidic or basic nature of Dairy wastewater. A solution is neutral at pH value 7. The results reveal that dairy wastewater is acidic in character; hence, the average value of pH in sampl#1 & sampl#2 is 6.38& 3.69 respectively.

2. Electric conductivity: Results of the tests indicate that electric conductance values are higher than the average value of raw wastewater (1500 Ms/cm). The average value of electric conductance for sample#1& sample #2 is 9880 Ms/cm & 9970 Ms/cm respectively.

3. Total dissolved solid: Portion of organic and inorganic dissolved matter that is not filterable. Solids smaller than one millimicron (mμ) fall in this category. The results of analysis show that the average value of total dissolved solids is 5390 mg/l in sample #1 and 5440 in sample #2 which comparatively higher than the typical value.

4. Chemical oxygen demand: It is measure of organic matter and represents the amount of oxygen required to oxidize the organic matter by strong oxidizing chemicals (potassium dichromate) under acidic condition. The results of chemical oxygen demand given in Table (4.1) show that the average value is 52000 mg/l in sample #1 and 24953 mg/l which means the organic content in the wastewater is high.

5. Salinity: The salinity of the soil water is related to, and often determined by; the salinity of the irrigation water. The average value of salinity is about 5.6% for the two samples .

6. Total solid: Organic and inorganic, settleable, suspended and dissolved matter. The average value of total solid is 3038 mg/l. which is high because the average water consumption in the camp is very low (55 l/c.d.).

7. Total suspended solid: Portion of organic and inorganic solids that are not dissolved. These solids are removed by coagulation or filtration. The average value of total suspended solid for Dairy wastewater is 979 mg/l where the typical value is between 105 to 5551 mg/l which means that the value of total suspended solid is very high..

CHAPTER

5 *APPROPRIATE DAIRY SEWAGE TRETMENT TECHNOLOGY*

5.1 Introduction

5.2 Criteria for Selecting Dairy Wastewater Treatment

5.3 Options for Dairy Wastewater Treatment

5.4 Selection of Treatment Process

CHAPTER FIVE
APPROPRIATE DAIRY SEWAGE TREATMENT TECHNOLOGY

5.1 Introduction

As mentioned earlier, dairy wastewater contains high levels of fat and proteins. The strength and nature of the dairy wastewater vary quite substantially, depending not only on the process but also on the operation. Because of its high levels of protein and lactose, discharging whey directly into the waterway could cause a severe pollution problem. Appropriate treatment should be applied before the effluent discharge in public wastewater networks with minimal operational and maintenance requirements.

Different treatment processes are used to treat wastewater from dairy industry, mainly aerobic processes, although in the last two decades anaerobic reactors have been applied increasingly. Adopting as low a level of whey treatment as possible is especially desirable in developing countries like Palestine, not only from point of view of cost but also in acknowledgement of the difficulty of operation complex systems reliably. As a conclusion, compact, enclosed and covered treatment systems are recommended for dairy factories in the Hebron area. This chapter discusses the options for dairy wastewater treatment as well the appropriate technology of dairy sewage treatment.

5.2 Criteria for Selecting Dairy Wastewater Treatment

A large variety of wastewater treatment system do exist. The selection of most appropriate technology will first of all be determined by the composition of the dairy wastewater flow coming to the sewage networks. The treatment process for whey wastewater is not available in all the dairy factories in the Hebron Governorate, and the whey wastewater which supposed to be treated is highly concentrated. The other important criteria for selecting dairy wastewater treatment is as follow:

1. The method should provide a sufficient treatment efficiency towards the removal of various categories of pollutants, i.e. Biodegradable organic matter (BOD), Suspended solids, pathogens, etc.
2. The stability of the system for interruptions in power supply, peak loads, feed interruptions and/or for toxic pollutants should be high.

3. The flexibility for the process should be high, e.g. with respect to the scale at which is applied, possibilities for future extensions, possibilities to improve the efficiency.

4. The system should be simple in operation, maintenance and control, so that a good performance does not depend on the (continuous) presence of highly skilled operators and engineers.

