BIRZEIT UNIVERSITY

Development of Wastewater Treatment Tariff System
A Case Study of Al–Bireh Wastewater Treatment Plant

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Nasser Abusharbak

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A thesis submitted in partial fulfillment of the requirements for the Master Degree in Water Engineering from the Faculty of Graduate Studies at Birzeit University - Palestine

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This thesis was prepared under the supervision of Dr. Rashed Al – Sa'ed and has been approved by all members of the examination committee

Examination Committee

Dr. Rashed Al–Sa'ed	(Chairman)…………………
Dr. Maher Abu–Madi	(Member)..…………………
Dr.Yousef Daoud	(Member)..…………………

Date of defense

The findings, interpretations and conclusions expressed in this study don't necessarily express the view of Birzeit University, the views of individual members of the MSc – Committee or views of their respective employers.

2004

DEDICATION

I am proud to dedicate this effort to:

The dearest persons to my heart,

My parents, brothers and sisters,

And every person helped me during my study.

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Abstract

The wastewater treatment sector is becoming more essential than ever, because of rapid population growth, urbanization, and water shortage in a developing country like Palestine. Urban municipal facilities in Palestine are still few in number and most of them are unsustainable. The old existing treatment plants are overloaded and the erection of newly ones is severely hampered due to political situations.

To establish a wastewater treatment plant a fund of several millions of dollars is needed, so the project of wastewater treatment plant must be considered as an investment made by the local authority, and the charge that polluters pay for treatment is the revenue of this investment. Hence, in order to have a successful investment, the present value revenues for the duration of the project must cover the present value of all costs of the project in addition to a normal return.

The aim of this research is to develop a suitable tariff system for wastewater treatment taking the treatment plant of Al-Bireh city as a case of study.

The research was accomplished by data collection from Albireh municipality and the German Agency for Technical Cooperation (GTZ) in order to calculate the capital costs of Albireh wastewater treatment plant, and also data was taken from the treatment plant (e.g. daily septage flow rate in every month of the year, daily and weekly working hours for every unit of the plant, electrical power demand, spare parts needed, chemicals consumed etc..) in order to calculate the annual running costs of the treatment plant.

Data analysis of the results obtained for the year 20003 showed that the calculated annual operational expenditures were 428,580 US$; yielding an annual specific costs of 8.57 US$/PE or 0.25 $/$m^3$ wastewater treated.

Including the annual capital expenditure in the present tariff would lead to new actual annual capital and operational costs of about 835,430 US$. To achieve a sustainable wastewater treatment facility in management and operation the study suggests six main price categories to calculate the actual incurred wastewater tariff based on polluter pays principles and the tax-beneficiary economy principles.

Table of Contents

List of Tables

List of Figures

List of Photos

List of Abbreviations and Acronyms

WWTP	Wastewater Treatment Plant
AWWTP:	Al-Bireh Wastewater Treatment Plant
WW:	Wastewater
MOC:	Marginal Opportunity Cost
GTZ:	German Agency for Technical Cooperation
PE:	Population Equivalent
DWF:	Dry Weather Flow
Aver:	Average
Max:	Maximum
Min :	Minimum
BOD:	Biological Oxygen Demand
COD:	Chemical Oxygen demand
OPEX:	Operational Costs or Expenditure
TOTEX:	Total Costs or Expenditure
PCBS:	Palestinian Central Bureau of Statistics
JWU:	Jerusalem Water Undertaking

Chapter 1
Introduction

1.1 Background

Al-Bireh city is located 12 km north of Jerusalem in the West Bank in the center of the Taweel Mountain. The local climate is Mediterranean with cool rainy winters and hot and dry summers. The mean air temperature is 18°c (it ranges from -8°c up to 42°c).

In 1997 Al-Bireh wastewater treatment plant was established in order to serve 50,000 PE in the first stage which started functioning in February 2000, and the plant will serve 100,000 PE when the second stage is executed.

The project site has an altitude of approximately 725m above sea level. The closest residential area of Al-Bireh city is at a distance of about 350m from the plant to the south (Al-Bireh municipality, 1999).

The wastewater is delivered by two gravity main sewer lines from Al-Bireh. Except for a few hundred meters the sewerage system of Al-Bireh was designed to collect wastewater only, but most of rain water is delivered to the treatment plant as people connect roof pipes to the sewer system.

Photo 1.1 Overview of Al-Bireh WWTP

1.2 Research Problem

Al-Bireh wastewater treatment plant was established with the help of the German government. Now the plant is functioning and the results are acceptable, however after 30 years, which is the life time of the plant, Al-Bireh municipality must be funded to establish a new plant which can replace the old plant. This fund must be saved from the revenue of the existing treatment plant (this is in accordance with the appropriate economic theory), but the municipality of Al-Bireh doesn’t take the fund of a new wastewater treatment plant into consideration when they calculate the tariff of wastewater treatment, and this is our major problem. The municipality of Al-Bireh had decided the tariff of wastewater treatment to be 1.2NIS for each cubic meter of potable water consumed by the polluter, this tariff was set without any reference to capital cost of the treatment plant or maintenance and operating costs or any other economic reference, and this is a real problem as the municipality doesn’t take future needs into consideration.

1.3 Research Objectives

The research aims to estimate the full economic (financially) tariff of wastewater treatment in Al-Bireh including the capital investment and running costs. The costs of wastewater collection and effluents disposal will not be considered as the municipality already collects those costs before connection. In addition the treated effluents could be sold and hold a revenue.

1.3.1 Specific Objectives

- To estimate the cost of wastewater treatment in Al-Bireh city.

- To develop a tariff system for wastewater treatment in Al-Bireh city.

1.3.2 Anticipated Results

- A detailed review of the wastewater treatment plant of Al-Bireh including the treatment program and stages.

- Calculation of the costs of wastewater treatment using the average incremental cost (AIC).

- Review of the current wastewater tariff system as well as the full economic (financially) cost of wastewater treatment.

- A design of a wastewater treatment charge system in which households, small shops and industries, large factories would be treated differently. A phased schedule of proposed tariffs was presented showing a gradual pricing reform.

1.4 Research Methodology

The research extends over a12 month period, beginning in March 2003.

The research depended mainly on four sources of information which are the municipality of Al-Bireh and the wastewater treatment plant, Jerusalem water undertaking and the GTZ.

Wastewater treatment and pricing was discussed with the officials and researchers from the four above mentioned institution. The discussions included the following:

- The costs of wastewater treatment
- The recent changes in pricing policy of wastewater

