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Water Quality Modeling of Al-Qilt Stream

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Dedication

Rising endless thanking to Allah for his uncountable blessing and guidance and mercy on me.

May Allah put peace and blessing on our prophet Mohammad and his saintly family and his elite superior companions.

All the credit and favor is due to our merciful Allah and my soulful parents who overwhelmed me with care kindness tender and endless support, I want to thank my mother and my father for believing in me, and for being the truly friends and companions in this journey.

Mother, I dedicate my soul for you. Mother, I dedicate my life for you. Mother, I dedicate my existence for you.

Father, you are the one who sculpted me with your own hands. May Allah gives me the strength to be dutiful son for you.

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الإقرار

أنا الموقع أدناه مقدم الرسالة التي تحمل العنوان:

Water Quality Modeling of Al-Qilt Stream

اقر بأن ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص، باستثناء ما تمت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل أو جزء منها لم يقدم من قبل لنيل أية درجة أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى .

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

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Date: **التاريخ:**

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List of Abbreviations

°C	Degree Centigrade
AGNPS	Annualized Agriculture Non-Point Source
ARIJ	Applied Research Institute/Jerusalem
ARS	Agricultural Research Service
BMPs	Best Management Practices
BOD5	Biochemical Oxygen Demand (after five days)
c	Tracer concentration.
cm	Centimeter
CBOD	Carbonaceous Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
Cs	Saturation Concentration
D	Dispersion coefficient.
DBM	Data-Based Mechanistic
DO	Dissolved Oxygen
DO_s	Saturated Dissolved Oxygen
DOC/ NPOC	Dissolved Organic Carbon/Nonpurgeable Organic Carbon
EC	Electric Conductivity
EF	Enrichment Factor
GIS	Geographical Information System
HDPE	High Density Poly Ethylene
INCA	Integrated Nitrogen in Catchments
JWWTP	Jericho Wastewater Treatment Plant
km/yr	Kilometer per Year
km^2	Kilometers Squared
L/sec	Liter per Second
LOM	Labile Organic Matter
m	Meter
a.m.s.l.	Above Mean Sea Level
b.m.s.l	Below Mean Sea Level
m^3	Cubic Meters
m^3/day	Cubic Meters per Day
MCM/y	Million Cubic Meter per Year
mg/L	Milligram per Liter
mm	Millimeter
mm/a	Millimeter per Annual
mm/yr	Millimeter per Year
MAGIC	Model for Acidification of Groundwater in Catchments
MERLIN	Model of Ecosystem Retention and Loss of

	Inorganic Nitrogen
MISO	Multi Input Single Output
mS	Millisiemens
NBOD	Nitrogenous Biochemical Oxygen Demand
NOAA	National Oceanic and Atmospheric Administration
PCBS	Palestinian Central Bureau of Statistics
PMD	Palestinian Meteorological Department
PWA	Palestinian Water Authority
ROM	Recalcitrant Organic Matter
RWQM	Receiving Water Quality Model
S1	First Scenario (current)
S2	Second Scenario (future)
S3	Third Scenario (future)
S_m	Mass flux per unit volume.
SMHI	Swedish Meteorological and Hydrological Institute
SWAT	Soil and Water Assessment Tool
SWMM	Storm Water Management Model
TDS	Total Dissolved Solids
TKN	Total Kjeldhahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USDA	United States Department of Agriculture
V	Volume of the control volume
VBA	Visual Basic for Applications
WWTP	Waste Water Treatment Plant
x_i	Principal directions of the dispersion coefficient tensor.

