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Small Scale Waste Water Treatment Plants in West Bank: Comparative Study

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Dedication:

"To Our Profit Mohammad (Peace be upon him)".

"To My Family and Friends".

Declaration

I certify that this thesis submitted for the degree of Master is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

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AS	Activated Sludge
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
DO	Dissolved Oxygen
EC	Electrical Conductivity
FC	Fecal Coliform
KHP	Potassium Hydrogen Phthalate
MBR	Membrane Bio Reactor
MCM	Million Cubic Meter
MoA	Ministry of Agriculture
MOU	Memorandum of Understanding
pH	Power of Hydrogen
PMD	Palestinian Metrological Department
PWA	Palestinian Water Authority
RO	Reverse Osmosis
TC	Total Coliform
TDS	Total Dissolved Solids
TOD	Total Oxygen Demand
TOC	Total Organic Carbon
TPC	Total Plate Count
TS	Total Solids
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket
UV	Ultra Violet
WHO	World Health Organization
WWTP	Waste Water Treatment Plant

Abstract:

In this work, a comprehensive contrast between small scale waste water treatment plants (WWTPs) that are located in deferent regions in Palestine utilizing different technologies is presented. During this investigation, eleven WWTPs have been visited. Two of these plants were found not functioning, four were found in bad conditions, and five plants were found functioning properly. Wastewater grab samples from the influent and effluent were taken from the selected plants once every month during the experimental period from January 2010 to December 2011.
Two kinds of analysis were carried out on these samples. The first analysis was carried out immediately once the sample has reached the lab. These include pH, Electrical conductance (EC), total plate count (TPC), total coliform (TC), fecal coliform (FC) and biological oxygen demand (BOD). The second group of analysis was measured in later stage. These include total solids (TS), total dissolved solids (TDS), total suspended solids (TSS), ionsand chemical oxygen demand (COD).

The efficiency of studied plants were calculating by considering the effectiveness of reducing COD, BOD_5, TS, TDS, and TSS of the final effluent from each plant. In Al Quds University WWTP the average reduction in TDS, TSS, TS, BOD_5 and COD are 99 %, 99 %, 99%, 95 % and 95%, respectively. For Nahaline the average reduction in TDS, TSS, TS, BOD_5, and COD are 52 %, 81 %, 58 %, 57 % and 57 %, respectively. For Nuba the average reduction in TDS, TSS, TS, BOD_5, and COD are 22 %, 35 %, 22 %, 54 % and 24 %, respectively. For Al Aroub WWTP the average reduction in TDS, TSS, TS, BOD_5, and COD are15 %, 45 %, 18 %, 42 % and 33%, respectively. For the Inter Continental Hotel In Jericho WWTP the average reduction in TDS, TSS, TS, BOD_5, and COD are 48 %, 96 %, 56 %, 59 % and 40 %, respectively.

Upon comparing the efficiency of all the studies plants, it can be concludes that membrane technology coupled with activated sludge process was found to give the best removal efficiency for all the studies quality parameters. Furthermore, upon comparing the actual cost of treatment of one cubic meter for each plant together with the removal efficiency, activated sludge technology is found to give the most economical technology. However, parallel to the actual cost, the sustainability of reuse and environmental cost should be addressed for future discussion in the adaptation of any treatment technology in Palestine by the decision makers.

Chapter One

Introduction

1. Introduction

1.1 Water Supply

Water supply and sanitation in the Palestinian territories is characterized by severe water shortage, which is exacerbated by the effects of Israeli occupation. According to the WASH Monitoring Program, Israelis use 85% of the water available from the mountain aquifer in the West Bank, and 82% of the water from the coastal aquifer under Gaza (Wikipedia, 2009). Israel denies the Palestinian rights to share and use water from Jordan River. The Palestinian Water Authority (PWA) was established after Oslo agreement (1995) to monitor, develop and distribute the limited drinking water supply allocated to it by the Israeli's Authority (UNEP, 2003).

The unfair distribution of water resources and the denials of the full control of the Palestinians over their natural water reservoirs make most of the Palestinian municipalities and villages to suffer from the shortages in fresh water supply especially in summer (Palestinian Media Center, 2003).

1.2 Water Resources

At an average sustainable rate, the amount of renewable shared freshwater available throughout the entire Jordan Valley from rivers and renewable aquifers is roughly 2700 million cubic meters per year (MCM/yr), out of which 1400 MCM/yr comes from groundwater and 1300 MCM/yr from surface water(Palestinian Media Center, 2003). The main sources of water available to Israelis and Palestinians are the Jordan River and groundwater underlying the West Bank and coastal areas. Israel has denied Palestinians access to the entire Lower Jordan River since 1967. After the start of Israel's military occupation in 1967, Israel declared the West Bank land adjacent to the Jordan River a closed military zone, to which only Israeli settler farmers have been permitted access (Palestinian Media Center, 2003). Groundwater is the major source of fresh water supply in Palestine. Currently, more than 85% of the Palestinian water from the West Bank aquifers is taken by Israel, accounting for 25% of Israel's water needs. The groundwater resources underlying the Palestinian Territories are the Mountain Aquifer (West Bank) and the Coastal Aquifer Basin (Gaza Strip). The Mountain Aquifer is replenished by the winter rains which mainly fall on the West Bank territory. A major quantity of this water flows underground outside of the West Bank, and moves gradually towards the slopes of the hills mainly within Israeli territory (Tamkeen, 2005)

The level of development in water infrastructure and services is far less in the Palestine Territories compared with Israel. After transfer of certain responsibilities and authorities by the Israelis to the PA and especially after the establishment of PWA in 1995, many projects have been implemented to construct new water networks or to rehabilitate existing ones. This is considered to be a time consuming task that requires commitments from the Palestinians and Israelis supported by the international community. The average water supply to the Palestinian communities of the Occupied Territories is about (63 Lc /day) in the West Bank and (140 Lc/day) in the Gaza Strip. However, water supply significantly varies throughout the Territories. In (7 %) of the Palestinian communities, is less than or equal to (30 Lc/day), in (36 %) of them it is between (30- 50 Lc/day), in (41 %) of them it is between (50 – 100 Lc/day), and finally, only in (16%) of them is (100 Lc/day), which is the minimum amount recommended by the World Health Organization. (Murad, 2005).

1.3 Water Quality

The quality issue is the second dimension of the water crisis. Quality is a primary concern, especially in the Gaza Strip, where over extraction (the extraction of water in quantities outrunning the recharging capacity of the aquifers) leads to the seepage of saltwater from the Mediterranean Sea into the underground aquifer and to the increase of brackish water from the deeper layers (AlSa'ed, 2000). However, the situation is also difficult in the West Bank as all of the Palestinian Territories are characterized by an extensive and inappropriate use of pesticides and fertilizers in the agricultural sector and by the absence and inadequacy of the sewage infrastructure. Today only (7%) of water in the Gaza Strip meets the World Health Organization’s standards. Diseases registered in the hospitals include cholera, dysentery, hepatitis, and yellow fever (WHO, 1996).

1.4 Rainfall Distribution

The large variations in rainfall and limited surface resources have led to widespread scarcity of the fresh water resources in the region, resulting in a heavy reliance on groundwater as the major source for various uses.

The contribution of surface water to the overall water balance is limited and marginal. The sources of water in the WB are those renewable waters of the Mountain aquifer that rises and outcrops in the WB but extends across and below the territories of Israel. The main recharge acceptance area is located in the core of the WB where water originating in altitudes higher than 400 meters feed the major aquifers in the area. The ground water recharge in the WB is the direct infiltration of rainwater through fractured, karstic rocks and porous soils. The overall balance in the West Bank is estimated to be 679 MCM/ yr, while in Gaza it is estimated at 45 MCM/ yr (Arij, 1998).

1.5 Water Abstraction

Table 1.1 shows the amount of water abstract from the aquifer in West Bank by the Palestinian and Israel, the amount of water that abstract by the Palestinian in the range is about 113 MCM – 138 MCM, or about (17-20%) of the estimated potential, and an Israeli over extraction of 389 MCM (80%) of the estimated potential.

Table (1.1): Water abstraction by Palestinian and Israeli from the Aquifer. (PWA, 2009).

		Abstractions MCM			**Excess over Article 40 allocation MCM**		
Aquifer	Estimated potential MCM	Total Palestinian	Total Israeli	Total Abstracted	Palestinian	Israeli	Total over extraction
Western	362.0	29.4	591.6	621.0	7.4	251.6	259.0
North Eastern	145.0	36.9	147.1	184.0	(5.1)	44.1	39.0
Eastern	172.0	71.9	132.9	204.8	(2.6)	92.9	90.3
Total	679.0	138.2	871.6	1,009.8	(0.3)	388.6	388.3

Palestinian abstractions have actually declined over the last ten years. Contrary to expectations under Oslo II, the water actually abstracted by Palestinians in the West Bank has dropped – from 138 MCM in 1999 to 113 MCM in 2007, and 88 MCM in 2009 (PWA, 2009).

With regard to the short term, the next 2-3 years or so, (PWA) is already focusing and intends to continue to focus on emergency measures to repair networks and provide additional piped water to those areas in the northern and southern West Bank without safe or reliable services. This program involves drilling and equipping new wells in the Nablus, Tubas and Jenin governorates and building transmission lines from the new Herodian and Bani Naim well fields in the southern West Bank to serve villages in the south and southwest (Word Bank, 2009).

1.6 Sanitation Sector in Palestine

1.6.1 Wastewater Situation in Palestine

The wastewater situation in the West Bank is not quite as alarming, but is serious nonetheless. Roughly (91 %) of the population relies on septic tanks for temporary storage of wastewater, none of which is treated. The majority of these septic tanks are emptied through private-sector vacuum trucks which discharge their contents into the closest Wadi. Of the (9 %) that is collected by sewers and sent to one of seven treatment plants, only that of al Bireh Municipality is functioning properly. The result is that roughly 25MCM of untreated wastewater per year is discharged into the environment at over 350 locations (UNEP, 2003).

There are about 688 WWTPs in West Bank which was constructed by the NGOs, all of these plants are onsite treatment plant and a few of them are decentralize WWTPs (15) (small to medium scale) and only(3) centralized WWTPs (large scale)where are in Albiereh, Ramallah, and Jenin. All data for these plants can be found in Addendum one.

Other initiatives include the development of wastewater treatment and reuse plants in Gaza, Hebron and in the northern West Bank. Finally PWA expects to make a start on developing desalination capabilities in Gaza. The plans for the above are well-advanced, but the funding has yet to be secured. On the institutional side, the priorities are establishing the coastal utility in Gaza and resuscitating the efforts to build a southern-area utility in the West Bank.. With the relatively high percentage of the population not connected to a sewerage network, this gives a high amount of raw sewage being returned to the natural environment (UNEP, 2004)

Generally, wastewater treatment and reuse projects are associated with many obstacles, which are mainly political, financial, social, institutional and technical (Metcalf& Eddy, 1991). Also, the Palestinians have not developed an integrated vision for the reuse issues. These include the political side, institutional, potential and locations of wastewater reuse, awareness, marketing and tariff setting. Political reasons and public acceptance could be considered the main factors affecting the wastewater reuse in agriculture. The unstable political situation, along with the lack of communication with the Israeli side, has made it very difficult in moving forward with proposed reuse projects. Also, Palestinian local society is still having concerns on using the treated wastewater in agriculture. To ease social constraints, efforts have been increased toward the development of integrated public awareness programs, which highly assist towards establishing a new perception of wastewater (Arij, 2004).

Despite the fact that the legal and institutional frameworks for the sustainable management of treated wastewater have been expressed in the Palestinian development plans and have been under focus in the policies and strategies of the Ministry of Agriculture (MOA) and the Palestinian Water Authority (PWA), the enforcement of such issues are still lacking.

The reuse of treated wastewater in agricultural production in Palestine is still on the pilot scale and the Palestinians lack the proper experience in using this resource in a safe and sound way. Nevertheless, wastewater in Palestine has a high reuse potential. New recycling techniques should be employed to make use of the wastewater discharged. It is important to emphasize the vitality of water reuse to the Palestinian water sector since recycling the wastewater will lower the burden and pressure on the water resources (Arij, 2004).

1.7 Nature of Municipal Wastewater

An understanding of the nature of wastewater is fundamental for the design of appropriate wastewater treatment plants and the selection of effective treatment technologies. Wastewater originates predominantly from water usage by residences and commercial and industrial establishments, together with groundwater, surface water and storm water consequently, wastewater flow fluctuates with variations in water usage, which is affected by a multitude of factors including climate, community size, living standards, dependability and quality of water supply, water conservation requirements or practices, and the extent of meter services, in addition to the degree of industrialization, cost of water and supply pressure (Assmuth & Strandberg, 1992).

1.8 Wastewater Quality

Wastewater quality may be defined by its physical, chemical, and biological characteristics. Physical parameters include color, odor, temperature, and turbidity. Insoluble contents such as solids, oil and grease, also fall into this category. Solids may be further subdivided into suspended and dissolved solids as well as organic (volatile) and inorganic (fixed) fractions. Chemical parameters associated with the organic content of wastewater include biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), and total oxygen demand (TOD). Inorganic chemical parameters include salinity, hardness, pH, acidity and alkalinity, as well as concentrations of ionized metals such as iron and manganese, and anionic entities such as chlorides, sulfates, sulfides, nitrates and phosphates (Metcalf & Eddy, 2003).

Bacteriological parameters include coliforms, fecal coliforms, specific pathogens, and viruses. Both constituents and concentrations vary with time and local conditions. The typical concentration ranges for various constituents in untreated domestic waste-water. Wastewater is classified as strong, medium or weak, depending on its contaminant concentration. The effects of the discharge of untreated wastewater into the environment are manifold and depend on the types and concentrations of pollutants. (APHA, 1998)

1.9 Wastewater Treatment

Conventional wastewater treatment consists of physical, chemical or biological processes or combinations of these processes to remove solids, organic matter and, sometimes, nutrients from wastewater.

The main stages of wastewater treatment according to (Jeremy, 1999) are:

1- Preliminary: removal of gross solids, sand; and fluctuating materials (oil and grease).

2- Primary: removal of settled suspended solids, and part of the organic matter in suspension.

3-Secondary: removal of the organic matter dissolved and in suspension which was not removed by the primary treatment.

4-Tertiary (or advanced): removal of specific components and/ or complementary removal of components which were not sufficiently removed by the secondary treatment, e.g. nutrients or pathogenic organisms.