5. The land requirements should be low, obviously especially when little land is available and/or the price of the land is high.

6. The number of required (different) process steps should be as low as possible.

7. The life time of system should be long.

8. The application of the system should not suffer from any serious sludge disposal problems.

9. The application of the system should not be accompanied with mal-odour nuisance problems, etc.

10. The system should offer good possibilities to come to recovery of useful by products, to irrigation and fertilization.

11. Sufficient experience with the system should be available.

5.2 Options for Dairy Wastewater Treatment

Each wastewater treatment plant always need to be composed of a combination of unit process and operations in such a way that the effluent quality will be matched to the criteria set by water pollution control boards or central government. This means that in selecting a treatment technology the first thing to do is to develop a logical flow diagram where the various unit processes and operations are systematically and logically put together to make a well balanced treatment scheme. This to large extend determines the performance of each individual unit operation or process and consequently will affect the overall performance of the treatment plant in the removal of the various effluent quality parameters.

Dairy wastewater treatment should give an effluent fit for irrigation or other purposes according to the future Palestinian standards. Biological and physico-chemical processes both can achieve significant pollutant removal. For wastewater with a high organic matter content, like dairy sewage, biological methods are commonly preferred as they have lower operational cost and higher removal performance; large fractions of the organic material are dissolved and hence are poorly removed by flocculation. Physico-chemical treatment, therefore, is generally not the preferred option. It is typically applied in industrial wastewater treatment for the removal of specific contaminants or to reduce the bulk pollutant load to the municipal sewer.

As mentioned earlier, the most common and effective biological treatment processes used for the treatment of dairy waste are; Aerobic treatment, such as Aerated Lagoon, Activated Sludge Process, or anaerobic treatment using Up flow Activated Sludge Blanket (UASB). A brief description to each processes are given in chapter two. Schematic flow diagrams of various treatment for dairy wastewater incorporating biological processes are shown in Figure (5.1), (5.2), and (5.3).

5.4 Selection of Treatment Process:

Many wastewater treatment options (processes) are described in previous section. Figure (5.4) shows the flowchart for selection of techniques for dairy sewage treatment. One process or many unit operations and processes can be combined to develop a flow scheme to achieve a desired level of treatment. The level of treatment may range from removal of BOD_5 and TSS, nitrogen, and phosphorus, to complete demineralization.

To develop the best possible flow scheme a designer must evaluate many factors that are related to operation and maintenance, process efficiency under variable flow conditions, land requirements, investment and running cost, reliability of the process, and environmental constraints. In Table (5.1) various factors that are considered important in selection of flow schemes are evaluated.

Table (5.1): Comparison Between Different Wastewater Treatment Operations and processes

Treatment Option	Process Type	Evaluation Factors				
		Land Requirements	Operation and Maintance	Effluent Quality	Reliability of the Process	Investment and Running Cost
1. Wastewater Stabilization Pond	Natural Aerobic	large	easy	good	good	low
2. Upflow Anaerobic Sludge Blanket	Mechanized Anaerobic	small	easy	very good	Very good	moderate
3. Activated Sludge Process	Mechanized Aerobic	moderate	complicate	excellent	high	high
4. Trickling Filters	Mechanized Aerobic	moderate	complicate	very good	Very good	high
5. Aerated Lagoons	Natural Aerobic	large	easy	good	Very good	moderate
6. Rotating Biological Contractors	Mechanized Aerobic	small	complicate	very good	good	moderate

The potential contaminant removal efficiency of the six wastewater treatment processes is presented in Table (5.2).

Now, the wastewater treatment for dairy factories in the Hebron area should be reliable to give an effluent fit for irrigation or throwing into public wastewater sewer network following the Palestinian Guidelines taking into consideration the selection criteria explained in the previous sections as follow.

Table (5.2): Potential Contaminant Removal Efficiency.