Water Quality Modeling of Al-Qilt Stream

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Abstract

Surface water resources are very limited in Palestine, so special interest must be given to the quantity and quality of such valuable resources. Al-Qilt streamwater is considered as essential source for agricultural uses. The water quality of Al-Qilt stream is subjected to several pollutions that severely affect and limit the full utilization of such valuable source. This thesis focused on water quality modeling of Al-Qilt streamwater considering the dissolved oxygen as a key quality parameter. The potential pollution sources in the area were explored. Using GIS shapefiles, and Google earth maps, several detailed maps, and elevation profile was created to describe the properties of the catchment with focusing on the main stream. Samples were collected regularly from the five selected locations on a monthly periodic time intervals. For the five locations, on site tests for the following parameters (DO, pH, Temp, TDS and EC) had been conducted. Laboratory analyses for (BOD_5, BOD_{20}, COD, Total Nitrogen (TN), Ammonium, Nitrate, Nitrite, and Total Suspended solids (TSS)) were performed for all the samples in PWA's laboratory. A water quality model (QUAL2Kw) was used and three different scenarios were assessed and simulated to predict the dissolved oxygen concentration levels along the stream. Four key input parameters controlled the modeling process; these are Reaeration, Deoxygenation, Nitrification, and Denitrification. The first scenario of the model simulated the current situation of Al-Qilt streamwater, the second scenario simulated the addition of stepped weirs at certain locations to improve the reaeration process, and the third scenario simulated the construction of a wastewater treatment plant to treat the raw wastewater flowing from Qalandia and Al-Ram region. The results of the reaeration, deoxygenation, and nitrification rates were much higher than the typical range. Results from the three model scenarios confirmed that the stream capable to conduct significant self remediation process that raised the dissolved oxygen concentrations up to the saturation levels. The proposed reaeration stepped weirs was found as suitable solution to improve the quality of water upstream and raised the dissolved oxygen concentrations from 2.5 mg/L up to around 7.5 mg/L. The effects of the WWTP for the flow running from Qalandia region were limited on the DO levels with only 4.7% raise.

Chapter One

Introduction

1.1 General Background

Water shortage in the West Bank and Gaza Strip is a dominant feature. Several factors had aggravated the problem of water shortage, such as climate change, pollution, lack of integrated management strategies and the unfair Israeli control over Palestinian water resources. Unless Palestinians gain their access to the Jordan River, they mainly depend on groundwater to fulfil their domestic, agricultural, and industrial needs. In general groundwater quality in the West Bank is considered acceptable. Nevertheless, several sources of pollution are affecting the groundwater quality in the West Bank. Three possible major pollution sources: anthropogenic effect, agricultural return flow and deep brine water and dissolution of salts from Lisan layers (Aliewi et al., 2001).

In this research, the integrated models for water streams models is being considered as effective tools to simulate the remediation process of polluted streams. Such tools were applied for Al-Qilt stream, one of the Jordan River attributes. Surface runoff during winter storms in addition to treated wastewater effluent from Al-Bireh Wastewater Treatment Plant (WWTP) contribute to the stream flow of Al-Qilt catchment. Pollution in Al-Qilt catchment can be attributed to verity of sources that includes physical, chemical, and biological substances. Human activities are the main source of pollution. Such activities include continuous discharge of untreated domestic and industrial wastewater, return flow from uncontrolled agricultural areas and traffic wastes and industrial air pollutions.

To change the management practices over the catchment, more information about pollution sources and their impacts on the water quality is required. However, the available information of water quality at the Palestinian Waster Authority is limited for the catchment. Therefore, the model in this study was created with the uttermost available information.

1.2 Problem Statement

Al-Qilt streamwater is considered as an important source for domestic uses, downstream, for the people living in Aqbet Jaber refugee camp. Accordingly, any pollutants get into the stream will deteriorate its quality and therefore will jeopardize the public health in the catchment.

Al-Qilt catchment contains several pollutions sources (point and diffuse sources) which are distributed randomly over the catchment, such as Israeli settlements, Israeli military base, uncontrolled agricultural practices, and the effluent of untreated wastewater. These sources are negatively affecting the stream's water quality. Direct effects as in the case of forthright pollutions, such as raw wastewater flowing into the stream. Indirect effects, as in the case of Israeli restrictions on the Palestinian management actions.

1.3 Research Motivations

Several reasons urge to study of Al-Qilt streamwater quality; among which are:

1. The catchment is the host of more than 128,000 citizens that are affected directly and indirectly by the deteriorating water quality (PCBS, 2007).
2. The water supply for Aqbet Jaber refugee camp downstream depends partially on the Al-Qilt streamwater. The water supplied by the stream with unacceptable quality, affecting the public health in the camp. The quality of the water supplied from the stream to the camp is highly questionable. Due to the primitive treatment process which based only on old sand filters.
3. The increasing trend of Palestinians to use the treated water and wastewater to bridge the increasing supply-demand gap in the West Bank.