A further stage involves the treatment of the surplus sludge generated along the process by stabilization and/or thickening and dewatering prior to reuse or disposal. The stages of the treatment are usually classified by the nature of the treatment applied. In the mechanical treatment, the use of physical forces (screening, sedimentation and filtration) prevails; the chemical treatments involve the use of external reagents and chemical reactions (flocculation, precipitation, redox, disinfection), the biological treatments are based upon the activities of micro organisms, mainly bacteria, which use the biodegradable organic pollutants as a substrate for their metabolism (activated sludge, trickling filters, lagoons, aerobic and anaerobic digestion); the thermal treatments use heat for the evaporation of water, the destruction of the organic components or for sludge treatment (dehydration, incineration) (Bouwer, 1978).

Table (1.2) shows the main processes in treatment of wastewater on the other hand table (1.3) described the removal efficiency of the quality parameters for each unit process employed in WWTP.

Table (1.2) Main processes in wastewater treatment. (Zanetti, 2006)

Pollutants	**Processes used**
Gross materials	Screening, degritting
Suspended solids Biodegradable organic compounds Nitrogen compounds Phosphorous	Sedimentation, flotation, flocculation, filtration Activated sludge, trickling filters biologic disks, lagoons Nitrification or biological denitrification, stripping Chemical precipitation, biological removal
Pathogenic agents	Chlorination, Ozonization, UV
Non-biodegradable organic compounds	Absorption of activated carbon, wet combustion, incineration
Dissolved inorganic compounds	Chemical precipitation, ion exchange, membrane processes

Table (1.3) Removal efficiency (expressed as %) of different types of treatment for municipal wastewater. (Zanetti , 2006)

Type of process	Suspended solids %	BOD_5 %	Phosphorous %	Nitrogen %	Coliforms %
primary sedimentation	50 – 60	25 – 30	10 – 15	10 – 15	30 – 60
Chemical flocculation	80 – 95	40 – 50	80 – 90	10 – 15	50 – 70
Biological treatment	80 – 90	80 – 90	15 – 25	20 – 30	90 – 99
Tertiary treatment	80 – 95	80 – 95	90 – 95	70 – 80	90 – 99
Disinfection	80 – 95	85 – 95	90 – 95	70 – 80	99

1.10 Classification of wastewater treatment plants

Wastewater treatment plants are classified on the basis of their size, i.e. on the number of equivalent inhabitants to be served, as micro, small, medium and large WWTP. Equivalent Inhabitants is a mean of expressing the strength of organic material in wastewater induced by humans. In a domestic wastewater system, microorganisms use up about 90 grams of oxygen per day for each person using the system (as measured by the standard BOD test).
Population Equivalent can be measured by the following Equation :
Population Equivalent, persons= (Flow, CM / day × BOD mg/L × 10^6 L/ CM) /(90,000 mg BOD/ day/ person) (Glossary of Environment Statistics, 1997).
Small plants serving single houses, terraces, apartment blocks and in any case any communities up to 50 equivalent inhabitants. Small to medium plants serving groups of apartment blocks, colleges, boarding schools and in any case any communities up to 300 equivalent inhabitants. Medium plants serving hospitals, barracks, and tourist villages and in any case any communities up to 2000 equivalent inhabitants. Medium to large plants serving neighborhoods and villages, in any case all the communities up to 10000 equivalent inhabitants. Large plants serving cities and in any case any communities from 10000 equivalent inhabitants up (Metcalf & Eddy, 2003).

1.11 Types of wastewater treatment plant

Wastewater treatment plants are divided into two main types aerobic treatment and anaerobic treatment. In the aerobic (or total oxidation) plants, the water is aerated with compressed air (in some cases oxygen), furthermore, the sludge generated by the digestive process can be partially reintroduced to the plant to improve the treatment process (activated sludge or total oxidation systems). On the contrary, the anaerobic systems operate in scarcity of oxygen.

The anaerobic systems use the action of micro organisms which can survive in absence of dissolved oxygen. The applications concern the treatment of the organic substance, led by heterotrophic bacteria. Within said process, the hydrogen removed by enzymatic way links mainly to the oxygen, carbon, nitrogen and sulphur contained in the organic molecules (Eckenfelder, 1989).

1.11.1 Preliminary treatments:

Preliminary treatment is the first stage in wastewater treatment. The purpose of this treatment is the removal of coarse solids and other large materials often found in raw wastewater. Removal of these materials is necessary to enhance the operation and maintenance of subsequent treatment units, protecting them from malfunction associated with accumulation of screenings, debris, inorganic grit, excessive scum formation or loss of efficiency associated with grease or oil films or fat accumulations (Metcalf & Eddy, 2003).

Preliminary treatment devices are therefore designed to remove or to reduce in size the large, entrained, suspended or floating solids (pieces of wood, cloth, paper, plastics, garbage, etc.

Together with some fecal matter remove grit, i.e. heavy inorganic solids (sand, gravel or glass) remove excessive amounts of oils or greases. Preliminary treatment of wastewater includes screening, grit removal, flotation, and equalization (Metcalf & Eddy, 2003).

Screening:

This operation is used to eliminate the gross solids present in the slurry. Screening may include coarse and fine screening, usually mechanically operated to intercept floating and suspended debris. The auxiliary equipment removes the screenings, flushes organic matter back to the sewage flow and compacts the final screenings residue for disposal off site (Metcalf & Eddy, 2003).

Grit tanks:

Degritting is aimed at removing gravel, sand, glass and metal pieces from the wastewater, i.e. materials whose specific weight and sedimentation rate is higher than the one of the perishable organic solids. Removal of grit prevents its downstream accumulation in process units and the potential for excessive wear in pumps, sludge dewatering plant and other machinery.

The silt traps can be divided into three categories, namely:

- Gravity (channel);
- Vortex;
- Aerated.

The channel grit tanks ensure a consistent velocity of the water flow, equal to approximately 0.3 m/s, which enables to remove approximately 90% of the organic material in suspension, if we consider an average sedimentation velocity variable between 1.6 and 2.2 cm/s. The consistent velocity is ensured through the introduction of a Venturi channel downstream the grit tank and by allocating the appropriate geometry to the channel itself (Metcalf & Eddy, 2003).

Flotation:

Flotation is the reverse phenomenon of settling, and it is applied to separate the particles in suspension. The flotation tank is therefore used when the slurry to be treated contains oil, fat and other light substances dissolved. These substances are taken to the surface by the injection of tiny air bubbles. Flotation consists of introducing air into the water so that the air bubbles come into contact with the suspended particles and lift them to the surface (Crittenden, 2005). The rising of the particles may occur as a result of the trapping or adhesion of air bubbles. Both mechanisms generate a diminution in the appearing density of the particles.

It must also be taken into account that in the floating tank the air bubbles attached to the particles tend to grow when rising since with the diminishing of the pressure, their specific weight is reduced. This leads to a reduction of the specific weight of the bubble-particle system and therefore to a greater raising rate of the particles (Metcalf & Eddy, 2003).

Equalization tank

The equalization unit is made by tanks set downstream the preliminary treatments. This enables to attenuate the peaks in terms of both flow rate and polluting load, thus ensuring the supply of a constant flow rate to the subsequent process and improving the performance of the treatment (Metcalf & Eddy, 2003).

1.11.2 Primary treatment

Primary treatment is the second stage in treatment and separates suspended solids from wastewater through sedimentation. Primary sedimentation is the operation by which water is separated from the heaviest organic materials and sludge. The water flows in tanks of circular or rectangular layout at an appropriate speed let the solid particles in suspension settle at the bottom (Metcalf & Eddy, 2003).

1.11.3 Secondary treatment

The purpose of secondary treatment (or biological treatment) is to remove dissolved organic matter from wastewater. The group includes a very wide range of processes and technologies. Biological treatment takes place in fixed media or suspended growth reactors using activated sludge, biofiltration, rotating biological reactors, constructed wetlands, etc. Nitrification/ denitrification and biological phosphorus removal can be incorporated at this stage in order to reduce nutrient concentrations in the outflow. The following paragraphs summarize some of the most widespread systems (Metcalf & Eddy, 2003).

a- **Trickling filters**

The trickling filter is an aerobic treatment system that utilizes microorganisms attached to a medium to remove organic matter from wastewater. This system is an attached growth process. It consists of a cylindrical structure whose height varies from one to some meters filled with stones of a size from (4 to 8 cm) or by manufactured products in plastic material which acts as a support for the development of the bacteria biomass and through which the slurry is filtered (Crittenden, 2005).

The trickling filter, supplied with settled effluent, is characterized by:

1- A distribution system of the inflow effluent (which must have been preliminarily submitted to primary sedimentation) developed to distribute the slurry as evenly as possible on the whole surface of the bed.

2- A filling media of large surface, whose conformation and structure enables to eliminate the possible generation of preferential routings of the waste, which would affect the performance of the filter.

3- A background ventilation and drainage system.

4- A recycling device of outflow oxidized effluent, for the re-introduction of part of the out flowing water, which because of the type of filter proposed - plays the role of ensuring a correct surface water load (Metcalf & Eddy, 2003).

b- Activated sludge systems

This is an aerobic biological treatment which involves the production of an activated mass of microorganisms capable of aerobically stabilizing the organic content of a waste.

Activated sludge plant involves:

- Waste water aeration in the presence of a microbial suspension,
- Solid-liquid separation following aeration,
- Discharge of clarified effluent,
- Wasting of excess biomass,
- Return of remaining biomass to the aeration tank.

In the activated sludge process, the wastewater containing organic matter is aerated in an aeration tank. Aeration is achieved by the use of submerged diffuser or surface mechanical aeration or combinations of both (Crittenden, 2005).

The degradation of the wastewater forms the so called "floc" which consists of millions of aerobic microorganisms (bacteria, fungi, protozoa, and worms), particles, coagulants and impurities that have come together and formed a mass. This mass is maintained in suspension by aeration and helps to collect pollutants, both organic and inorganic, in the wastewater by adsorption, absorption or entrapment. Following a period of contact between the wastewater and the activated sludge, the outflow is separated from the sludge in a secondary settlement tank. To maintain the desired microbiological mass in the aeration tank, sludge is returned to the aeration tank while an excess due to biological growth is periodically or continuously wasted. The concentration at which the mixed liquor is maintained in the aeration tank affects the efficiency of treatment (Metcalf & Eddy, 2003).

Sludge Blanket Unit

This is an anaerobic treatment of the waste. The anaerobic systems use the action of micro-organisms which can survive in absence of dissolved oxygen. The applications concern the treatment of the organic substance, led by heterotrophic bacteria. Within said process, the hydrogen removed by enzymatic way links mainly to the oxygen, carbon, nitrogen and sulphur contained in the organic molecules (Crittenden, 2005)

The chemical reactions which occur within the anaerobic digester produce a series of gases which are also called biogases: typically methane (70%), CO_2 (25-30%), nitrogen (2-5%) hydrogen sulphide and hydrogen. Its heating value is approximately 5000 to 6000 Kcal/m³ against 11,000 of the network methane (Crittenden, 2005).In the decomposition process, the anaerobic reaction is strongly influenced by the temperature and - consequently - by the availability of the biogas which is used to maintain the ideal conditions. Furthermore, the operating efficiency is linked to the generation of granular sludge: every granule consists of a set of anaerobic bacteria which can transform the organic substances into biogas. Studies developed with the support of the electronic microscope have revealed some areas within the granule which are specialized in acidification, methanation of both the fat acids and hydrogen. The generation of sludge during the anaerobic treatment is very low, since the highest portion of the organic matter converts into biogas. Furthermore, it can be re-utilized to start new anaerobic reactors, or used as fertilizer. The management cost of the sludge is therefore minimal. Nevertheless, this type of treatment is generally less efficient than the aerobic one and -consequently - it is more commonly applied as a preliminary treatment system, in case of heavily concentrated wastewater (Crittenden, 2005)

Biodisks

This system is an attached-growth process.

They are disks in high-density laminar polyethylene - whose diameter is generally no greater than 3.5 m - axially connected by a shaft which is usually no longer than (7.5 m) and partially submerged in a tank (by approximately 40%). The shaft rotates slowly (approximately 20 m/min or less) and ensures appropriate oxygenation for the generation of micro-organisms. As in the case of the trickling filters, the biofilm detaches naturally once it reaches a significant thickness (Metcalf & Eddy, 1991).

The treatment system consists of a series of biodisks (two to four) located on several treatment lines.

The advantages of the biodisk systems are as follows:

1-Since they operate in a closed environment, the issues relevant to odor nuisance and insects are easily overcome.

2- Since the system can be fully inspected in all its parts, it is more easily controlled and the risk of clogging is reduced.

3- By simply changing the rotation velocity of the disks, the operational features of the plant can be modified and therefore a better adjustment can be achieved than with conventional trickling filters.

4- The effluent does not need to be recycled, and thus there are obvious savings in energy. Energy consumption is limited to what is required for the rotational movement of the drum (Crittenden, 2005).

The disadvantages of this type of system are

1-The land surfaces required are greater than the case of activated sludge plants of similar performance.

2-The installation cost is greater than the one of the activated sludge plants, because of both the greater complexity and need to provide coverage. As the number of biodisks is a function of required treatment efficiency, if the number of necessary biodsks involves high costs of maintenances and excessive space for facilities, a different treatment system must be choose (Crittenden, 2005).

1.11.4 Secondary Sedimentation

The secondary sedimentation tanks settle out the secondary sludge which is the organic matter washed from the biological treatment.

The water flows into a large tank where the solids (mostly clumps of microorganisms) are allowed to settle to the bottom. The clean water flows out near the top. The contaminated water (or sludge) is periodically removed from the bottom of the tank. The sludge then receives further treatment. Such secondary sedimentation removes most of the remaining contaminants. This step is often the last treatment process. The wastewater will still contain from (5- 15 %) of the contaminants it contained at the beginning of the treatment.

After this step, the water is discharged into the receiving body, unless a further, advanced treatment process step is required (Metcalf & Eddy, 1991).

1.11.5 Tertiary treatments

Tertiary (or advanced) treatment may be defined as any treatment process in which unit operations are added to the secondary treatment. These treatments are necessary to remove nitrogen, phosphorus, additional suspended solids, refractory organics, heavy metals and dissolved solids (Metcalf & Eddy, 2003).

1- Filtering

Filtering is a tertiary treatment particularly suitable when it is necessary to reduce significatively the suspended solids, for example in wastewater reuse. This treatment is also applied for water recycling in industrial processes. In case of disk filters, the water flows by gravity into the segments of the filter from the drum set at the center. The solids are separated from the water by the fine filter mounted on the two sides of the segments (generally filtration degree >10-20 micron depending on specific aim). When the screen stops, the suck back cycle starts and the solids are delivered to the collection tank (Erbe, 2002).

