(technical evaluation and optimization of water treatment plant) in Jericho

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TECHNICAL EVALUATION AND OPTIMIZATION OF WATER TRETMENT PLANT IN JERICHO

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This thesis was prepared under the supervision of Dr. Rashid Al-Sa'ed and has been approved all members of the Examination committee.

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The findings, interpretations and conclusions expressed in this study do not necessarily express the views of Birzeit University, the views of the individual members of the MSc-committee or the views of their respective employers.

DEDICATION

TO MY MOTHER AND MY FATHER DR. ISMAEL NAWAHDA

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ABSTRACT

Since 1956 when **Jericho water treatment plant** (JWTP) was established, this plant produces around 500 cubic meters of fresh drinking water per day for more than 5000 inhabitants living in Aqbat-jabr camp. Water springs at wadi-qilt are considered the main raw water supply for the JWTP.

JWTP operates properly in summer time under poor management and lack of maintenance. The present treatment process entails slow sand filtration and disinfection process. In rainy days the influent fecal coli forms are about 800-colonies/100 ml, which are significantly above those recommended by the WHO and the Palestinian standards for drinking water. The turbidity is more than 30 NTU; extensive growth of algae in the feeding open canal and in the slow sand filters is visible.

The water of wadi-qilt springs is polluted while flowing in the open canal more than 13 km long to JWTP. From 1996 to 1997, a few incidents of waterborne diseases were reported as a result of inadequate filtration and interruption of the process of the disinfection. JWTP is the only source of drinking water for Aqbat-jabr but the failure of the treatment process at JWTP in water time forces the people of Aqbat-jabr to use another water supply from the Israeli water company (MEKKORTH). The supplied quantity of water by MEKKORTH is insufficient and also it is more expensive than the water supplied by JWTP. Therefore the major objective of this study is to identify the means and measures for establishing a water system under the conditions of water scarcity so that the JWTP can confront the pollution, especially during rainy days, which causes fecal coli forms, higher turbidity, and algae growth.

The results of the analysis conducted on the experimental model of slow sand filter (SSF) indicate that the existing water treatment plant must be modified with the addition of a settling tank in front of the sand filters in order to treat varying water qualities effectively especially in winter time. After executing the modifications on the experimental model of SSF, the efficiency of removing turbidity reached in worst conditions to 85% and no algae growth has been observed.

My recommendation for the future is to utilize water resources at wadi-qilt effectively because the whole region suffers from water shortage.This will require actually additional civil works and water management policy of water resources and optimized operational management of JWTP in order to cope with water demand beyond the coming 10 years.

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SYMBOLS AND ABBREVIATIONS

SYMBOLS

Cl_2	Chlorine
CWR	Clear water reservoir
DO	Dissolved oxygen
D	Depth
EC	Electrical conductivity
MCM	Million cubic meters
NH_4^+	Ammonium
NO_3^-	Nitrate
NTU	Nephelometric turbidity unit
PO_4^{3-}	Phosphate
Sal.	Salinity
SS	Suspended solids
SSF	Slow sand filter
TDS	Total dissolved solids
T	Temperature
TPC	Total plate count

ABBREVIATIONS

APHA	American public health association
ARIJ	Applied research institute-Jerusalem
BZU	Birzeit university
JWTP	Jericho water treatment plant
PNA	Palestinian national authority
PWA	Palestinian water authority
UFW	Unaccounted for water
UNRWA	United nation relief and works agency for Palestinian refugees
WBWD	west bank water authority
WQ	Wadi-qilt

CHAPTER 1

INTRODUCTION

1.1 Background

Jericho district is located about 350m above sea level at the north east border of the district, and about 370m below sea level at the area adjacent to the Dead Sea. Six main valleys cross Jericho district, namely wade Al-mallaha, wada Al-Auja, wada Abu ubeida, wada An-nuw ema, wada-qilt and wadi Al-Ghazal. The climate of Jericho district is classified as arid. The maximum average of temperatures during January (coldest month) and august (hottest month) is aground 19°C and 38°C respectively. The highest maximum temperature reached to 49°C in June 1998(Jericho weather station, 1998).

The rainy season in the Jericho district starts at mid October and continues to the end of April. The mean of annual rainfall at the Jericho city for the period 1968-1992 was 166mm. the evaporation rate in the Jericho district highly varies between 59mm when solar radiation is at its lowest level and 298.5mm in July when solar radiation is at its highest. The geology of Jericho is composed of marl & Pleistocene Alluvial formations (ARIJ, 1998).

Water resources

Jericho water resources are part of the eastern Aquifer basin (EAB). Within EBA there are several aquifer systems in the Jericho district: mainly lower Cenomanian, Upper cenomanian, turonian, tertiary, and Quaternary Aquifer systems. Wada-quilt springs are issuing for the upper cenomanian Aquifer. (Elmosa, 1997).

Groundwater sources

1- Groundwater wells: there are 63 irrigation wells in the Jericho district, 48 private wells owned by Palestinians, and 15 coomperative association wells owned by the Arab development society.

2- Springs: there are four main spring systems in the Jericho district 1) wada-qilt spring system which has a total average annual discharge of about 5 MCM; wada-qilt is fed from three main springs Ein Fara, Ein Fawwar and Ein –quilt. 2) Ein Al-sultan spring system. 3) Dyouk spring system. 4) Al- Auja spring system (Rofe and Raffety, 1965).

The Palestinian water Authority (PWA) represented by the west bank water department (WBWD) is responsible for the water quality of wada-qilt. Literature data on water quality analysis of wada-qilt springs between 1967 and 1996 is illustrated in table 1.1. A full detailed chemical analysis of water taken from several springs in the region is illustrated in table 1.2.

Table 1.1: chemical water analysis [1] of wada-qilt springs (PWA, 1998).

Date	TDS	NO_3^-	HCO_3^-	SO_4^{-2}	Cl^-	K^+	Na^+	Mg^{++}	Ca^{++}
Sep-1967	**234.6**	**11**	**232**	**4.1**	**28**	**1.2**	**14**	**36.4**	**26**
21-04-1982	**216.9**	**11**	**173**	**10**	**29**	**2**	**23**	**15**	**42**
25-11-1989	**284.6**	**5**	**244**	**8.5**	**44**	**3.3**	**17**	**20**	**67**
18-06-1991	**264.2**	**8**	**240**	**10**	**27**	**1.4**	**19**	**16**	**65**
22-11-1992	**250.6**	**11**	**207**	**11.5**	**29**	**2.6**	**17.6**	**18.3**	**59**
30-10-1995	**-**	**15**	**225**	**8**	**35**	**2**	**20**	**17**	**50**
29-10-1996	**-**	**13**	**192**	**9**	**31**	**2**	**16**	**19**	**45**

[1] All data are in mg/L

Table 2: full chemical analysis [1] for some springs the west bank (Al-Saّed, & Alawneh, 1997).

Spring	TDS	NO_3^-	HCO_3^-	SO_4^{-2}	Cl^-	K^+	Na^+	Mg^{++}	Ca^{++}
Bertaّa	**513**	**19**	**450**	**16**	**73**	**0.5**	**41**	**47**	**96**
Shobli	**369**	**16**	**295**	**15**	**59**	**2.2**	**32**	**29**	**72**
Quilt canal	**261**	**11**	**230**	**10**	**30**	**1.8**	**19.8**	**18.6**	**58**

[1]All data are in mg/L

The existing water treatment plant in Jericho supplies Aqbat-Jabr camp with drinking water. This water treatment plant was built in 1956 by UNRWA A and is still operated and managed by their staff. At present, about 5000PE are served through a central water supply network, the actual current average of daily water consumption is less than 100 liters per capita per day.

Wada-quilt springs are the main water source for the JWTP. The water is transported through a 13-km long old open canal. In the past (PNA, 1996), technical proposals were made ton transport that water through pipes instead of using the open canal. However, due to financial constraints, these proposals were not implemented.

The treatment plant works properly in summertime, but since 1997 the operation of the treatment plant has been stopped in wintertime. Figure 1.1 shows the flow diagram for the water treatment process. The water treatment plant consists of three main slow sand filters (one filter is standing by) and a chlorinating unit.

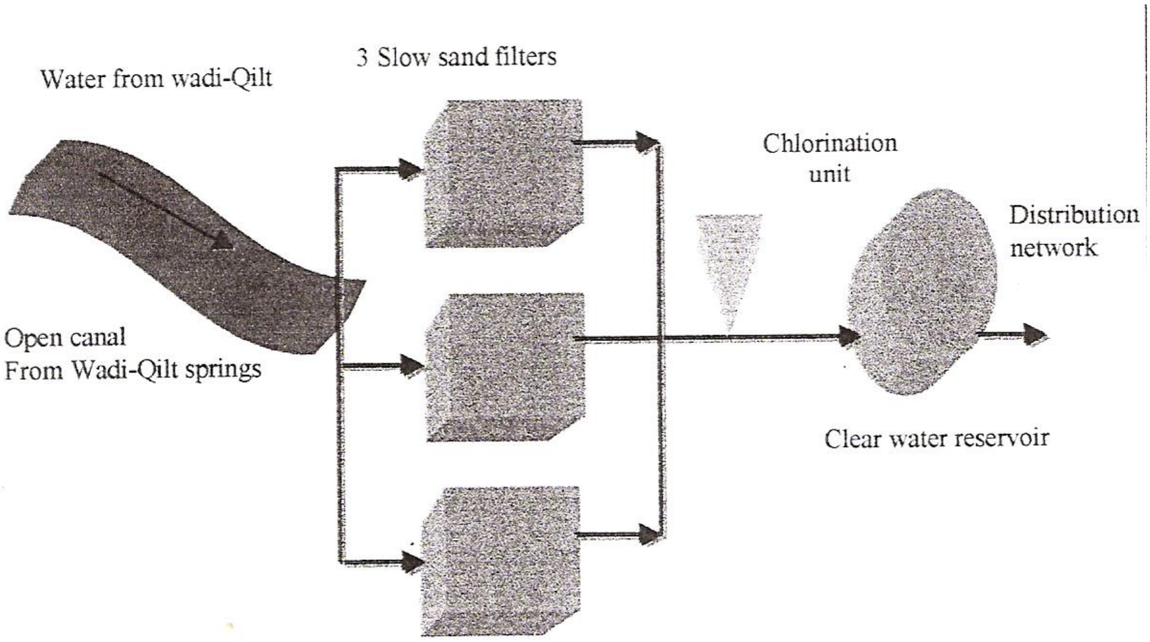


Figure 1.1: schematic flow diagram for JWTP

The location of the study area is shown in figure 1.2. It shows Jericho district, Aqbat-Jabr refugees camp, Jericho water treatment plant JWTP, and the surrounding valleys and springs.

Figure 1.2: location of the study area in Jericho district.

1.2 Scope of work

a) Aim

The main aim of this research is to investigate means of developing the technical solutions and cost effective reliable measures those optimize and enhance the operation of Jericho water treatment plant.

b) Objectives

The aim of this research includes the following objectives:

- Identify and evaluate the present and future water demands.
- Identify the existing technical problems of the existing water treatment plant.
- Study the water pollution sources and provide pollution preventive measures.
- Develop and introduce sustainable operational and managerial techniques.
- Economical analysis of the water price based on the proposed technical measures.

C) Materials and methods

In order to achieve the aforementioned objectives, the following research methods will be carried out.

1) A comprehensive literature review has been conducted with respect to surface water treatment including specialized readings on slow sand filters, settling, and disinfecting. Field trips were made in order to identify the operational and technical problems. Also professionals from UNRWA staff and decision-makers who work at people from Aqbat-jabr camp were contacted.

2) To know the potential pollutants, samples are collected from several stations along the open canal.

3) To measure water quality and the efficiency of the water treatment plant, samples are collected from the inlet and outlet of the water treatment plant

4) Water sampling and analysis were carried out to find the operational parameters of the slow sand filter.

5) Define and develop the most possible and reliable operational parameter to achieve best water quality. For this, an experimental model of a slow sand filter was constructed, operated and monitored.

6) In order to enhance the efficiency of the water treatment plant and to avoid operational and technical problems, a new management structure of the water treatment plant is suggested.

7) In order to be able to achieve the analytical sampling and analysis; sampling bottles, chemical analysis and portable lab kits and equipment were necessary to carry out this research proposal. Chemical and biological analyses were made according to APHA (1989).

d) Schedule of activities

The study was initiated in September 1998; field work was carried out to collect local information and technical data for the existing water treatment plant in Jericho. On site a physical and chemical water analysis were carried out during the field work. A literature review was made on sow sand filter, chlorination, and settling processes.

The time schedule to conduct this research is described as follows:

1) Data collection for the treatment plant and field visits to the camp office manager for history, maps, drawings, and establishment: October and November 1998.

2) Sampling and analysis: December 1998, January 1999, and February 1999.

3) Construction of slow sand filter experimental mode: March 1999.

4) Results analysis and discussion, Conclusions and recommendations: April 1999-may 1999.

CHAPTWR 2 LITERATURE REVIEW

CHAPTER 2

LITERATURE REVIEW

2.1 slow sand filter

In slow sand filter water is treated by natural mechanisms involving transport, attachment, and detachment. Transport mechanisms include screening, interception, gravitational settling, diffusion, and hydrodynamic conditions. Filter medium, filtration rate, temperature, density and size of the suspended particles are the factors affecting the efficiency of suspended solids removal. Attachment mechanisms include straining, van der walls forces, electrostatic interactions, and adsorption. Filter medium, chemical characteristics of water are the main factors affecting the attachment efficiency. Detachment mechanisms include hydraulic shearing forces which are proportional to the filtration rate (Pojasek, 1977).

The main objectives in using SSF are:

- To remove suspended solids.
- To remove pathogenic organisms (Bacteria, viruses, Giardia…).
- To remove organic matters.
- To remove Na^+, Fe^{2+} ions.
- To remove NH_4^+ ions.

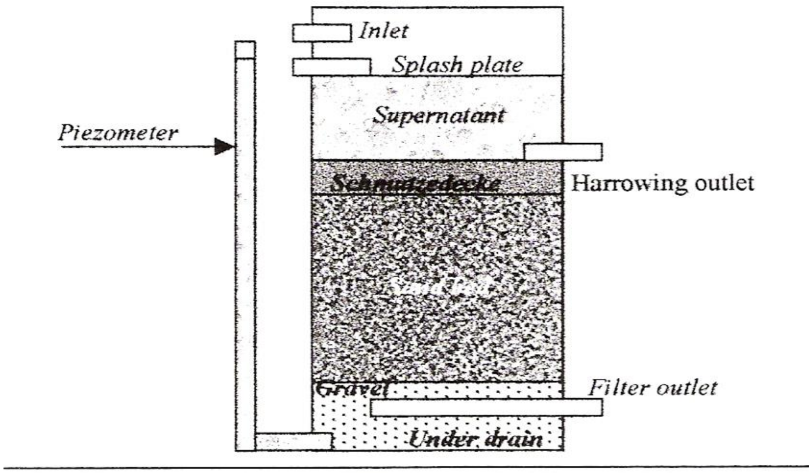
2.1.1 Biological processes in SSF

During filtration, organic matters are oxidized and small amount of absorbed organic matter sere as food for bacteria which can be water born bacteria, but it will die due to scarcity of food and oxygen in the filter bottom. Intestinal bacteria will die soon due to the fact that the water in the bottom is colder than the natural habitat, and there are no sources of food or oxygen and present of chemicals or viruses. (Al-Saό ed, 1998).

After passing a layer of about 60cm of sand at normal conditions, water must be free of micro organisms, the major part of removal takes place in the top layer, the reduction in bacteria is about 99.9%(AWWA, 1990).

2.1.2 Technical features & operational conditions

Figure 2.1 shows a typical schematic diagram of a slow sand filter.



Filter 2.1: schematic diagram of a slow sand filter (Blackburn, 1999).

Some process optimum conditions are (AWWA, 1990):

- Effective bad depth = 0.7m
- Total bed height = 1m
- Filtration rate = 0.1-0.3 m/hr
- Diameter of sand grains = 0.2-0.4mm
- Runtime =20-100 day
- Cleaning is done manually or mechanically by removing the top layer of 1.5-2cm (skimming). The dirty sand can be washed and reused or sent for land filling.

Smaller-size grains improve particulate removal, but also increase head loss development and may shorten the runtime. If the filtration rate is increased, the solids flush deeper into the filter and into the effluent. Negative head occurs when the effluent exits to the clear well below the filter medium, it cause air binding, more rapid head loss development, and poor effluent quality. The rate of head loss is proportional to the captured solid by the filter a filter increasing the filtration rate.

The developed biological layer (Schmutzedecke) is removed with the skimmed sand at the top of the sand bed, where most of the particulate are removed. Improvement period (ripening period) which ranges from two hours to weeks occur at the beginning of each cycle after the schmutzdecke has been removed. (AWWA, 1990). Prechlorination is not detrimental to performance because the slow sand filter is partially a biological process. It was found that a slow sand filter that received superchlorinated water with influent about 6 to 12mg/L free chlorine and with free chlorine in the filtrate worked better than a filter without Prechlorination in bacterial removal and cycle length (AWWA, 1990).

The source water must have almost acceptable color because the color removal in sand filters is less than 25%. Water with periodic blooms of algae may cause clogging in the sand filters, the acceptable source water should have chlorophyll less than 5mg/m^3 and turbidity less than 5NTU(AWWA, 1990).