1.4 Research Objectives

The following are the key objectives:

1. To simulate Dissolved Oxygen (DO) in the main stream of Al-Qilt as a key water quality parameter under current and future conditions.
2. To propose proper remediation options of the local environment along Al-Qilt stream.

1.5 Research Outputs

The following are the ultimate research outputs:

1. DO model for Al-Qilt streamwater that simulated three different scenarios. The first scenario represented the current existing situation, while the other two scenarios represented future suggested solutions.

2. A decision of the proper treatment technique that could be used to enhance the remediation process. The technical and economical aspects in addition to the molding results, were important part to reach the recommended solution.

1.6 Thesis Outline

The thesis is organized in seven chapters. Chapter 1 gives an introduction along with background information, research problem, motivations, objectives and the expected outputs. Chapter 2 presents the related literature review. Chapter 3 presents the research study area. Chapter 4 illustrates the applied methodology and presents laboratory tests and modeling approach and development of QUAL2Kw models for the case study. Chapter 5 presents the results and the discussion of the models results and the characteristics of the stream. Chapter 6 presents the proposed key conclusions and recommendations.

Chapter Two

Literature Review

2.1 Al-Qilt Streamflow Quality and Pollution

The effects of urbanization on the natural resources is the main issue in most of the environmental studies discussing Al-Qilt catchment. Elevated concentrations of pollutants in Al-Qilt stream are a concern to rural communities especially Aqbet Jaber Camp. Since nitrate and dissolved organics in excess amounts can cause environmental and health problems. Rural areas, where livestock and drinking water supplies are found in common locations, are particularly at risk as animal manure contains high levels of nitrogen and organics. Moreover, many adjacent communities discharge wastewater freely, in a way that caused the higher risk to pollute Al-Qilt streamflow (Abu Hilou, 2008).

Due to the absence of efficient treatment plants and control of wastewater in the West Bank and some Israeli settlements along the Wadis path, this sewage flows into the natural streams surrounding the basin, which drained directly into the Wadis runoff, and percolating to the groundwater (ARIJ, 1997). Such pollutants sources comes from west of Ramallah toward Al-Qilt catchment which influences ground and springs water and make it deteriorated and unsuitable for different uses and applications. In turn this pollution, can influence the economic, social and political situation in the study area. Additional pollutions of the springs due to other sources has occurred, e.g., Bedouins living at the downstream dumping their wastewater into the stream, leaching from stone quarries and the municipal and other industrial wastewater that discharging from the eastern side of the city of Al-Bireh polluting surface and groundwater resources across water path(Abu Hilou, 2008).

In Al-Qilt catchment, sediments and topsoil are enriched clearly by anthropogenic pollutants due to discharge of raw wastewater, dumping sites, roadside and urban runoff, and sometimes due to natural effects. Since Al-Qilt streamflow is considered one of the important streamflows in the area and it is used for domestic purposes, there are no guaranties from pollution if there is no management plan to control the pollution (Samhan, 2013).

In Al-Qilt catchment, there were few studies, for example, CH2MHill, 1999 was one of these. They did a survey and monitored the Eastern basin of the West Bank. The main objective for their survey was to understand the wastewater potential and expected pollution to local resources in the Eastern basin; they monitored and analyzed the following parameters: Ammonia, Potassium, Nitrates, Chloride and TDS, Antimony, Lead, Selenium, Thallium, Iron, Beryllium, Mercury, Cadmium and Arsenic. Results revealed that there were incremental of pollutants levels in the springs downstream which used for domestic purposes (CH2MHill, 1999).

2.2 Fate and Transport

Sources of pollution are recognized by two types which are both subjected to fate and transport processes, these sources can be categorised as:

- Point sources: these have identified location of discharges into streams such as outfall of sewer pipes.

  Examples of point sources include:

  1- Discharges from wastewater treatment plants.