Treatment Option	Process Type	Removal Efficiency (%)				
		BOD	**TSS**	**N**	**P**	**Fecal Coliform**
1. Wastewater Stabilization Pond	Natural Aerobic	50-70	50-70	-	-	good
2. Upflow Anaerobic Sludge Blanket	Mechanized Anaerobic	75-80	75-80	-	-	good
3. Activated Sludge Process	Mechanized Aerobic	90-98	90-95	20-30	25-50	fair
4. Trickling Filters	Mechanized Aerobic	80-95	80-85	10-15	15-20	fair
5. Aerated Lagoons	Natural Aerobic	60-80	60-70	-	-	good
6. Rotating Biological Contractors	Mechanized Aerobic	60-80	60-80	15-20	15-20	fair

Natural or land treatment of wastewater is not recommended due to the large area requirement where the land area in the dairy factories is very limited and possibility of groundwater contamination, although operation and maintenance are easy and inexpensive. Highly advanced wastewater treatment like activated sludge could be considered but it has high investment cost of equipments, high energy requirements, and need for skilled operators, who are not may be yet available. Conventional wastewater treatment strategies are considered feasible in this project. Minimizing the use of mechanical units, lower the need of energy, need of chemicals and need for highly trained operators guarantee the sustainability of the treatment system.

Following the steps given in Figure (5.1) and consider the points explained up, first the average values obtained for BOD and COD are 1250 mg/l and 25000 mg/l respectively, which gives COD/BOD ratio equal to 2.0<3, which means biological treatment process is required. The selection has to be made between Aerobic treatment (Aerated lagoons, Activated Sludge Process) or Anaerobic treatment (Upflow Activated Sludge Blanket) because the too process is simple for operation and maintenance.

In the dairy factories of Hebron area, it is important to include anaerobic treatment as the first step, hence, wastewater is highly concentrated and the land area is very limited. Upflow Activated Sludge Blanket (UASB) has been chosen by the work team. To increase the removal efficiency, the combination between aerobic treatment using Activated Sludge process and anaerobic processes using UASB can be adopted as shown in Figure (5.3).

CHAPTER

6 CONCLUSIONS

CHAPTER SIX
CONCLUSIONS

In this project an attempt is made to study the problem of wastewater from dairy industry (whey) in Palestine, where most of the dairy factories dispose of their effluent into municipal sewers, causes severe pollution problem. The study investigates the use of the anaerobic digestion system for the treatment of dairy wastewater in the Hebron area. The main conclusions drawn from the preliminary present study are:

1. In Palestine, the white cheese and labaneh are considered the main sources for whey production, most factories produced large amount of whey, but these amount are disposed into wastewater without utilization.

2. The large dairy factories in the Hebron area throw milk whey into public wastewater network. while small dairy factories dispose of their effluent into lands or pastures. These practices threat surface and ground water. The environmental impact of these factories can be very high, especially due to the discharge of very large flows of wastewaters with a high content of organic matter and nutrients (N, P).

3. Wastewater from dairy industries which is characterized by their high BOD and COD contents is treated in many places in the world using aerobic and anaerobic wastewater treatment technologies. Although the typical activated sludge treatment have used in most of the dairy factories, it has been known that wastewater of many dairy factories in the world is treated using UASB and other anaerobic wastewater treatment technologies.

4. Whey, the liquid residue of cheese and casein production, is one of the biggest reservoirs of food protein still remaining largely outside human consumption channel. Whey surplus can be supplied into drinking water for farm animals. Whey has been used as an agricultural fertilizer. Whey is also used as a skim milk replacer in ice cream. Liquid whey can be used in bakery products, beverages, yeast products, and in animal feed.

5. The results achieved in several high-rates aerobic and anaerobic treating different dairy wastewaters show that the overall reductions for the aerobic treatment were 97% for BOD_5, 93% for COD, 92% for TOC, and 91% for TKN, where anaerobic reservoir could remove above 75% of the BOD and COD all year round.

6. The large quantity of whey in the Hebron dairy factories are produce by manufacturing cheese and labaneh. It is estimated that 82-84% of milk used in white cheese production ends up as whey; while in labaneh this fraction is (60-63) %.