2.1.3 Filter media

Sand or other materials used as a filter must have the following properties:

- Hard
- Durable
- Free of impurities
- Insoluble in water

Filter sand is selected on the basis of effective size and uniformity coefficient. The effective size is the size of sieve opening which will permit the passage of 10% by weight of the sand grains. The uniformity coefficient is the ratio of sieve size which will pass 60% and 10% of the sample respectively (Pojasek, 1977).

Depending on the desired rate of filtration the effective size ranges from 0.25-0.55mm and the uniformity coefficient varies from 1.5-3.0; the most commonly used media for municipal water filtration is sand.

2.1.4 Filtration hydraulics

The flow hydraulics in a filter are the same as those of ground water flow, thus flow in a clean and even clogged filter bed is laminar, and Darcy's law can be applied (AWWA, 1990).

$$U = K_P.S_1$$

$$S_1 = h_f/L$$

Where u = flow velocity (m/s)

K_P = Permeability coefficient (m/s)

S_1 = hydraulic gradient

h_f = head loss (m)

L = depth of the filter (m)

The void space in the filter can be considered analogous to small pipe, therefore Dracy-Weisbach's relationship can be used or:

$$h_f = f\ L\ V^2 / 2\ D\ g$$

Where f = friction factor

D = diameter (m)

V = mean flow velocity (m/s)

g = gravitational acceleration (m/s^2)

It can be noted that as the filtration proceeds, the solids fill up the void space and the head loss increases (Pojasek, 1980).

2.2 Chlorination

Chlorination is one of the familiar means for disinfection. Chlorine is used in two forms, a gaseous element or as solid or liquid chlorine containing hypo chlorine compound. The stability of the hypochlorite solutions is affected by temperature, light, pH, and the presence of heavy metals. When chlorine is dissolved in water it forms hypochlorus and hydrochloric acids (Schippers, 1995):

$$Cl_2 + H_2O \leftrightarrow HCl + HOCL$$

$$HOCL \leftrightarrow H^+ + OCL^-$$

There are tow important factors affecting the efficiency of disinfection: time of contract and concentration of chlorine. Free available chlorine residual is the concentration of HOCL in a water sample. It is the most effective for disinfection due to the fast penetration on the cell wall of the micro organisms, because it is neutralized and has a low molecular Weight, while the efficiency of disinfection decreases with the PH increase (kool, 1979). Combined available chlorine is the total quantity of dichloride and monochlorine, when the chlorine reacts with any compound containing nitrogen atom, the reaction are as follows (sawyer, et al, 1994):

$$NH_4^+ + HClO \rightarrow H_2NCl + H_2O$$

$$NH_2Cl + HClO \rightarrow NHCl_2 + H_2O$$

$$NHCl_2 + HClO \rightarrow NCl_3 + H_2O$$

2.2.1 Breakpoint chlorination

The minimum quantity of the free residual chlorine is about 0.2 mg/L fore effective disinfection. The chlorine is added to oxidize any compounds in the water, then increased to destroy chloramines, and increased finally to cut up the highly bactericidal free chlorine residual. While the distraction of the chloramines there is a dip in the chlorine residual present which is called the break point chlorination, after passing this part the free residual rises again as shown in fig. 2.2?

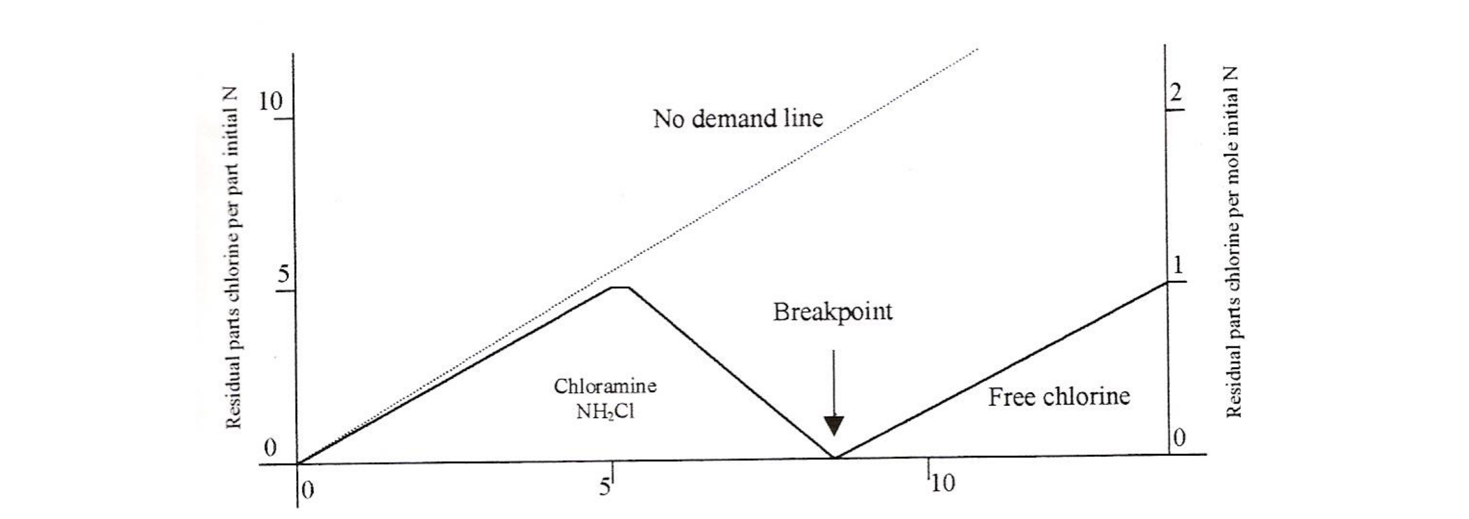


Figure 2.2: diagrammatic representation of completed breakpoint (sawyer, et al, 1994).

Chlorination demand is defined as the amount of chlorine needed to take the reaction through the break point. In order to prevent the formation of Trihalomethanes (THMs) ammonia is added before chlorine, because (THMs) cause cancer, although the ammonia provides nutrients sufficient to produce algal blooms in the water reservoirs.

2.2.2 Dechlorination

Dechlorination is used to remove all or part of the total combined chlorine residuals using sulfur dioxide and/or aqueous solutions of sulfate compounds (AWWA, 1990):

- Free chlorine $SO_2 + HOCl + H_2O \rightarrow SO_4^{2-} + Cl^- + 3H^+$
- Combined chlorine $SO_2 + NH_2Cl + 2H_2O \rightarrow SO_4^{2-} + Cl^- + 3H^+ + NH_3$

2.2.3 Drawbacks to chlorination

Chlorine is a highly effective disinfection agent, which is available at a reasonable price (sawyer, et al, 1994) however:

- ☺ THMS may be produced, where certain organic materials combine with chlorine.
- ☺ Turbidity in water can reduce the disinfection efficiency.
- ☺ Variation in water quality may reduce the disinfection efficiency.
- ☺ Noticeable taste and odor in the water if exceeding the necessary level.
- ☺ Chlorine is a dangerous gas.

There are three sources for chlorine obtaining for disinfection (AWWA, 1990):

1) Solid calcium hypochlorite Ca $(OCl)_{2}$: it causes scale formation if the water is hard, on the other hand it is more expensive than the other chemical sources.
2) Liquefied chlorine gas: it is cheaper than calcium hypochlorite, but it is very dangerous to handle and store.
3) Sodium hypochlorite: it is more expensive than liquefied gas of chlorine, but it is less dangerous to handle.

Brine and saline solutions electrolysis is used to produce chlorine and hypochlorite.
However there are several types of chlorination stages:

Prechlorination: it is used to minimize the growth of the biological slime layer in filters, tanks, and pipe, and to reduce potential taste and odor problems, the most common use of prechlorination is with rapid mixing when a coagulant is added.

Prechlorination: it is used for microbial reduction; chlorine is added immediately after filtration or before the clear water reservoirs.

Superchorination: it is used when treating poor-quality water, where chlorine is added beyond the breakpoint in order to oxidize ammonia in this water, a dechlorination is needed after words in order to reduce organic by-products.

2.3 settling

Settling is a description for all types of particles falling under gravity force through a liquid medium. There are three types of settling (AWWA, 1990):

Type 1: settling of discrete particles in low concentration.
Type 2: settling of particles in low concentration with flocculation.
Type 3: zones of settling which developed due to different settling velocities.

The velocity of a single particle settling under its own weight in a liquid increases if the density of the particle is greater than the liquid density. Settling velocity remains constant when the weight of the particle equals the drag, this velocity is called terminal settling velocity (V_s) the equation of V_S is derived by equation the forces upon the particle. Hence,

$$F_d = F_g - F_b$$

Where F_d = drag
F_g = gravity
F_b = buoyancy

And, $$F_d = 0.5.\ C_d.\ V_S^2.\ P.\ A = V.\ g.\ (P_S - P)$$

Where C_d = drag coefficient
V_S = settling velocity (m/s)
P = mass density of liquid (kg/m^3)
A = projected area of particle in the direction of flow (m^2)
P_s = density of the particle (kg/m^3)
V = effective volume of the particle (m^3)

So, $$V_S = [2g(P_S - P)\ V]^{1/2}\ /C_d\ P\ A$$

The drag coefficient is related to Reynolds number as illustrated in fig. 2.3.

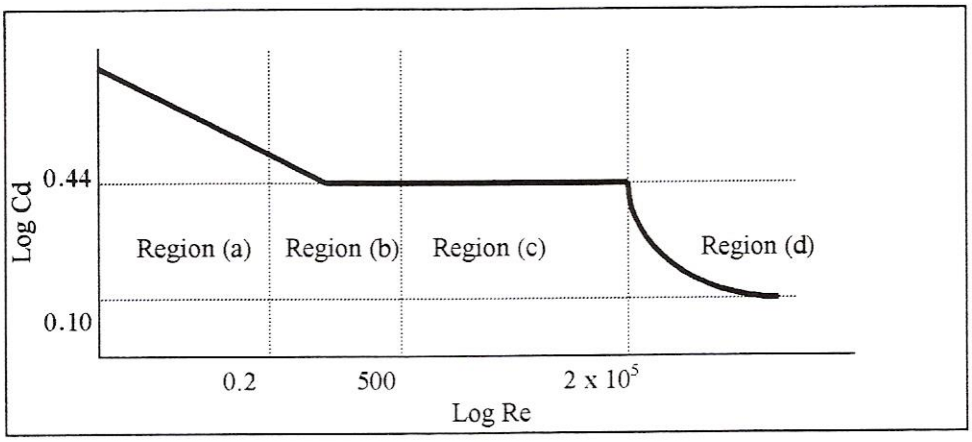


Figure 2.3: variation of drag coefficient with Reynolds number for single particle sedimentation (AWWA, 1990).

Region a: $C_d = 24 / Re$
Region b: $C_d = 24 / Re + 3 / Re^{1/2} + 0.34$
Region c: $C_d = 0.44$
Region d: $C_d = 0.1$

2.3.1 settling in tanks

The particle with a velocity exceeding the velocity of the liquid will be retained. Hence,

$$V_s > Q / A$$

Were Q: influent flow rate (m^3/s)
A: cross section of the tank (m^2)

in rectangular water tanks the settling velocity has two components horizontal and vertical as illustrated in fig.

Where L: horizontal distance traveled (m)
t: time of travel (s)
H: depth of liquid (m)
W: width of tank (m)
h: vertical distance traveled (m)

for ideal condition when all particles have the same settling velocity, then the settling efficiency depends only on the tank area, and retention time (T_F) which depends on water depth, as given by:

$$T_R = A\ H/Q$$

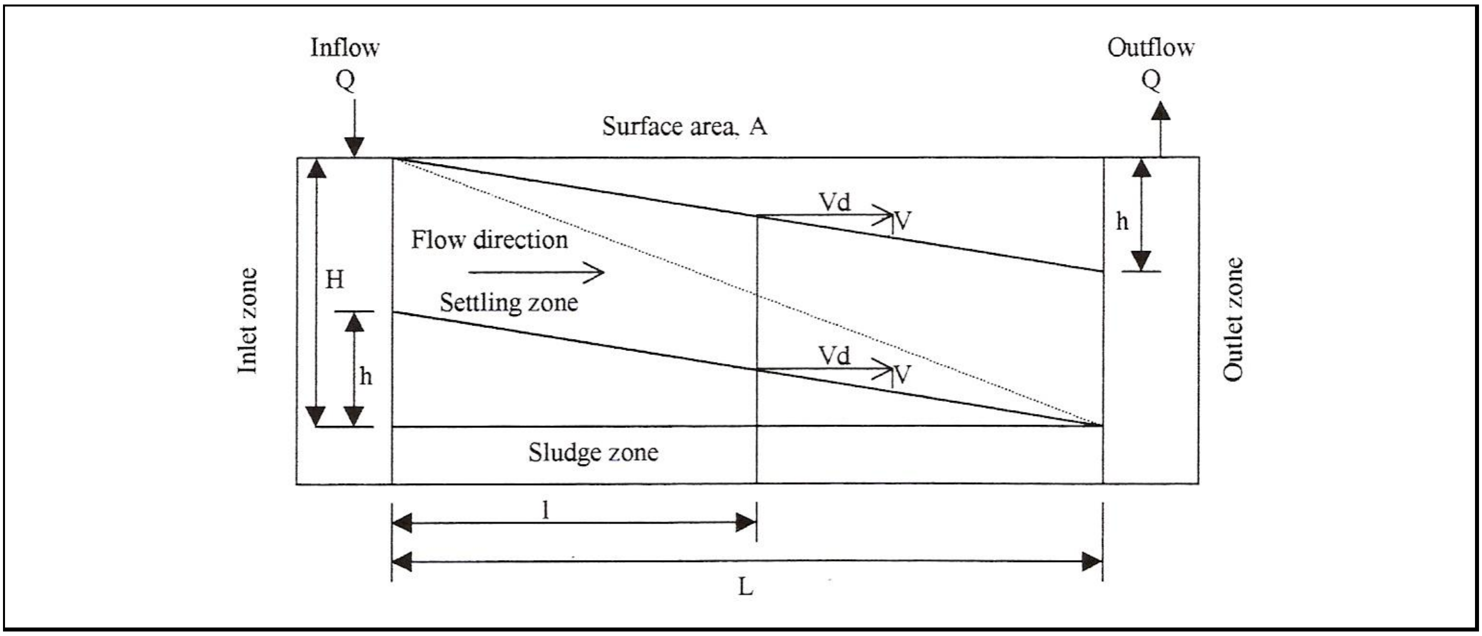


Figure 2.4: horizontal and vertical components of settling velocity, (AWWA, 1990) .

CHAPTER 3

3. MATHRIALS AND METHODS

Field work has been carried out in Jericho district within the period from September 1998 to April 1999. Local data of the existing water system and water treatment plant JWTP, urban development, qualities and quantities of raw water at wadi-qilt have been collected. The collected data are necessary for the optimization of JWTP, since there is a lack of data which concern the water system for the study area, the field work includes physical, chemical, and biological analysis for the raw water in the open canal at wadi-qilt region.

3.1 Jericho water treatment plant JWTP

JWTP consists mainly of three slow sand filters, two supply water reservoirs, and chlorinating unit. The layout of the plant of JWTP which shows units presented in annex A specifications of the water treatment unites are listed in table 3-1.

Table 3.1: the capacities of the water treatment units at JWTP.

Unit	Area (m^2)	Water depth (m)	Volume (m^3)
Filter NO. 1	**134**	**1.0**	**134**
Filter NO. 2	**134**	**1.0**	**134**
Filter NO. 3	**134**	**1.0**	**134**
Tank NO. 1	**157**	**2.3**	**361.1**
Tank NO. 2	**113**	**5**	**565**

3.1.1 Plant operation

The slow sand filters were stopped before January 1999; therefore the only source of water was an Israel water company (MEKKORTH), and January 1999, there was a little amount of rainfall during the period of study. So the effect and contribution of the pollution sources over the open canal was minimized, and the slow sand filters were cleaned and restarted to treat raw water from the open canal.

3.2 slow sand filter experimental model

A slow sand filter is simple in design, construction, and operation. The filter is mainly a bed of sand supported by gravel, which is contained within a box by means of adding and removing the water. One of the main objectives for constructing the experimental model of a slow sand filter is to determine the effect of turbid water on the sand filter operation, and to compare the results when constructing a settling tank as a pretreatment stage.

3.2.1 Palling and design

The experimental model of the slow sand filter will produce about 20 liters per hour or 480 liters per day if it operates continuously. Turbid water was prepared by mixing a specific quantity of soil with raw water from a rainfall collection well, which has the following characteristics: 0.3 NTU turbidity level, and a temperature of 15°C.

3.2.2 tools

- Gravel and sand screens for sizing and cleaning.
- Sand and gravel washing equipment.
- Drill and drill bits, $^3/_4$in. bit to drill holes in the plastic barrel for a $^3/_4$in. pipes.
- Barrel joining tools.

3.2.3 Parts and materials

- Raw water settling tank (60L) for pretreatment to decrease turbidity.
- Two plastic barrels with a volume of 200 liters.
- 250 liters of sand with an effective size of 0.15-0.35mm.