CHAPTER 2

Al-Bireh Wastewater Treatment Plant

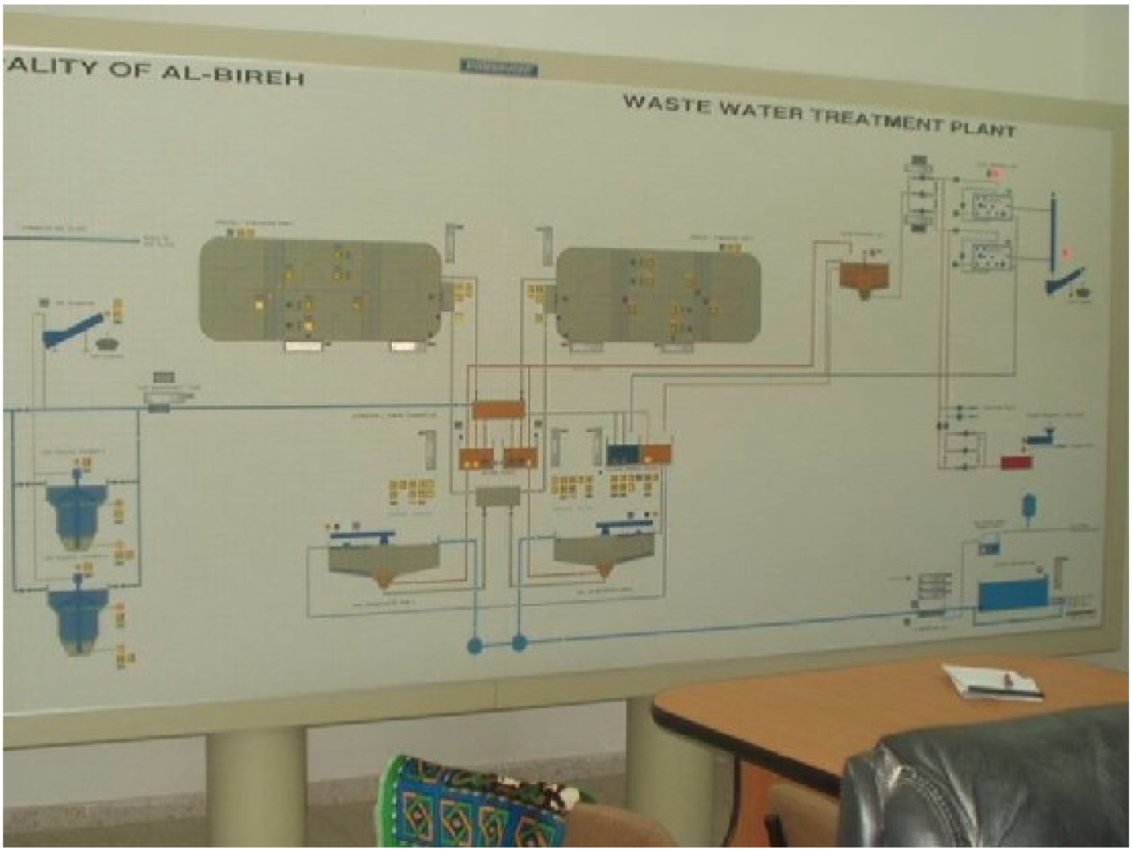

Photo 2.1 Operating panel of Al-Bireh WWTP

2.1 Treatment Process

In order to achieve the required effluent standards, the process design for the biological sewage and the sludge treatment were developed according to the activated sludge process. It includes a low–loaded activated sludge stage, which besides the removal of carbonaceous compounds (BOD removal) also widely achieves oxidation of nitrogen compounds (nitrification). The treatment plant was designed such that the oxidized nitrogen compounds can be removed by a controlled denitrfication. Thus operational problems in the final clarifiers caused by denitrification can be avoided. At the same time, due to low sludge quantity is achieved simultaneously.

2.2 Description of Units

2.2.1 Distribution and Pumping Chamber

This unit consists of a mixing and distribution chamber for aeration tank feeding, distribution and regulation chamber for sedimentation tank feeding as well as return and excess sludge pumping station.
In the first stage one chamber was built, while for the second stage another chamber would be added and connected to the existing chamber.

Function Description

Raw sewage influent is fed into the first mixing and distribution chamber where the incoming flow is mixed with the return sludge continuously. At the mixing chamber two effluent pits, equipped with height adjustable overflow weirs are added for equal flow regulation to aeration tanks.

Due to design of mixing chamber sewage and return sludge, inflows are mixed rapidly before overflow into effluent chambers and feed into aeration tanks by inverted siphon lines.

Aeration tank effluent is being fed into a similar arrangement via inverted siphon lines from aeration tank effluent wiers and discharged into two effluent pits with overflow weirs for flow regulation to sedimentation tanks.

Civil Design

The unit was designed as a rectangular tank with two square sized pumping pits as center structure and two mixing and distributing arrangements added.

The unit was executed as a concrete structure, and it was arranged beside the main road between the culvert box and sedimentation tanks.

Pipelines, branching in and off the unit are connected to the walls by wall passing pieces.

Electro-mechanical Equipment

Sludge pumping pits of distribution chamber is equipped with 1+1 return sludge and one excess sludge pump per each.

Return sludge conveyance takes place by submersible pumps into mixing chamber via individual pressure lines.

For excess sludge discharge to sludge thickener, one submersible pump is installed per pit which will feed a main heading by single pressure lines. One was stored as stand by.

Both pumping pits are connected by a sluice gate to bypass one pump per each in case of failure.

Operation and Control

Return sludge pumps (1+1) are operated continuously. Capacity of pumps is chosen for conveyance of Q.RS/3 f(150%of Q.DW) per each to feed 100% of Q.DW with two pumps.

In case of process requirements or long period rainy weather conditions a third pump will be switched to feed with a total capacity of 3*Q.RS/3 =150%of Q.DW = 100% of Q.RW, controlled by the signal of flow measurement. For emergency case 130% of Q,DW can be supplied by switching the fourth pump.

2.2.2 Aeration and Stabilization Tank

Biological purification and simultaneous sludge stabilization takes place within two loop type aeration tanks, each equipped with tree Al-Bireh municipality mammoth rotors four submersible mixers.

For future extension, a fourth aerator might be added to cover further requirements on aeration capacity. Site arrangement of tanks respects stage II.

Description of Function

Aeration capacity is supplied by horizontal surface aerators of the mammoth rotor type following the concept of deep tanks with separate aeration and mixing. Submersible mixers are foreseen to prevent settlement of activated sludge and to develop proper mixing of sewage and activated sludge.

Aeration tanks are fed from the distribution chamber. Treated sewage effluent is regulated by height adjustable effluent weirs.

Aeration tanks are designed for nitrification/denitrification with simultaneous sludge stabilization for stage I (50,000PE) with a minimum sludge age of 20 d, total tank volume is calculated to 13,845 m^3. Aeration capacity is calculated with an OC load of 2.2 kg O_2/kg BOD_5 leading to a total number of 6 aerators.

Civil Design

Units are designed as loop type rectangular tanks with middle separation wall, curved edges and guidance bows for flow stabilization. Each tank is equipped with two concrete installation bridges of aerosol and noise protective design.

Units are executed as concrete structures. Pipelines, branching in and off are connected to the walls by wall passing pieces.

Electro-mechanical Equipment

Aeration tanks are equipped with three aerators per each tank, mammoth rotors are installed under concrete installation bridge.

Concrete bridges are executed with covered installation openings for the aerator with gearbox and drive.

Effluent regulation takes place by one height adjustable overflow weir with electric drive per tank.

For operation control one measuring unit of dissolved oxygen (QIR-O_2) with local display and remote transmission is installed per each tank.

Operation and Control

Biological purification is controlled by O_2 content measuring regarding the monitoring of effluent parameters, this is due to the fact aeration tanks are designed for simultaneous nitrification dinitrification and this process is controlled by one parameter.

Individual aerators are switched on and off depending on the content of dissolved oxygen with respect of defined maximum and minimum values.

Submersible mixers are operated continuously but preselected. One or two mixers are operated on base load, additional mixers will be switched in case of switching off all aerators.

The effluent weir is adjusted for average daily sewage flow. With respect to the signal of the venture flow measurement it will be automatically adjusted to two preselected levels by the electric drive.

2.2.3 Final Sedimentation Tank

Aeration tank effluent is lead to final sedimentation for final clarification via distribution chamber.

Description of Function

The mixture of activated sludge and clarified sewage is being fed into a center inlet structure via inverted siphon line from distribution chamber. Inlet sewage flows to peripheral overflow weirs after passing a diffuser cylinder which is assembled at tank scraper bridge.

Activated sludge and solids which settles on the tank bottom are being conveyed into a central sludge hopper under the inlet structure by bottom scraper mechanism and discharged into sludge pumping station continuously.

The clarified sewage flows into peripheral effluent channel via V-notched overflow weir with scum board. Scum and other floating materials are collected by a scimming system with discharge pump. It is discharged into filtrate collecting tank of treatment plant drain system.

For the first stage two circular sedimentation tanks with diameter of 24m each are provided. They are being fed equally from distribution chamber.

Civil Design

Sedimentation tanks are executed as concrete structures. Center supporting structure is designed as machinery platform on the top of the supporting columns.

Diffuser cylinder is provided as steel construction for assembling under scraper bridge. Pipelines, branching in and off are connected to the walls by wall passing pieces.

Electro mechanical Equipment

Sedimentation tanks are equipped with circular scraper bridges with bottom scraper, scum removal system with scum discharge pump and center diffuser.

Operation and Control

Scraper bridges are being operated continuously independent from sewage flow. Scum discharge is operated discontinuously controlled by timer.

2.2.4 Sludge Thickener

For excess sludge storage and thickening one sludge thickener with picket fence scraper mechanism is executed. The water depth of the tank is 4.5m.

2.2.5 Sludge Dewatering

Excess sludge dewatering takes place by mechanical sludge with belt presses which is installed in a machinery building as shown in photo 1.3.

Photo 2.2 Sludge dewatering

2.2.6 Filtrate Pumping Station

Filtrate from belt filter presses as well as sludge water and scum from sludge thickening and final sedimentation will be lead into a filtrate pumping station and discharged to inlet structure of the wastewater treatment plant.

Description of Function

Filtrate pumping station consists of an inlet chamber with scum baffle wall and pumping chamber. Filtrate inflow will be led into the separation chamber where scum and other floating materials will be separated.

Civil Design

The unit is designed as a rectangular tank consisting of two square sized pits, the first is operated as separation zone and the other is operated as pumping pit.

The pumping station is executed as a concrete structure, and pipelines, branching in and off are connected to the walls by wall passing pieces.

Electro mechanical Equipment and Control

Filtrate pumping station is equipped with one plus one submersible pumps with local control. Filtrate pumps are operated discontinuously controlled by level switches.