2- Nutrient removal

In wastewater treatment, nutrient removal generally refers to compounds of nitrogen and phosphorus. Excessive levels of these substances in the outflow is the primary cause of eutrophication in surface waters. The scope of the nutrient removal stage is then to reduce the concentrations of phosphorus and nitrogen in the wastewater so as to prevent algal blooms and excessive aquatic plant growth in the receiving waters.

The long-term effects of over-enrichment include low dissolved oxygen, fish kills, and depletion of desirable flora and fauna. In the course of biological treatment only a small amount of nutrients are taken up by microorganisms so that it could be necessary add a further treatment unit to remove the residual load. Nutrients can be removed from wastewater using physical-chemical or biological processes. Phosphorus removal is usually achieved by chemical precipitation with salts of iron (e.g. ferric chloride), aluminum (e.g. alum), or lime to form chemical flocs. These flocs are then settled out to remove phosphorus from the wastewater. Chemical phosphorus removal requires significantly smaller equipment than biological removal, is easier to operate and is often more reliable than biological phosphorus removal. The disadvantages are the excessive sludge production and the cost of the added chemicals (Erbe, 2002).

In the case of nitrogen, there are three basic physical, chemical nitrogen removal techniques available for application:

- Ammonia stripping.
- Selective ion exchange.
- Breakpoint chlorination.

All these processes have the advantage that they are unaffected by toxic compounds that can disturb the performance of a biological removal process, their behaviour is predictable in process, and the space requirements for the treatment units are less than the biologic-treatment units. Note that the only nitrogen-removal process that actually has been used on a plant scale in wastewater treatment is ammonia stripping (Crittenden, 2005).The biological processes that primarily remove nitrogen are nitrification and denitrification. During nitrification ammonia is oxidized to nitrite by one group of autotrophic bacteria, most commonly Nitrosomonas. Nitrite is then oxidized to nitrate by another autotrophic bacteria group, the most common being Nitrobacter (Erbe, 2002). Denitrification involves the biological reduction of nitrate to nitric oxide, nitrous oxide, and nitrogen gas. Both heterotrophic and autotrophic bacteria are capable of denitrification. The most common and widely distributed denitrifying bacteria are Pseudomonas species. Nitrogen removal from wastewater does not occur by nitrification. Rather, denitrification is needed to convert nitrate to nitrogen gas. Nitrification occurs in the presence of oxygen under aerobic conditions, and denitrification occurs in the absence of oxygen under anoxic conditions. Phosphorus can also be removed biologically in a process called enhanced biological phosphorus removal. In this process, specific bacteria, called polyphosphate accumulating organisms (PAOs), are selectively enriched and accumulate large quantities of phosphorus within their cells.[(24)]There are several biological nutrient removal processes available. Some of them are designed to remove only total nitrogen or total phosphorus, while others remove both. The configuration most appropriate for any particular system depends on the target effluent quality, operator experience, influent quality, and existing treatment processes, if retrofitting an existing facility. Process configurations vary based on the sequencing of environmental conditions (i.e., aerobic, anaerobic, and anoxic) and timing (Erbe, 2002). Although the exact configurations of each system differ, systems designed to remove total nutrient must have an aerobic zone for nitrification and an anoxic zone for denitrification, and systems designed to remove total phophorus must have an anaerobic zone free of dissolved oxygen and nitrate. Often, sand or other media filtration is used as a polishing step to remove particulate matter when low total nitrogen or total phophorus effluent concentrations are required. Sand filtration can also be combined with attached growth denitrification filters to further reduce soluble nitrates and effluent total nitrogen levels (Crittenden, 2005).

3- Ions removal by reverse osmosis

Reverse osmosis systems invert the principle of osmosis. High pressure is applied to the feed side of the reverse osmosis membrane (Fig.1). The pressure forces water through the semi-permeable RO membrane, this water becomes the permeate flow and is returned for process use. Particles and dissolved salts are unable to pass through the membrane and instead flow past into what becomes the concentrate flow to drain. (Nuhoglu, 2004)

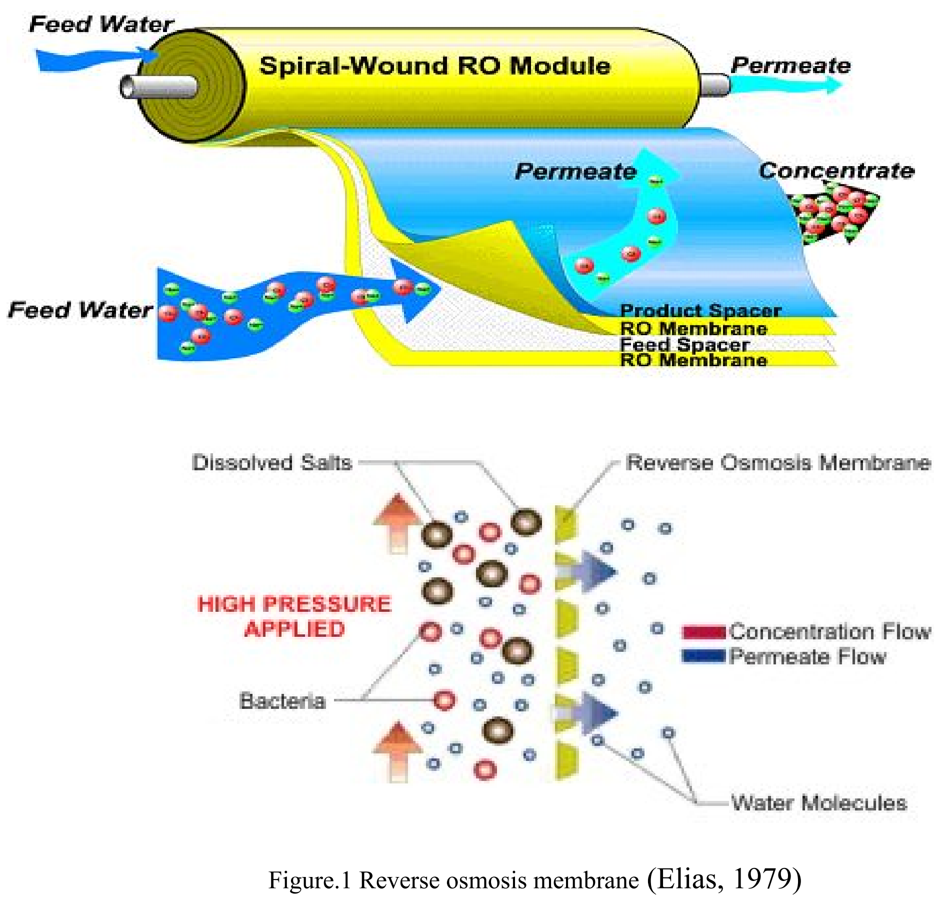

Figure.1 Reverse osmosis membrane (Elias, 1979)

Figure.2 Reverse osmosis system 400 l/hr (Elias, 1979)

In RO, feed water is pumped at high pressure through permeable membranes, separating salts from the water. The feed water is pretreated to remove particles that would clog the membranes. The mechanism of Reverse Osmosis water treatment plant is shown below.

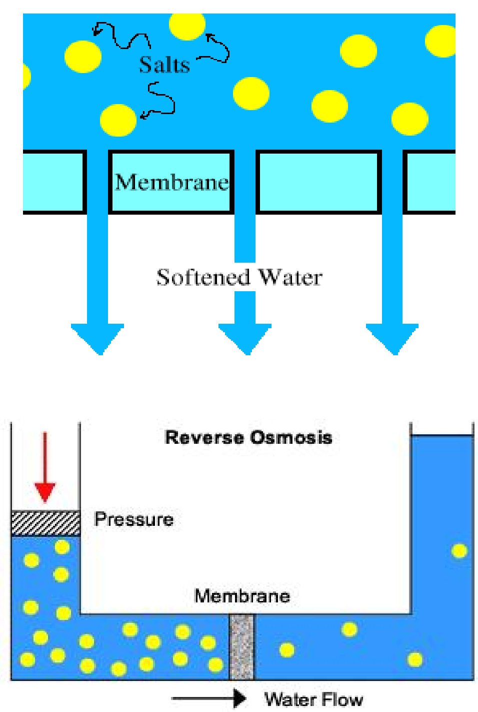

Figure 3: Mechanism of Reverse Osmosis plant (Elias. 1979)

RO can meet most water standards with a single-pass system and the highest standards with a double-pass system. RO rejects (99.9 %) of viruses, bacteria and pyroxenes. Pressure, on the order of (14 to 70 bars), is the driving force of the RO purification process. It is much more energy efficient compared to heat-driven distillation and more efficient than the strong chemicals required for ion exchange. No energy-intensive phase change is required (Karrman, 2001).

4- Disinfection

The primary scope of disinfection is the inactivation/destruction of pathogenic organisms to prevent the spread of waterborne diseases.

Activated sludge and bioflllm systems will disinfect the wastewater to some degree but few remove more than (80-90%) of pathogenic microorganisms. For complete disinfection, further treatment is necessary (Crittenden, 2005).The organisms of concern in domestic wastewater include enteric bacteria, viruses, and protozoan cysts. The main techniques for the disinfection of municipal wastewater fall into three main categories:

- Chemical;
- Physical;
- Irradiation.

Chemical disinfectants include chlorine, ozone and hydrogen peroxide. The main physical methods rely on enhanced removal of solids and membrane technologies.

Ultra-violet (UV) light is the principal method of irradiation used. In huge treatment plants the use of UV is limited; due to high costs of construction and maintenance (for example the amount of energy required is considerable). Therefore it is generally employed only when a high water quality level is required, for example, in cases of wastewater reuse (Erbe, 2002). Due to the fact that chlorination is the most widely technique used for the disinfection of municipal wastewater, this issue will be examined in depth. Chlorine exerts a powerful anti bacteria and virus destructive action by blocking the vital activities of the micro-organisms, through rater complex mechanisms. An appropriate contact time is required for chlorine to operate efficiently. Furthermore, its efficiency depends on its concentration in the solution. Chlorination results to be a particularly efficient disinfection process on the slurry which was previously submitted to primary and tertiary treatments.

Table (1.4) reports the minimum dosage values of activated chlorine defined by the American Water Pollution Control Federation, which must be adopted on the effluents of the different treatments indicated (activated sludge, primary sedimentation, etc), allowing a minimum contact time of 15 minutes, with reference to the maximum flow rate and therefore referring also to the maximum rainfall rate routed to disinfection, in case of combined sewerage systems (Erbe, 2002).

Table(1.4): Dosage of active chlorine required for chlorination of the effluents according to the different viable treatments. (Masotti, 2005)

Type of treatment	Dosage of active chlorine [mg/l]
primary sedimentation	5-10
primary sedimentation with dry slurry	12-40
Trickling filters	3-10
Activated sludge	2-8
Chemical treatment	3-10
Sand filters (slow type)	1-5

1.12 Influent and Effluent Quality

The main issues related to the low quality of the treated wastewater in the West Bank and Gaza are to put in relation with the characteristics of the influent, the lack of effective monitoring and control, and the restrictive quality standards and other conditions imposed by the December 2003 Memorandum of Understanding (MOU) on Guidelines and Technical Criteria for Sewerage Projects, signed between Israel and the PWA. Table (1.5) shows the classification of waste water by the concentrations of organic meters. On the other hand table (1.6), table (1.7) and table (1.8) shows the standards of the treated waste water which is listed by the Memorandum of Understanding (MOU) for different levels of the effluent from WWTP to reuse in agriculture and the artificial recharge for the aquifer.

Table (1.5) : major constituents of typical domestic wastewater

Constituent	Concentration mg/l		
	Strong	**Medium**	**Weak**
Total solids	1200	700	350
Dissolved solids (TDS)	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
BOD_5[2]	300	200	100

"The Memorandum of Understanding of December 12, 2003, lists the following effluent disposal options according to different hydrological sensitive areas:

i. For irrigation in areas of high hydrological sensitivity areas: Secondary treatment by activated sludge plus tertiary treatment including nutrient removal, filtration and disinfection. The quality of this water is good for unrestricted irrigation including public parks, gardens and sports grounds.

ii. For irrigation in areas of medium to low hydrological sensitivity: Secondary treatment by activated sludge and disinfection or equivalent. The quality of this water is good for restricted irrigation for olives, peanuts, citrus trees, vegetables to be cooked, fruits for canning and trees.

iii. For irrigation of inedible crops: Anaerobic Ponds, oxidation ponds or aerated lagoons. The quality of this water is good for crops like cotton, sugar beets, cereals, green and dry fodders, and seeds.

iv. For discharge into the wadis/streams/rivers (include all tributaries): Secondary treatment by activated sludge plus tertiary treatment including nutrient removal, filtration and disinfection. The quality of this water is good for unrestricted crops, including public parks, gardens and sports grounds.

The Memorandum of Understanding also sets out clear effluent quality criteria for various parameters including Biochemical Oxygen Demand (BOD), Suspended Solids (SS), Chemical Oxygen Demand (COD), Chloride, Boron, etc. The above treatments (ii & iii) will not however, get rid of the eggs of the nematodes and effluent salinity will not be affected by the three methods of treatment." (PWA, 2003).

At present, Al-Bireh and Al- Quds University are the only plants in West Bank that produce effluent which meets standards. As a result of poor standards of efficiency and treatment, effluent from all the treatment plants cannot currently be used for restricted or unrestricted irrigation.

Table (1.6) Effluent standards (WSSPS, 2000) for agriculture reuse and aquifer recharge recommendations by PWA

(PWA)Effluent standards	Reuse (and for Coastal Region recharge)	Recharge (excluding Coastal recharge)
S.S.	15 mg/l	30 mg/l
BOD	10 mg/l	20 mg/l
Nitrate	10 mg/l	30 mg/l

Table (1.7) Effluent quality standards for minimum to secondary treatment level recommends by memorandum of understanding (MOU)

(MOU) Effluent standards	Minimum to Secondary level
S.S.	30 mg/l
BOD	20 mg/l
Nitrate	25 mg/l

Table (1.8) Effluent quality criteria: for tertiary treatment level recommends by memorandum of understanding (MOU)

Hydrological Areas	For irrigation in areas of high hydrological sensitivity areas, and discharge into the wadis/streams/rivers		For irrigation in areas of medium to low hydrological sensitivity, and irrigation of inedible crops	
Pollutant	Average	Maximum	Average	Maximum
T.S.S.	10 mg/l	15 mg/l	30 mg/l	60 mg/l
BOD	10 mg/l	15 mg/l	20 mg/l	40 mg/l
Total Nitrogen	10 (iv), 25 (i)	15 (iv), 40 (i)	25 mg/l	40 mg/l

The Ministry of Agriculture and the PWA have adopted WHO recommended microbiological quality guidelines:

- WHO microbiological guideline (≤ 1000 fecal coliforms per 100 ml for unrestricted irrigation, and ≤ 1 intestinal nematode egg per liter) and;
- WHO guideline (≤ 200 fecal coliforms per 100 ml and ≤ 1 intestinal nematode egg per liter) for restricted irrigation, where direct contact with the public is possible or for spraying of crops which will be eaten uncooked." (HWO, 2004)

1.13 Economics of Wastewater Treatment

The selection and design of wastewater treatment plant depends on the costs criteria associated with treatment process, including the capital cost, operation and maintenance cost, land requirements, sludge handling and disposal, and monitoring costs.