- 60 liter of gravel which has the following size: 20 liters 0.4-3.3mm, 20 liters 3.3-6mm, 20 liters of 6-12mm.
- 6 meters of $^3/_4$in. plastic pipe, 4 ball valves, sealant, small tiles.

3.2.4 construction and operation

To simulate the water treatment process at JWTP, a small-scale slow sand filter experimental model was constructed, operated, and monitored. The slow sand filter is made of two plastic barrels, each of which holds 200 liters: one stacked on the top of the other, making a total height of 180cm. then four holes are cut in the barrels: one for the coming raw water (influent), one for the treated water (effluent), one to drain the scum off the surface of the sand bed, and the fourth hole to drain the supernatant water at resending time. Fig. 3.1 shows the two plastic barrels where the influent valve is installed at 135cm high from the bottom, and the effluent hole is 6cm high from the bottom. The scum valve is 170cm high from the bottom, and the drainage valve is 85cm from the bottom.

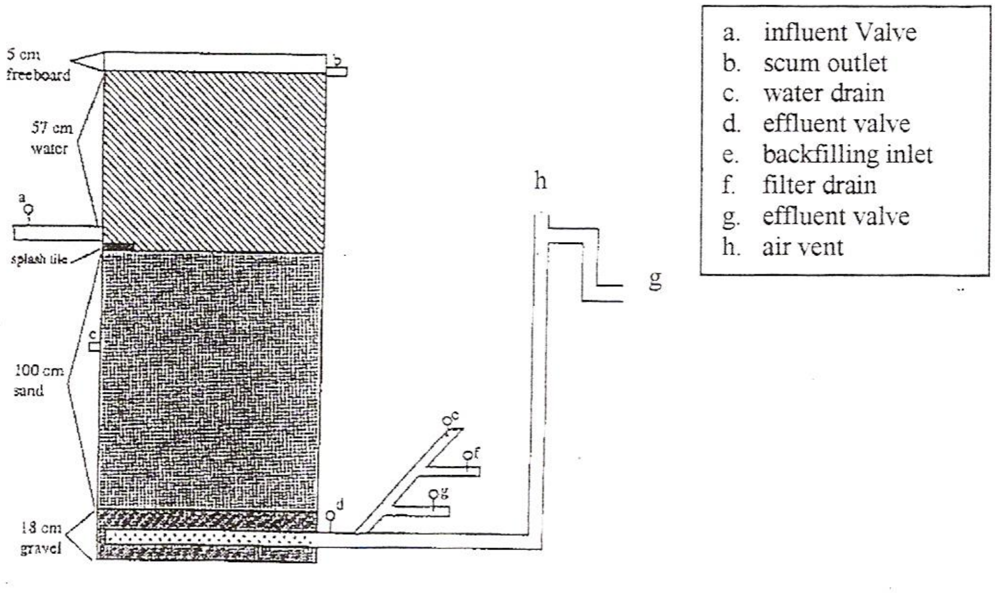


Figure 3.1: configuration of the inlets and the outlets in the experimental model of the SSF

The water drain system consists of the gravel that support the sand layer and a plastic pipe is perforated with a 3mm bit to the under drain pipe, connected to the effluent valve. The gravel and sand are sized and cleaned, then the large gravel is put first, then followed by the smaller gravel for a total height of 18cm. then the lower barrel is filled with sand for a total height of 100cm. small tiles are placed on the surface of the sand bed to prevent erosion of the sand bed.

The startup phase of the slow sand filter was up filling of the barrels in order to remove air pockets from the sand bed. The up filling is performed by supplying water from the effluent valve while the remaining valves are closed except the drainage valve which is left open to remove the water from the surface of the sand bed. Fig. 3.2 shows the experimental model for the SSF under construction.

3.2.5 water quality analysis of the experimental model

When the gelatinous brown layer of schmutzedecke emerged on the top of the sand bed, the sampling bottles were sterilized by washing them with boiling water for a few minuets, then 100ml samples were collected and labeled for each experiment. Turbidity was measured by using the turbidity meter of the HACH laboratory kitt. Collected water samples for the bacterial enumeration (total plate count, TPC), were preserved in an ice cooler. TPC analysis were conducted at the microbiology laboratory of Al-Quds university. Each parameter was analyzed triplicate during the period of operation (March- April 1999).

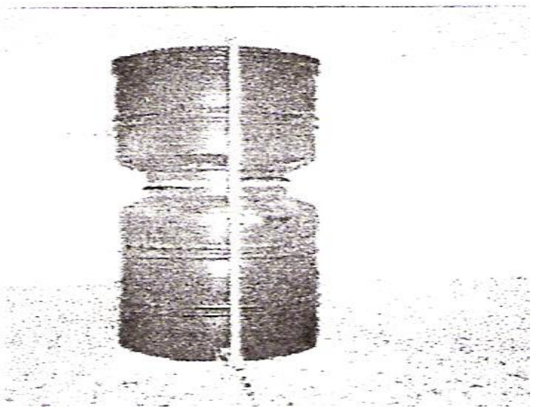


Figure 3.2: experimental model for the SSF at JWTP.

3.3 water quality analysis at JWTP

In order to identify the characters tics of the raw water, and to evaluate the efficiency of JWTP, composite samples were taken from the influent of the slow sand filters with an interval of one hour between each sampling, starting at 10 AM,11 AM,12 AM, and grab samples from the supply water reservoir were taken. Fig. 3.3 shows the sampling point in the influent manhole.

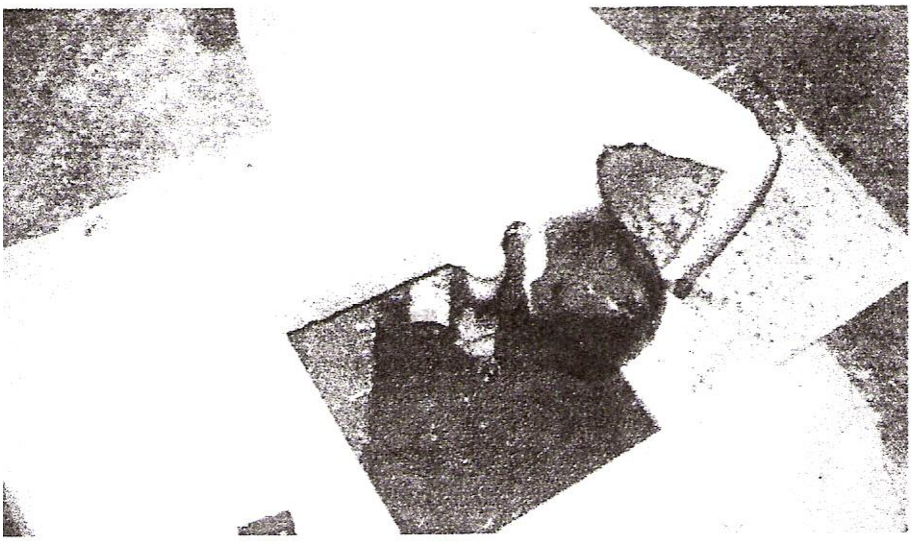


Figure 3.3: water sampling from the influent manhole at JWTP

3.4 site measurements at wadi-qilt

In order to identify pollution sources, and water quality, six sampling stations were selected along the open canal in wadi-qilt, starting from fawar-spring and ending at JWTP. The sampling stations are shown in annex b. the analysis and methods of preservation for the collected samples followed the procedures laid down in standard methods for examining water and wastewater, (PAHA, 1989). The preservation methods and analysis are summarized in table 3.2.

Parameters of interest to measure are: ammonia (NH_3), nitrate (NO_3^-), Phosphate (PO_4^{-3}), dissolved solids (TDS), Electrical conductivity (E C), Turbidity (NTU), temperature, Ph, Sal. %, chlorine, total plate count, and fecal Coli forms.

Table 3.2 methods of analysis and preservation of samples.

Species	**Analysis method**	**preservation**
TDS	Standard method	-
Total plate count fecal coli forms	Standard method	Refrigeration at 4°C
NH_3	Standard method- HACH	Refrigeration at 4°C
NO_{3-}	Standard method- HACH	Refrigeration at 4°C
Chlorine	Standard method- HACH	-
PO_4^{-3}	Standard method- HACH	Refrigeration at 4°C

Beside the sampling in the water open canal at wadi-qilt, many photos of the open canal, sampling stations, and for JWTP were taken to show water pollution sources and for documentation purposes.

CHAPTER 4

RESULTS AND DISCUTION

4.1 Water demand

Discharge flows in Jericho water treatment plant (JWTP) are classified as: production, delivery, consumption and leakage (fig. 4.1).

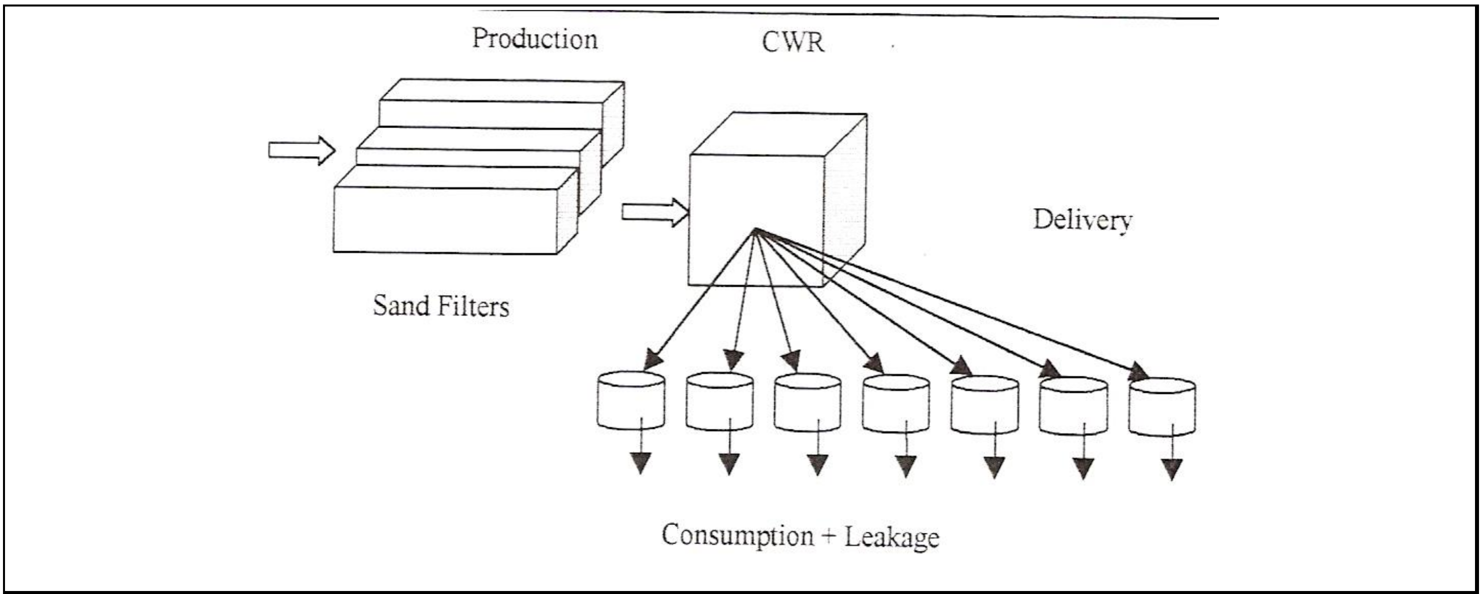


Figure 4.1: water system at Aqbat-jabr

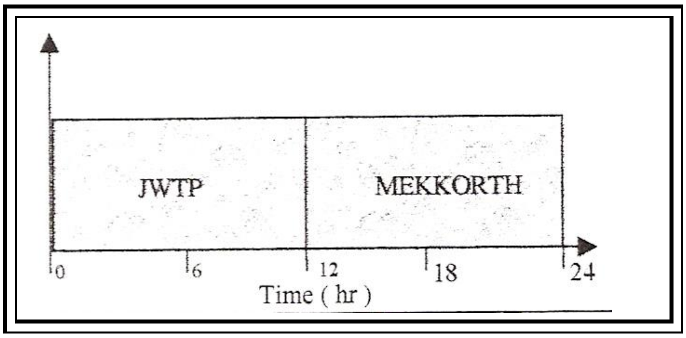
4.1.1 Water production

The existing open canal which supplies the JWTP with raw water from wadi-qilt springs has an annual average flow rate of 1000m^3 per day. Sine 1956 the owner of the open canal has been supplying the JWTP with 240m^3 per day for production of drinking water and the remaining amount is used for agriculture, and since 1995 an extra 260 m^3 per day quantity of raw water has been being supplied for the JWTP to provide adequate quantity of potable water for Aqbat-jabr camp.

4.1.2 Water delivery

A clear water reservoir was constructed to be balance storage at the entrance of the distribution network. The produced quantity of water is directly pumped from the treatment plant into the network, and for the past five years an additional pipe from MEKKORTH was used to supply more water for the camp, the delivery pattern is illustrated in fig. 4-2.

Figure 4.2: daily water delivery pattern for Aqbat-jabr



4.1.3 Water consumption

There is a variation in the water consumption at Aqbat-jabr which caused by the following factors:

- Seasons: during the past summer the water consumption exceeded 800 cubic meters per day, while in winter it was less than 400 cubic meters per day.
- Capacity of source: the depth of water in the open canal was observed during the period of study. The maximum recorded depth of water was in the winter of 1999, about 15 cm at the entrance of the JWTP, which it was about 5 cm in the summer of 1998.
- Raw water quality: it was found that there was a drop in water consumption when there were problems in the JWTP. That drop was caused by an extensive discharge of pollutants in wadi-qilt.

4.1.4 Water leakage

Water transport system at Aqbat-jabr is of a serial or branched type. The total water network lengthy is more than 2.3 km, the diameter of the main pipe is 6 inches of ductile iron, eater leakage is more or less considered to be constant and small because the old main pipes were replaced by new one.

4.1.6 Nondomestic demand

It is the water that consumed by livestock and for irrigation, the quantities for water needed for both types is in Jericho are illustrated in tables 4.1, 4.2.

Table 4.1: seasonal crop water needs (Trifunovic, 1997).

Crop	**Season Days per year**	**Consumption mm / season**
Banana	**300 – 365**	**1200 – 2200**
Potato	**105 – 145**	**500 – 700**
Tomato	**135 – 180**	**400 – 800**

Table 4.2: Animal water consumption (Trifunovic, 1997).

Animal	**Consumption L / animal .day**
Cow	**25 – 150**
Sheep . Goat	**5 – 6**
Chicken per 100	**25 – 30**

4.1.7 demand forecasting

Exponential model is used in order to predict water demand forecasting for the coming ten years. Thus,

$$Q_{2009} = Q_{1999} * (1 + a / 100)^n$$

Where Q_{2009} = water damned forecasting in 2009, cubic meter per day.

Q_{1999} = 500 cubic meter per day in 1999.

A = average annual population growth = 3.0%

N = design period = 10 years.

SO, Q_{2009} = 67.96 (672 cubic meter per day).

4.2 Sources of pollution

The several walks along the open canal starting from fawar spring towards the JWTP, have shown that there are four principal pollution sources: natural pollution, pollution from wastewater discharge in wadi-qilt, pollution reaching bodies by an indirect way, and pollution incidental to water sources management.

Natural pollution: it involves pollution of rain by the impurities of the atmosphere from the following sources:

- Large stone cutting and asphalt making factories several kilometers far from wadi-qilt, which discharge clouds of dusts and hazardous impurities.
- The dumping sites for the following areas: Al-Bireh city, Anata, hezma, jabaa, mukmas, kfr-Aqb, Anata-camp, and the Israelis settlements near those villages. These sites are not owned by the municipal council in each location. Most sites are started with small areas, then expanding on the expense of the local authorities, on the other hand these sites are not chosen in accordance with environmental considerations, and some of these sites are unable to receive any solid waste. There is no treatment facility in these sites, except burning the body of the land fill which generates huge black smoke and hazardous impurities in the atmosphere.
- Soil and rocks pollution.

4.2.1 pollution from wastewater discharge

The streams of wastewater (untreated, partially treated, intensively treated) reach wadi-swenetta directly or indirectly by soil pollution and leaching out of soil pollution by percolation to ground water or surface runoff as shown in figure 4.4. streams of wastewater are discharged directly in the same wadi, from the following areas:

- Al-bireh city
- Kfr-Aqb
- Jabaa
- Anata camp
- Al-bireh dumping site
- Anata
- The following Israeli settlements:
  - Besjat-zeieb, Alamon, Antot, ras-taweel, maٌ ale Adummim, and pesabot

The largest wastewater pollution in wadi-qilt was in 1987 where all fish and other forms of life died and the color of water turned into a gray color with odor. The main source of that pollution was Al-bireh city, besgat-zeieb, and Jerusalem electricity company. The Israeli nature authority prevent some of the mentioned settlements from discharging their wastewater into the valley. These measures have reduced the waste water pollution, but the problem still exists, especially in winter, as shown in fig. 4.3, where large areas in wadi-qilt were covered with wastewater.