CHAPTER 3
Data Collection

Data collection was conducted over a period of about 12 months. The main sources of our data were :

- Al-Bireh Municipality
- Al-Bireh wastewater treatment plant
- Jerusalem water undertaking
- The GTZ (German Agency for Technical Cooperation)

The main topics of data we were trying to gather are:

- Number of inhabitants of Al-Bireh city in the present and the future, and the percentage that is connected to the wastewater treatment plant.

- Capital cost of Al-Bireh wastewater treatment plant in details.

- Operation and maintenance costs of Al-Bireh wastewater treatment plant in details.

- Hydraulic load and wastewater quantity treated in Al-Bireh wastewater treatment plant during one year.

- The quantity of money collected by Al-Bireh municipality from the polluters for the same period.

3.1 Capital Costs

Capital (investment) costs can be divided into three main kinds of costs according to the following:

Table 3.1 capital costs of Al-Bireh WWTP

Description	**Cost in us $**
• Land cost	500,000
• Site preparation	350,000
• Wastewater treatment facilities	
a. Civil works	3,000,000
b. Mechanical works	2,500,000
c. Electrical works	200,000
Total investment cost	**5,700,000**

3.1.1 Wastewater Treatment Facilities Costs

Civil works costs

Three screening units

Two grit removal champers

One distribution chamber

Two sedimentation tanks

Two aeration tanks

Two UV disinfection units

One thickener

One polymers tank

One polymers mixing tank

Two dry sludge containers

One regulation tank

One dewatering tank

Non potable water balancing tank

Potable water pressure tank

Orabi pumping station

Om Alsharayet pumping station

Industrial zone pumping station

Mechanical works

Three screening units

Two diffusers (grit removal chambers)

Two aerators (grit removal chambers)

Conver pump

Venturey with ultra sonic unit

Four pumps (240m^3/h) in distribution chamber

Two excess sludge pumps (30m^3/h)

Eight mixers (aeration tanks)

Six surface aerators (aeration tanks)

Two measuring units for oxygen and temperature (aeration tanks)

One wear for measuring water level

Tow scum scrapers (sedimentation tanks)

Two solids scrapers (sedimentation tanks)

Two buffers (sedimentation tanks)

Two UV disinfection units every one has eighty lamps (life time100 h)

Mechanical separator (thickener)

Dewatering machine

Two belt filter bress

Two polymer pumps

Polymers mixer

Three sludge pumps

Conveyer(to transfer dry sludge to the containers

Two nonpotable water pumps (30m^3/h)

Two sewage pumps

Small mixer

Stand bye generator 630KWh

3.2 Operating and Maintenance Costs

Annual operating costs are as shown in Table 3.2 according to the municipality of Al-Bireh:

Table 3.2 Annual operating costs of Al-Bireh WWTP (as taken from the municipality)

Description	Cost in US $
• Electrical power demand 182,000	
• Staff costs 80,000	
• Chemicals 40,000	
• Maintenance 50,000	
• Lab monitoring costs 3,000	
• Sludge transport and disposal 8,000	
• Management and overhead costs 15,000	
• Water demand 2,500	
• Vehicle maintenance 1,000	
• Equipment rent 1,500	
• Telephone bill 700	
• Jawwal bill 4,000	
• Office equipment maintenance 500	
• Vehicle fuel 9,000	
• Vehicle insurance	

1,500
• Miscellaneous 2,500
• Total cost 401,200

3.3 Water Demand for Served District

Water demand of the served district is as shown in table 3.3.

Table3.3 Water demand in the served district.

Period	Water demand m^3
• January + February	118,417
• March + April	126,035
• May + June	145,420
• July + August	157,579
• September +October	196,147
• November + December	158,357
• Total consumption	901,955

Jerusalem water undertaking sells water with a price begins at about **1$/m^3** and this price goes up with the quantity consumed.

3.4 Wastewater Entered the Treatment Plant

Average quantities of waste water that enter the plant (monthly) are shown in table 3.4.

Table 3.4 Average monthly flow to Al-Bireh WWTP

Period	**Wastewater m^3/d**
• January	4,296

• February	9,504
• March	6,915
• April	4,682
• May	3,812
• June	3,682
• July	3,500
• August	3,564
• September	3,479
• October	3,474
• November	3,473
• December	4,186
• **Total amount**	**54,567**

3.5Wastewater Revenue From Served District

Annual revenues collected from wastewater treatment (from the served district) are shown in table 4.5.

Table 3.5 Wastewater treatment revenues.

Period	**Revenue in US$**
• January + February	31,735
• March + April	33,911
• May + June	39,148
• July + August	42,245
• September +October	52,613
• November + December	42,417
• Total revenue	242,069

3.6 Served District and Kinds of Beneficiaries

According to the municipality of Al-Bireh only about 60% of population of the city are served by the treatment plant, and within the end of this year about 80% of the population of the city will be served.

According to Jerusalem water undertaking about

- 85% of water consumption in Al-Bireh city is consumed in house use.
- 10% of water consumption in Al-Bireh city is consumed in commercial use.
- 5% of water consumption in Al-Bireh city is consumed in industrial use

Up to date there are 5800 beneficiaries in Al-Bireh city, about 29000 PE

Classification of beneficiaries according to pollution load divides the beneficiaries into three groups:

- Low polluting beneficiaries
- Medium polluting beneficiaries
- Heavy polluting beneficiaries

3.6.1 Low Polluting Beneficiaries

Households are the lowest polluting participant.

Also there are some businesses that cause only low wastewater pollution (Meirejohan, 1999) like:

- **Laboratories**: there are six laboratories in Al-Bireh which carry out simple medical tests, generating small quantities of wastewater of average pollution.
- **Film processing shops**: waste chemicals caused from photo developing are not harming the treatment process as they come in very small quantities.

- **Gas filing stations**: in Al-Bireh city there are four gas stations, they sell petrol and oil without any car maintenance or changing motor oil. These stations do not cause pollution of wastewater.

- **Print shops**: printing process does not need water, and if left over chemicals from cleaning the printing plates are handled with care, there will be no pollution.

- **Pharmacies**: in Al-Bireh city there are 19 pharmacies, most of them sell products that produced in factories, and some of them produce medical crèmes without generating major quantities of wastewater.

- **Detergent producers**: these companies fill detergents from big barrels in small bottles and containers. Water may be used for cleaning the equipment and this may not consume big quantity of water, and it is not carried out very often.

3.6.2 Medium Polluting Beneficiaries

This class of beneficiaries contains mainly light industries workshops (Meirejohan, R.2000).

- **Sweet shops**: The sweet shops use water to separate the salt from the cheese. This process results in big quantities of salty wastewater with some cheese in it. There is no way to avoid this pollution and there is enough capacity in the plant to deal with the biochemical pollutants.

- **Dry cleaning companies**: these companies use perchlorethanol in washing clothes, and this may produce small quantities of liquid waste composed of perchlorethanol, fat and traces of textiles.

- **Restaurants and hotels**: restaurants and hotels use enormous quantities of cooking oil, and it is common practice to discharge it in the sewers, and it also may contain some left over food.

- **Car washing companies**: in Al-Bireh city there are three car washing companies. Car washing is not harmful to the wastewater as it contains no poisonous materials, but some times these companies change motor oil for cars, and oil is discharged into the sewer system.

- **Hospitals and clinics**: in general hospital wastewater causes no problem to wastewater treatment plant, but these institutions use disinfectants and some chemicals which may be discharged to the sewer and cause problems.

3.6.3 Heavy Polluting Beneficiaries

This class of polluters consists of heavy polluting industries, factories and cars workshops (Meirejohan, R.2000).

- **Stone cutting factories**: In Al-Bireh city there are eleven stone cutting factories. These factories use big quantities of water as it is used as a lubricant and for cooling the saw blades. These factories recycle the water, and the wastewater is discharged into simple sedimentation tanks. Lime sludge is collected within the sedimentation tanks and has to be sucked out from time to time, and it must not be discharged to the sewer, as big quantities of lime sludge will not allow the bacteria to incorporate the biological pollutants or even it may kill the bacteria.

- **Suction truck business**: as mentioned before about 40% of Al-Bireh district is not served with the sewer system, this district is equipped with cesspits, which have to be sucked out by suction tankers. These tankers which serve about 40% of Al-Bireh district discharge their contents into the main sewer out of the treatment plant and they do not pay for the treatment of their contents. Also these tankers may discharge cesspit sludge from outside the boundaries of Al-Bireh, while the treatment plant is designed to receive only wastewater of Al-Bireh.

- **Car maintenance**: In Al-Bireh city there are 32 operating garages for car repairing changing motor oil is one service of which these garages offer. Even it is forbidden to discharge motor oil into the sewer system, and there are some specialized companies which collect used oil for recycling, but samples taken from several garages show extremely harmful discharge of used motor oil into sewers, where as motor oil can bring biological treatment process to a complete standstill.