A cost effective wastewater treatment solution is one that will minimize total costs of the resources over the life of the treatment process (Qasim, 1999). Resources are the capital costs, operation and maintenance costs, and environmental costs.

1.13.1 Estimation of Capital Cost

The capital costs of investments including piping, instrumentation and controls, pumps, installation, engineering, delivery and contingencies. Historical cost data are commonly used for capital cost estimation.

We can use the six tenths rule to compare the cost of two plants using the same technology but with different capacity by the following equation (AWWA & ASCE, 1990).

$$\text{Cost new plant} = \text{Cost existing plant} \times (\text{Capacity new plant}/\ \text{Capacity existing plant})^{0.6}$$

1.13.2 Land Requirements Cost

This cost is for the total land area needed for the equipment plus pump controls, access areas etc…). The land requirement depends in equipment diminutions. The land requirement is further multiplied by the corresponding land cost to obtain facility specific land cost estimation (USEPA, 1998).

1.13.3 Operation and Maintenance Cost (O&M):

The operation and maintenance cost include the costs of maintenance, taxes and insurance, labour, energy, treatment chemicals (if it used) and residuals management (if needed).
The following table determined the cost for each item in USD.

Table (1.9): Standard operation and maintenance cost factor breakdown. (USEPA. 1998)

Factors	**O&M USD/ year**
Maintenance	4 % of total capital cost
Taxes and Insurance	2 % of total capital cost
Labour	30,000$ – 31,200 $ per man - year
Electricity	0.08 $ / KW
Chemicals	57 $ / ton
Residuals management	Technology – specific cost

Table (1.9) present annual Operation and maintenance costs for various system derived by the USEPA from venders information or from engineering literature (USEPA.1998).

3. Hypothesis:

The Activated Sludge can be assumed to be the most effective, economics technology can be use for treating wastewater in Palestine.

4. Objectives:

The main objectives are:

1- To identify the small scale wastewater treatment plants that is operational in West Bank.

2- To analyze the efficiency of treatment of selected small scale WWTPs.

3- To analyze the economy of treatment of selected small scale WWTPs that can help the decision makers to identify the appropriate WWT technology for Palestine.

Chapter Two

Material and Methods

2- Experimental

2.1. Instrumentation

Sterilization of glass bottles and solutions were performed on Tuttnauer Autoclave, steam sterilizer, Model 2340M, USA. Micro filtration were carried on Membranes filters (cellulose nitrate filter), pore size 0.45 μ m lot. The filters were used to filtrate the pathogens (Total coliform, Fecal coliform) from the wastewater samples. Disposable sterile plastic Petri dishes, (45 and 90 mm) diameter were used to measure the coliform after 24 hours in the incubator. UV/VIS spectrophotometer, (PERKIN ELMER, Germany) was used to measure COD in the samples. Water bath, (Type JBL, England) was used to incubate the samples for 5 days at 20 ^{o}C. Analytical balance, Type D0422601283, Capacity 220g, (Made in Japan) was used to weigh materials used in the analysis part. Culture test tubes 25 ml x 1 cm Micropipettes, micropipettes Tips (1ml, 5 ml, 10 ml).BOD bottles 330 ml. Evaporation dishes. Thermometer . Comfort, hetomaster shake, spd50/bio, polyscience, 9105.Microprocessor Oximeter. OXI 196 from WTW was used measure the amount of dissolved oxygen in BOD samples .pH – EC- TDS meter M201 portable HANNA instrument, HI 9811 was used to calculate pH, EC, and TDS.

2.2 Chemicals and Reagents

Peptone water from Oxoid No. 311311was used for sample dilution to count the coliforms. Plate Count Agar from Himedia Laboratories, catalogue No. 9488 (XL183) was used to count the total number of all pathogens in waste water samples. M -Endo Agar from Himedia Laboratories, Pvt. LTd, catalogue No. M1106, is used to count the total coliform in the samples. M- FC Agar from Himedia Laboratories, Pvt. LTd, catalogue No. M1122, was used to count the fecal coliform in the samples. Potassium Dichromate ($K_2Cr_2O_7$) from SIGMA – ALDRICH, catalogue No. P5271- 500G, was used to oxidize the organic and nonorganic meter. Sulphuric Acid 96 % (H_2SO_4) from CARLO ERBA, catalogue No. CASNr 7664-93-9, code no.410306, was used to oxidize the organic and nonorganic mater. Silver Sulphate ($HgSO_4$), from SIGMA- ALDRICH, catalogue No. 497266-50G, code no. MKBB1964V was used to oxidize the organic and nonorganic mater in the samples to measure the amount of COD.

2.3**Methodology**

Field visits were conducted to identify wastewater treatment plants that are operating in West Bank, the technology employed, the cost, and the efficiency of treatment for each selected plant. Wastewater grab samples were taken once a month from the influent and effluent during the experimental period (from January 2010 to September 2011). The influent samples were taken from the main entrance to the plant. The effluent samples were taken after the wastewater passes all stages of treatment in the plants. The samples were collected in glass bottles, labeled and divided according to the required analysis. Standard method was used for all analysis we use the standard methods for examination of water and wastewater (Andrew, 1998). A comparison between the efficiency and the cost of treatment for the studied plants toward removal of pollutants were analyzed by excel spread sheets.

2.4 Lab Analysis

The analysis of wastewater is divided into two types: the first was to be carried out immediately once it reaches the lab such as the pH, EC and BOD, and the second type were measured later like total solids TS, and COD. Standard methods were used for all analysis (Andrew. 1998). BOD was determined by measuring the dissolved oxygen (DO) by oximeter before and after incubation for 5 days at 20 ^oC (APHA, 1998)

The chemical oxygen demand (COD) is measured by the transfer of 2.5 ml of samples, or different standards of potassium hydrogen phosphate (KHP), to test tubes. Then 1.5 ml of digestion solution (10.216 g of $K_2Cr_2O_7$) , 167 ml, concentrated H_2SO_4 (and 33.5 g of $HgSO_4$ in 1000 ml distilled water) and 3.5 ml sulfuric reagent (5.5 g of Ag_2SO_4 per one kilogram of conc. H_2SO_4) were added and refluxed for two hours in the oven at 150 ^oC. Samples and different standards were centrifuged and their absorbance was measured on UV/VIS spectrophotometer at 600 nm (Andrew, 1998).

The total solids is measured by the transfer of certain quantity of samples to evaporation dishes and heated at 103 ^oC in the oven. The same procedures are applied for total dissolved and suspended solids using filtration before evaporation by filters (Andrew, 1998).

2.5 Total and Fecal Coliform Bacteria

Serial dilutions of the samples were prepared by using peptone water, 9 ml of peptone water were poured in screw- caped culture tubes, then were autoclaved, after that, 1 ml of the sample was transferred using a sterile pipette tip to the first test tube then 1 ml of second tube was transferred to the third and consequently up to 10^{-6} dilutions. Suitable media for each test were prepared and cooled in water up to $50^{o}C$, then 1 ml from each dilution was filtered through 0.45 Millipore filter by vacuum – filter, after filtration, the membrane which retain the bacteria was placed on selective media for each test. Media holding membranes after filtration was incubated at $37^{o}C$, or $44.5^{o}C$ depend on the test type for suitable time (24 hours, or 48 hours) .

2.6 Descriptions of the Technology of the visited WWTPs in West Bank

During the field work, eleven WWTPs were visited. Six of these WWTPs were operating, three were in bad condition, and two of these plants did not operate. Inspection of table (3) reveals that Al- Quds WWTP, Nahalin WWTP, Al- Beireh WWTP, AL- Auja WWTP, Al-Duha WWTP and Intercontinental Hotel WWTP were found operating. On the other hand Kharas and Bani Zaied were not operating, but Nuba, Al- Aroub, and Ramallah were operating in bad condition. Different technology was found existing in these plants, like Epuvalization using Duck Weed, Membrane technology, Activated Sludge, and Wetland. The data for Ramallah WWTP, Al- Beireh WWTP, Al-Duha WWTP, and Al-Auja WWTP is presented in Addendum two.

Table(2): Description of selected WWTPs in Palestine together with their treatment technology.

Name of the plants	**Type of technology used**	**Number of person served**	**Capacity of the plants**	**Notes**
Al Quds University Plant	Membrane Technology (RO)	14000 person*	20 CM/day	Operational
Nuba plant	Wetland	2400 person	120 CM/day	Operational in bad conditions
Kharas plant	Wetland	2400 person	120 CM/day	Do not Operational
Bani Zaied plant	Wetland	2400 person	120 CM/day	Do not Operational
Inter Continental In Jericho plant	Activated sludge	Depend on the number of tourism	2000 CM/day	Operational
Al Aroub college plant	Epuvalization using Duck Weed	1500 person	50 CM/day	Operational in bad conditions
Nahalin plant	Activated sludge	5000 person	50 CM/day	Operational
Ramallah WWTP	Activated sludge	32000 person	4000 CM/day	Operational in bad conditions
Al- Beireh WWTP	Activated sludge	50000 person	5500 CM/day	Operational
Al- Duha WWTP	Wetland	6 person	1 CM/day	Operational
Al- Auja WWTP	Wetland	40 person	5 CM/day	Operational

*. This is the number of the students in the university campus during the study days.

During the field visits, the technology and unit operation of each plant was analyzed and described this information is from the operation side of each plant. The data are discussed as follows:

2.6.1 Nahalin WWTP:

The employed technology in Nahalin plant is activated sludge. The layout of the plant is presented in photo (1). The stages of the treatment plant are:

1- Equalization tank, to distribute wastewater quantity to the next steps in an acceptable flow.

2- Then wastewater goes through three followed chambers that works as follow:

- The first chamber works as a sedimentation tank, and under anaerobic condition nitrogen removal could happen by denitrification process.

- The second chamber is under aerobic condition by aeration pumps, where aerobic bacteria degrade the organic matter and ammonia turn into nitrate.
- The third chamber is clarifying chamber.
- Disinfection stage by chlorination system.
- Sand filter.
- Underground storage tank.

Photo (1): Nahalin wastewater treatment plants

2.6. 2 AL-Aroub Farming School Wastewater Treatment Plant:

The plant contains three pools as shown in photo (2, and 3), the first two pools used for treating waste water by duckweed, and the last one is a storage bond for the treated wastewater. On the other hand there is a desalination machine but it does not operate.

Photo (2): the first pool using for wastewater treatment by Duckweed

Photo (3): second pool used for treating wastewater by Duckweed

Photo (4): the desalination machine in Al- Aroub

Description of Duckweed technology:

Duckweed is small green floating plants of the Lemnaceae family. Under ideal conditions they densely grow on the surface of quiescent waters, forming a blanket or mat like cover. Under ideal conditions (nutrients, temperature, light) Lemnaceae can double their weight in 2 to 4 days by rapid growth (although every frond finally dies, it yields 10 to 20 or more others before doing so). In its reproduction mechanism (every frond divides and produces a new one), duckweed resembles more an exponentially growing microbial culture than a slow growing macrophyte. This fact offers the potential for selective breeding of saline and temperature (high and low extremes) tolerant species. Selection of species that produce certain amino acids or excrete antibiotics, active against blue-green algae and pathogenic bacteria are perhaps other possible applications (Skillicorn, 1993).

2.6.3 Nuba Wastewater Treatment Plants:

The technology employed in this plant is Up flow Anaerobic Sludge Blanket (UASB) and Wetland (WL), photo (4) shows the process and stages of the technology.

The principles of this technology are:

- The raw wastewater passes through a bar screen followed by a grit & sand removal channel to make the mechanical removal of the solid parts.
- Then the effluent inter to the UASB tank which is used to make the primary treatment (anaerobic treatment).
- Then the effluent flow through a subsurface flow wetland to make the secondary treatment (aerobic treatment), this wetland made of lagoons (two lagoons)is coated with polyethylene to prevent wastewater leakage, in addition to different sizes of gravel contained within the wetland lagoons with reed plants are planted on the surface.
- There is also a sludge drying bed to treat the sludge, the water that results from this process will be back to the wetland through conveyance pipes.
- Finally the treated water will be collected into a storage tank to reuse for agricultural purposes or for other activities.

Photo (5): Nuba WWTP

2.6.4 Al -Quds WWTP:

The wastewater treatment plant of Al-Quds University is consisted of activated sludge process followed by two cut-off membrane filter machines, followed by a reverse osmosis system as shown in photo (5). The secondary treated effluent from the activated sludge technology is pumped to the hollow fiber ultra filtration unit, then to a spiral wound ultra filtration unit, then to the reverse osmosis unit.

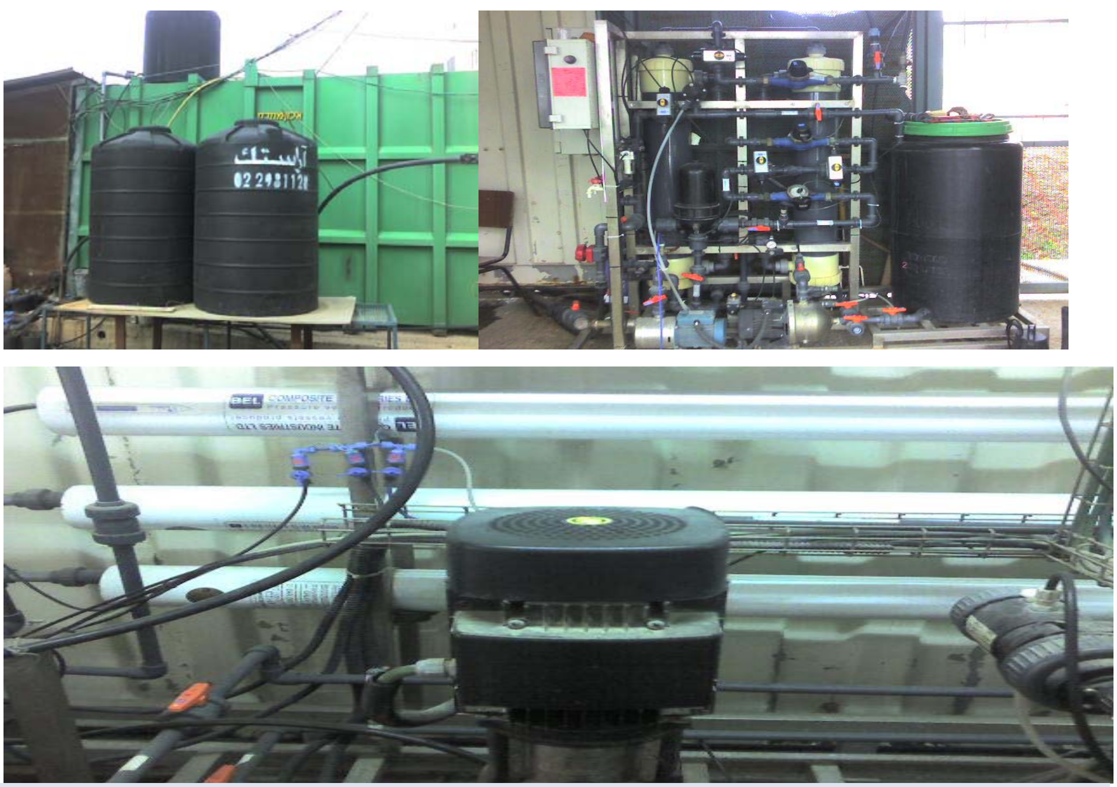

Photo (6): Al- Quds University WWTP

2.6.4.1 Activated sludge treatment system:

A locally made package wastewater treatment plant with capacity of 50 m^3/day was installed at Al-Quds University at Abu-Deis in 1998. It is based on the activated sludge extended aeration treatment process.