  2- Operational wastes from industries.

  3- Combined sewer outfalls.

- Diffuse sources: these have several sources spread over rural or urban areas, and pollutants passed through several terrains before it reach the stream, such as surface runoff reaching a stream (Queensland, 2012).

  1- Sediments from construction, forestry operations and agricultural lands.

  2- Oil, grease, antifreeze, and metals washed from roads, parking lots and driveways.

  3- Nutrients and pesticides from agricultural areas.

Fate and transport refers to the way chemicals move through the environment and their ultimate destinations and how they arrive. Defining the fate and transport for any single contaminant is often complex. Fate and transport begins with a source point or diffuse source. A chemical's initial release into the environment and environmental conditions are important for determining its free moving lifespan and ultimate destination (Samuel, 2013).

Diffusion and dispersion are the processes by which a tracer spreads within a fluid. Diffusion is the random advection of tracer molecules on scales smaller than some defined length scale. At small (microscopic) length scales, tracers diffuse primarily through Brownian motion of the tracer molecules, whereas at larger scales, tracers are diffused by random macroscopic variations in the fluid velocity. In cases where the random macroscopic variations in velocity are caused by turbulence, the diffusion process is called turbulent diffusion. Where spatial variations in the macroscopic velocity are responsible for the mixing of a tracer, the process is called dispersion (Chin, 2013).

Al-Qilt catchment includes various activities and land uses such as agricultural, industrial, urban, and tourism uses. This requires a simulation model that can integrate several units and incorporate with the complexity of tenths of parameters and require large measurements databases for calibration (Gabriele et al., 2009). In such cases, according to Gabriele the use of the limited available information approach can be critical in order to provide useful and reliable results.

The effect of each pollution source varies with its nature and with its effect on the catchment, such as: urban and agricultural runoff affects negatively the environment and public health, for example:

1. Affecting the streamwater quality and polluting the groundwater aquifers.
2. Threatening the public health, biodiversity, and aquatic life.
3. Affecting soil fertility which in turns limiting land use for agricultural activities.

4. Hosting several pollutant like viruses, organic and non-organic matter, chemicals, heavy metals, solids, grease and oil, and many other profanations in the wastewater.

2.2.1 Dissolved Oxygen Sag Curve

“When a wastewater with significant amount of organic matter is discharged into a stream or river, the dissolved oxygen level decreases and drops to a minimum value. As reaeration slowly replenishes the dissolved oxygen over time and with distance, the stream DO level comes back to predischarged concentration” (Riffat, 2013). This is known as the DO sag curve.

The curve is created when the concentration of DO in a stream where sewage or other pollutant has been discharged is plotted against the distance downstream from the sewage outlet. Samples of water must be taken at areas upstream and downstream from the sewage outlet. The presence of sewage reduces the oxygen content of the water and increases the Biochemical Oxygen Demand (BOD). This is due to the action of saprotrophic organisms that decompose the organic matter in the sewage and in the process use up the available oxygen (Oxygen sag curve, 2004) a sag curve is shown in Figure 2.1.