- **Slaughter house**: if fat is removed and blood is collected separately, then slaughter house wastewater will be no more harmful to the biological treatment process. Fat and sediments are disposed within the landfill, and so as the blood which can be used in agriculture as fertilizer.

- **Dairy production**: milk and milk products have a biological load which can be easily treated in the municipal wastewater treatment plant. In Al-Bireh city only one diary is operating, and it produces cheese and yoghurt from milk. As the company proceeds only $20m^3$ of milk per day, it is not expected to discharge big quantities of wastewater, but large quantities of old milk may harm the treatment process through overstressing the bacteria.

- **Palestine Aluminum Company**: this company paints aluminum profiles in different colors applying the most modern process. With regard to the wastewater, the critical step of the production is the preparation of the aluminum for painting. After the aluminum is rinsed by acids, the material is metallized with chrome in electrolytic baths. The surplus of acids and chrome is washed away in a quantity of about $50m^3$ per month. The most hazardous material in this factory is the chrome baths which contain a very high concentration of chrome and which has to be changed annually. Such concentrates can be recycled but the company lacks the proper equipment.

- **Electrochemical metallizing establishment**: this establishment is the only one of its kind in Al-Bireh city. This establishment galvanizes iron parts such as windows and doors in order to protect them from oxidation. The establishment has a capacity of $400m^2$ of galvanizing iron parts per year and it operates in full capacity. The annual water consumption of the establishment for all purposes is about $300m^3$, which is very low but there is no pretreatment in operation which means that the effluent wastewater is discharged rich of harmful chemicals and acids the thing that may cause damages in cement containing constructions like manholes and pipes, even asbestos pipes. The effluent also contains Zinc in unacceptable concentrations.

- **Pharmaceutical factories**: In Al-Bireh city there are four operating pharmaceutical factories, two of them are considered as large factories while the other two factories are small. These factories purchase pharmaceutical components from different foreign producers for manufacturing drugs and medical syrups. Key products are antibiotics, beta-blockers and vitamins. Both of large factories consume about 5000m^3 of water per year each, the quantity which is equal to those of 150 households can consume in one year. Failed charges, left over chemicals, outdated drugs, polluted packing material, and many other similar things may cause hazardous wastes, which must be discharged to the landfill and not discharged to sewer system. As the components of medical drugs may cause a high biological or chemical load and as antibiotics may kill the effective bacteria of the treatment plant, it must be insured that pharmaceutical factories fulfill the requirements of acceptable effluent wastewater. Water is used for cleaning the machines and the premises, for normal human consumption and for the laboratories.

CHAPTER 4

Results and Discussions

4.1Electrical Power Demand

Calculation of power demand is done according to the following considerations (Al-Bireh municipality, 1999):

For stage 1:

- Two aeration tanks, simultaneous sludge stabilization.
- Population equivalent: 50000PE
- Mean dry weather flow: 5750 m^3/d
- Average percentage: 80%
- Average flow (aver.DWF): 4600 m^3/d
- BOD load: 3003 kg/d
- Average flow (aver.DWF): 2252 kg/d
- Return sludge 479 m^3/h
- Average quantity: 383 m^3/h
- Excess sludge: 2793 kg DS/d
- Average quantity: 2095 kg DS/d

For stage 2: two aeration tanks, sludge digestion

- Two aeration tanks, simultaneous sludge stabilization.

- Population equivalent: 100000PE
- Mean dry weather flow: 11500 m^3/d
- Average percentage:
- Average flow (aver.DWF): 9200 m^3/d
- BOD load: 6006 kg/d
- Average flow (aver.DWF): 4505 kg/d
- Return sludge 821 m^3/h
- Average quantity: 657 m^3/h
- Excess sludge: 5586 kg DS/d
- Average quantity: 4189 kg DS/d

4.1.1 Mechanical Sewage Treatment

- Septage tank
  - 0peration period 50 min/h
  - tank volume 78 m^3
  - pump capacity 30 m^3/h

Table 4-1: Energy consumption of septage tank

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Septage pump	2	4.00	1.3	5.0	5.2	26.0	1.4
mixer	1	2.25	4.0	5.0	9.0	45.0	2.3

- Bar screens
  - Operation period 15 min/h

Table 4-2: Energy consumption for bar screens

Description	No	Power absorbe	Working time	Energy consumption Daily	per week	per year

		d kW	h/d d/w	KWh/d	kWh/w	MWh/a
Screen unit	2	1.38	6.0 7.0	8.3	58.0	3.01
Belt conveyor	1	2.02	6.0 7.0	12.1	85.0	4.42

- Balancing tank
  - Operation period 50d/a
  - Tank volume 540 m^3
  - Pump capacity 100 m^3/h

Table 4-3: Energy consumption for balancing tank

Description	No	Power absorbed kW	Working time h/d d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Basin cleaning system	1	6.24	2.0 1.0	1.25	12.0	0.62
Discharge pump	1	2.70	5.4 1.0	14.6	14.0	0.73

- Grit removal system
  - Operation period 10 min/h

Table 4-4: Energy consumption for grit removal system

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Paddle stirrer	2	3.61	24.0	7.0	86.6	606.1	31.52
Blower of airlift pump	2	9.02	8.0	7.0	72.2	505.1	26.3
Blower for aeration	2	1.23	16.0	7.0	19.7	137.8	7.16
Grit classifier	1	0.90	6.0	7.0	5.4	37.8	1.97

- Flow measurement

Table 4-5: Energy consumption for flow measurement.

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
US level indicator	1	0.10	24	7.0	2.4	16.8	0.87

- Biological sewage treatment
  - Ave. sewage flow 4600 m^3/d
  - Ave. BOD load 2552 kg/d
  - Return sludge Qty. 718 m^3/h

- Aeration tank
  - Ave. OC load 2.20 kg/kg

- Aeration capacity 227kg O_2/h
- Aerators required 3.0 each

Table 4-6: Energy consumption for aeration tank.

Description	No	Power absorbed kW	Working time h/d d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Mammoth rotor	6	111.0	24 7.0	2988	20914	1087.5
Mixing units	8	20.0	12.0 7.0	240.0	1680	87.4
Over flow weir	2	1.62	1.0 7.0	1.6	11.3	0.6
Oxygen measurement	2	0.32	24 7.0	8.6	60.3	3.1

- Return sludge pumping station
  - Return sludge flow 383 m^3/h
  - Pump capacity 240 m^3/h

Table 4-7: Energy consumption for return sludge pumping station.

Description	No	Power absorbed kW	Working time h/d d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a

Return sludge pump	2	10.0	24.0	7.0	240.0	1680.0	87.4
Standby sludge pump	1						
Level measurement	4	0.4	24.0	7.0	8.6	60.5	3.1

- Final clarifier

Table 4-8: Energy consumption for final clarifier

Description	No	Power absorbed kW	Working time		Energy consumption		
			h/d	d/w	Daily KWh/d	per week kWh/w	per year MWh/a
Circular scraper bridge	2	0.64	24.0	7.0	15.4	108.0	5.6
Scum pump	2	3.00	6.0	7.0	18.0	126.0	6.6

- Disinfection unit

- Ave. capacity 240 m^3/h
- Ave. flow rate 192 m^3/h

Table 4-9: Energy consumption for disinfection unit.

Description	No	Power absorbed kW	Working time		Energy consumption		
			h/d	d/w	Daily KWh/d	per week kWh/w	per year MWh/a
Disinfection unit	1	8.51	24	7.0	204.3	1430.4	74.4

- Effluent regulation tank ***no electrical consumption***

- Sludge treatment

- Excess sludge Qty.2095 kgDS/d
- Raw DS concentration 0.8%
- Raw sludge volume 262 m^3/d
- Pump capacity 30m^3/h
- Operation time 4.4 h/d

Table 4-10: Energy consumption for sludge treatment.

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Excess sludge pump	2	5.0	10.0	7.0	50.0	350.0	18.3
Level measurement	1	0.1	24.0	7.0	2.2	15.1	0.8

- Sludge thickener

Table 4-11: Energy consumption for sludge thickener.

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Central drive	1	0.44	24.0	7.0	10.6	74.2	38.7

- Sludge dewatering with belt filter press

- Thickened DS conc. 4.0%
- Thickened sludge vol. 73m^3/d
- Filter press cap. 15 m^3/h
- Operation time 2.4 h/d
- Dry sludge DS conc. 20.0%
- Dry sludge vol. 11.0 m^3/d

Table 4-12: Energy consumption for sludge dewatering.