The hydraulic retention time in an aeration tank is 16-20 hours. The microorganisms metabolize the organic matter which subsequently decreases BOD value of treated wastewater. Wastewater is then treated with aluminum sulfate as coagulating agent to promote the removal of suspended solids before filtration with sand filter. The destruction of high population of microbes is carried out by chlorination using the treated wastewater and is collected for reuse in a special pond. Part of the activated sludge secondary treated wastewater is connected to the UF hollow fiber system without treatment with chlorine.

2.6.4.2 Ultra filtration (UF) plant:

Two small scale membrane treatment plants with capacity of 12 m^3/day were installed in Al-Quds University in 2004 and 2006. The first unit was equipped with two pressure vessels made Vendor (AST technologies, model number 8000 WW 1000-2M) that house the hollow fiber membranes with 100 KD cutoff (Vendor, AST technologies model number 8000-WWOUT-IN-8080). The second UF unit was equipped with 2×4 inch pressure resistance up to 150 psi. Each vessel holds two separation membrane (spiral wound with 20 KD cut off, which is equivalent to 0.01 micron separation rate)

2.6.4.3 Reverse Osmosis System:

Reverse osmosis (RO) is a membrane filtration method that removes many types of large molecules and ions from solutions by applying pressure to the solution when it is on one side of a selective membrane (can remove molecular weight greater than 150- 250 Daltons).The result is that the solute is retained on the pressurized side of the membrane and the pure solvent is allowed to pass to the other side. To be "selective," this membrane should not allow large molecules or ions through the pores (holes), but should allow smaller components of the solution (such as the solvent) to pass freely (Karman. 2001).

Chapter Three

Result and

Discussion

3.1 Results

3.1.1Chemical and Physical Performance

3.1.1.1- Al-Quds University Waste Water Treatment Plant:

Table (3.1) summarizes the result of chemical, physical and biological analysis for Al-Quds University WWTP for the three samples of the influent and effluent waste water.

Table(3.1): Data Analysis for Al- Quds University WWTP

parameter	Inlet sample 1	Inlet sample 2	Inlet sample 3	Average inlet	Outlet sample 1	Outlet sample 2	Outlet sample 3	Average outlet
COD mg/L	430	526	440	465	32	31	22	28
BOD5 mg/L	200	183	204	196	12	10	10	10
T.S mg/L	700	1215	1200	1038	15	10	12	12
E.C µs/cm	1510	1920	1710	1713	80	50	75	68
T.P.C cfu/ 1mL	1.5×10^{7}	2×10^{6}	1.4×10^{7}	1×10^{7}	7×10^{2}	2×10^{2}	6×10^{2}	5×10^{2}
T.C cfu/ 1mL	3×10^{6}	4×10^{5}	2.9×10^{5}	1.2×10^{5}	0	0	0	0
F.C cfu/ 1mL	6×10^{5}	2×10^{4}	5.5×10^{5}	3.9×10^{5}	0	0	0	0
TDS mg/L	955	945	850	917	10	8	10	9
TSS mg/L	290	270	350	303	5	2	2	3
pH	7.4	7.2	7.1	7.23	6.7	6.6	6.8	6.7

From table (3.1) the average inlet COD, BOD_5, T.S, TDS, and TSS were 465 mg/l, 204 mg/l, 1038 mg/l, 917 mg/l, and 303 mg/l respectively, the average pH for the inlet was 7.23. All these values were normal according to WHO standard. The average outlet COD, BOD_5, T.S, TDS, and TSS were 28 mg/l, 10 mg/l, 12 mg/l, 9 mg/l, and 3 mg/l, the average pH for the outlet was 6.8. According to WHO standard these values were found below the maximum value, which means that the efficiency of this WWTP in removing the pollutions from wastewater is very high.

3.1.1.2 **Nahalin Waste Water Treatment Plant:**

Table (3.2) summarizes the result of chemical, physical and biological analysis for Nahalin WWTP for the three samples of the influent and effluent waste water.

Table(3.2): Data Analysis for Nahalin WWTP

parameter	Inlet sample 1	Inlet sample 2	Inlet sample 3	Average inlet	Outlet sample 1	Outlet sample 2	Outlet sample 3	Average outlet
COD mg/L	903	870	930	901	302	383	483	389
BOD5 mg/L	268	258	265	264	125	115	94	111
T.S mg/L	3064	2900	3100	3021	1290	1190	1290	1257
E.C µs/cm	4770	4570	4270	4537	2290	2390	2490	2390
T.P.C cfu/ 1mL	9×10^{4}	8.5×10^{5}	9.2×10^{5}	6.2×10^{5}	5×10^{4}	4×10^{4}	5×10^{4}	4×10^{4}
T.C cfu/ 1mL	7.5×10^{4}	7.7×10^{4}	8.1×10^{4}	7.7×10^{4}	2.5×10^{3}	3.5×10^{3}	4.5×10^{3}	3.5×10^{3}
F.C cfu/ 1mL	6×10^{3}	8×10^{3}	7.9×10^{3}	7.3×10^{3}	2.2×10^{3}	1.9×10^{3}	2×10^{3}	2×10^{3}
TDS mg/L	2400	2400	2500	2433	1150	1100	1190	1147
TSS mg/L	664	500	600	588	140	90	100	110
pH	7.3	7.1	7.4	7.3	6.7	6.8	6.9	6.8

From table (3.2) the average inlet COD, BOD_5, T.S, TDS, and TSS were 901 mg/l, 264 mg/l, 3021 mg/l, 2433 mg/l, and 588 mg/l respectively, the average pH for the inlet was 7.3, some of these values were found out of range for wastewater and in high concentrations. The average outlet COD, BOD_5, T.S, TDS, and TSS were 389 mg/l, 111 mg/l, 1257 mg/l, 1147 mg/l, and 110 mg/l respectively, the average pH for the outlet was 6.8. According to WHO standard these values were found out of range for treated wastewater and in high concentrations, which means that the efficiency of this WWTP in removing the pollutions from wastewater is very low. These values were attributed to technical and cost problems.

3.1.1**.3 Nuba Waste Water Treatment Plant:**

Table (3.3) summarizes the result of chemical, physical and biological analysis for Nuba WWTP for the three samples of the influent and effluent waste water.

Table(3.3): Data Analysis for Nuba WWTP

parameter	Inlet sample 1	Inlet sample 2	Inlet sample 3	Average inlet	Outlet sample 1	Outlet sample 2	Outlet sample 3	Average outlet
COD mg/L	708	678	690	692	520	531	541	531
BOD5 mg/L	230	199	217	215	95	104	97	99
T.S mg/L	1448	1377	1321	1382	1065	1090	1077	1077
E.C µs/cm	2180	2220	2190	2197	1950	1950	1600	1833
T.P.C cfu/ 1mL	7.5×10^{6}	2.3×10^{6}	7.5×10^{6}	5.7×10^{6}	4.1×10^{5}	5.6×10^{5}	4.1×10^{5}	4.6×10^{5}
T.C cfu/ 1mL	2.7×10^{6}	2.9×10^{5}	2.7×10^{6}	1.8×10^{6}	6.5×10^{4}	2×10^{4}	6.5×10^{4}	5×10^{4}
F.C cfu/ 1mL	4×10^{5}	8×10^{5}	4×10^{5}	5×10^{5}	4×10^{3}	7×10^{3}	4×10^{3}	5×10^{3}
TDS mg/L	1090	1090	1110	1097	800	790	980	857
TSS mg/L	358	355	231	315	265	254	110	210
pH	7.7	7.3	7.3	7.43	7.1	7.1	7.1	7.1

From table (3.3) the average inlet COD, BOD_5, T.S, TDS, and TSS were 692 mg/l, 215 mg/l, 1382 mg/l, 1097 mg/l, and 315 mg/l respectively, the average pH for the inlet was 7.43, some of these values were found out of range for wastewater and in high concentrations. The average outlet COD, BOD_5, T.S, TDS, and TSS were 531 mg/l, 99 mg/l, 1077 mg/l, 857 mg/l, and 210 mg/l respectively, the average pH for the outlet was 7.1. According to WHO standard these values were found out of range for treated wastewater and in high concentrations, which means that the efficiency of this WWTP in removing the pollutions from wastewater is very low. This result was attributed to technical problems.

3.1.1.**4 Al Aroub Waste Water Treatment Plant:**

Table (3.4) summarizes the result of chemical, physical and biological analysis for Al-Aroub WWTP for the three samples of the influent and effluent waste water.

Table(3.4): Data Analysis for Al- Aroub WWTP

parameter	**Inlet sample 1**	**Inlet sample 2**	**Inlet sample 3**	**Average inlet**	**Outlet sample 1**	**Outlet sample 2**	**Outlet sample 3**	**Average outlet**
COD mg/L	585	395	470	483	505	189	320	388
BOD5 mg/L	100	180	150	143	55	108	87	83
T.S mg/L	1016	872	950	946	862	688	782	777
E.C µs/cm	1830	1510	2200	1847	1800	1160	1800	1587
T.P.C cfu/ 1mL	8×10^{4}	2.8×10^{5}	7.9×10^{4}	6×10^{4}	6×10^{3}	3×10^{4}	8×10^{3}	1.4×10^{4}
T.C cfu/ 1mL	2×10^{4}	3×10^{4}	1.9×10^{4}	2.3×10^{4}	3×10^{3}	4×10^{3}	5×10^{3}	4×10^{3}
F.C cfu/ 1mL	2×10^{3}	4×10^{3}	3×10^{3}	3×10^{3}	2×10^{2}	3×10^{3}	2×10^{3}	1.7×10^{3}
TDS mg/L	920	750	820	830	820	580	740	713
TSS mg/L	96	122	130	116	42	108	42	64
PH	7.6	7.6	7.3	7.5	7.1	7.1	6.9	7.0

From table (3.4) the average inlet COD, BOD_5, T.S, TDS, and TSS were 483 mg/l, 143 mg/l, 946 mg/l, 830 mg/l and 116 mg/l respectively, the average pH for the inlet was 7.5. All these values were normal according to WHO standard. The average outlet COD, BOD_5, T.S, TDS, and TSS were 389 mg/l, 111 mg/l, 1257 mg/l, 1147 mg/l, and 110 mg/l respectively, the average pH for the outlet was 6.8. According to WHO standard these values were found out of range for treated wastewater and in high concentrations, which means that the efficiency of this WWTP in removing the pollutions from wastewater is very low. This result was attributed to technical and cost problems.

3.1.1.**5The Inter Continental Hotel in Jericho WWTP:**

Table (3.5) summarizes the result of chemical, physical and biological analysis for Inter Continental Hotel in Jericho WWTP for the three samples of the influent and effluent waste water.

Table(3.5): Data Analysis for Inter Continental Hotel in Jericho WWTP

parameter	**Inlet sample 1**	**Inlet sample 2**	**Inlet sample 3**	**Average inlet**	**Outlet sample 1**	**Outlet sample 2**	**Outlet sample 3**	**Average outlet**
COD mg/L	1410	985	1200	1198	880	540	740	720
BOD5 mg/L	135	155	170	153	75	60	50	62
T.S mg/L	1487	1370	1170	1342	876	576	376	609
E.C µs/cm	2557	2350	2220	2376	1740	1540	1350	1543
T.P.C cfu/ 1mL	1.2×10^4	1×10^4	9.5×10^3	1×10^4	7×10^2	5×10^2	3×10^2	5×10^2
T.C cfu/ 1mL	4×10^3	3×10^3	2.5×10^4	1×10^4	2×10^2	1.5×10^2	1×10^2	1.5×10^2
F.C cfu/ 1mL	7×10^2	6×10^2	3×10^2	5×10^2	80	50	40	57
TDS mg/L	1290	1110	970	1123	870	570	360	600
TSS mg/L	197	260	200	219	6	6	16	9
PH	7.3	7.1	7.2	7.2	7.2	6.8	6.9	7

From table (3.5) the average inlet COD, BOD_5, T.S, TDS, and TSS were 1198 mg/l, 153 mg/l, 1342 mg/l, 1123 mg/l, and 219 mg/l respectively, the average pH for the inlet was 7.2, some of these values were found out of range for wastewater and in high concentrations. The average outlet COD, BOD_5, T.S, TDS, and TSS were 720 mg/l, 62 mg/l, 609 mg/l, 600 mg/l, and 9 mg/l respectively, the average pH for the outlet was 7. According to the standard values BOD was found over the standard value (62 mg/l), but TSS was near the standard (9 mg/l), which means that the efficiency of this WWTP in removing the pollutions from wastewater is medium. This result was attributed to technical and cost problems.

3.1.3 Efficiency of the plants

3.1.3.1 Efficiency for Al- Quds University WWTP

Figure (4) summarizes the result of the efficiency of Al- Quds University WWTP in removing the pollutant from waste water for the three samples.