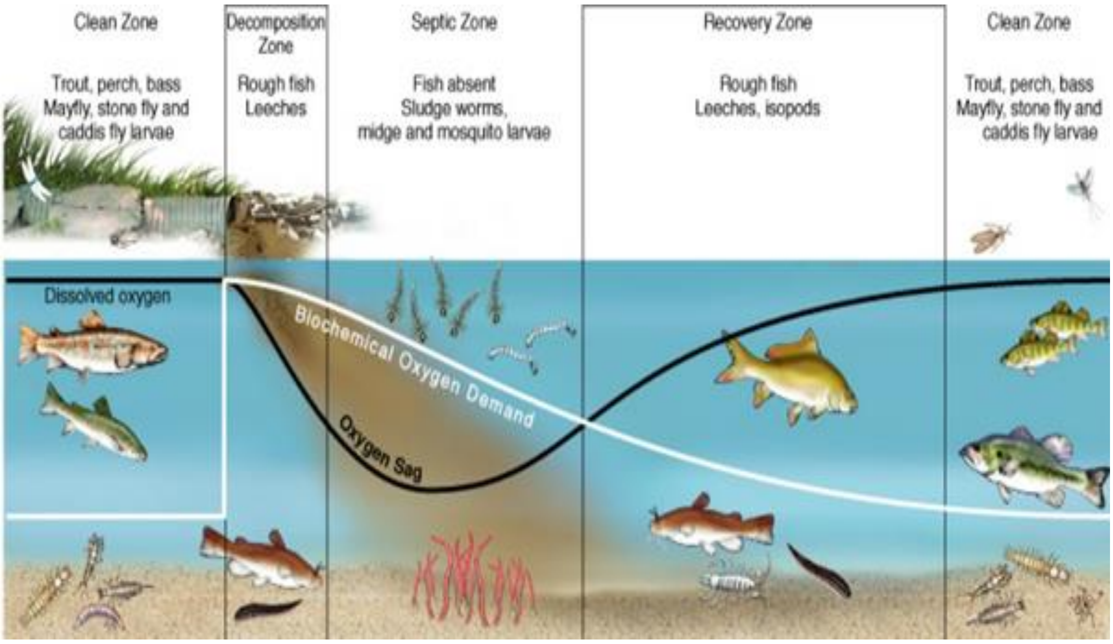

Figure (2.1): Dissolved Oxygen Sag Curve (Davis and Cornwell, 2008)

The variability of dissolved oxygen concentration in streams is influenced by many factors in which those major influences can be categorized as being either sources or sinks. As major sources of dissolved oxygen, the oxygen are usually obtained from the reaeration/enhanced aeration process, photosynthesis oxygen production, and introduction of dissolved oxygen from other sources such as tributaries (Yudianto and Yuebo, 2008). On the other hands, the depletion of dissolved oxygen can be caused by the oxidation of organic material and other reduced matter in the water column, degassing of oxygen in supersaturated water, respiration by aquatic plants, addition of biochemical oxygen demand by local runoff, removal of oxygen by nitrifying bacteria, and the oxygen demand exerted by stream bed sediments. In water quality modeling, most of those processes are expressed in mathematical terminology in the form of differential equations. It would be very complex to simulate all of the chemical reactions and biological processes affecting each element. It is also not necessary or not possible to measure all data from the field site. Therefore, many available dissolved oxygen models usually use Streeter and Phelps equations to describe the biochemical oxygen demand and dissolved oxygen profiles. The simplest form of this equation is usually applied for a stream characterized by plug flow system with constant hydrology and geometry under steady state condition (Yuduanti et al., 2008), a typical pollutant diffusion behavior is shown in Figure 2.2.

The principal equation of the advection-dispersion is (Chin, 2013):

$$\frac{\partial c}{\partial t} + \sum_{i=1}^{3} V_i \frac{\partial c}{\partial t} = \sum_{i=1}^{3} D_i \frac{\partial^2 c}{\partial {x_i}^2} + S_m \qquad 2.1$$

Where:

D: Dispersion coefficient. S_m: is the mass flux per unit volume.

x_i: is the principal directions of the dispersion coefficient tensor.

V: is the volume of the control volume. c: is the tracer concentration.