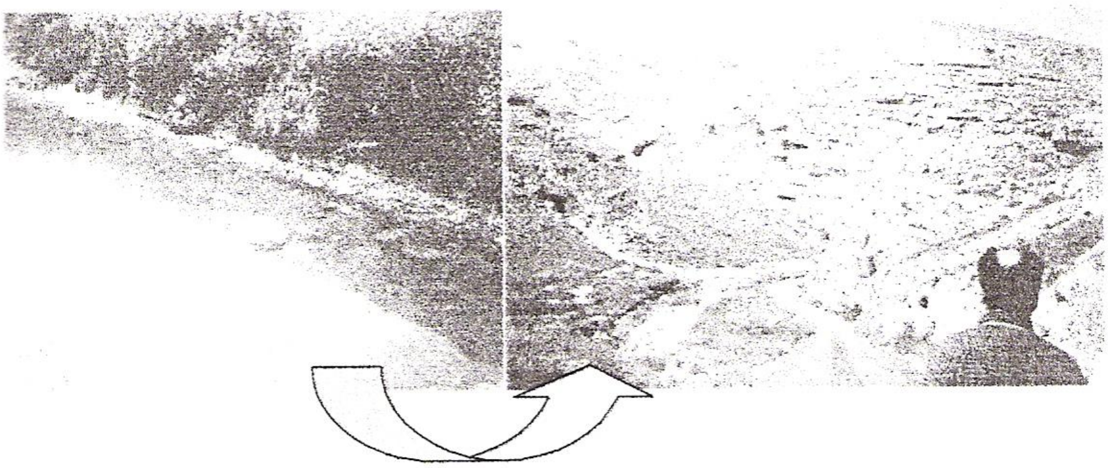


Figure 4.3: wastewater near fawar-spring in wadi-qilt

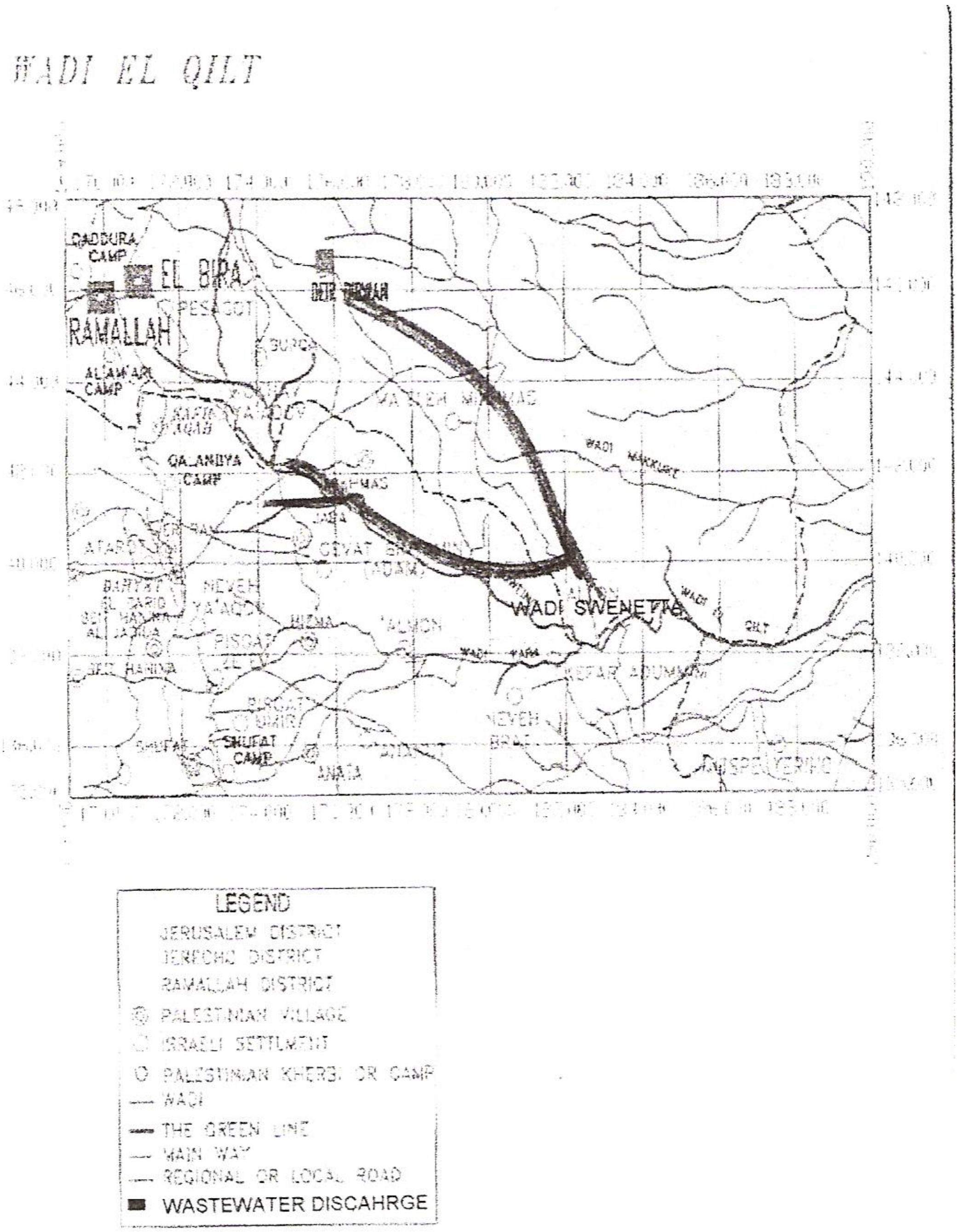


Figure 4.4: wastewater discharge in wadi-swenetta

4.2.2 Pollution from livestock

The presence of large numbers of livestock in wadi-qilt have an obvious and direct effect on bacterial contamination in the from of fecal coli form bacteria in the water of the open canal. On the other hand many Bedouins who are living their used to wash and clean their cattle directly in the open canal. Manure and wastewater from animal feeding operations in the open canal add pollutants to the water stream such as: nitrogen, phosphorus, sediment, pathogens, heavy metals, hormones, antibiotics and ammonia.

4.2.3 Pollution from recreational activities

Recreational activities, such as camping and walking in wadi-qilt, can impact the water quality and flow properties in the open canal large number of visitors are visiting this area because it is the oldest and lowest area in the world, and there is a very old church (Der Mar-Jaries) down the valley. The open canal itself, where many visitors are walking along the canal until they reach Jericho is polluted. Large quantities of cans, plastic bags, bottles, clothes, stones and others can be seen along the open canal, as shown in fig. 4.5.

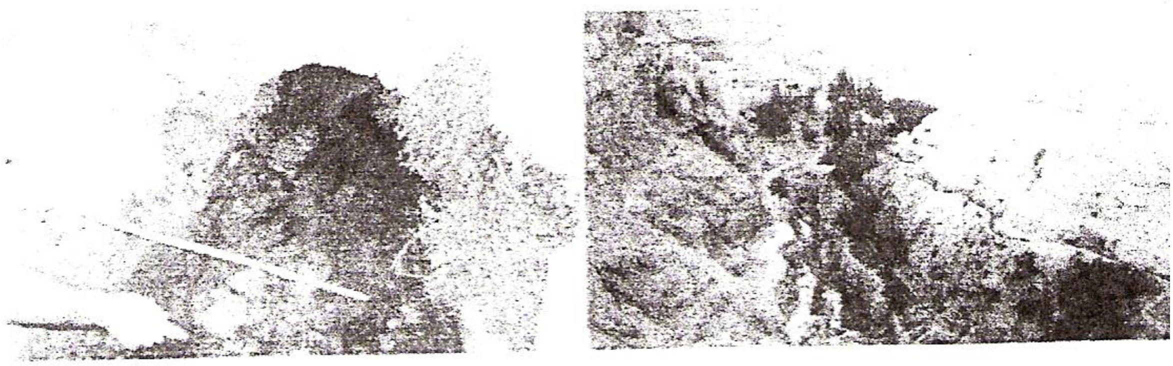


Figure 4.5: stones and plastic in the water open canal near Der Mar Juries.

4.2.4 pollution from algae

Surface water is habitats for the growth of algae, the amount of growth of algae in the open canal is extensive because there are nutrients, and turbidity, temperature, and sun light in summertime and in wintertime as shown in fig. 4.6.

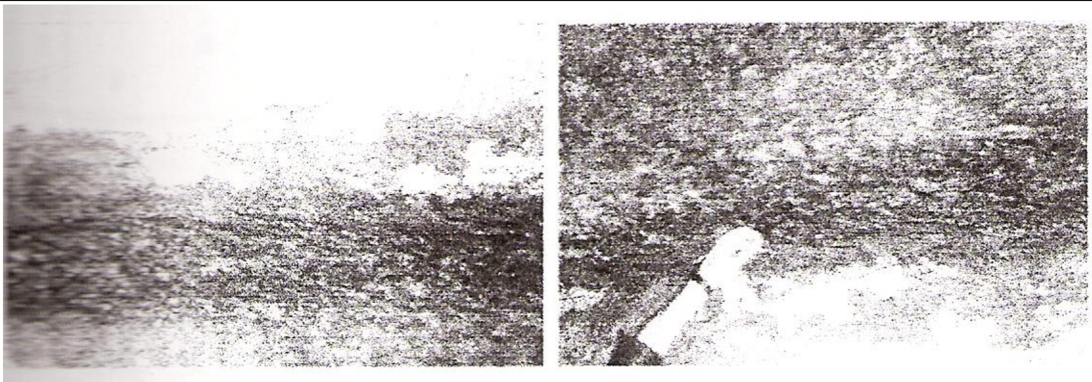


Figure 4.6: extensive growth of algae in the water open canal

The growth of algae in the open canal in wadi-qilt is gradually increasing with increasing of new residential colonies in the surrounding area, which increase the discharge of municipal wastes in the valley. In January 1999 through May a high growth of blue-green algae was observed and in July 1998 through December green algae was observed. The blue-green algae showed a maximum growth rate in April 1999, and a minimum growth in January 1999, while green algae showed a maximum growth in August 1998, and a minimum growth in December 1998.

Phosphorus and nitrate are an essential factors in supporting the growth of algae. The concentrations of both species in the samples which were collected during the period of study from the open canal at entrance of the JWTP are shown in fig. 4.7.

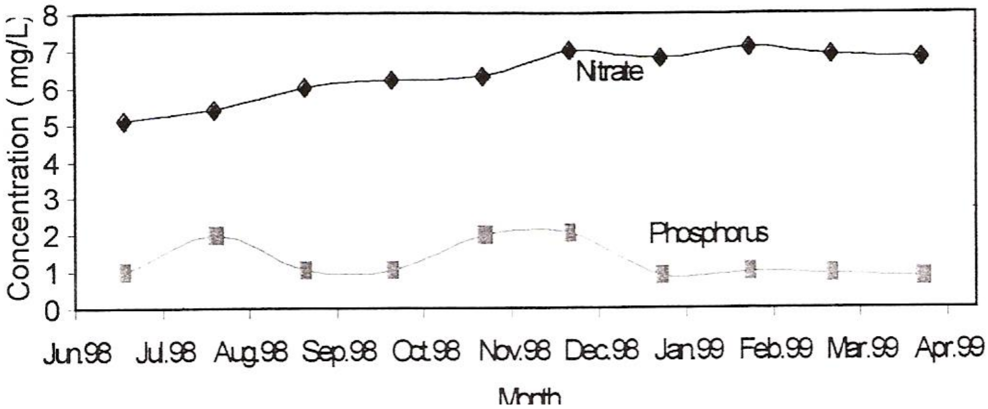


Figure 4.7: phosphorus and nitrate concentration in the sampling stations. (1998-99)

4.3 water sampling in the water open canal

In order to predict the water quality in the open canal through its traveling 13km long branch in wadi-qilt, where it is subjected to the several types of pollution, samples were collected from different stations along the open canal, each station is about 2km far from the other station starting from fawar-spring as shown in appendix B. tables 4.3, 4.4 shows chemical analysis of the water in the open canal. The concentration of nitrate between WQ1 and WQ6 was relatively small, and there was no big difference.

Table 4.3: water samples analysis for the water open canal – 27/12/1998

Station	PH	T (°C)	TDS (mg/L)	Salinity (%)	EC (us)	NO_3^- (mg/L)	$CACO_3$ (mg/L)	Turbidity NTU
WQ1	7.01	14.2	442	0.2	800	8.0	0.25	3.5
WQ2	7.03	14.9	446	0.2	805	8.5	0.27	3.7
WQ3	7.12	14.7	449	0.2	805	8.5	0.28	4.2
WQ4	7.22	14.6	452	0.2	817	9.0	0.3	5.3
WQ5	8.01	15.0	461	0.2	830	10.0	0.3	7.0
WQ6	8.02	15.5	470	0.2	835	12.0	0.3	10.5

Table 4.4: water samples analysis for the open canal – 11/04/1999

Station	PH	T (°C)	TDS (mg/L)	Salinity (%)	EC (us)	NO_3^- (mg/L)	$CACO_3$ (mg/L)	Turbidity NTU
WQ1	7.6	19.5	340	o.3	701	6.0	0.4	1.5
WQ2	7.73	19.9	341	o.3	702	5.0	0.4	2.0
WQ3	7.74	20	342	o.3	717	8.0	0.5	3.0
WQ4	8.14	22.9	344	o.3	718	7.0	0.7	4.0
WQ5	8.13	22.8	344	o.3	718	6.0	0.7	4.0
WQ6	8.2	22.7	343	o.3	718	6.0	0.8	4.5

At the entrance of the JWTP water samples were collected during the period of study (19998-1999), and several measurements for the turbidity were performed as shown in fig. 4.8. during the peak values of turbidity the JWTP was stopped and the turbid water was used for irrigation only and the pipe of MEKKORTH was opened to supply Aqbat-jabr with water which has a turbidity level less than 1 NTU.

Table 4.5 shows that the concentrations of nitrate, and ammonia at sampling stations which were not large. This is because of extensive algal growth and weak nitrification process in the open canal, since nitrifiers are Cessile bacteria, which need support material and non- turbulent flow velocity, and these conditions are not prevailing in the open canal. So do not expect much nitrate in the raw water, even it might be polluted, however during the sampling period the pollution from wastewater was at minimum.

Table 4.5: nitrate, ammonia, and ammonium concentrations – 04/08/1999

Station	NO_3 (mg/L)	NH_3 (mg/L)	NH_4^+ (mg/L)
WQ1	4	1	1.30
WQ3	5	1.1	1.43
WQ6	6	0.9	1.17

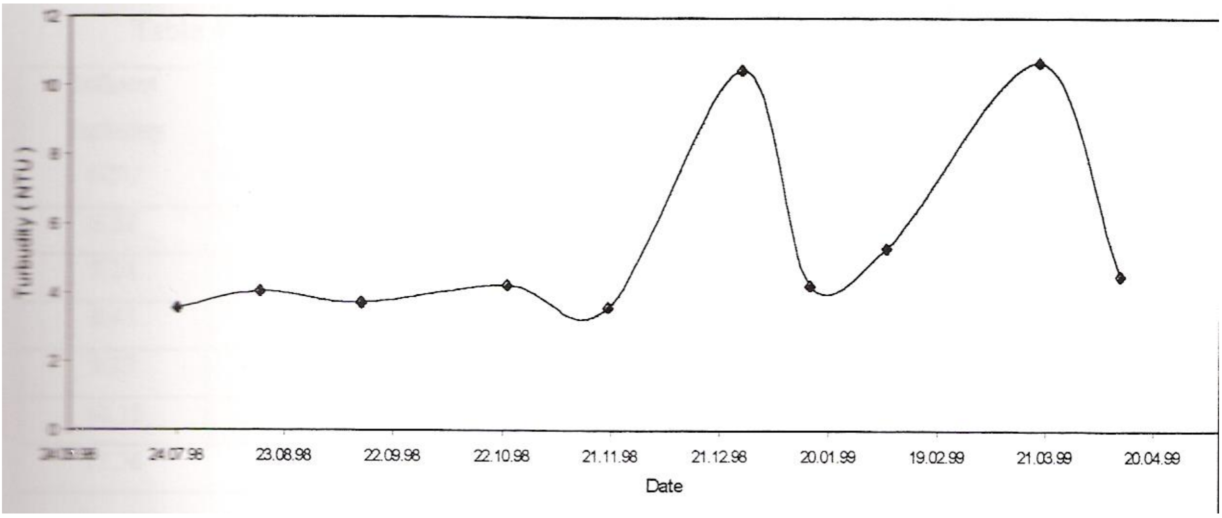


Figure 4.8: variation of turbidity at the entrance of JWTP.

4.4 Operation and management at JWTP

The water treatment plant JWTP was visited frequently each week during the period of study in order to identify the operational and management problems. There are three principal sources of operational problems: turbidity, extensive algae growth in the open canal and the filters, and available water pressure. There are three principal sources of management problems: management structure in JWTP, training of the operators in JWTP, and communications.

4.4.1 Turbidity

When the turbidity levels exceeded 20 NTU the slow sand filters were stopped due to clogging of the voids among the sand grains. A pretreatment, including settling is proposed to lower the turbidity levels: fig. 4.9 shows the proposed layout at JWTP, the settling used for another purposes such as pre-chlorination when there is a heavily polluted raw water from the open canal, and for chemicals dosing. Laboratory tests to predict the proposed pretreatment which includes settling, were carried out utilizing the designed experimental model of a slow sand filter during the period of study. Table 4.6 lists the input level of turbidity in the influent and the levels of turbidity in the effluent without using a pretreatment. Table 4.7 lists the effluent turbidity when using the proposed settling tank. Both results are shown in fig. 4.10. fig. 4.11 shows the removal efficiency for the experimental model in both cases.