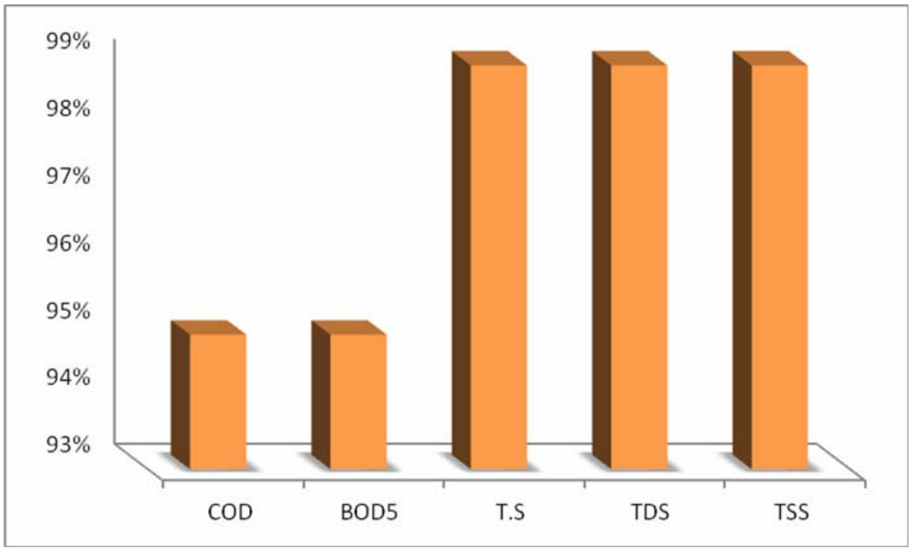

Figure (4): Efficiency of Al Quds WWTP

From figure (4) the percent of removal from Al Quds University WWTP for COD, BOD_5, T.S, TDS, and TSS were 95 %, 95 %, 99 %, 99 %, and 99% respectively. By this value, the effective of this type of technology to treat the waste water was found very high.

3.1.3.2Efficiency for Nahalin WWTP

Figure (5) summarizes the result of the efficiency of Nahalin WWTP in removing the pollutant from waste water for the three samples

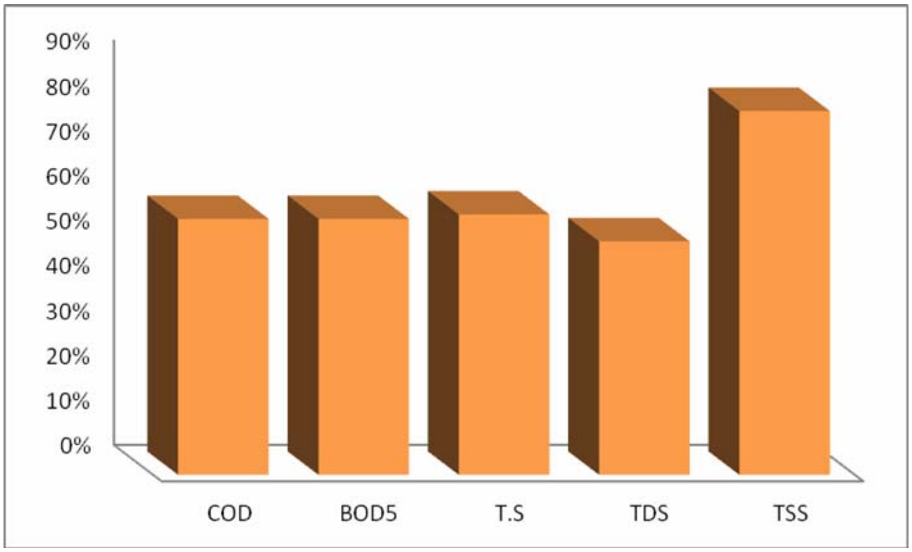

Figure (5): Efficiency of Nahalin WWTP

From figure (5) the percent of removal from Nahalin WWTP for COD, BOD_5, T.S, TDS, and TSS were 57 %, 57 %, 58 %, 52 %, and 81 % respectively. From these values, this WWTP was found working in difficult conditions, which cause this low efficiency in treating waste water. This result was attributed to technical difficulties and has no relation to the type technology used.

3.1.3.3Efficiency of Nuba WWTP

Figure (6) summarizes the result of the efficiency of Nuba WWTP in removing the pollutant from waste water for the three samples

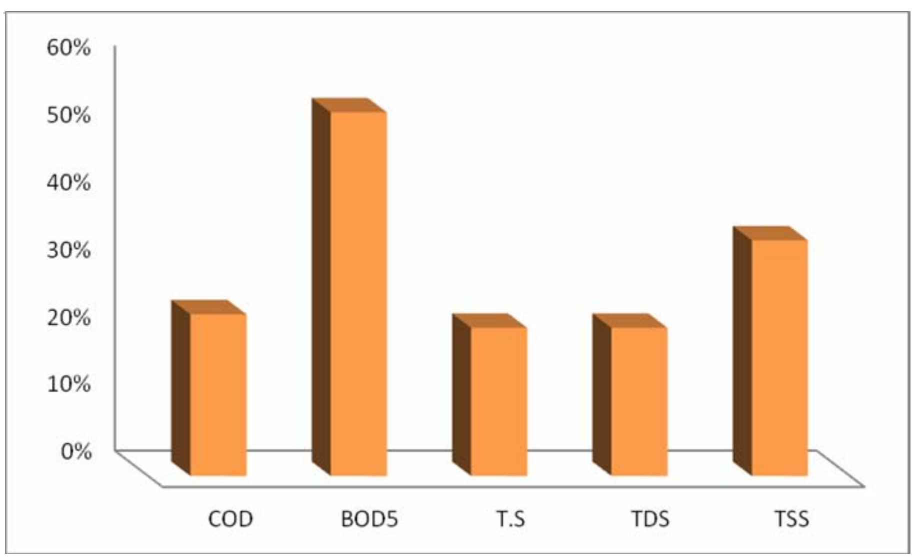

Figure (6): Efficiency of Nuba WWTP

From figure (6) the percent of removal from Nuba WWTP for COD, BOD_5, T.S, TDS, and TSS were 24 %, 54 %, 22 %, 22 %, and 35 % respectively. From these values, this WWTP was found working in difficult conditions, which cause this low efficiency in treating waste water. This result was attributed to the type of technology used and to the technical conditions.

3.1.3.4 Efficiency of Al- Aroub WWTP

Figure (7) summarizes the result of the efficiency of Al- Aroub WWTP in removing the pollutant from waste water for the three samples

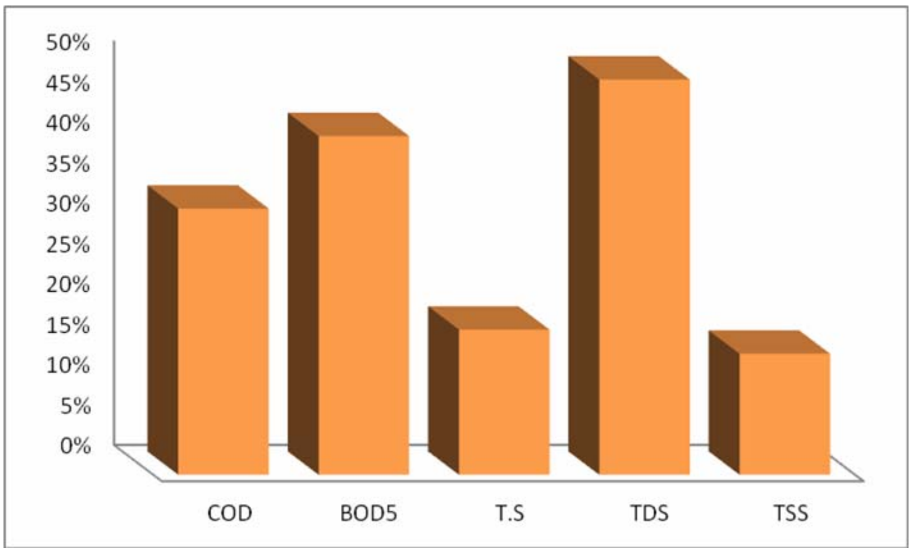

Figure (7): Efficiency of Al Aroub WWTP

From figure (7) the percent of removal from Al Aroub WWTP for COD, BOD_5, T.S, TDS, and TSS were 33 %, 42 %, 18 %, 15 %, and 45 % respectively. From these values this WWTP work was found working in difficult conditions which cause this low efficiency in treating waste water. This result was attributed to the type of technology used and to the technical conditions.

3.1.3.5 Efficiency for Inter Continental Hotel in Jericho WWTP

Figure (8) summarizes the result of the efficiency of Inter Continental Hotel in Jericho WWTP in removing the pollutant from waste water for the three samples

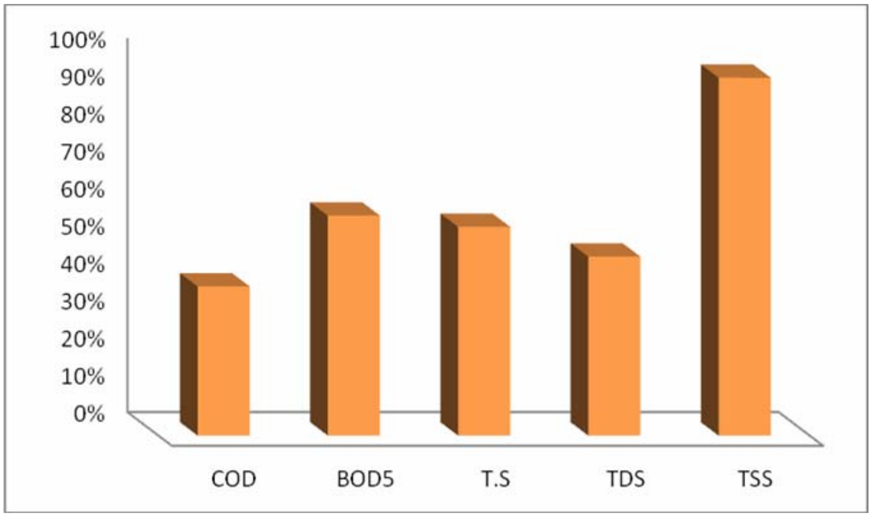

Figure (8): Efficiency of the Inter Continental Hotel WWTP in Jericho

From figure (8) the percent of removal from Inter Continental Hotel WWTP in Jericho for COD, BOD_5, T.S, TDS, and TSS were 40 %, 59 %, 56 %, 48 %, and 96 % respectively. From these values, this WWTP was found working in difficult conditions, which cause this low efficiency in treating waste water. This result was attributed to technical difficulties and has no relation to the type technology used.

3.2 Discussion:

Scientist (Colmenarejo , 2006) had used the standard tables that has been mentioned in chapter one to determine the general efficiency indicator. These data can be used to compare overall performances of the different plants in terms of average TSS, COD, BOD_5, and ammonia removal efficiencies. Similarly, the efficiency of plants is generally measured in terms of removal of organic matter (Cpheeo, 1993). The pH directly affects the performance of a secondary treatment process (Metcalf & Eddy, 2003) because the existence of most biological life is dependent upon narrow and critical range of pH. Since, the solid's removal is an important measure for the success of a primary treatment unit (McGhee, 1991) and the dissolved solids content of the wastewater is of concern as it affects the reuse of wastewater for agricultural purposes, by decreasing the hydraulic conductivity of irrigated land the total dissolved solids content in the water exceeds 480 mg/l (Bouwer, 1978). Also, BOD removal is indicative of the efficiency of biological treatment processes (Sincero, 1996), special consideration has been given in the current study to the organic content, characterized by BOD_5, and COD, based on the performance study conducted for different parameters.

3.2.1 Characteristics of wastewater influent to inlet of WWTPs:

Out of three samples taken from each plant once a month the results were calculated by lab analysis as follow:

At Al -Quds WWTP the average inlet concentrations of TDS, TSS, BOD_5, and COD were 917 mg/l, 303mg/l, 196 mg/l, and 465 mg/l respectively from (table 3.1). While in Nahalin WWTP the average inlet concentrations of TDS, TSS, BOD_5, and COD were 2433 mg/l, 588 mg/l, 264 mg/l, and 901 mg/l respectively from (table 3.2). In Nuba WWTP the average inlet concentrations of TDS, TSS, BOD_5, and COD were 1097 mg/l, 315 mg/l, 215 mg/l, and 692 mg/l respectively from (table 3.3). In Al-Aroub WWTP the average inlet concentrations of TDS, TSS, BOD_5, and COD were 830 mg/l, 116 mg/l, 143 mg/l, 483 mg/l respectively from (table 3.4). The Inter Continental Hotel In Jericho WWTP the average inlet concentrations of TDS, TSS, BOD_5, and COD were 1123 mg/l, 219 mg/l, 153 mg/l, 1198 mg/l respectively from (table 3.5).

3.2.2 Characteristics of treated wastewater effluents from WWTPs

Out of three samples taken from each plant once a month the results were calculated by lab analysis as follow:

At Al- Quds WWTP the average outlet concentrations of TDS, TSS, BOD_5, and COD were 9 mg/l, 3 mg/l, 10 mg/l, 28 mg/l respectively from (table 3.1). While in Nahalin WWTP the average outlet concentrations of TDS, TSS, BOD_5, and COD were 1147 mg/l, 110 mg/l, 111 mg/l, and 389 mg/l respectively from (table 3.2). In Nuba WWTP the average outlet concentrations of TDS, TSS, BOD_5, and COD were 857 mg/l, 210 mg/l, 99 mg/l, and 531 mg/l respectively from (table 3.3). In Al-Aroub WWTP the average outlet concentrations of TDS, TSS, BOD_5, and COD were 713 mg/l, 64 mg/l, 83 mg/l, and 388 mg/l respectively from (table 3.4). The Inter Continental Hotel In Jericho WWTP the average outlet concentrations of TDS, TSS, BOD_5, and COD were 600 mg/l, 9 mg/l, 62 mg/l, and 720 mg/l respectively from (table 3.5).

3.2.3 Overall Efficiency of the case study WWTPs

The main purpose of any WWTP is the removal of pollutants from the waste water, and the reduction of emissions mainly (organic matter, solids), specially when the effluent of these plants were discharged in wadies or it used in irrigation, or other purposes. Also the cost of treated waste water is important to the continuity of the WWTPs.

By guidelines for reuse of effluent from WWTP, and health safeguards were developed by the World Health Organization in 1971 (WHO, 1971), focused on defining appropriate levels of treatment needed for different types of reuse. It was considered that available treatment technologies and use of chlorinated could achieve a bacteriological quality of 100 coliform organisms / 100 mL, and this would give rise to only a limited health risk if used for the unrestricted irrigation of food crops.

Table (3.6): Comparative between the efficiency of the WWTPs in our case study as percentages.