Description	No	Power absorbed kW	Working time h/d	d/w	Energy consumption Daily KWh/d	per week kWh/w	per year MWh/a
Feed pump 1	1	2.5	2.4	5.0	6.1	30.5	1.6
Feed pump 2	1	3.0	2.4	5.0	7.3	36.7	1.9
Belt filter press	2	3.6	6.0	5.0	21.6	108.0	5.6
Wastewater pump	2	8.8	2.4	5.0	21.5	107.5	5.6
compressor	2	2.4	2.0	5.0	4.8	24.0	1.3
Flocculants preparation	2	2.4	2.0	5.0	4.8	24.0	1.2
FHM dosing pump	2	0.9	4.0	5.0	3.6	18.0	0.9
Screw conveyor	2	4.9	6.0	5.0	29.4	147	7.7
Drainage pump	1	2.6	0.5	5.0	1.3	6.5	0.3
Fan coil units	2	0.6	7.0	5.0	3.9	19.6	1.0
Lighting sockets	1	4.0	3.0	5.0	12.0	60.0	3.1

- Filtrate pumping station
  - Supernatant vol. 259 m^3/d
  - Pump capacity 50 m^3/h
  - Operation time 2.6 h/d

Table 4-13: Energy consumption for filtrate pumping station.

Description	No	Power	Working	Energy consumption

		absorbed	time		Daily	per week	per year
		kW	h/d	d/w	KWh/d	kWh/w	MWh/a
Centrate pump	2	2.8	2.6	7.0	7.3	50.8	2.6

- Administration building

Table 4-14: energy consumption for administration building.

Description	No	Power absorbed	Working time		Energy consumption		
					Daily	per week	per year
		kW	h/d	d/w	KWh/d	kWh/w	MWh/a
Control units	1	1.6	24.0	7.0	38.4	268.8	14.0
Lighting, sockets	1	8.0	3.0	7.0	24.0	168.0	8.7
Lighting the area	1	16.0	3.0	7.0	48	336.0	17.5

- Others

Table 4-15: energy consumption for other uses.

Description	No	Power absorbed	Working time		Energy consumption		
					Daily	per week	per year
		kW	h/d	d/w	KWh/d	kWh/w	MWh/a
Non potable water	1	11.6	3.0	5.0	34.8	174.0	9.0
Potable water network	1	6.0	3.0	7.0	18.0	126.0	6.6
Automatic sampling	1	0.4	4.0	7.0	1.6	11.2	0.6
Reserve	1	4.0	3.0	1.0	12.0	12.0	0.6

- **Total power demand (for stage one)** **4353** kWh/d, **30474** kWh/w, **1589** MWh/a.

- Emergency power generator

Installed power 498 KW

Reserve capacity 10 %

Simultaneous factor 65 %

Total 356 kW

Rating with cos Ø = 0.8 **445 KVA**

4.2 Operational Costs

(Calculations are made for 50,000 PE, while data in table 3.2 was taken from Al-Bireh municipality.)

1. Energy cost = power demand x specific costs = 1589000kWh/a x 0.13$

= **206,570 $**

2. Costs for personal

General Director 1

Technical plant manager 1

Operators 1

Assistant 1

Employees total cost = **80,000 $**

3. Operation materials costs

Sludge dewatering

Q of raw sludge = 765 t/a

FHM demand 4.5 kg/tDS = 4.5 x 765 = 3442.5 kg

FHM cost = 12 $ X 3.442 **= 41,310 $**

4. Maintenance

50,000 $

5. Lab monitoring costs

4,500 $

6. Sludge transport and disposal

8,000 $

7. Management and overhead costs

15,000 $

8. Water demand

2,500 $

9. Vehicle maintenance

1,000 $

10. Equipment rent

1,500 $

11. Telephone bill

700 $

12. Jawwal bill

4,000 $

13. Office equipment maintenance

500 $

14. Vehicle fuel

9,000 $

15. Vehicle insurance

1,500 $

16. Miscellaneous

2,500 $

17. Total cost

428,580 $

18. Specific costs / m^3 sewage

0.25 $

19. Specific costs per PE

8.57 $

20. Specific costs / m^3 water consumed

0.48 $

* These results will be used in calculating tariff because the influent to the treatment plant is almost equal to the maximum load and sometimes it is much higher, which is related to illegal connections and also suction trucks activity.

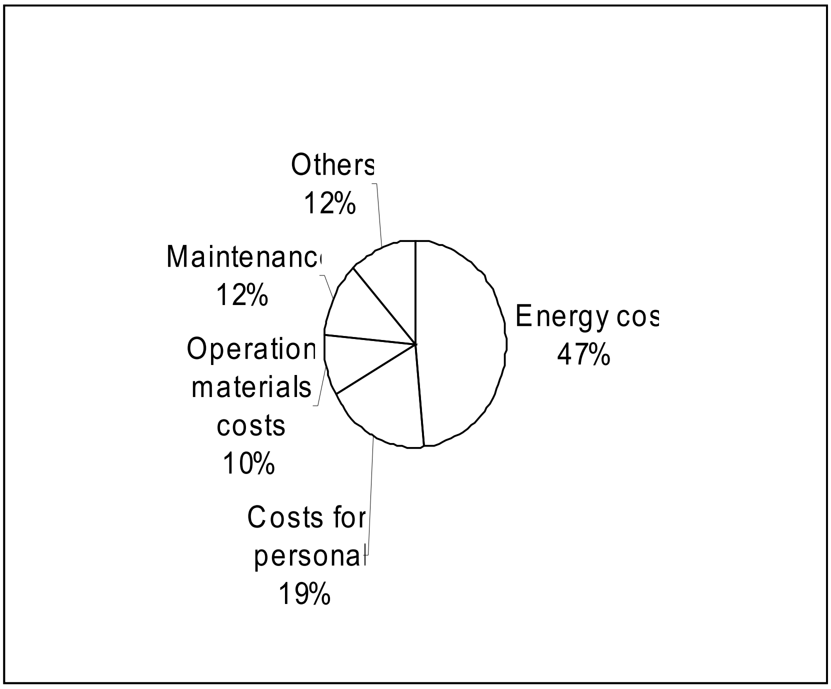

Figure 4.1 Operating costs of AWWTP

4.3 Theories

Capital cost or development cost usually can not be financed initially from the users, so it is usually taken as a loan from banks or any other financial institutions, (and some times the fund can be taken as a grant from a donor). In order to insure the recovery of this loan, the incremental cost of this loan must be taken in consideration besides depreciation costs, as the technical life of a facility is limited. So the institution should reserve for depreciation of facilities and incremental cost in order to keep going in its project.

So the revenues collected from users should cover the following expenses:

- Operational costs
- The cost of replacement of infrastructural components (depreciation costs which must be reserved during the life period of the facilities)
- Amortization costs, which is needed to keep the loan cost within bounds.
- The loan cost which is required to compensate the lender (interest).

And these costs should be collected from users within the tariff .

4.3.1 Depreciation Costs

The value of the facilities and equipments is reduced by a constant percentage during the assumed life time, and this loss in the value is called depreciation (Vapot.W.A. 1972). The beneficiaries must contribute for depreciation, and this contribution should be deposited in the capital recovery account in the bank which will be used in the future for the replacement of facilities and equipments.

Depreciation costs are calculated as annual or periodical payments paid by the users or beneficiaries.

How to calculate depreciation costs?

If I = Investment cost
L = life time
d = depreciation rate
n = number of years
m = number of periods within a year
i = interest rate
F = future value
A = annual payment
A_p = periodical payment
Then:
d = 1/L
$F = I \times (1+i)^n$ ……………………………………4.1
This formula can be used with annual payments, but when we calculate for periodical payments we use the next formula:
$F = I \times (1+i/m)^{nm}$ …………………………………4.2

To calculate the periodical payment we can use the following equation:
$A = F(i/((1+i)^n - 1)$, this is for the annual payment ……..4.3

$$A_P = \frac{F(i/m)}{(1+i/m)^{nm} - 1} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.4$$

4.3.2 Costs Calculations Approach

Costs calculations will be done using the following approach:

1. Incremental capital cost will be calculated considering no loan cost, and taking inflation cost only.
2. At first the future worth of each facility at the end of its life time must be calculated.
3. the depreciation ratio for each facility is to be calculated
4. Annual payments from the beneficiaries are calculated as the sum of depreciation costs, inflation costs and operating costs.

4.3.3 Incremental Costs Calculations.

Capital costs are the sum of civil works costs, mechanical works costs, electrical works costs, and others (Abu-Madi, M. 2004).