Table 4.6: SSF experimental model removal efficiency without settling tank.

Influent Turbidity NTU	Effluent Turbidity NTU	Removal Efficiency %	Influent Turbidity NTU	Effluent Turbidity NTU	Removal Efficiency %
5.22	1.73	67	15.71	3.63	77
7.31	2.16	71	16.34	4.01	75
8.43	2.25	70	19.67	4.38	78
9.27	2.78	71	21.31	5.13	76
10.15	2.70	74	25.49	6.97	73
11.36	3.12	73	27.85	*	0

Table 4.7: SSF experimental model removal efficiency with settling tank.

Influent turbidity NTU T=0 hour	Influent turbidity NTU T=1 hour	Influent turbidity NTU T=2 hour	Influent Turbidity NTU	Removal Efficiency %
5.22	4.31	3.21	0.72	86
7.31	6.45	4.78	0.81	89
8.43	7.12	5.12	0.98	88
9.27	8.11	6.26	1.82	91
10.15	9.32	6.83	2.02	80
11.36	10.36	7.03	2.51	78
12.82	11.55	8.34	2.66	79
13.58	12.57	9.46	2.98	78
15.71	13.23	10.14	3.31	79
16.34	14.15	10.79	3.55	78
19.67	15.62	12.09	4.03	80
21.31	18.66	14.88	4.67	78
25.49	20.34	16.79	4.98	81
27.85	24.36	17.87	5.33	81
42.74	36.54	19.91	6.33	85
50.87	41.22	25.98	6.76	86

(*: The filter was clogged, effluent flow rate=0)

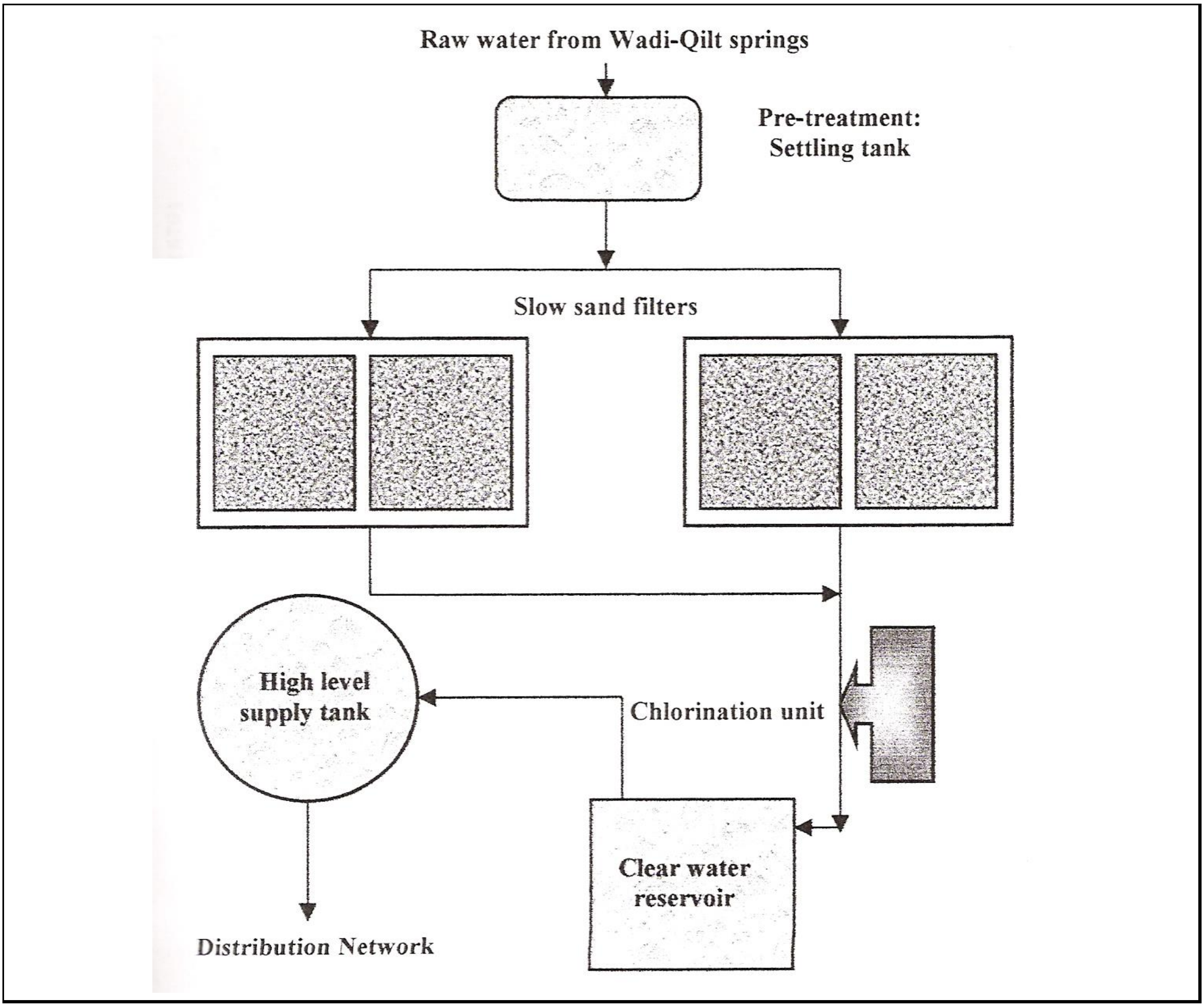


Figure 4.9: schematic diagram for the proposed water treatment plant at JWTP.

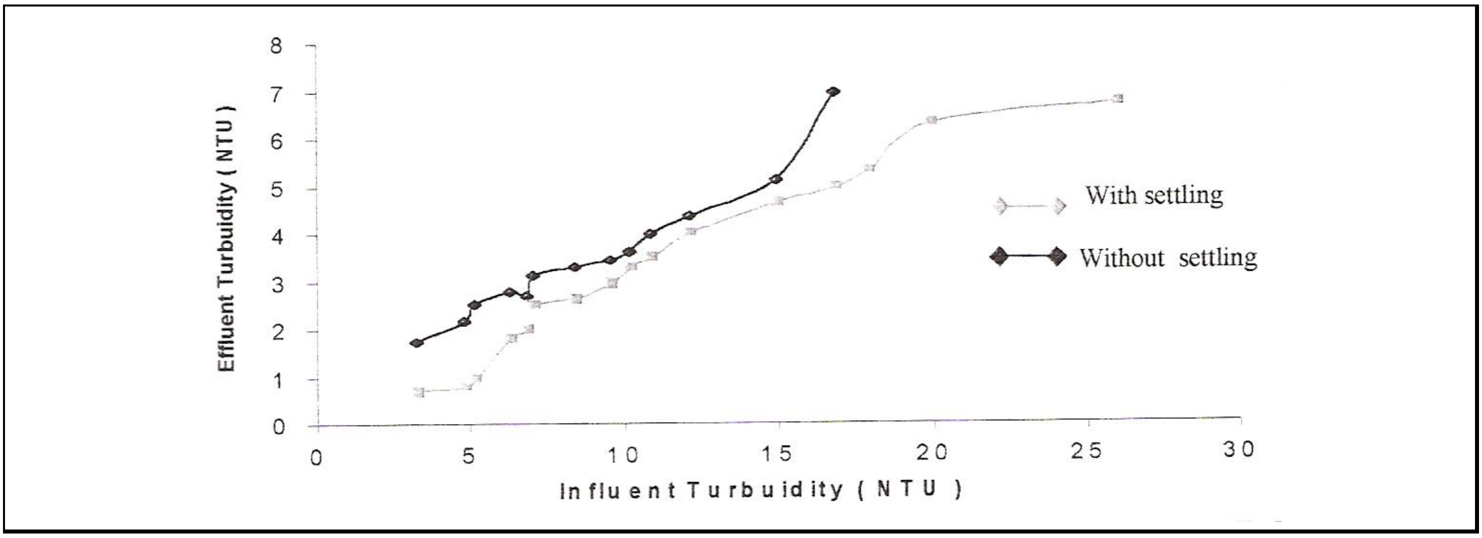


Figure 4.10: effluent turbidity levels with and without settling tank.

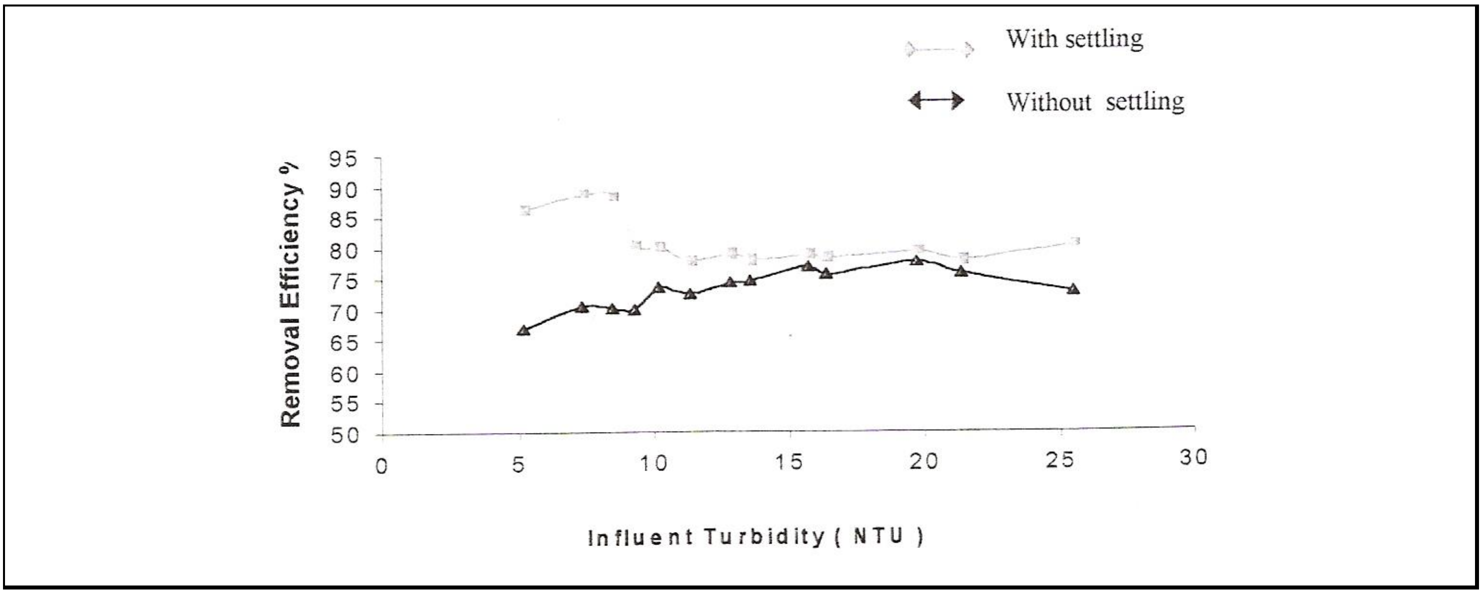


Figure 4.11: turbidity removal efficiency for the SSF experimental model.

4.4.2 Algae growth

Water open canal, sand filter basins, and water supply tank, are habitats for algae growth, which are mainly affected by the light and nutrients in the raw water. The following problems are found in JWTP due to algae growth:

* Taste and odor in the treated water.
* Resistance of water flow in the treatment plant, and in the water open canal.
* Filter clogging.
* blue algae produces extracellular products and toxins in the water.
* Filter cleaning.
* Algae removal and disposal.

To minimize the effect of algae at JWTP there are two options:

1) Adding copper sulfate 1.7mg/L in the pretreatment stage (AWWA, 1990).
2) Covering the sand filters with removable plastic cover which reduce the sunlight, there fore it reduce the algae growth.

4.4.3 Pressure of the supplied water

During the visits to Aqbat-Jabr, most of the people are complaining from water pressure saying that it is not enough to fill their roof tanks, and other consumers such as the YMCA have to buy booster pumps to fill the tanks. It was found that the length of the network is more than 23km, so the quantity of the treated water is not enough to fill the whole network. On the other hand the main supply line has a diameter of 6inches, which is relatively large.

There are other operational problems such as controlling the feeding rate. While taking samples it was noticed that the operator used to increases the water feeding rate for more than 0.6 m/h to fill the sand filter more quickly. Another technical problem is that the erosion of the sand when feeding the filters and short-circuiting is likely to happen.

4.4.4 Management structure at JWTP

The evaluation of the water treatment plant management program at JWTP illustrates some of the unique problems of conflicting goals and constraints associated with an area under rapid development while facing conditions of scarcity. Figure 4.12 shows the existed management structure at JWTP

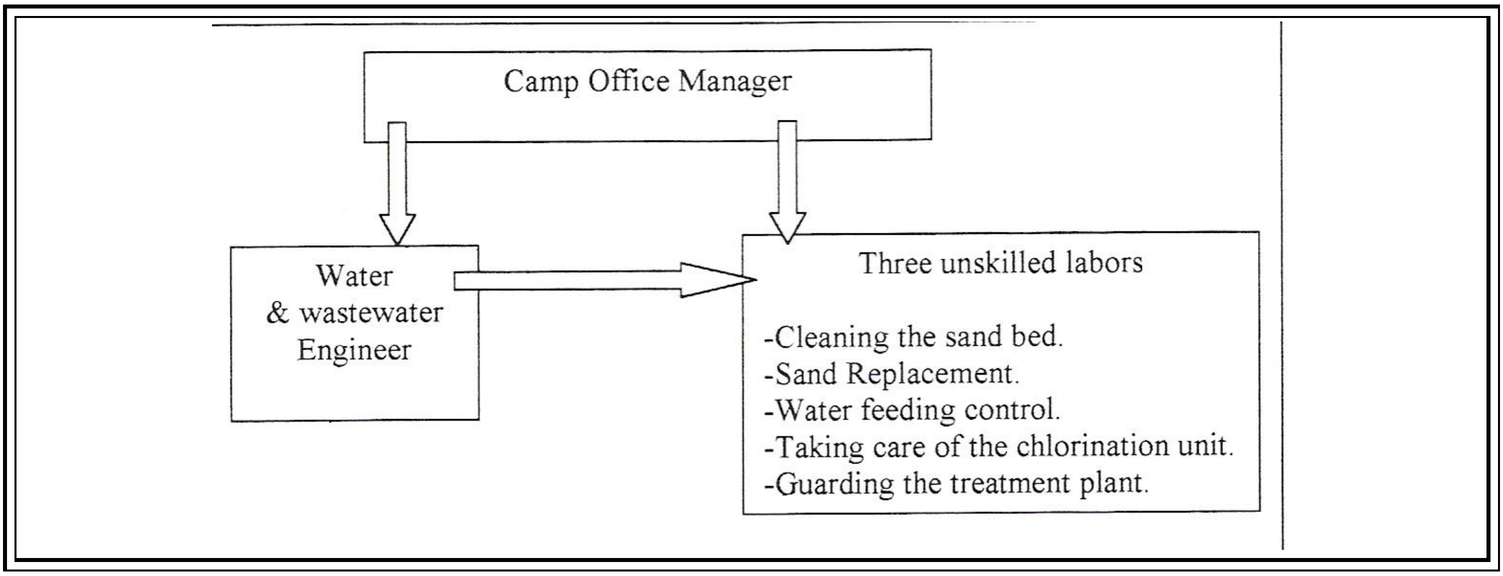


Figure 4.12: schematic presentation of the existing management structure at JWTP.

The proposed management structure includes another skilled labor, who will perform water sampling from the pretreatment tank, water reservoir, water supply tank, and five sampling points in Aqbat-jabr camp. Also he will perform a monthly sampling from selected sampling points along the water open canal in wadi-qilt, and he will do the chlorination for the water reservoir. All samples should be collected in accordance with procedures set forth in the standard methods for examination of water and wastewater. The sampling employee will measure the following parameters monthly from the water open canal:

1) Color
2) Total coli form/100ml.

3) Odor
4) PH.

Another chemical analysis such as measuring nitrate, sodium, chloride, Alkalinity, hardness, iron, and manganese, should be measured semi-annually. These guidelines for monitoring the water supply system require the presence of laboratory equipment at JWTP, there are many types of portable laboratory such as HACH kits which can be used effectively. Biological test can be done at the nearest laboratory in Jericho district. Fig. 4.13 shows the proposed management structure.