Analysis parameter	**Al Quds University WWTP**	**Nahalin WWTP**	**Nuba WWTP**	**Al Aroub WWTP**	**Inter Continental Hotel in Jericho WWTP**
COD	95 %	57 %	24 %	33 %	40 %
BOD_5	95 %	57 %	54 %	42 %	59 %
T.S	99 %	58 %	22 %	18 %	56 %
TDS	99%	52 %	22 %	15 %	48 %
TSS	99 %	81 %	35 %	45 %	96 %

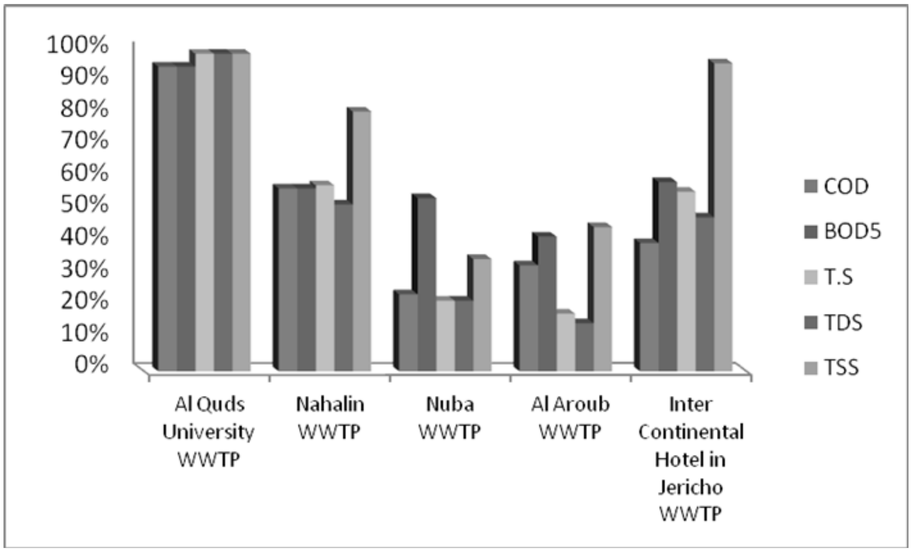

Figure (9): Comparative between the efficiency of the visited WWTPs

The technology chosen should produce effluent quality that is up to standard with regards to the various quality measurement of BOD, COD, TSS, and TDS etc. Different technologies provides different levels of treated water, removing pollutants by various methods, respectively to table (3.11) Al- Quds University WWTP reach the standard guideline (level A) to use the effluent in all type of irrigation, on the other hand Nuba WWTP, Nahalin WWTP, Al Aroub WWTP, and Inter Continental Hotel in Jericho WWTP reached the (level B) standard guideline were can use to irrigate special crops. Table 3.12 shows the level of treatment for WWTP, the effluent in these three level used for certain crops.

Table (3.7): Maximum limits of the standard criteria for treated wastewater used for irrigation purposes. (WHO, 1996)

Parameters	Level A	Level B	Level C
BOD mg/L	30	100	150
COD mg/L	75	200	300
DO mg/L	4	-	-
TDS mg/L	0-1000	1500	1500
SS mg/L	50	150	150
PH	6-9	6-9	6-9

By retrain to table 3.12 the Level A effluent from WWTP can be used for all type of crops (Forest trees, cereal crops, industrial crops, fodder, landscaping, roadsides, foreign, fruit trees, parks, sports stadiums, and roadsides in cities, cooked vegetables). On the other hand level B, and C effluent from WWTP used for special crops (Forest trees, cereal crops, industrial crops, fodder, landscaping, roadsides, foreign,) By comparing the efficiency of Al-Quds University WWTP, Nahlin WWTP, Nuba WWTP, Al-Aroub WWTP, and the Inter Continental Hotel In Jericho WWTP, and the percent of removal for each plant, we found that the best technology that can be used to treat the waste water is the membrane technology coupled with activated sludge as shown in figure (9).

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Chapter Four

Cost Analysis

4.1 Results

4.1.1 Economy of small scale WWTPs in Palestine

The selection and design of wastewater treatment facilities is greatly dependent on the costs associated with treatment processes, including:

1. Capital investment (Total Capital costs): the capital costs of investment Include:

Total Construction Costs: which include?

1- Equipment cost.
2- Installation.
3- Piping.
4- Instrumentation and controls.
5- Land requirements.
6- Sludge handling and disposal.
7- Monitoring costs.

Total Indirect Cost (TIC): which include?

1- Engineering.
2- Contingency.

2. Operation and maintenance cost:

A- Labor cost.
B- Material, chemical and energy cost.
C- Depreciation Cost.

During the visit to WWTP, cost sheets were filled from the operation side of case study WWTPs.

Table (4.1): Cost sheet for the Intercontinental Hotel of Jericho WWTP

Name of the Plant	Type of Technology used	Location	Capacity of the Plant	Operation Side
Intercontinental Hotel of Jericho	Activated Sludge	Jericho	Designed capacity is 2000 CM/day but the amount of waste water were treated daily is 1000 CM/day	Casino

No.	Cost Structure	Cost In US dollars (or other currency specify)	Notes
1-	Main Cost :		
	Price of the plant.	12 millions $	
	Cost of installation.	Including the price	
	Cost of transportation.	Including the price	
	Cost of initial operating.	Including the price	
	Cost of training.	Including the price	
2-	cost of infra structure		
	Cost of land used for construction.	113000 $	
	Cost of concrete base.	Including the price	
	Cost of ponds and tanks assembly.	Including the price	
	Cost of extensions of water and electricity.	Including the price	
	Cost of buildings and laboratories.	Including the price	
3-	Operation cost:		

	Cost of the technical supervision.	24000 $ / year	
	Cost of chemical and biological tests.	0 $	
	Cost of chemicals.	12500 $/ year	
	Cost of operating technician.	24000 $/ year	
	Cost of water consumption.	700 $/ year	
	Cost of electricity consumption.	8600 $ / year	
	Cost of periodic maintenance and spare parts.	3000 $ / year	
4-	Additional operation cost due to loss of life of the plant.	1200000 $/ year	Period time 30 years
5-	Total	12185970 $	
6-	Cost / Cubic meter	0.202 $	This is for O&M cost only without the depreciation cost

Table (4.2) Cost sheet for Nahalin WWTP

Name of the Plant	Type of Technology used	Location	Capacity of the Plant	Operation Side
Nahalin WWTP	Activated Sludge	Nahalin Village – West of Bethlehem City	50 CM/day	Nahalin Village council and Arij Office

No.	Cost Structure	Cost In US dollars (or other currency specify)	Notes
1-	Main Cost :		
	Price of the plant.	125000 $	
	Cost of installation.	10000 $	
	Cost of transportation.	It is part of plant price	
	Cost of initial operating.	7000 $	
	Cost of training.	3000 $	
2-	cost of infra structure		
	Cost of land used for construction.	1400 $/ year	
	Cost of concrete base.	Included with plant price	
	Cost of ponds and tanks assembly.	Not founded	
	Cost of extensions of water and electricity.	13000 $	
	Cost of buildings and laboratories.	Not founded	
3-	Operation cost:		
	Cost of the technical supervision.	10000 $	
	Cost of chemical and biological tests.	3000 $ /year	
	Cost of chemicals.	No chemical used	

	Cost of operating technician.	400 $/ month	
	Cost of water consumption.	50 $ / month	
	Cost of electricity consumption.	50 $ / month	
	Cost of periodic maintenance and spare parts.	20000 $ / year	
4-	Additional operation cost due to loss of life of the plant.	18750 $ / year	15 % from the price of the plant
5-	Total	211650 $	Monthly cost= 2532 $ / month
6-	Cost / Cubic meter	1.688 $ / C M	

Table (4.3) Cost sheet for Nuba WWTP

Name of the Plant	Type of Technology used	Location	Capacity of the Plant	Operation Side
Nuba WWTP	Wetland	Nuba Village North West of Hebron City	120 CM/day	Nuba Village council
No.	Cost Structure		Cost In US dollars (or other currency specify)	Notes
1-	Main Cost :			
	Price of the plant.		50000 $	
	Cost of installation.		It is part of plant price	
	Cost of transportation.		It is part of plant price	
	Cost of initial operating.		It is part of plant price	
	Cost of training.		It is part of plant price	
2-	cost of infra structure			
	Cost of land used for construction.		50000$	

	Cost of concrete base.	Included with plant price	
	Cost of ponds and tanks assembly.	Not founded	
	Cost of extensions of water and electricity.	0 $	
	Cost of buildings and laboratories.	Not founded	
3-	Operation cost:		
	Cost of the technical supervision.	7000 $	
	Cost of chemical and biological tests.	0 $ /year	
	Cost of chemicals.	No chemical used	
	Cost of operating technician.	4800 $/ year	
	Cost of water consumption.	0 $ / year	
	Cost of electricity consumption.	0 $ / year	
	Cost of periodic maintenance and spare parts.	0 $ / year	
4-	Additional operation cost due to loss of life of the plant.	7500 $ /year	15 % from the price of the plant
5-	Total	61800 $	Monthly cost= 400 $ / month
6-	Cost / Cubic meter	1.43 $ / C M	

Table (4.4) Cost sheet for Al-Quds University WWTP

Name of the Plant		Type of Technology used	Location	Capacity of the Plant	Operation Side
Al-Quds University WWTP		-Tow Ultra Filtration Units (Hollow Fiber & Spiral Wound) -Reverse Osmosis	Al-Quds University – Abu- Dies East of Jerusalem	50 CM/day	Al-Quds University
No.	Cost Structure			Cost In US dollars (or other currency specify)	Notes
1-	Main Cost :				
	Price of the plant.			70000 $	
	Cost of installation.			It is part of plant price	
	Cost of transportation.			It is part of plant price	
	Cost of initial operating.			It is part of plant price	
	Cost of training.			It is part of plant price	
2-	cost of infra structure			Not found	
	Cost of land used for construction.			Not found	
	Cost of concrete base.			Not found	
	Cost of ponds and tanks assembly.			Not found	
	Cost of extensions of water and electricity.			Not found	
	Cost of buildings and laboratories.			Not found	
3-	Operation cost:				
	Cost of the technical supervision.			15000 $/ year	
	Cost of chemical and biological tests.			3000 $/ year	

	Cost of chemicals.	3000 $/ year	
	Cost of operating technician.	9600 $/ year	
	Cost of water consumption.	500$/ year	
	Cost of electricity consumption.	1000 $/ year	
	Cost of periodic maintenance and spare parts.	4000 $/ year	
4-	Additional operation cost due to loss of life of the plant.	7000 $/ year	10 % from the price of the plant
5-	Total	113100 $	
6-	Cost / Cubic meter	2.4 $ /CM	This is the operation and maintenance cost only

4.1.2 Comparing the cost of treated one cubic meter from the WWTPs:

The operational and maintenance cost had been calculated according to the WWTPs operators.

Table(4.5) Cost of treated one cubic meter of waste water

Name of the WWTP	Type of the technology used	Capacity of the WWTP	Cost/ m^3
Al Quds University	Reverse Osmosis	50 m^3/ day	10 Nis
Nahalin	Activated Sludge	50 m^3/ day	2.5 Nis
Nuba	Wetland	120 m^3/ day	0.7 Nis
Al Aroub	Wetland/ Duck weed	50 m^3/ day	1.0 Nis
Inter Continental Hotel In Jericho	Activated Sludge	2000 m^3/ day	2.0 Nis

From table (4.4) the cost of treating one cubic meter by Reverse Osmoses technology was 10 Nis, this cost is for the three unit of treatment in Al- Quds University WWTP (Ultra filtration Hollow Fiber, Ultra filtration Spiral Wound, and Reverse Osmosis), by the Activated Sludge Technology was between 1.7- 2.5 Nis, and by the Wetlands was about 0.5 – 1.0 Nis. This was only the operation and maintenance cost. If we compare the cost of the treating waste water with the efficiency of the plants we find that the best technology that can be used to treat waste water was the activated sludge. By this result we had satisfied our Hypothesis.

4.2 Discussion

There are several options one can choose from in order to find the most appropriate technology for a particular region.

In wetland treatment, natural forces (chemical, physical, and solar) act together to purify the wastewater, thereby achieving wastewater treatment. A series of shallow ponds act as stabilization lagoons, while water hyacinth or duckweed act to accumulate heavy metals, and multiple forms of bacteria, plankton, and algae act to further purify the water. Wetland treatment technology in developing countries offers a comparative advantage over conventional, mechanized treatment systems because the level of self sufficiency, ecological balance, and economic viability is greater. The system allows for total resource recovery (Rose, 1999).

Lagoon systems may be considered a low-cost technology if sufficient, non-arable land is available. However, the availability of land is not generally the case in big cities. The demand of flat land is high for the expanding urban development's and agricultural purposes (Van Leir, 1998).

The decision to use wetlands must consider the climate. There are disadvantages to the system that in some locations may make it unsustainable. Some mechanical problems may include clogging with sprinkler and drip irrigation systems, particularly with oxidation pond effluent. Biological growth (slime) in the sprinkler head, emitter orifice, or supply line cause plugging, as do heavy concentrations of algae and suspended solids (Metcalf, 2002).

Another treatment option available, if there is little access to land, is anaerobic digestion.

Anaerobic bacteria degrade organic materials in the absence of oxygen and produce methane and carbon dioxide. The methane can be reused as an alternative energy source (biogas). Other benefits include a reduction of total bio-solids volume of up to 50-80% and a final waste sludge that is biologically stable can serve as rich humus for agriculture (Rose, 1999).

Soil aquifer treatment (SAT) is a geopurification system where partially treated sewage effluent artificially recharges the aquifers, and then withdrawn for future use. By recharging through unsaturated soil layers, the effluent achieves additional purification before it is mixed with the natural groundwater. In water scarce areas, treated effluent becomes a considerable resource for improved groundwater sources. The Gaza Coastal Aquifer Management Program includes treated effluents to strengthen the groundwater, in terms of both quantity and quality. With nitrogen reduction in the wastewater treatment plants, the recharged effluent has a potential to reduce the concentration of nitrates in the aquifer. In water scarce areas such as in the Middle East and parts of Southern Africa, wastewater has become a valuable resource that, after appropriate treatment, becomes a commercially realistic alternative for groundwater recharge, agriculture, and urban applications (SIDA, 2000).

(SAT) systems are inexpensive, efficient for pathogen removal, and operation is not highly technical. Most of the cost associated with an SAT is for pumping the water from the recovery wells, which is usually (20-50 \$ / m^3). In terms of reductions, SAT systems typically remove all BOD, TSS, and pathogenic organisms from the waste and tend to treat wastewater to a standard that would generally allow unrestricted irrigation. The biggest advantage of SAT is that it breaks the pipe-to-pipe connection of directly reusing treated wastewater from a treatment plant. This is positive attribute for those cultures where water reuse is taboo (Rose, 1999).