Table 4.16 shows each facility and its cost and life time

Table 4-16 facilities, costs and lifetime

Unit description	Cost in US $	lifetime	Depreciation ratio d
Civil works	3,000,000	30	0.033
Mechanical works	2,500,000	15	0.067
Electrical works	200,000	15	0.067
Land cost	500,000	________	_______
Site preparation	350,000	30	0.033

Future worth of each item is calculated using formula 4.1

$F = I \times (1+i)^n$ (n for civil works is taken as 30 and for mechanical and electrical is 15), the only interest rate was taken for inflation which is 2%

Table 4.17 shows each item and its future worth in the end of its lifetime.

Description	Cost US$	Future worth US$	Annual payment US$	Periodical payment US$
Civil works	3,000,000	5,434,085	133,950	22,191
Mechanical works	2,500,000	3,364,671	194,564	32,198
Electrical works	200,000	269,174	15,565	2,576
Land cost	500,000			
Site preparation	350,000	633,977	15,627	2,589
Total	**6,550,000**	**9,701,907**	**359,706**	**59,554**

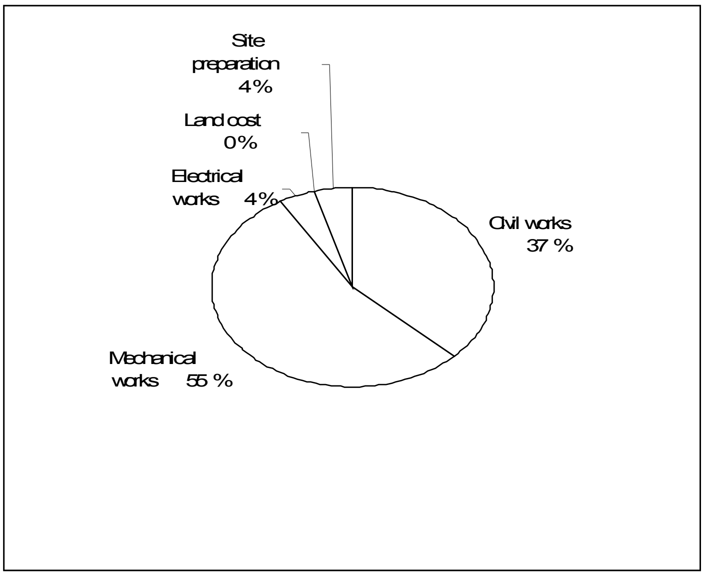

Figure 4.2 Periodical capital cost distribution

4.3.4 Total Periodical Cost Calculations

Total periodical costs are the sum of capital and running costs.

Running costs (operation and maintenance costs) were calculated as annual costs so we need to calculate them periodically by dividing them on the number of periods (6) per year. And here it is noticed that annual running costs are considered to be a loan taken from the bank and returned at the end of the financial year, and that is because of the delay of payments from beneficiaries which may cause financial shortage.

Using formula 4.1 (**F = I x (1+i)^n**), and using an interest rate of 11%

Annual running costs = 428580 x $(1.11)^1$ = **475724 US$.**

Using formula 4.4

$$A_P = \frac{F(i/m)}{(1+i/m)^{nm} - 1} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.4$$

Periodical running cost = 475,724 x 0.01833/((1.018)^6-1) = **75,730 US$**

Total periodical costs = periodical capital costs + periodical running costs

= 59,554 + 75,730

= **135,284 US$**

Table 4-18 Total periodical costs

Description	Annual US$	Periodical US$
Capital costs	359,706	59,554
Running costs	475,724	75,730
Total costs	**835,430**	**135,284**

4.3.5 Costs of Treated Wastewater.

In order to calculate the cost of treatment of wastewater for each m^3 treated, we have to calculate the amount of wastewater treated within one year, and also we have to calculate the amount of water consumed by the beneficiaries as the revenue of treatment will be collected according to the bill of water consumption.

Table 4-19 shows the quantity of consumed water and treated wastewater and the percentage of the consumed to the treated during the year 2003.

Table 4-19 Consumed water and treated wastewater. In (2003).

Month	**Water consumed m^3**	**Treated wastewater m^3**	**Tww./ con.w.**
January	53288	133179	2.50
February	65129	275607	4.23
March	56716	214375	3.78
April	69319	140453	2.03
May	65439	118158	1.81
June	79981	112477	1.41
July	70911	101518	1.43
August	86668	110120	1.27
September	88266	104177	1.18
October	107881	107707	1.00
November	71261	104380	1.46
December	87096	129775	1.49
Total	**901955**	**1651926**	**1.83**

Table 4-20 Treated wastewater in 2003

Month	Treated ww. m³	Average m³/d	Treated/max design load.
January	133179	4296	0.75
February	275607	9504	1.66
March	214375	6915	1.20
April	140453	4682	0.81
May	118158	3812	0.66
June	112477	3628	0.63
July	101518	3384	0.59
August	110120	3552	0.62
September	104177	3473	0.60
October	107707	3474	0.60
November	104380	3479	0.61
December	129775	4189	0.73
Total	**1651926**	**4532**	**0.79**

(*In colomn 4 the ratio was >1 as a result of illegal connections and also the flow from suction trucks)*

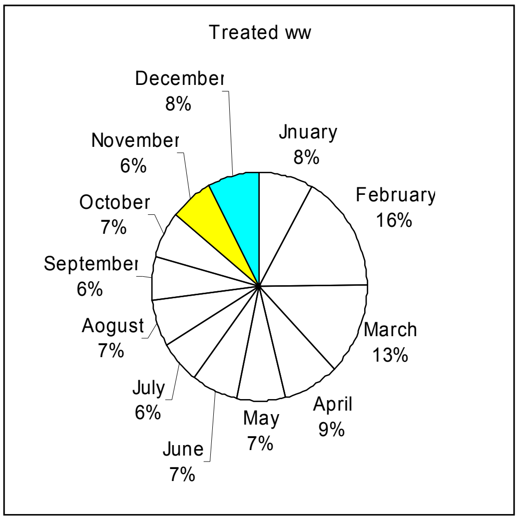

Figure 4.3 Distribution of treated ww. during 2003

The monthly distribution of treated wastewater in AWWTP during 2003 shows that the highest percentage is in February which is 16%, and the lowest percentage is in July which is 6%, and this is a strong indicator of the percentage of rain water that enters to AWWTP.

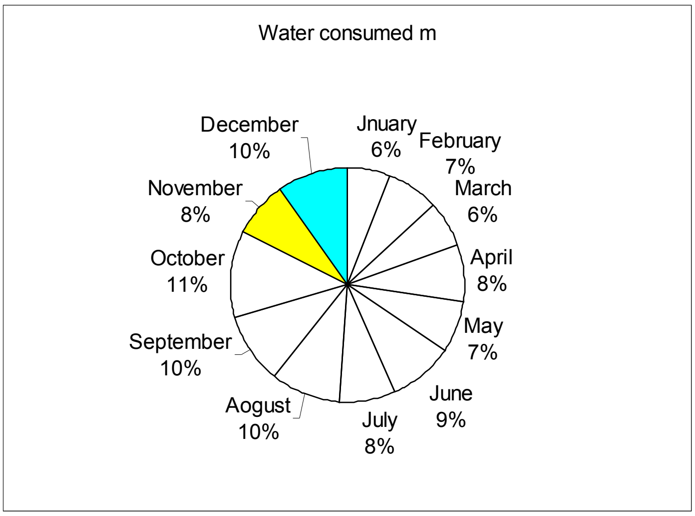

Figure 4.4 Distribution of water consumption during 2003

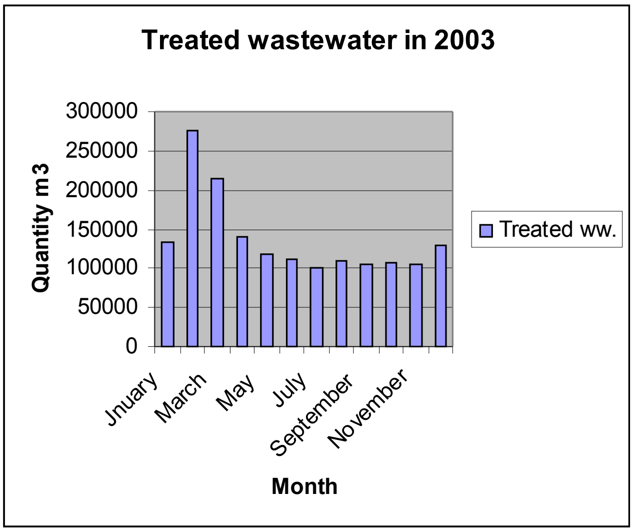

Figure 4.5 Treated wastewater in 2003

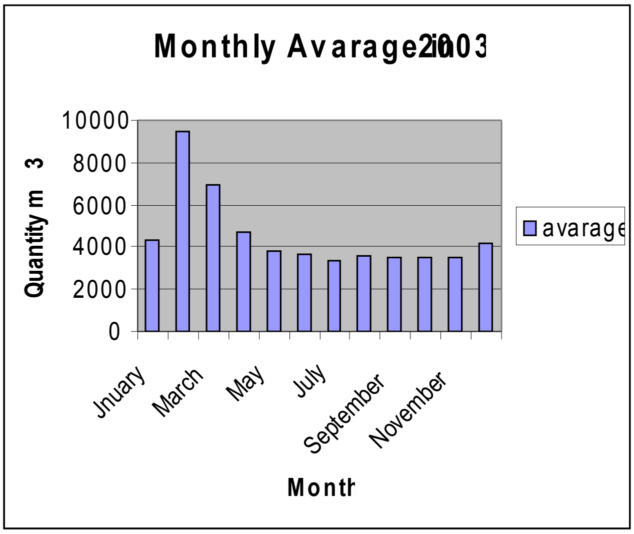

Figure 4.6 Monthly average of treated ww. in 2003

The average of treated wastewater in the dry season is nearly a straight line.