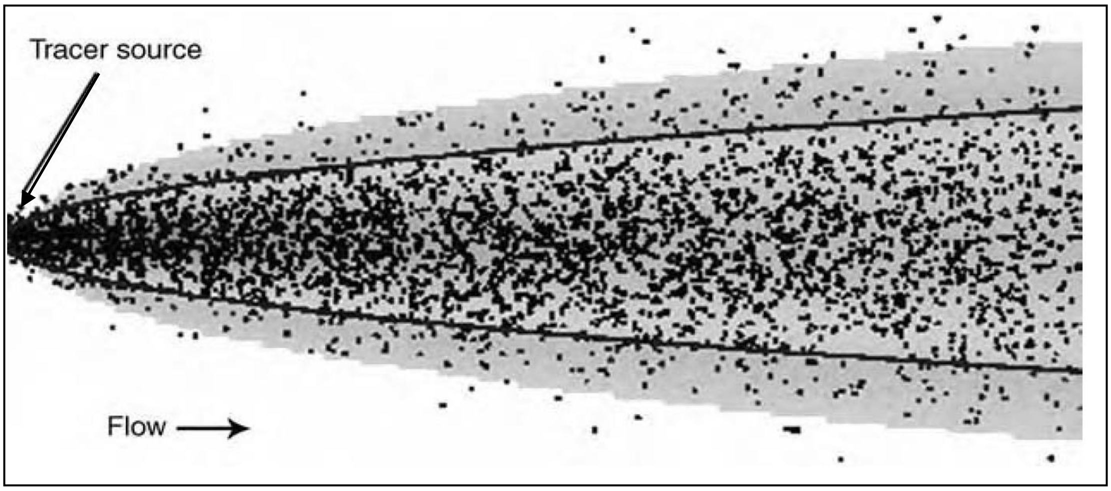

Figure (2.2): Turbulent diffusion of tracer particles in uniform flow (NOAA, 2005)

The solution of the above equation is in Streeter-Phelps model, the model describes how DO and Chemical Oxygen Demand (COD) degradation will be in the stream. The equation was derived by Streeter and Phelps in 1925, based on field data from the Ohio River. The equation is also known as the DO sag equation (Streeter-Phelps equation, 2013).

Assumptions of Streeter-Phelps Model:

1- Stream is an ideal plug flow reactor
2- Steady-state flow and BOD and DO reaction conditions
3- The only reactions of interest are BOD exertion and transfer of oxygen from air to water across air-water interface

The Streeter-Phelps equation, assuming a perfectly mixed stream at steady state is (Chin, 2013):

$$D = \frac{k_1 L_{ca}}{k_2 - k_1}\left(e^{-k_1 t} - e^{-k_2 t}\right) + D_a e^{-k_2 t} + \frac{k_n L_{an}}{k_2 - k_n}\left(e^{-k_n t} - e^{-k_2 t}\right) \qquad 2.2$$

Where:

D: saturation deficit.

D_a: initial oxygen deficit.

k_1: deoxygenation rate constant.

t: elapsed time.

k_2: streamreaeration rate constant.

k_n: nitrogenous decay constant.

L_{ca}: ultimate CBOD.

L_{an}: ultimate nitrogenous demand NBOD.

2.3 QUAL2Kw Parameters and Theory

QUAL2kw is a one-dimensional water quality model that uses Microsoft Excel as its data entry, data analysis, and graphical user interface and Microsoft Excel VBA and FORTRAN 95 as its program languages (Pelletier et al, 2006).

QUAL2Kw is a framework for the simulation of water quality in streams and rivers. Dynamic daily heat budget and water quality kinetics are calculated for one-dimensional steady-flow systems. The framework includes a genetic algorithm to facilitate the calibration of the model in application to particular water bodies. The genetic algorithm is used to find the combination of kinetic rate parameters and constants that results in a best fit for a model application compared with observed data. The QUAL2Kw framework allows up to three steady-flow synoptic survey data sets to be simultaneously calibrated to the same set of kinetic rate parameters and constants (Pelletier, 2005).

“The QUAL2Kw framework includes the following new elements:

- pH, alkalinity and total inorganic carbon are simulated. The river’s pH is then simulated based on these two parameters.
- Software Environment and Interface, Q2K is implemented within the Microsoft Windows environment. It is programmed in the Windows macro language: Visual Basic for Applications (VBA). Excel is used as the graphical user interface.
- Carbonaceous BOD speciation, Q2K uses two forms of carbonaceous BOD to represent organic carbon. These forms are a slowly oxidizing form (slow CBOD) and a rapidly oxidizing form (fast CBOD).
- Anoxia, Q2K accommodates anoxia by reducing oxidation reactions to zero at low oxygen levels. In addition, denitrification is modeled as a first-order reaction that becomes pronounced at low oxygen concentrations.
- Sediment-water interactions, sediment-water fluxes of dissolved oxygen and nutrients are simulated internally rather than being

prescribed. That is, oxygen (sediment oxygen demand) and nutrient fluxes are simulated as a function of settling particulate organic matter, reactions within the sediments, and the concentrations of soluble forms in the overlying waters.