7. The wastewater quality parameters tested are not within the ranges given for diary wastewater, which are well documented in the literature. The high organic content is indicated by the existence of high readings of BOD (2030 mg/l) and (3020 mg/l) COD (52000 mg/l) and (24953 mg/l) respectively, which is greater than the level usual in developed countries. The values of total suspended and dissolved solids are also high which are795 mg/l and 742 mg/l respectively.

8. Wastewater treatment should be reliable to give an effluent fit for irrigation following WHO guidelines and Palestinian standards. Land treatment is not recommended due to the large area requirement and possibility of ground water contamination. Advanced and mechanized wastewater treatment is also not recommended due to the high investment cost of equipments, high energy requirements and the need for skilled operators. In diary factories, it is important to include anaerobic treatment as the first step, since wastewater is highly concentrated Up flow Activated Sludge Blanket (UASB) has been chosen by the work team. And to increase the removal efficiency, it is suggested to follow (UASB) by wetland or ponds, so the treated water can be used for irrigation purpose.

APPENDIX C

Figure (C.1):Measuring of pH Parameter

Figure (C.2): Laboratory Conductivity Meter

Figure (C.3): Chemical Oxygen Demand Meter

Figure (C.4): Explorer Balance

Figure (C.5): Biochemical Oxygen Demand Device

Figure (C.6): Oven

Figure (C.7): Samples

Figure (C.8): Different Appratus

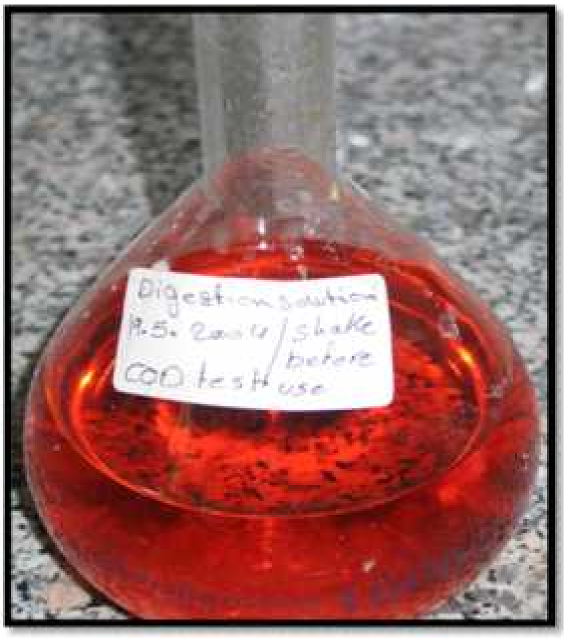

Figure (C.9): Digestion Solution

Figure (C.10): SO_4

APPENDIX A

GLOSSARY

GLOSSARY

1. Activated Sludge:

The suspended solids in an areation tank or at the bottom of a secondary clarifier in a sewage treatment plant, consisting mostly of living microoganisms.

2. Activated Sludge Process:

A biochemical sewage treatment system in which living microbes, suspended in tants and convert them to stable substance.

3. Activated Treatment:

Purification processes used after or during secondary wastewater treatment to remove nutrients or additional solids and dissolved organics; also called tertiary treatment.

4. Aeration:

A physical treatment process which air is thoroughly mixed with water or wastewater for purification.

5. Aerobic:

Presence of dissolved oxygen.

6. Anaerobic:

Absence of dissolved oxygen.

7. Biochemical Oxygen Demand (BOD):

(1) The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions. (2) A standard test used in assessing wastewater strength.

8. Biosolids:

Treated sewage sludge; a primarily organic solid product, produced by wastewater treatment processes, that can be beneficialy recycled.

9. Chemical Oxygen Demand (COD):

It is a measure of organic matter and represents the amount of oxygen required to oxidize the organic matter by strong oxidizing chemicals (potassium dichromate) under acidic condition.

10. Constituents:

Individual components, elements, or biological entities such as suspended solids or ammonia nitrogen.

11. Contaminants:

Constituents added to the water supply through use.

12. Decomposition:

The process by which complex organic and inorganic substances are broken down into simpler substances by biological or physical processes; also called decay.