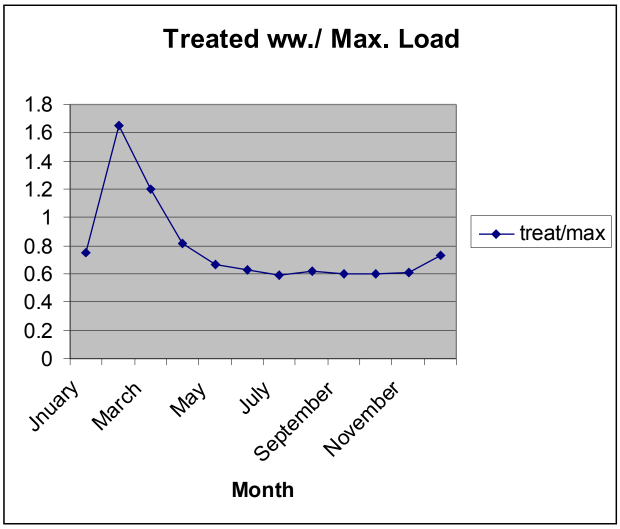

Figure 4.7 Treated ww/ max. load in 2003

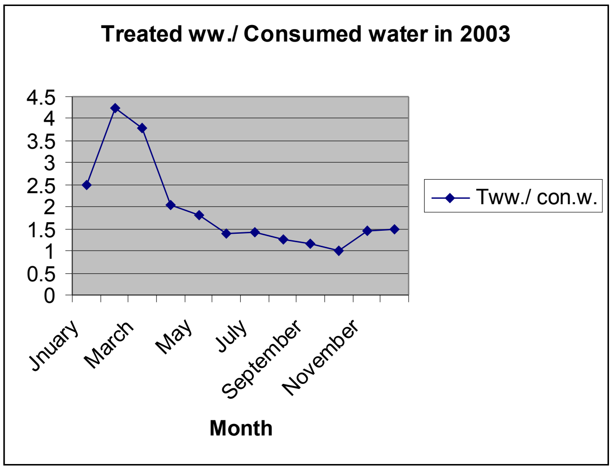

Figure 4.8 Treated ww. / consumed water in 2003

Now to calculate the costs of treating wastewater (US / m^3) we will use the following formula

If:

C_t = total annual costs US$

Q_t = total annual treated amount m^3

C = Cost US$/ m^3

Then

$C = C_t / Q_t$ ……………………………………4.5

Using formula 4.5

C = 835430 US$ / 1651926 m^3 = 0.505 US$/$m^3$

4.4 Proposed Tariff System

An efficient tariff system must (at least) to recover the total costs of the treatment, and also it must deal with polluters as classes depending on the kind of polluters and also the kind of their pollutants. Polluters or beneficiaries can be classified into three main kinds as shown in ch.3 (low polluting beneficiaries, medium polluting beneficiaries, and heavy polluting beneficiaries) and also we can classify them in more detailed classification as shown in table 4.21.

Table 4.21 beneficiary's classification in Al-bireh city

No.	Kind of activity	Number of firms	Population or number of workers
1	Hotels	3	25
2	Restaurants	87	210
3	Vehicle service garages	32	102
4	Hospitals	8	239
5	Medical laps	6	12
6	Gas stations	6	23
7	Car washing stations	1	5
8	Sweets shops	5	37
9	Diary factory	1	12
10	Pharmaceutical factories	4	?????
11	Agriculture and animal raising	10	27
12	Light industries	284	1828
13	Construction sector	16	212
14	Commercial shops and personal goods selling	811	1262
15	Transportation	34	248
16	Financing	36	90
17	Banks	8	265
18	Building companies	138	480
19	Educational institutions	31	443
20	Health and social institutions	72	270

21	Bakery	15	
22	Dry cleaning companies	7	22
23	Stone cutting factories	11	84
24	Palestine aluminum company	1	??????
25	Electrochemical metallizing establishment	1	?????
26	Suction trucks	21	42
27	Miscellaneous	72	300
28	**Total**	**1721**	**6258**
29	**Householders**	**5967**	**32222**

When we talk about tariff a very important object must be taken into consideration, which is the willingness to pay that decides the ability of the proposed system to be used or not (M.D.N.2003). The industrial and commercial sectors willingness to pay is higher than the households sector as water is essential for their work or in other words it is a work element, and also they must be licensed every year from the municipality and so their tariff can be higher.

Our proposed system divides tariff into two parts which are:

1. Constant charge, must be paid monthly and not depending on water consumption.
2. Variable charge, must be paid monthly depending on water consumption

Also both of constant and variable charges value depends on the kind of polluters. Table 4.22 shows the proposed wastewater tariff system in details.

Table 4.22 Proposed constant tariff for WWT in Al-Bireh

No.	Kind of activity	Number of firms	Constant tariff $/month	Sum US$	Yearly sum US$
1	Hotels	3	100	300	3600
2	Restaurants	87	30	2610	31320
3	Vehicle service garages	32	20	640	7680
4	Hospitals	8	100	800	9600
5	Medical laps	6	20	120	1440
6	Gas stations	6	50	300	3600
7	Car washing stations	1	100	100	1200
8	Sweets shops	5	30	150	1800
9	Diary factory	1	30	30	360
10	Pharmaceutical factories	4	100	400	4800
11	Agriculture and animal raising	10	10	100	1200
12	Light industries	284	30	8520	120240
13	Construction sector	16	10	160	1920
14	Commercial shops and personal goods selling	811	10	8110	97320
15	Transportation	34	10	340	4080
16	Financing	36	10	360	4320
17	Banks	8	30	240	2880
18	Building companies	138	10	1380	16560
19	Educational institutions	31	50	1550	18600
20	Health and social institutions	72	10	720	8640
21	Bakery	15	30	450	5400
22	Dry cleaning companies	7	50	350	4200
23	Stone cutting factories	11	50	550	6600
24	Palestine aluminum company	1	100	100	1200
25	Electrochemical metallizing establishment	1	100	100	1200
26	Suction trucks	21	100	2100	25200
27	Miscellaneous	72	10	720	8640
28	**Total**	**1721**		**31300**	**375600**
29	**Householders**	**5967**	**2.5**	**14917.5**	**179010**

For variable charge the system divides the beneficiaries into three groups as follows:

1. Households group, members of this group pays only half the cost of treatment (running cost of treatment which is 0.5 US$) according to their water consumption, in other words households **pay 0.25 US$/m^3 of water consumed.** This group consumes about 85% of the water consumed by the connected area in Al-Bireh city which is about 766662m^3/year and this means that we can collect about **191,666 US$/year.**

2. Suction trucks, this group pay full charge of treatment for the quantity they discharge which is **0.25US$/m^3** of treated wastewater (that is because of two major reasons, the first is every suction truck has to pay 100 US$ monthly and the second is mostly wastewater discharged from these trucks is from houses). Suction trucks used in the area of Al-Bireh city and near it are about 21 trucks each of 7m^3 capacity, with an average of 5 lefts full tank a day about of 22050m^3 monthly average or about 85% of the deference between consumed water and treated wastewater in the dry weather period. Calculating the revenues from suction trucks we find that we can have **5,512.5 US$/month or 66,150 US$/year**

3. All other users, this group members pay full charge of treatment for consumed water which is **0.5 US$/m^3** of consumed water (that is because of two major reasons, the first is even most of these beneficiaries consume little quantities of water but their pollutants are mostly very harmful and difficult to treat, the second is these beneficiaries use water mostly as an element of work and they collect revenues from these quantities of water they consume and which later discharged as wastewater. This group consumes about 15% of the hole consumption of the

connected area in Al-Bireh city which is about 135293m^3/year and this means that we can collect about **67,647 US$/year**.