The pretreatment requirements for SAT vary depending on the purpose of groundwater recharge, sources of reclaimed water, recharge methods, and location. Some may only need primary treatment or treatment in a stabilization pond. However, pretreatment processes should be avoided if they leave high algae concentrations in the recharge water. Algae can severely clog the soil of the infiltration basin. While the water recovered from the SAT system has much better water quality than the influent, it could still be lower quality than the native groundwater. Therefore, the system should be designed and managed to avoid intrusion into the native groundwater and use only a portion of the aquifer. The distance between infiltration basins and wells or drains should be as large as possible, usually at least 45 to 106 m to allow for adequate soil-aquifer treatment. (Metcalf, 2002).

All the systems described allow for the reuse of treated wastewater in order to have a cyclic, sustainable system. These treated wastewaters provide essential plant nutrients (nitrogen, phosphorus, and potassium) as well as trace nutrients. Phosphorus is an especially important nutrient to recycle, as the phosphorus in chemical fertilizer comes from limited fossil sources. The application of treated wastewater, as well as sludge, has considerable potential in a cyclical approach to crop applications, provided health risks and quality restrictions are taken into consideration (SIDA, 2000). Public health is the most critical issue regarding reclaimed wastewater.

4.2.1 Strategies for Implementing New Treatment Technology:

A wastewater treatment developer must perform an appropriate risk assessment before implementing the reuse of wastewater. Proper consideration to the health risks and quality restrictions must be a part of the assessment. Source point measures rather than end of pipe solutions are essential. Source-point measures require extensive industrial pre-treatment interventions, monitoring and control programs, and incentives to the community not to dispose of any harmful matter to the sewers (SIDA, 2000).

For the implementation and promotion of new technology, strategies must include local participation as well as municipal. The importance of local participation is a positive growing trend in government projects. The participation must fit with the local population to meet particular local needs. Local communities can contribute indigenous, valid ideas for cost savings in the project.

It will be possible to recommend a coupled technology plant that uses both technologies (Activated Sludge followed by Desalination machine and Wetland Duck Weed). According to our result the combination between these two technologies i.e. activated sludge followed by Desalination machine and wetland duck weed technology will be a very good procedure to treat wastewater in Palestine especially if the effluent reused in irrigation or runoff in the wadis. This dual procedure will protect our ground water and our environment from the pollutant.

Until now there is no unit that use both techniques for tertiary treatment in Palestine, this technology can be used in the future. It will be efficient with a low cost tertiary treatment method for the treatment of waste water by simple activated sludge waste water treatment plant that will be then followed by wetland duck weed technology. This technology may remove about (80-85 %) of organic matter from wastewater, on the other hand the desalination machine reduce the electric conductivity (EC) which have the negative effect for the soil when we reuse the effluent for irrigation, the reduction of EC by this machine about (90-95 %) , finally the duck weed will remove about (70-80 %) of nonorganic matter. The final efficiency of this dual technology may reach (80-85 %).

This effluent maybe also used in irrigation, but if there is any Operational problems especially in desalination machine it will be a negative effects in the soil, the amount of salts will be increase by the time. Also we should use disinfection by chlorine or the ultra violet (UV) radiation, or ozone (O_3) to kill the pathogens in the treated water, but if the treated water runoff in the wadi there is no need to disinfect the treated water.

Also we can use the duck weed after drying in sunlight as food for animals including domestic animals and fish. The Duck weed has a high growth rate especially in waste water. So we can get large amounts of animal food

Chapter Five

Conclusion and Recommendations

5.1 Conclusion

Based upon this work and the experimental work done, the following points can be concluded.

1- The unfair distribution of water resources and the denials of the full control of the Palestinians over their natural water reservoirs had make most of the Palestinian municipalities and villages suffering from the shortages in fresh water supply especially in summer.
2- Wastewater in Palestine has a high reuse potential. New recycling techniques should be employed to make use of the wastewater discharged.
3- The reuse of treated wastewater in agricultural production in Palestine is still on the pilot scale and the Palestinians lack the proper experience in using this resource in a safe and sound way.
4- It is important to emphasize the vitality of water reuse to the Palestinian water sector since recycling the wastewater will lower the burden and pressure on the water resources.
5- The efficiency of Reverse Osmosis (RO) technology to reduce all pollutants, pathogens from the waste water is 95- 99 % (very high).
6- The efficiency of Activated Sludge (AS) technology to remove the pollutants, pathogens from the waste water is 50 – 80 % (medium).
7- The efficiency of Wetland (WL) technology to remove the pollutants, pathogens from the waste water is 25-50 % (very low).
8- The cost of treated one cubic meter by Reverse Osmoses technology is 10 Nis.
9- The cost of treated one cubic meter by Activated Sludge Technology is between 1.7- 2.5 Nis.
10- The cost of treated one cubic meter by the Wetlands is about 0.5 – 1.0 Nis.
11- If we compare the cost of the treating waste water with the efficiency of the plants we find that the best technology that can be used to treat waste water is the Activated Sludge (AS).

5.2 Recommendations

1- Encouraging the researchers to study the performance and the cost for these waste water treatment plants.

2- It is recommended that the (PWA) should control the existing waste water treatment plants and establish new waste water treatment plants to stop the pollutant which is precipitate to the ground water and the environment.

3- It recommended that the municipalities should construct new wastewater treatment plants especially in rural area to protect the environment from the pollutions which is the result of disposed raw waste water by the sewage tanks in the agricultural areas.

4- It is recommended that, Stakeholders should develop strategies and programs for education, training course for municipalities stuff to control the waste water treatment plants.

5- It is recommended to try to implement an activated sludge technology to treat waste water in Palestine but this technology need good control to produce a good production, this control can be satisfied by daily or weekly analysis for COD, TSS, TDS, EC, TC, FC, TPC, and once a months for BOD.

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Addendum 1

WWTPs in Palestine

Implementing Agency	Type of Technology	Location	No. of units	Capacity
FAO	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Hebron	33	One Cubic Meter / day
		Salfit	10	
		Tulkarem	6	
		Nablus	6	
		Jenin	9	
PWEG	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Ramallah	80	One Cubic Meter / day
QWC	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Ramallah	48	0.5 CM/day
ARIJ	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Hebron	166	(0.7- 1) CM/day
		Bethlehem	113	(0.7- 1) CM/day
PHG	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Hebron	10	School level
		Bethlehem	3	School level
		Ramallah	12	School level & House hold level
		Nablus	15	School level & House hold level

		Qalqilia	1	School level
		Jenin	60	House hold level
PHG	UASB & Wetland	Nuba & Kharas	2	120 CM/ day for each one
PHG	Septic tank & bio- filter	Deir Samit	1	15 CM/day
PHG	UASB & Wetland	Ramallah	1	N.D
PHG	UASB & Wetland	Nablus		N.D
PHG	UASB & Wetland	Qalqilia		N.D
PHG	UASB & Wetland	Tulkarim		N.D
PHG	UASB & Wetland	Bethlehem		N.D
PARC	Gray water Treatment Up-Flow Gravel filter followed by Aerobic Sand filter	Ramallah	20	1 CM/day
		Jenin	50	1 CM/day
		Tubas	15	1 CM/day
		East Jerusalem	1	16 CM/day
		Tulkarim	3	15 CM/day
		Qalqilia	1	14 CM/day
		Salfit	1	12 CM/day
WEDO	Constructed Wetland	Jericho	1	5 CM/day

Addendum 2

Data analysis for addition WWTPs (micro and Large scale) in Palestine.

1- Ramallah WWTP

Type of technology used: Activated Sludge (oxidation bond)
Type of inlet waste water: Black water
Date of sample:
Sample one: 12/10/2010
Sample two: 15/11/2010

sample	PH	E.C ms/cm	TDS mg/L	TSS mg/l	TS mg/L	BOD5 mg/l	COD mg/l	T.C cfu/1ml	F.C cfu/1ml	T.P.C cfu/1ml
Inlet sample 1	7.2	2.14	1070	371	1441	320	1397	1900000	300000	36000000
Inlet sample 2	7.2	2.16	1100	397	1497	284	1177	2200000	300000	40000000
Outlet sample 1	7.5	1.92	960	150	1110	87	530	60000	10000	2000000
Outlet sample 2	7.7	1.93	970	167	1137	84	483	60000	6000	1500000

2- Al –Beireh WWTP

Type of technology used: Activated Sludge (aerobic bond)
Type of inlet waste water: Black water

Date of sample:

Sample one: 12/10/2010
Sample two: 15/11/2010

sample	PH	E.C ms/cm	TDS mg/L	TSS mg/l	TS mg/L	BOD5 mg/l	COD mg/l	T.C cfu/1ml	F.C cfu/1ml	T.P.C cfu/1ml
Inlet sample 1	7.1	1.75	890	492	1382	143	1317	12000000	500000	28000000
Inlet sample 2	7.3	1.79	900	484	1384	174	1293	9000000	400000	30000000
Outlet sample 1	7.5	1.37	690	10	701	45	240	4000	1000	80000
Outlet sample 2	7.7	1.36	680	8	688	33	236	6000	1000	90000

3- Duha and Al Auja WWTPs:

First samples:
Date of sample: 11/07/2011
Type of technology used: Wetland
Type of inlet waste water: Gray water

Sample	pH	BOD5 mg/L	COD mg/L	EC ms/cm	TDS mg/L	TSS mg/L	TS mg/L	TPC cfu/1ml	TC cfu/1ml	FC cfu/1ml
Auja inlet	7.1	190	650	1.90	990	110	1100	$15 X10^5$	0	0
Auja outlet	7.2	80	410	1.73	340	25	365	$30X10^4$	0	0
Duha inlet	7.65	175	640	1.83	730	94	824	$45 X10^5$	0	0
Duha out let	7.2	63	320	1.53	330	18	348	$17 X 10^5$	0	0

Second samples
Date of sample: 19/10/2011

Sample	pH	BOD5 mg/L	COD mg/L	EC ms/cm	TDS mg/L	TSS mg/L	TS mg/L	TPC cfu/1ml	TC cfu1ml	FC cfu/1ml
Auja inlet	7.22	181	680	2.2	1200	120	1320	$10 X10^5$	0	0
Auja outlet	7.10	121	398	1.3	540	15	555	$50X10^4$	0	0
Duha inlet	7.76	164	930	1.41	680	73	753	$30 X10^5$	0	0
Duha out let	7.3	51	410	0.85	430	20	450	$15 X 10^5$	0	0

Addendum 3

Cost sheet for large scale WWTP (Al-Beireh WWTP)

Name of the Plant	Type of Technology used	Location	Capacity of the Plant	Operation Side
Al-Beireh WWTP	Activated sludge	Albeireh city	5500 CM/day	Albeireh Municipality

No.	Cost Structure	Cost In US dollars (or other currency specify)	Notes
	Cost of chemical and biological tests.	1200 $/ year.	
1-	Main Cost :		
	Cost of chemicals.	2400 $ / year	
	Price of the plant.	14.3 million $	
	Cost of operating technician.	22800 $/ year	
	Cost of installation.	Included by the plant price	
	Cost of water consumption.	600 $/ year	
	Cost of transportation.	Included by the plant price	
	Cost of initial operating.	Included by the plant price	
	Cost of electricity consumption.	288,000 $/year	
	Cost of training.	5000 EUR	
2-	Cost of infra structure		
	Cost of periodic maintenance and spare parts.	8,000 $/year	
	Cost of land used for construction.	70,000 $	
4-	Additional operation cost due to loss of life of the plant.	8 % from the plant price= 1.144 million $ /year	
	Cost of concrete base.	Included by the plant price	
5-	Total	158548000 $	
6-	Cost / Cubic meter	0.744 $	
	Cost of ponds and tanks assembly.	Included by the plant price	
	Cost of extensions of water and electricity.	Included by the plant price	
	Cost of buildings and laboratories.	Included by the plant price	
3-	Operation cost:		
	Cost of the technical supervision.	6000 $/ year	

الملخص العربي:

محطات المعالجة صغيرة الحجم في الضفة الغربية : دراسة مقارنة

الاسم: مجدي شاكر شاهين

اسم المشرف: الدكتور معتز القطب

يتركز موضوع الرسالة على المقارنة بين محطات معالجة المياه العادمة صغيرة الحجم والتي تقع في مناطق مختلفة من فلسطين وتعمل بانواع مختلفة من التقنية في المعالجة. وهذه المحطات هي محطة جامعة القدس و محطة نحالين ومحطة نوبا ومحطة العروب ومحطة خاراس ومحطة بني زيد و محطة رام ا ومحطة البيرة ومحطة فندق اريحا السياحي ومحطة منزلية في الدوحة في بيت لحم ومحطة منزلية في منطة العوجا باريحا.

لقد تم زيارة احد عشرة محطة في مناطق مختلفة ومن خلال الزيارة وجد ان محطتين لا تعمل و اربع محطات تعمل ضمن ظروف صعبة ولا تقوم بالتنقية المطلوبة وخمسة محطات تعمل بالشكل المطلوب.

لقد تم اخذ العينات من المياه العادمة التي تدخل الى المحطة ومن المياه العادمة المعالجة خلال عام كامل من الفترة ما بين (2010 – 2011) مرة كل شهر. وكانت التحاليل يتم اجرائها على مرحلتين حيث يتم فحص كل من الطلب الحيوي على الاوكسجين (BOD) و الحموضة (pH) و الموصلية الكهربائية (EC) و فحص الممرضات (TPC, TC, FC) مباشرة عند الوصول الى المختبر. اما التحاليل المتبقية فيتم اجرائها لاحقا.وتشمل هذه التحاليل كل من الطلب الكيميائي على الاوكسجين (COD) و والمواد الصلبة الكلية(TS) والمواد الصلبة الذائبة (TDS) والمواد الصلبة المعلقة (TSS).

من خلال التحاليل تم الوصول على النتائج المطلوبة لكل محطة وهي موضحة في الجداول في الفصل الثالث من الرسالة. وتم تحديد كفائة كل محطة في المعالجة من خلال معادلات حسابية تم اجرائها. وتم الوصول الى ان افضل نوع تقنية يمكن استخدامة لمعالجة المياه العادمة هو (Reverse Osmosis) المعالجة باستخدام فلتر الضغط العكسي. وبمقارنة كفائة كل محطة بتكلفة المعالجة للمتر المكعب الواحد لكل محطة وبعد اجراء المقارنة تم الوصول الى ان تقنية الحمأة المنشطة (Activated Sludge) هي افضل تقنية يمكن استخدامها لمعالجة المياه العادمة لان تكلفة المعالجة تكون قليلة مقارنة بالضغط العكسي وكفائة المعالجة للمياه العادمة تكون ضمن المواصفات المطلوبة عالميا.