13. Digestion:

The decomposition of organic waste by microbes under controlled conditions in a sewage treatment plant or garbage compost facility.

14. Disinfection:

Reduction of disease-causing microorganisms by physical or chemical means.

15. Effluent:

Partially, or completely treated wastewater flowing out of a treatment plant, reservoir, or basin.

16. Electrical Conductivity:

(EC_w for water , EC_e for the soil saturation extract) – A measure of salinity expressed in millimhos per centimeter (mmho/cm) or decisiemens per meter (ds/m) at 25°C.

17. Gravity Flow:

Open channel flow in a pipe, ditch, or stream bed, Characterized by a free liquid surface at atmospheric pressure.

18. Hydraulic Retention Time:

The time in which the wastewater is maintained within the system, measured by the volume of the system over the flow.

19. Hydrogen-Ion Concentration:

Is indication of acidic or basic nature of wastewater. A solution is neutral at pH 7.

20. Industrail Sewage:

Used water from industrial or manufacturing facilities that carries chemical waste products.

21. Influent:

Liquid that flows into a water or wastewater treatment plant or purification process.

22. Impurities:

Constituents added to the water supply through use.

23. Land Treatment:

The controlled spreading of wastewater, sludge, or hazardous waste on selected land parcels for waste treatment and/or disposal.

24. Nutrients:

Both nitrogen and phosphorus, along with carbon, are essential nutrients for growth. When discharge to the aquatic environment, these nutrients can lead to the growth of undesirable aquatic life. When discharge in excessive amounts on land, they can also lead to the pollution of groundwater.

25. Odor:

Fresh wastewater may have a soapy or oily odor, which is somewhat disagreeable. Stale wastewater has putrid odors due to hydrogen sulfide, indol and skatol, and other products of decomposition. Industrial wastes impart other typical odors. Because of odors associated with wastewater treatment facilities, area residents have often vigorously resisted and rejected wastewater treatment plant projects.

26. Organic Compound:

A substance usually made up of complex molecules that comprise carbon with hydrogen, oxygen, and other elements.

27. Oxidation:

A chemical reaction involving combination with oxygen and/or loss of electrons.

28. Parameter:

A measurable factor such as temperature.

29. Pollutants:

Constituents added to the water supply through use.

30. Preliminary Treatment or Pretreatment:

Is the very first stage, it is the removal of larger materials and grit that if not removal could hinder subsequent treatment processes. It is accomplished through the use of equipment such as bar screens, macerators, comminutors, racks and removal systems. Removal of wastewater constituents such as rags, sticks, floatables, grit, and grease that may cause maintenance or operational problems with the treatment operations, processes, and ancillary system.

31. Primary Treatment:

(1) The first major treatment in a wastewater treatment facility, usually sedimantation but not biological oxidation. (2) The removal of a substantial amount of suspended matter but little or no colloidal and dissolved matter. (3)

Wastewater treatment processes usually consisting of clarification with or without chemical treatment to accomplish solid-liquid separation.

32. Recycling:

The reuse of treated wastewater and biosolids for beneficial purposes.

33. Reuse:

Beneficial use of reclaimed or repurified wastewater or stabilized biosolids.

34. Screening:

A physical treatment process for water or wastewater in which relatively large floating objects are removed as the liquid passes through a coarse bar or wire mesh screen.

35. Secondary Traetment:

(1) Generally, a level of treatment that produces removal efficiencies for BOD and suspended solids of 85%. (2) Sometimes used interchangeable with concept of biological wastewater treatment, particularly the activated sludge process. Commonly applied to treatment that consists chiefly of a biological process followed by clarification with separate sludge collection and handling.

36. Settling Tank:

A steel or concrete basin in which settleable solids are allowed to separate from water of wastewater under the force of gravity; also called a clarifier.

37. Sludge:

Is the solid matter (often having a high water content) that is formed both when sewage is allowed to stand surface with the applied wastewater being treated as it flows through the plant-soil matrix.

38. Sludge Dewatering:

The process of drying liquid sludge, thereby changing its condition to that resembling potting soil.