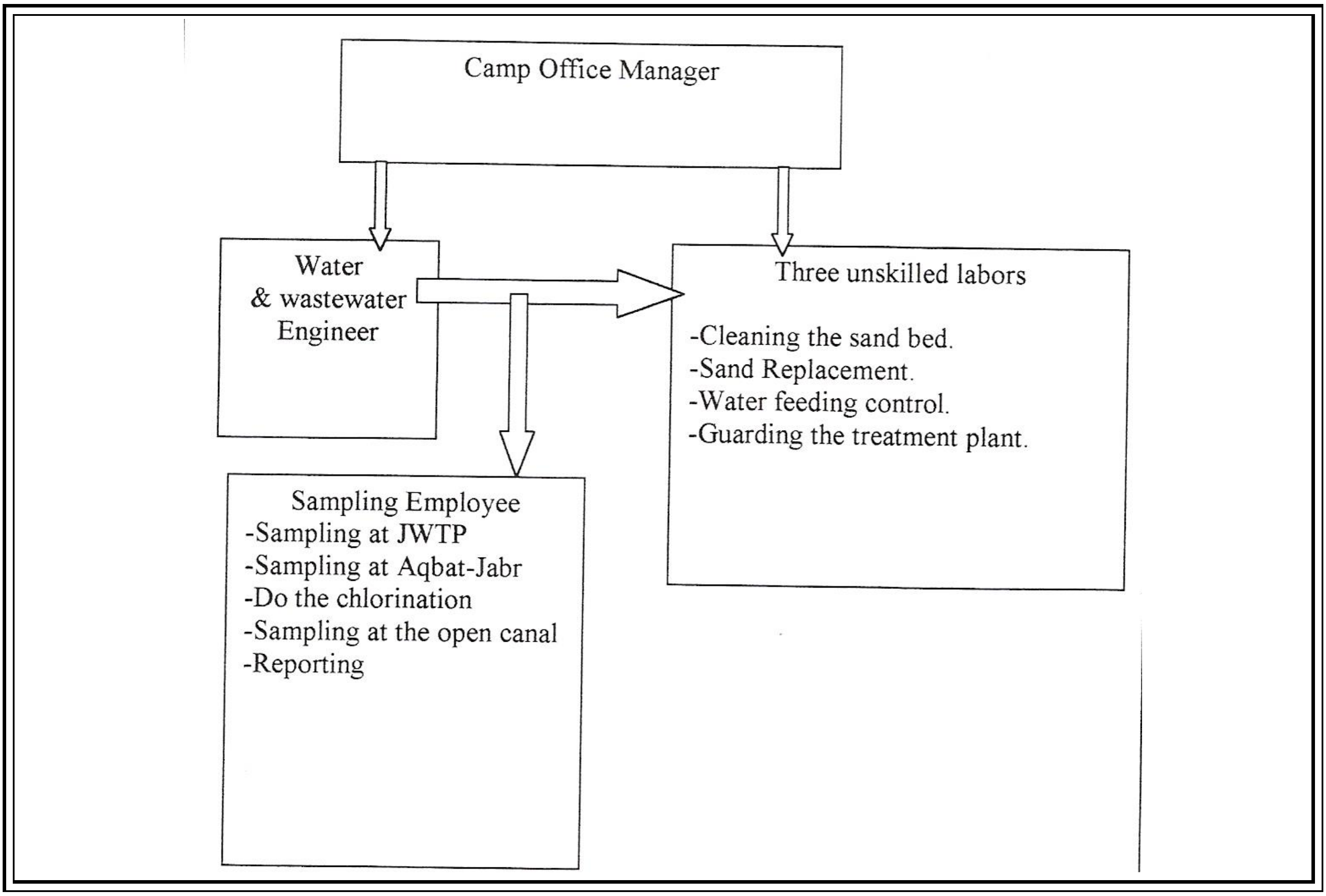


Figure 4.13: schematic presentation of the proposed management structure at JWTP.

Training: many problems in the technical operation results from the lack of training of the maintenance labors, such problems can be seen in fig. 4.14 where it shows incorrect method for measuring the residual chlorine for a water sample from the water reservoir. On the other hand there is no communication device such a telephone between the labors at JWTP and the camp office manager.

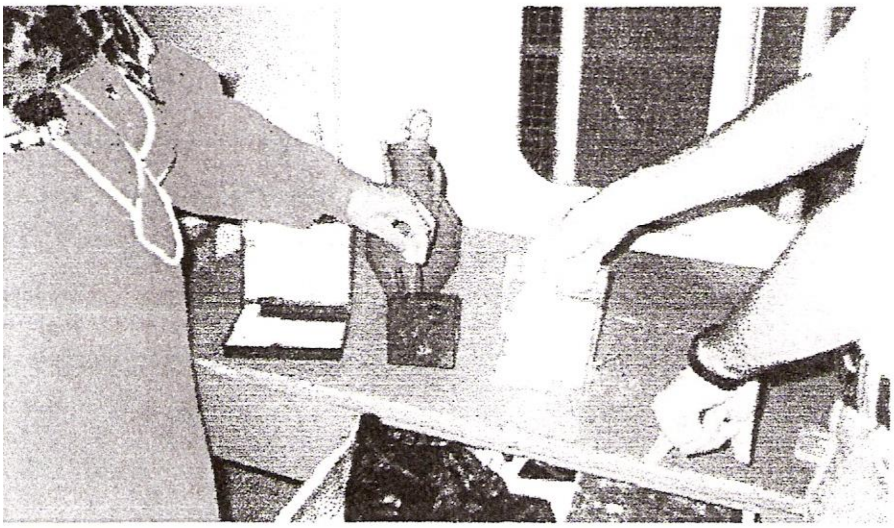


Figure 4.14: measuring the residual chlorine for a sample from the CWR.

Operation

The technical operation of JWTP must fulfill the following requirements: treated water as drinking water source, all parties involved in the technical operation of JWTP (management level UNRWA, Aqbat-jabr camp and technical staff) are responsible for providing a safe drinking water of the following:

- Free of water born disease causing pathogens.
- Free of microorganisms.
- Clear, odor free, and without objectionable taste by consumers.
- Water quality according to the Palestinian standards for drinking water.
- Sufficient quantity of drinkable quality, and with enough pressure to households.

Management level

The UNRWA and Aqbat-jabr camp are responsible for management and operation of JWTP. They must fulfill the followings:

- The JWTP must be operated to deliver a drinkable water according to the Palestinian standards for drinking water.
- Provision of organizational, personnel, and financial aspects to ensure adequate operation of JWTP. Proper personnel and adequate water quality monitoring program must be provided. Job description, duties, and responsibilities of technical staff must be defined.
- The operators must have adequate level of education and training. They must get regular technical and scientific training. New operators, must undertake regular health check, or every three years once by an accredited medical laboratory.
- Provision of safety measures and regulations. Public awareness, campaigns on the role and significance of JWTP should be made.

Technical staff

- The duties and responsibilities of technical staff are clear and well specified in the job description and employment contract.
- The staff have to report regularly on water quality, of treated water and on pollution events, to identify the source, causes, and provide proper solution.
- The staff must be mentally and physically best qualified for this high demand post. Technical understanding, hard work skills, basic natural and engineering knowledge in water treatment and water analysis must be available.
- Germ carrier, ill or epidemic suspected persons are not qualified as technical staff. The technical staff should apply all possible and available safety protective measures and regulation.

4.5 economical analyses

The prices of the supplied water at Aqbat-jabr are as follows:

- From JWTP: 1.0 NIS per cubic meter.
- From MEKKORTH: 2.0 NIS per cubic meter.

If the water consumption exceeds 500 cubic meters per day the owner of the water open canal takes 0.5 NIS for each additional cubic meter.

4.5.1 Investment costs for JWTP process modification

In order to apply the management and technical modification they must be economically feasible. After cost estimation for process modification, a water price comparison between JWTP and MEKKORTH is made as follows:

The modifications on water treatment process are as follows:

- Erection of new settling tank (30m^3) = 30000 NIS
- plastic cover for sand filters = 5000 NIS
- mobile water quality Kitts = 10000 NIS

The total annual costs of this process modification consist of the fixed and variable costs. The fixed costs are those for settling tank, plastic cover, and mobile water quality Kits. The variable costs are the salary of the new employee and operation and maintenance costs (2000 NIS).

For a consumption of 500 cubic Meter per day:

Water supply: JWTP
Monthly water consumption = 500×30= 15000 cubic meter per month
Monthly cost = 15000×1 NIS = 15000 NIS
Annual cost = 15000×12 = 180000 NIS
Fixed cost = 45000 NIS
Money back period (n) =10 years

Assuming Interest rate (r) =8%

$$Annuity = I \times (r/ (1-(1/ (1+r)^{n}))$$

Where, I: Investment

Hence, Annuity = 6706.3 NIS

Total annual cost = 180000+6706.3+2000×13= 212706.3 NIS

Water supply: MEKKORTH

Monthly water consumption = 500×30= 15000 cubic meter per month

Monthly cost = 15000×2 NIS = 3O000 NIS

Annual cost = 30000×12 = 360000 NIS

Fixed cost = O NIS

Total annual cost = 360000 NIS

The difference between the annual costs = 147294 NIS

⇒ The Annuity increase over the ten years (with MEKKORTH) = 14729 NIS/ year.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

- After ten years, in 2009 JWTP will be able to provide a sufficient quantity of water if a new slow sand filter is added near the existing filters, since the forecasting water demand will be about 672 cubic meters of water per day, while JWTP has a production capacity of 500 cubic meters of water per day.

- The existing clear water supply tank has a volume of 361 cubic meters, which is insufficient for filling the pipes in the network which has a length of 23km. therefore the available pressure will be insufficient for filling the roof tanks of the consumers at Aqbat-jabr.

- The search for pollution sources in the study area shows that, the discharge of municipal wastes at wadi-swenetta is mainly coming from Al-Bireh city and the near Israeli settlements. Therefore, both parts must be responsible for water quality degradation, and any related damaged for the environment.

- The identified recharge area in the study area which is located within the green line is not Representative, because it must be defined with reference to the location of the existing springs (see Annex c).

- The water sampling and analysis show turbidity levels above 20 NTU for more than a few days at a time, which causes failure of the treatment process and clogging of the sand filters.

- There are two options that can be used to reduce extensive algal growth in the slow sand filters. First, by reducing the sunlight over the sand filters, using plastic covers. Second, by adding chemicals such as cupper sulfate.

- The relationship between the growth of blue algae and temperature is positive at JWTP, while it is negative between the growth of green algae and temperature.

- According to the raw water sampling analysis (fig. 4.7), the extensive growth of algae has a close relation with the concentration of phosphorus and nitrate in raw water.

- JWTP is poorly operated and managed.

- According to the results of the experiments on the designed slow sand filter experimental model, turbidity and coli forms are the main constraints for the operation of a SSF. A turbidity level more than 20 NTU will cause clogging of the sand bed, and the large number of coli forms requires an efficient method for disinfection, such as chlorination.

- Based on the results of the experiments on the experimental model of a slow sand filter, the existing treatment process at JWTP can be operated continuously with a turbidity removal efficiency exceeding 85% if there is a settling tank for the influent.

- Sand erosion at the surface of the sand bed is likely to happen because the water feeding rate at JWTP exceeds the design value (0.2-0.3m/h), also because of short-circuiting which occurs through the sand bed.

- According to the results of the economical analysis, it is found that JWTP with the proposed modification will be an economical feasible option compared to MEKKORTH.

Recommendations

- It is recommended for future planning that the water from the open canal must be used at JWTP, because high percent of the used water in agriculture is lost by evaporation. On the other hand the people of the region must start thinking more seriously in reuse of wastewater for irrigation since the region will suffer in the coming future from the conditions of water scarcity.

- Erection of new operation units (sedimentation tank, slow sand filter, upgrading the size of clean water holding tank as an urgent need). This will enhance the treatment efficiency of JWTP at low investment costs.

- It is recommended one the sensitive areas are defined, the outside recharge areas activities resulting from urban development should not be ignored. Therefore a regional water quality management plan is needed to identify specific regulations and land use for this area, also it will be responsible for taking samples at water sources and analyses.

- A training program must be given to all labors at JWTP in order to avoid operational, managerial problems, and minimize public health risks.

- In order to decrease water losses effective maintenance is needed. Therefore it is important to have a specialized group with necessary tools, vehicles, and well-organized plan for the proper maintenance of the network, meters, and the treatment plant.

- Conducting of public awareness programs in the sphere of aquatic environment protection, the wise use of water will minimize pollution and pressure of water sources. And raise the public environmental awareness through media, schools, seminars, video clips, and Professional conferences.

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Appendix A

Layout of the existing water treatment plant in Jericho

FIGURE 1: shows the site plan for Jericho water treatment plant

Which contains the following units?

- Three existing water pools (slow sand filters).
- The site for the proposed slow sand filter.
- Two supply water reservoirs.
- The guard room which contains the chlorinating unit and the electrical control box for JWTP.
- Pump room which is an old mechanical pump used to pump water to a service tank (not shown in the map because it is out of the site plan).
- Part of the open channel.
- Treatment plant entrance.

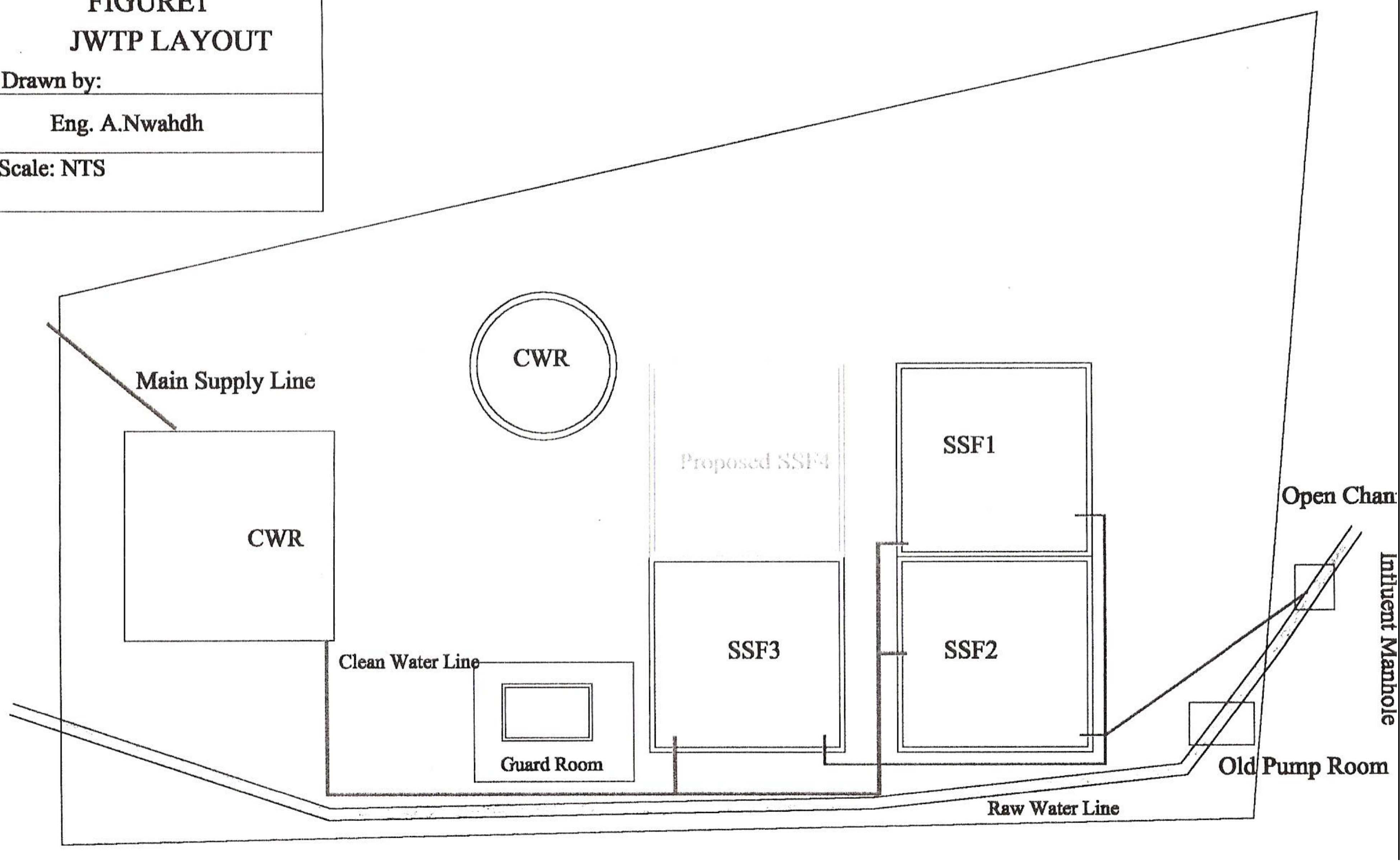
FIGURE1

JWTP LAYOUT

Drawn by:

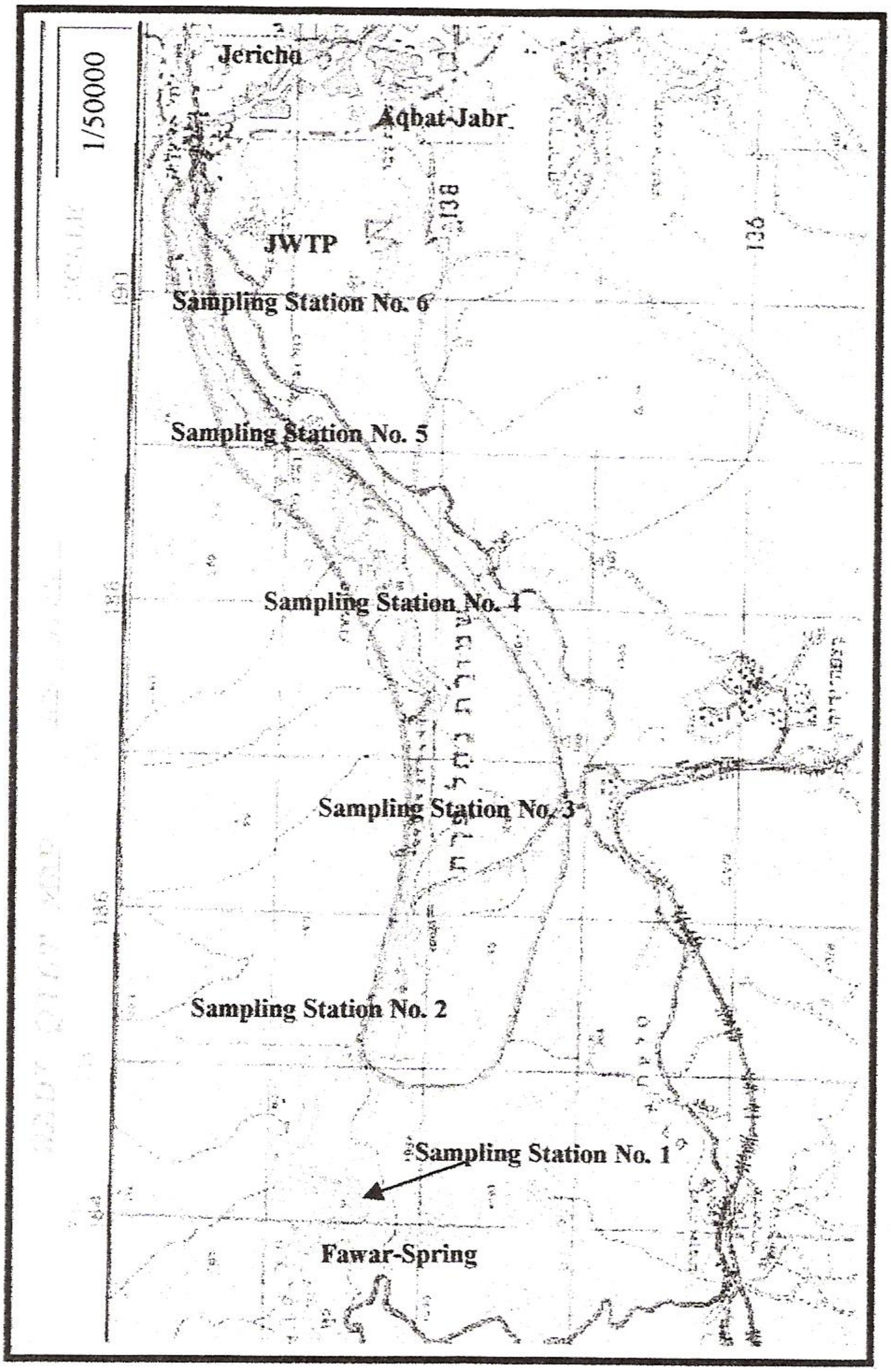
Eng. A.Nwahdh

Scale: NTS



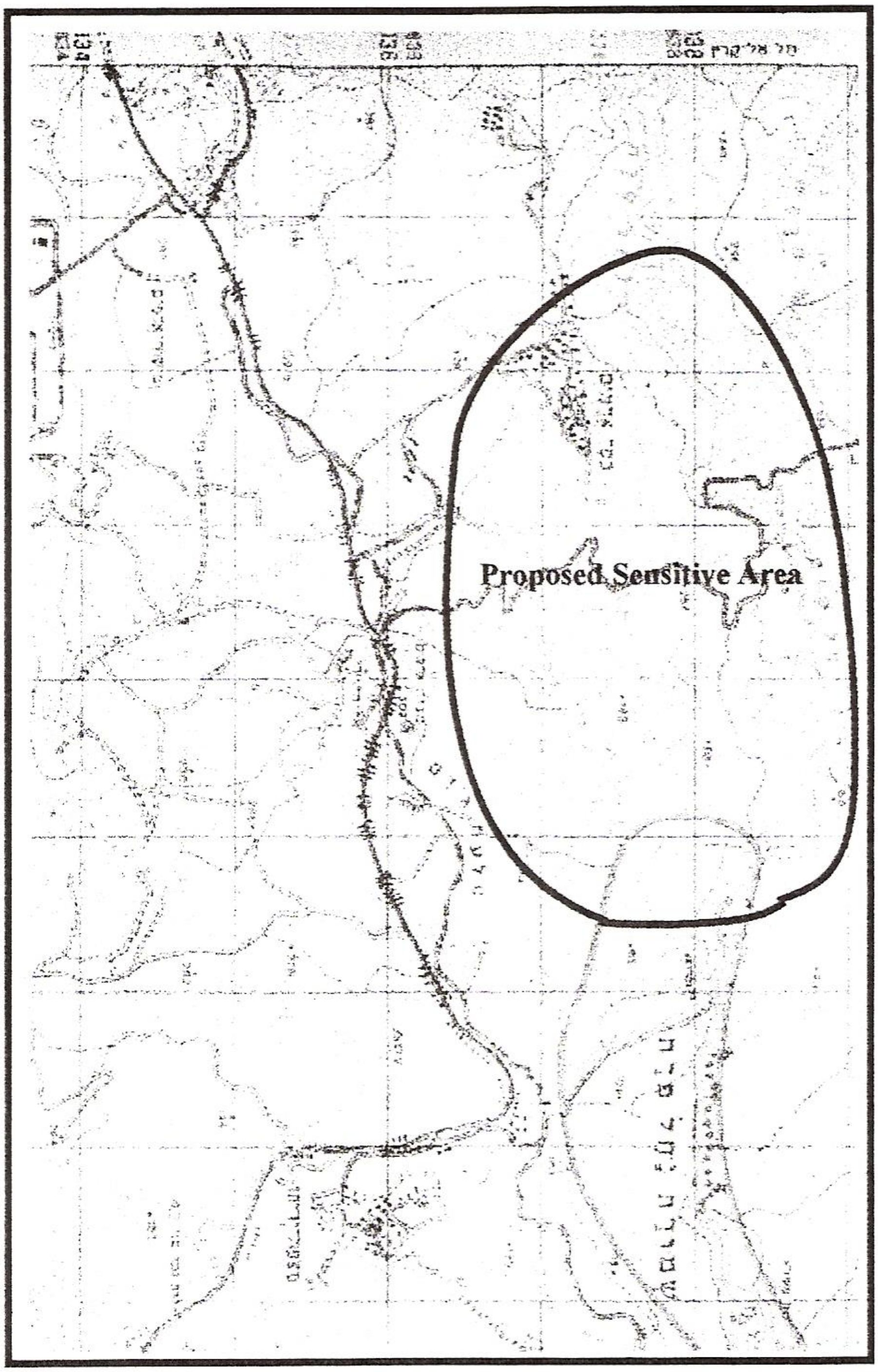
Appendix B

B.1: water sampling stations in the water open channel at wadi-qilt

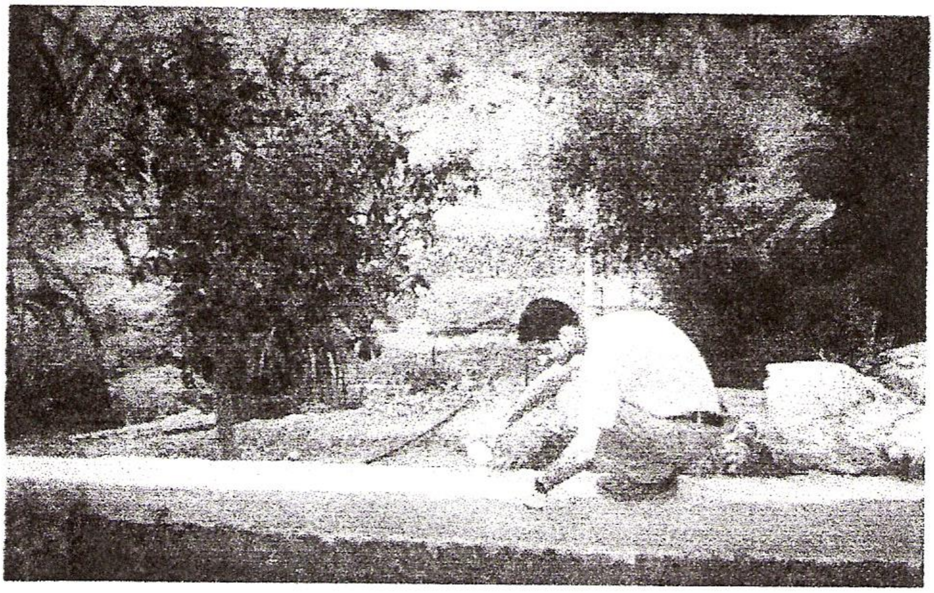


Appendix C

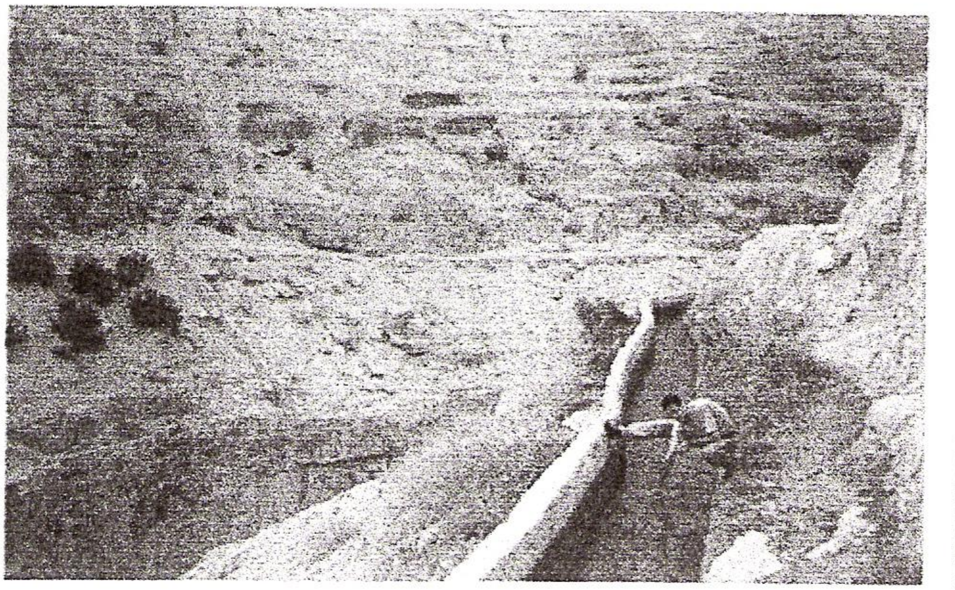
C.1: proposed sensitive area at wadi-qilt



Sampling Station (WQ3)



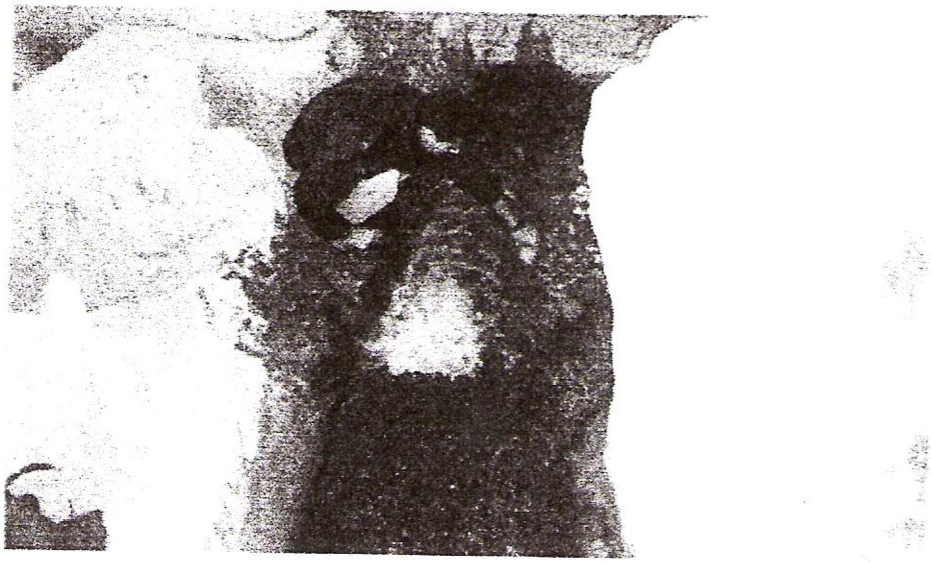
Sampling Station (WQ 4)



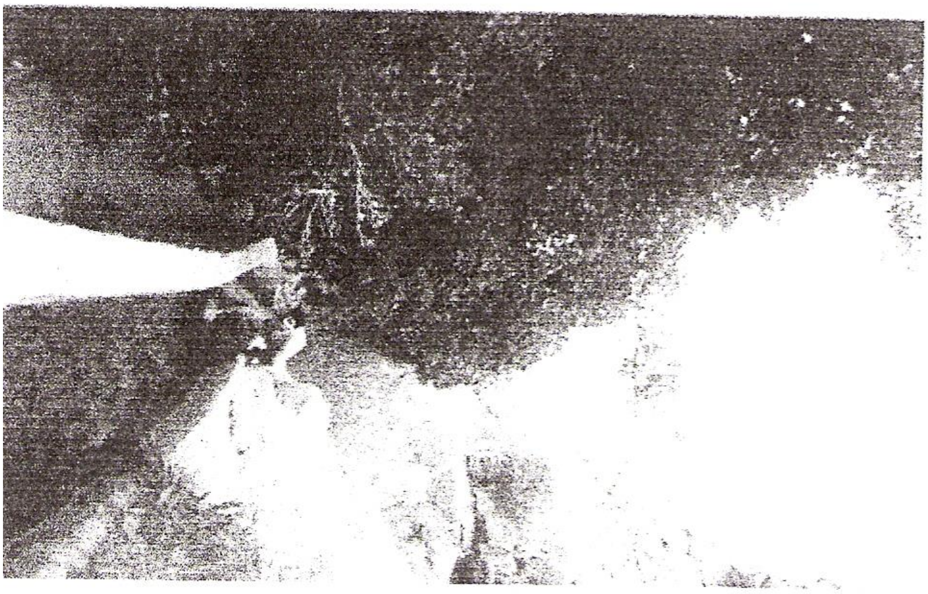
Appendix D: pictures for the study area and for JWTP

D.1: water sampling stations

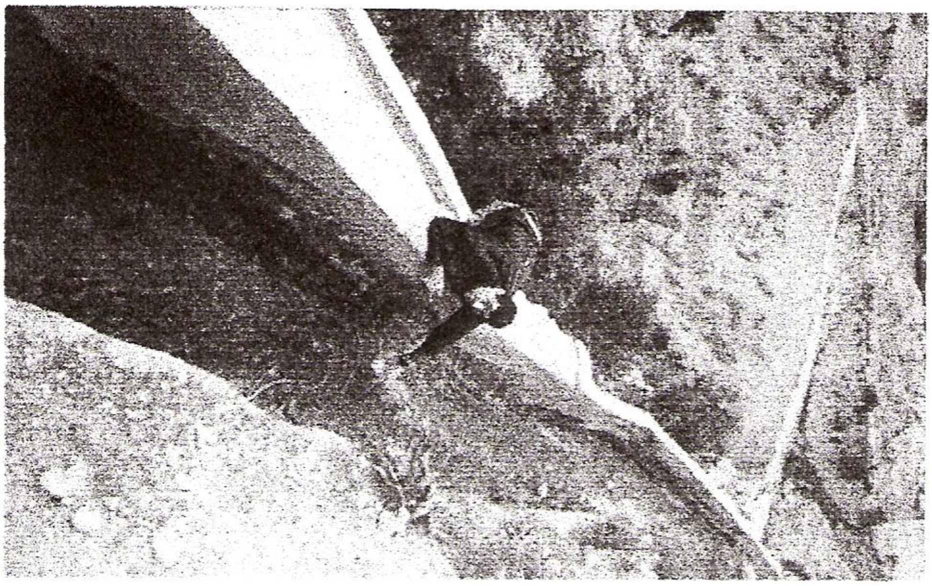
Sampling Station (WQ1)



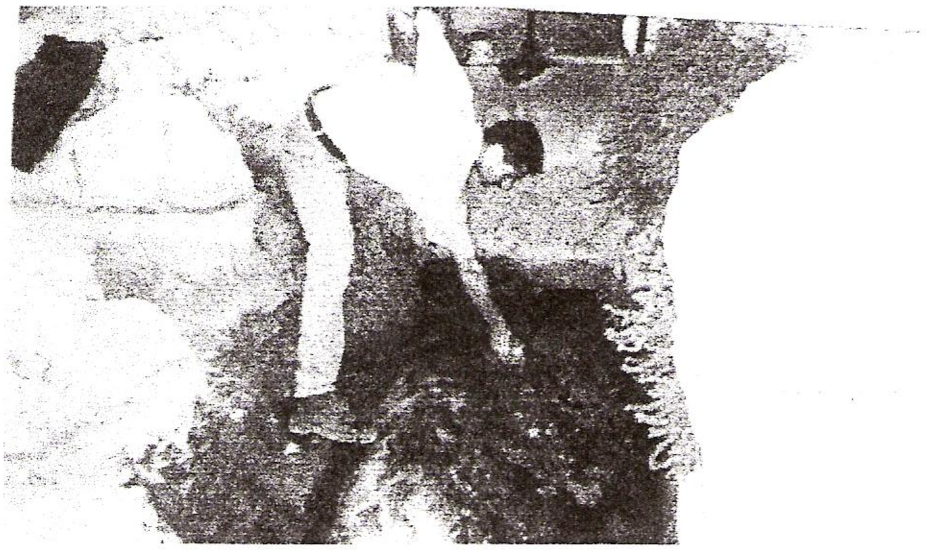
Sampling Station (WQ2)