To calculate the total revenues using this tariff system by adding the constant charges to the variable charges we see that we can collect about **880,073 US$/year**, whereas the total annual costs are about **835,430 US$/year** and this means that there is a profit of about **44,643 US$/year.**

Chapter 5
Conclusions and Recommendations

5.1 Conclusions

The objective of this study was to create a tariff system for wastewater treatment that insures the ability of the municipalities and local authorities to rebuild wastewater treatment plants at the end of life time of these plants from the profits that collected as charge of treating wastewater from beneficiaries. This tariff system must meet the ability and willingness to pay of the beneficiaries. Based on the study the following conclusions were drawn:

- The municipality of Al-Bireh doesn't take the fund of wastewater treatment plant replacement at the end of its life time in consideration.

- The existing tariff system in Al-Bireh doesn't recover the running costs of the treatment plant, the annual running costs of the treatment plant are about **359,706 US$,** while the beneficiaries had to pay about **240,000 US$** and only about half of this amount was collected.

- There is a huge difference between the quantity of water consumed in the connected area and the quantity of wastewater entered to the plant in the same period (2003), and this difference is related to rain water entrance to the plant, and also suction trucks that serves the unconnected area and the city of Ramallah and other close villages (about 85% of the difference in the dry weather period is related to the suction trucks).

- Municipalities and other local authorities don't have any control on suction trucks and their work, and mostly they don't pay for wastewater they charge to the treatment plant.

- All connected beneficiaries are paying the same tariff depending on the quantity of consumed water without any classification to the beneficiaries or the use of water or the contents and pollutants of wastewater discharged.

- According to (Abu-Madi, 2004), the share of energy consumption of running costs is about 38.3%, while as we can see from figure 4.1 the share of energy cost in AWWTP from OPEX is about 48% which seems to be a good sign.

- Personal costs as a percentage of OPEX is 59.3% in Jordan and 38.8% in Tunisia (Abu-Madi, 2004), while in AWWTP it is about 19% only, which reflects the low average of salaries.

- Wastewater operational costs in Jordan is 0.37US$ (Abu-Madi, 2004), while in AWWTP it is 0.25US$.

5.2 Recommendations

During the preparing of this study several problems were faced in collecting data and studying the existing tariff system, also several management and organizing problems were noticed in municipality of Al-Bireh which was our case of study, to come over these problems the following recommendation can be followed:

- Municipalities and other local authorities must cooperate with ministry of transport in order to the licensing of suction trucks and collecting the annual charge from them.

- Reuse of effluents from wastewater treatment plants must be activated in order to achieve profits that will reduce the charge paid from people connected to the wastewater treatment plant.

- Activation of cooperation between municipal and village councils in order to establish shared wastewater treatment plants to reduce the share of capital costs from the annual costs of the plants.

- Local authorities must put big bills on people who connect rain water to the sewer system in order to reduce the hydraulic load on the treatment plant.

- Financial system of the wastewater treatment plant must be separated from the financial system of the municipality or the local authority, and the profits from the wastewater treatment plant must be invested in short period investments or put in the bank with a good interest rate in order to insure the fund needed to rebuild the plant in the end of its life time.

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Annex 1

Reports of Monthly Flow Enters Al-Bireh Wastewater Treatment Plant

Annex 2

Correspondences with Al-Bireh Municipality

Annex 3
Correspondences with Palestinian Central Bureau of Statistics

Annex 4

Correspondences with Jerusalem Water Institute

بسم الله الرحمن الرحيم

جامعة بيرزيت
كلية الدراسات العليا
معهد الدراسات المائية

تطوير نظام تعرفة معالجة المياه العادمة
الحالة الدراسية: محطة بلدية البيرة لتنقية المياه العادمة

إعداد
ناصر عبد السلام ابوشربك
الرقم الجامعي 1015230

إشراف
الدكتور راشد "محمد ياسر" الساعد

قدمت هذه الرسالة استكمالا لمتطلبات درجة الماجستير في هندسة المياه من كلية الدراسات العليا في جامعة بيرزيت- فلسطين

2004

الخلاصة

إن إنشاء وتأسيس محطات تنقية المياه العادمة لهو من أهم الأمور التي يجب على البلديات والسلطات المحلية الأخرى الاهتمام بها ووضع الخطط والدراسات المستقبلية، حيث إن معالجة المياه العادمة هي ضرورة بيئية تتمثل في الحفاظ على المياه الجوفية والبيئة المحيطة من التلوث وكذلك فإن قلة مصادر المياه في المنطقة عموما وفي بلادنا خصوصا وما نعانيه من سرقة مصادر المياه الجوفية من قبل الاختلال يفرض علينا التوجه نحو إعادة استخدام المياه المكررة أو المعالجة في محطات التنقية.

إن طريقة إدارة محطات التنقية هي مسألة غاية في الأهمية ولعل معظم البلديات والسلطات المحلية في بلدنا تحاول أن لا تفصل إدارة المحطات سواء كانت من الناحية المالية أو الإدارية عن إدارة البلدية أو السلطة المحلية، علما أن الفصل هو الطريقة الأمثل حيث من خلاله يمكن الاهتمام أكثر بالمحطة ومستقبلها.

ولعل من أهم المعضلات والمشاكل التي تواجه إدارة المحطة هي تحديد تعرفة معالجة المياه العادمة ووضع نظام التعرفة المناسب والذي يتلائم مع قدرات المشتركين وقابليتهم للدفع وكذلك مع متطلبات المحطة المادية. حيث إن هذه المتطلبات تنقسم في مجملها إلى نوعين من المتطلبات هي:

أ – تكلفة الإنشاء أو الاستثمار وهي تكلفة إنشاء المحطة الإجمالية وهي في الغالب إما أن تكون قرضا طويل الأمد أو منحة من احد الدول المانحة. ويجب حساب هذه التكلفة على شكل دفعات دورية سنوية كانت أو شهرية يتم جبايتها من المشتركين وذلك لضمان إعادة القرض وإعادة تأهيل المحطة في نهاية العمر الافتراضي للمنشآت الحالية فيها.

ب- تكلفة الصيانة والتشغيل: وهي التكلفة الإجمالية لعملية تشغيل المحطة وما يتطلبه ذلك من مصروفات في مجال توفير الصيانة وقطع الغيار واستهلاك الطاقة والمواد الخام المستخدمة في المعالجة وأجور الموظفين وماغير ذلك من مصروفات وتكاليف ناتجة عن تشغيل المحطة. وهذه التكلفة أيضا يجب أن يتم جبايتها من المشتركين.

إن أي نظام تعرفة يتم وضعه يجب أن يراعي عدة أمور أساسية هي:

1- الكفاءة في تغطية كافة تكاليف المحطة سواء كانت تكاليف الإنشاء أو التشغيل.
2- قدرة المشتركين على الدفع وقابليتهم واستعدادهم للدفع.
3- قابلية النظام للتطبيق والنجاح في جعل المشتركين يسددون اشتراكهم.

4- تصنيف المشتركين حسب قواعد أساسها أغراض استخدام المياه ونوعية المياه العادمة الناتجة عن هذا الاستخدام.

وفي هذه الدراسة تم وضع نظام تعرفة للمياه العادمة مع أخذ مدينة البيرة كعينة للدراسة. ويتمثل هذا النظام في الآتي:

أ –تم تصنيف المشتركين إلى تسع وعشرين نوعا من المشتركين تم تصنيفهم حسب نوعية استخدامهم للمياه ونوعية المياه العادمة الناتجة عنهم.

ب- حسب نظام التعرفة المقدم في هذه الدراسة فإن القطاع الصناعي وقطاع الفنادق تفرض عليهم أعلى تكلفة وذلك كون المياه العادمة الناتجة عنهم هي الأكثر تلوثا وصعوبة في المعالجة.

ج- الاشتراكات المنزلية يتم فرض أقل تكلفة ممكنة عليها حيث إن المياه العادمة الناتجة عنهم هي الأقل تكلفة والأبسط في المعالجة.

د- الجباية من القطاع التجاري والصناعي وكافة المؤسسات والمنشآت وحتى صهاريج النضح يتم ضمانها من خلال اشتراط التسديد لتجديد تراخيص هذه المنشآت والمصالح.

هـ - عند حساب التعرفة تم حساب تكلفة الإنشاء و تكلفة التشغيل, والنظام المقدم في هذه الدراسة يضمن تغطية هذه التكاليف مع فائض معقول.

و- المبالغ التي يتم جبايتها يجب استثمار ما يتبقى منها بعد حسم المطلوب منها لتسديد تكلفة التشغيل في مشاريع ربحية قصيرة الأمد أو وضعها في حساب خاص في البنك مع فائدة معقولة وذلك لضمان توفر المبلغ اللازم لإعادة تأهيل المحطة في نهاية العمر الافتراضي لها.