39. Sludge Digestion:

Biochemical stabilization of organic sludge to reduce its volume, destroy pathogens, and prepare it for drying.

40. Sludge Thickening:

A process that increases the solids concentration of sludge in order to reduce its overall volume.

41. Solids:

Material removal from wastewater by gravity separation (by clarifiers, thickeners, and lagoons) and is the solid residue from dewatering operations.

42. Stabilization Pond:

A type of oxidation pond in which biological oxidation of organic matter is affected by natural or artificially accelerated transfer of oxygen to the water from air.

43. Suspended Solids:

Solids carried water or sewage that would be retained on a glass-fiber filter in a standard lab test.

44. Temperature:

The temperature of wastewater is slightly higher than that of water supply. Temperature has effect upon microbial activity, solubility of gases, and viscosity. The temperature of wastewater varies slightly with the seasons, but is normally higher than air temperature during most of the year and lower only during the hot summer months.

45. Total Dissolved Solids:

The sum of all dissolved solids in water or wastewater and an expression of water salinity in mg/l empirically related to electrical conductivity (EC) in mmhos/cm multiplied by 640.

46. Total Suspended Solid:

(1) Portion of organic and inorganic solids that are not dissolved. These solids are removal by coagulation or filtration. (2) portion of the total solid retained on a filter with a specified pore size, measured after being dried at a specified temperature (105°C). The filter used most commonly for the determination of TSS is the Whatman glass fiber filter, which has a nominal pore size of about 1.58μm.

47. Upflow Anaerobic Sludge Blanket:

The most common type of anaerobic reactor for wastewater treatment.

48. Wastewater:

The once-used water of a community or industry which contains dissolved and suspended matter.

49. Wastewater Characteristics:

General classes of wastewater constituents such as physical, chemical, biological and biochemical.

APPENDIX B

Measurements of Total Dissolved Solids

Name: Total Dissolved Solids

Definition: The sum of all dissolved solids in water or wastewater and an expression of water salinity in mg/l empirically related to electrical conductivity (EC) in mmhos/cm multiplied by 640.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

To determine TDS with the sension7 meter:

1. Press the TDS key on the keypad. The instrument will display the TDS value for the currently displayed conductivity measurement.
2. The standard method to determine TDS (Total Dissolved Solids) is to evaporate the sample to dryness at 180 °C, then weigh the residue.
3. Another way to estimate TDS is by calculating the concentration of sodium chloride that would have the same conductivity as the sample at the same temperature.
4. The sension7 meter reports a sample's TDS value in mg/L of sodium chloride by comparing the sample conductivity and temperature to data stored in the meter's memory.
5. Data were obtained from empirical procedures using sodium chloride solutions.

Measurements of Salinity

Name: Salinity

Definition: The salinity of the soil water is related to, and often determined by; the salinity of the irrigation water.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

1. To determine salinity with the sension7 meter, press the SAL key on the keypad. The instrument will display the salinity value for the sample being measured.
2. Salinity, a measure of the mass of dissolved salts in a given mass of solution, is used to describe seawater, natural, and industrial waters. Salinity is a relative scale based on a KC1 solution. A salinity value of 35 is equivalent to a KC1 solution containing 32.4356 g KCI in 1 kg of solution at 15 °C. Salinity is measured in %o (ppt - parts per thousand).
3. The meter calculates the salinity based on the Extended Practical Salinity Scale of 1978, as referenced in 17th edition of Standard Methods, 25200 B. The applicable range is 0 to 42% and -2 to 35 °C.

Measurements of Conductivity

Name: Conductivity

Definition: The Electrical Conductivity (EC) of water is a measure of the ability of a solution to conduct an electrical current.

Apparatus: Laboratory Conductivity Meter (sension7).

Method: APHA standard methods, 1995

Procedure:

1. Determining conductivity with the sension7 meter is easy; just press the COND key on the keypad. The instrument will display the conductivity value for the sample being measured.
2. For conductivity, place the probe into the sample and make sure the slot on the end of the probe is totally immersed. Agitate the sample with the probe for 5-10 seconds to remove bubbles that may be trapped in the slot.