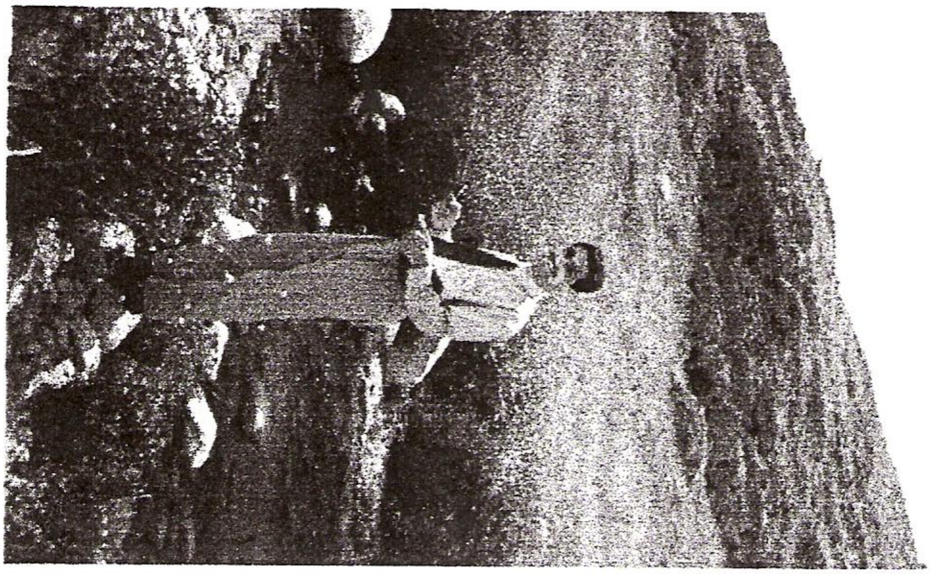
Sampling Station (WQ5)



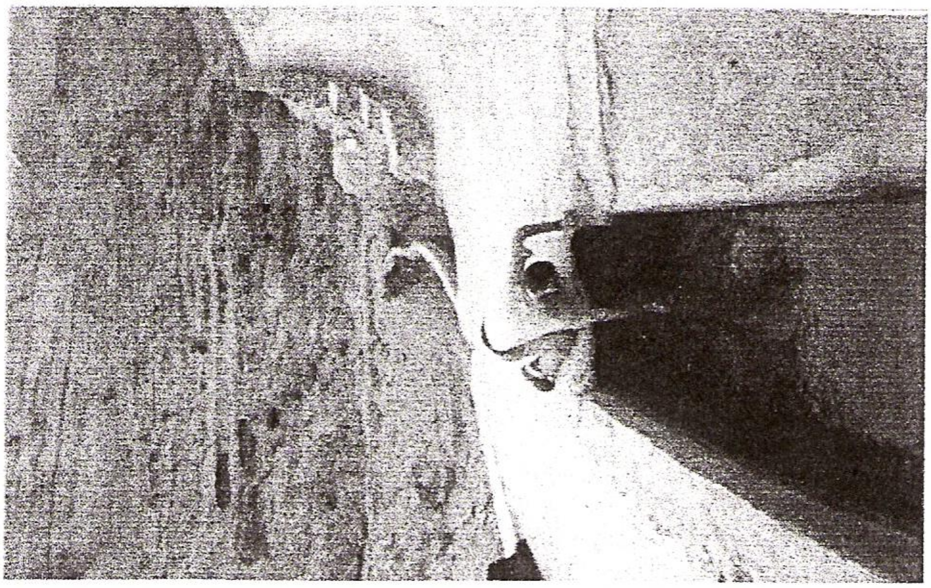
Sampling Station (WQ6)



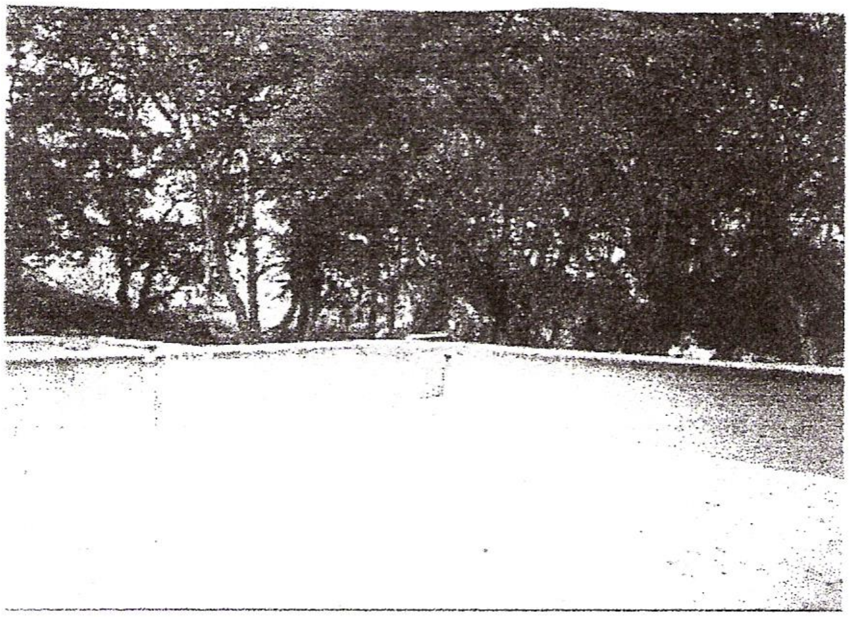
Reporting at Fawar-Spring

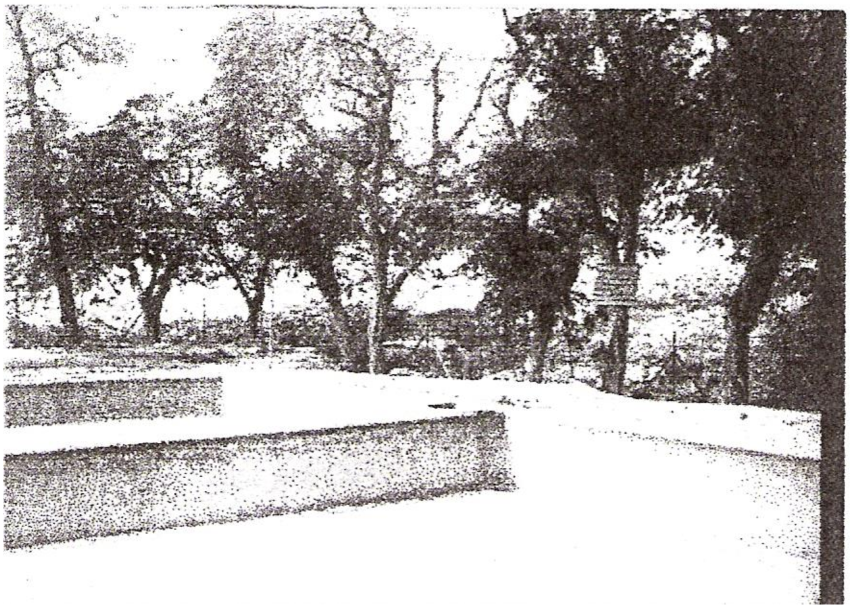


Sampling in the Open Canal

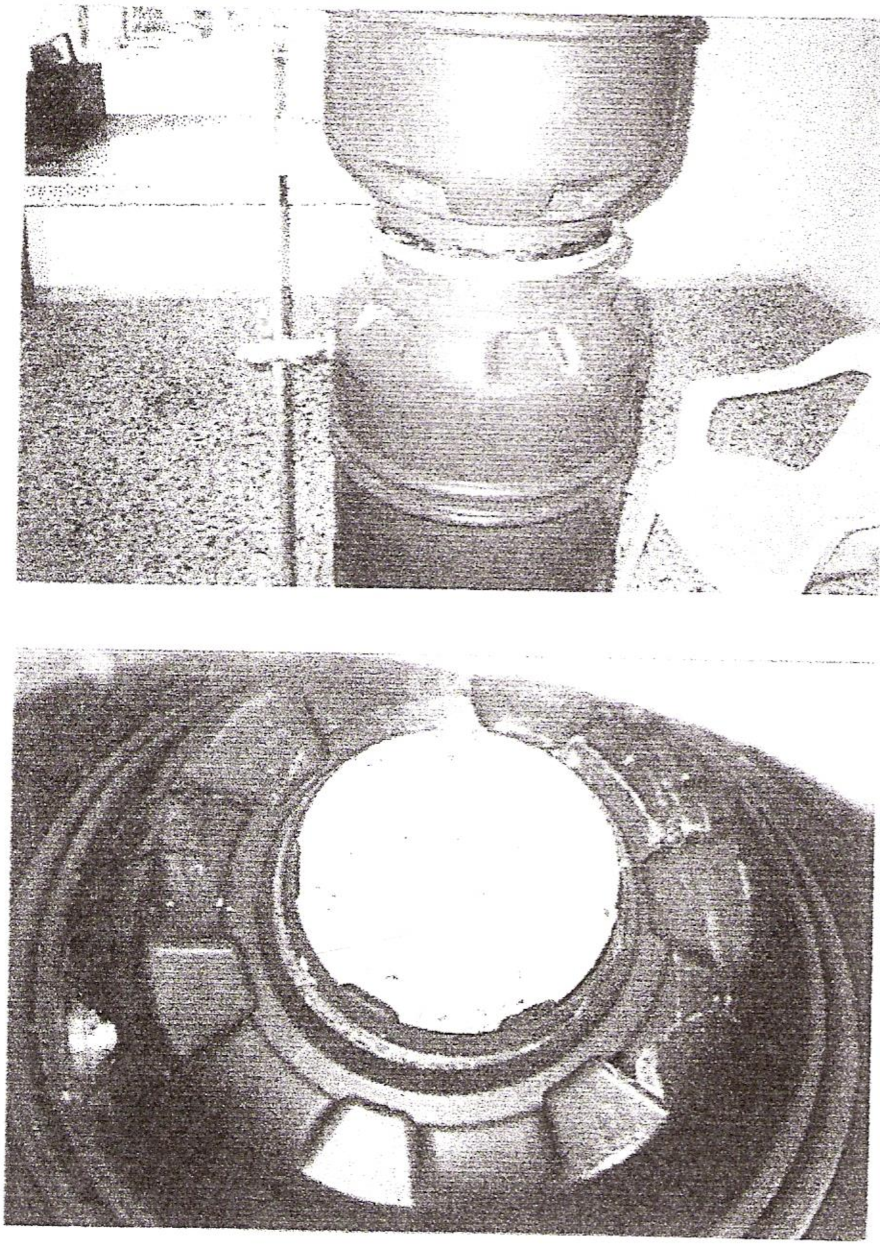


Slow Sand Filters at JWTP





Experimental Model for SSF



Appendix E: field tests at Wadi-qilt

E1: turbidity variation in the open channel (WQ6)

Date	PH	Temperature (°C)	Turbidity NTU
24.07.98	8.14	22.9	3.54
16.08.89	8.14	22.7	4.01
13.09.98	8.13	22.4	3.71
23.10.98	8.20	22.6	4.2
20.11.98	8.22	22.5	3.57
27.12.98	8.21	16.0	10.5
15.01.99	7.74	19.5	4.21
05.02.99	7.60	18.0	5.3
19.03.99	7.73	15.0	10.71
11.04.99	7.74	21.0	4.5

E.2: Phosphorus and nitrate concentration in the open channel (WQ6)

Date	PH	Temperature (°C)	NO_3^-(mg/L)	PO_4^{-3}(mg/L)
July 1998	8.14	23.0	5.1	1.00
August 1998	8.14	22.7	5.4	2.00
September 1998	8.13	22.4	6.0	1.04
October 1998	8.20	22.6	6.2	1.06
November 1998	8.22	22.5	6.3	2.01
December 1998	8.21	16.0	7.0	2.04
January 1999	7.74	19.5	6.8	0.90
February 1999	7.60	18.0	7.1	1.01
March 1999	7.73	15.0	6.9	0.96
April 1999	7.74	21.0	6.8	0.84

E.3: Total and free chlorine concentrations

Station	Free Chlorine mg/L	Total Chlorine mg/L
WQ1	0.02	0.03
WQ2	0.02	0.03
WQ3	0.01	0.03
WQ4	0.01	0.03
WQ5	0.01	0.02
WQ6	0.01	0.02
CWR at JWTP	0.44	0.46

E.4: total plate count and fecal coli forms concentrations-27/12/98

Station	TPC/100 ml	Fecal-coli forms/100 ml
WQ1	200	100
WQ2	300	100
WQ3	300	100
WQ4	400	200
WQ5	400	200
WQ6	500	200
CWR at JWTP	0.0	0.0

E.5: Total plate count and fecal coli forms concentrations-11/4/99

Station	TPC/100 ml	Fecal-coli forms/100 ml
WQ1	400	200
WQ2	400	200
WQ3	400	200
WQ4	600	300
WQ5	600	300
WQ6	600	300
CWR at JWTP	0.0	0.0

خلاصة

تم في هذا البحث تناول محطة معالجة المياه الموجودة حاليا في مدينة أريحا و التي هي الوحيدة من نوعها في فلسطين تنتج يوميا ما يقارب 500 متر مكعب من المياه الصالحة للشرب و التي تستهلك من قبل سكان مخيم عقبة جبر و البالغ عدد سكانة5000 نسمة . تم تأسيس هذه المحطة عام 1956 من قبل وكالة الغوث الدولية و تم تحديث طريقة عملها من قبل مساعدات مالية خارجية من ألمانيا ,إدارة و تشغيل المحطة منوط بالأنروا من خلال إدارة مخيم عقبة جبر للاجئين الفلسطينيين.
تتكون المحطة الحالية من ثلاثة أحواض رملية تعمل بنظام الترشيح البطيء و بعد ذلك يتم إضافة الكلور من أجل تعقيم المياه من الميكروبات و الجراثيم و من ثم يتم تخزين المياه المعالجة في خزان التوزيع لشبكة مياه المستهلكين هذه المحطة تعمل بشكل جيد في فصل الصيف و لكنها تعمل بشكل منقطع في الفصول الأخرى و بالأخص في فصل الشتاء , إن مصدر المياه الطبيعية لمحطة المعالجة هو الينابيع الموجودة في الوادي القلط و التي ينبع منها مياه عذبة و لكنها تلوث من خلال رحلتها الطويلة أكثر من13 كم في القناة المكشوفة بسبب عناصر كثيرة أهمها الاتصال بالمياه العادمة القادمة من المناطق المجاورة و التي تسبب تلوث بكتيري في الأيام الماطرة يصل لأكثر من 880 مستعمرة بكتيرية لكل 100 مللیمتر من الماء , و يصل معدل العكارة في المصدر يزيد عن(NTU 0 3)و يوجد نمو كثيف للطحالب في كل من القناة المياه المغذية و أحواض المعالجة الرملية .هذا من ناحية فنية أما من ناحية أدارية فأن المحطة غير قادرة على الاستمرار في العمل بشكل فعال في ظل الطاقم الموجود حاليا بسبب قلة المهارة و الخبرة في أدارة المحطة. تعد محطة معالجة المياه المصدر الوحيد لمياه الشرب و لكن انقطاعها في الآونة الأخيرة دفع المستهلكين للبحث عن مصدر بديل و هو شركة(مكروت) الإسرائيلية و التي زودتهم بكمية قليلة من المياه و سعر مضاعف .
أن الهدف من أجراء هذا البحث هو أيجاد الوسائل الفعالة من أجل تحديث محطة معالجة المياه الحالية من الناحية الفنية و الإدارية لتعمل بكفاءة عالية حتى تزود مخيم عقبة جبر بمياه ذات بجودة عالية. حيث أظهرت نتائج التحاليل المخبرية و تجارب العملية في هذا البحث أن المحطة الحالية يجب أن يتم تطويرها فنيا بحيث يتم إضافة خزان ترسيب و الذي يعمل في أيام الشتاء بشكل خاص و في أي وقت تكون فيه عكارة المياه عالية أو وجود تلوث بكتيري ' كما أثبتت التجارب التي تمت على النموذج التجريبي أن المحطة يمكنها أن تصل إلى كفاءة 85% في إزالة عكارة المياه عالية و دون نمو الطحالب في حالة تحديث الوضع الحالي للمحطة .

دلت جميع المعطيات من هذا البحث على ضرورة استخدام المصادر الطبيعية المتوفرة في وادي القلط و أي مكان أخر في فلسطين بشكل فعال لأن المنطقة بأكملها تعاني من شح المياه . هذا يتطلب إضافة منشات فنية جديدة و تبني سياسة أدارية فاعلة ففي أدارة و عمل محطة معالجة المياه و المصادر الطبيعية المتاحة من أجل تلبية احتياجات السكان في غضون سنوات القادمة .

تقييم و تحديث محطة معالجة المياه في مدينة أريحا

رسالة ماجستير مقدمة من

أمين إسماعيل أمين نواهضة

الرقم الجامعي:975139

بأشراف:
الدكتور راشد"محمد ياسر"الساعد

قدمت هذه الرسالة استكمالا لمتطلبات درجة الماجستير في هندسة المياه من كلية الدراسات العليا في جامعة بير زيت
_فلسطين
بير زيت 1999