Measurements of pH

Name: Conductivity

Definition: pH is indication of acidic or basic nature of wastewater. A solution is neutral at pH value 7.

Apparatus: Laboratory pH Meter (sension3).

Method: APHA standard methods, 1995

Procedure:

1. Place the electrode in the sample. Press READ/ENTER stabilizing.., will be displayed, along with the sample temperature and the pH or mV reading. These values may fluctuate until the system is stable.
2. If the Display Lock is enabled, Stabilizing.., will disappear and the display will "lock in" the pH or mV and sample temperature when a stable reading is reached. If the Display Lock is off, Stabilizing.., will still disappear, but the display will show the current reading and temperature and the values may fluctuate.
3. Record or store the pH and mV value.

Measurements of COD

Name: Chemical oxygen demand

Definition: It is a measure of organic matter and represents the amount of oxygen required to oxidize the organic matter by strong oxidizing chemicals (potassium dichromate) under acidic condition.

Apparatus: Thermo spectronic

Method: Closed reflux

Procedure:

1. Put 0.4g $HgSO_4$ in a reflux flask. Add 20 ml of sample, or an aliquot of sample diluted to 20 ml with distilled water. Mix well, so that the chlorides are converted into poorly ionized mercuric chloride.
2. Add 10 ml of standard $K_2Cr_2O_7$ solution. Slowly add 30 ml of sulfuric acid solution which already contains silver sulfate, and swirl the flask.
3. If the color turns green, either take a fresh sample with smaller aliquot or add more dichromate and acid. The final concentration of H_2SO_4 should always be 50% or more.
4. Connect the flask to the condenser and reflux for 2 hrs. Cool and wash down the condenser with a small quantity of distilled water. Remove the flask and add about 50 ml of distilled water.
5. Reflux a reagent blank under identical conditions preferably simultaneously with the sample.
6. For determining low COD samples follow up the same procedure using 0.05 N $K_2Cr_2O_7$ and 0.025 N FAS.

Measurements of BOD

Name: Biochemical Oxygen Demand (BOD)

Definition: The quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specified temperature, and under specified conditions.

Apparatus: Memmert.

Method: A standard test used in assessing wastewater strength

Procedure:

1. Neutralize the sample to pH around 7 using alkali or acid (NaOH or HCl).
2. The sample should be free from residual chlorine. If it contains residual chlorine, remove it by using Na_2SO_3 solution as given below:
   a. Take 50 ml of the sample and acidify with 10 ml of 1:1 acetic acid.
   b. Add about 1g of Kl.
   c. Titrate with sodium sulfite using starch as indicator.

Calculate the volume of Na2SO3 required per ml of the sample to be tested for BOD.

3. At least two dilutions of the sample are prepared so that the oxygen consumption will end in the range of 40 to 70 %.
   a. The required quantity of sample is taken in a one liter capacity volumetric flask.
   b. Dilute this by filling with dilution water to the mark and mix well.
   c. Rinse three BOD bottles with the diluted sample and then fill to overflowing. As far as possible avoid entrapment of air bubbles from the bottle or during filling by knocking gently the BOD bottle sides with its stopper. Stopper the bottles immediately after filling.

4. Keep one bottle of every dilution series for the determination of the initial (Zero day) dissolved oxygen concentration and incubate two bottles at 20°C for 5 days.

To the air seal neck of the bottles incubated, water should be added daily, to prevent oxygen penetration.

5. Prepare four blanks by filling only dilution water into four bottles. These bottles should be first rinsed and then filled with the dilution water. Two of these blanks should be used to determine the initial dissolved oxygen and the other two are incubated for 5 days at 20°C. Usually the oxygen consumption in the blank should not be more than 0.2 mg/l in 5 days.
6. Dissolved oxygen, initial and endpoint, is determined using DO meter.
7. If the dilution water is seeded, measure the BOD of the seed material separately according to the above method, and calculate the contribution of the BOD of the amount of seed applied in the standard test.

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