- Hyporheic metabolism, hyporheic exchange and sediment pore water quality are simulated, including optional simulation of the metabolism of heterotrophic bacteria in the hyporheic zone.
- Automatic calibration, a genetic algorithm is included to determine the optimum values for the kinetic rate parameters to maximize the goodness of fit of the model compared with measured data", (Pelletier, 2005).

2.3.1 Segmentation and Hydraulics

The model simulate the main stem of a river. Tributaries are not modeled explicitly, but can be represented as point sources, a scheme for the segmentation of QUAL2Kw principle is shown in Figure 2.3.

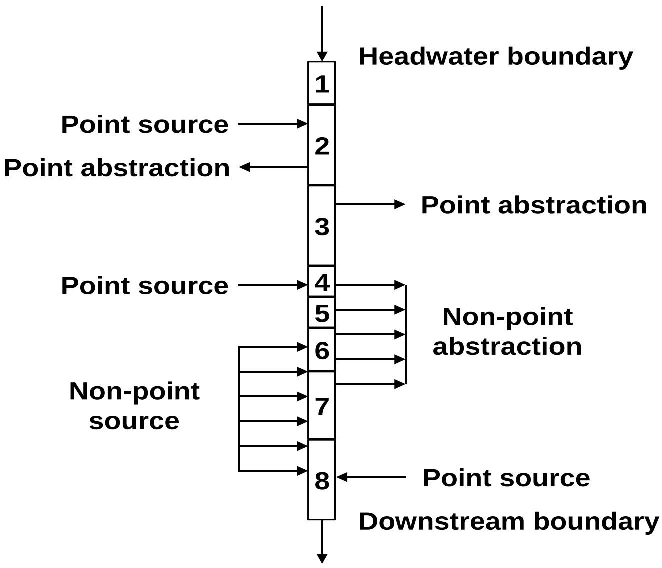

Figure (2.3): QUAL2Kw segmentation scheme (QUAL2KwTheory and Documentation, 2008)

2.3.2 Quantities

- Temperature.
- Conductivity.
- Inorganic suspended solids.
- Dissolved oxygen.
- Slowly reacting CBOD.
- Fast reacting CBOD.
- Organic nitrogen.
- Ammonia nitrogen.
- Nitrate nitrogen.
- Organic phosphorus.
- Inorganic phosphorus.
- Phytoplankton.
- Detritus.
- Pathogen.
- Alkalinity.
- Total inorganic carbon.
- Bottom algae (periphyton) biomass.
- Bottom algae (periphyton) nitrogen.
- Bottom algae (periphyton) phosphorus.

2.3.3 Inputs

- Location, date, numerical integration control options.
- Conditions and concentrations of the headwater boundary flow and the tributary point sources and diffuse sources.

- Reach segment lengths, elevations, hydraulic geometry (rating curve or Manning equation inputs for depth and velocity).
- Air temperature, dew point temperature, wind speed, cloud cover, shade.
- Light attenuation parameters.
- Options for models of solar radiation, evaporation, and long wave radiation.
- Parameters for water quality kinetics rates and constants.
- Parameters to control the genetic algorithm for optional automatic calibration of water quality kinetics rates and constants.

2.3.4 Outputs

- Longitudinal predictions of daily minimum, average, and maximum concentrations for state variables.
- Daily predictions of state variables in the water column and hyporheic pore water.

2.3.5 Key Input Parameters

Four key input parameters used in the modeling process; these are Reaeration, Deoxygenation, Nitrification, and Denitrification.

Reaeration: is the process by which oxygen is introduced into a water surface from the atmosphere. In QUAL2kw, the reaeration rate can either be specified by the user or calculated internally by QUAL2kw using a variety of prescribed methods. Reaeration rate is described by Owens-Gibbs, using the following empirical equation

$$K_r = 5.32\ \frac{v^{0.67}}{H^{1.85}} \qquad 2.3$$

Where H is the average stream depth, and v is the average stream velocity, this formula is valid when the depth range is 0.1 m< H<3 m and the velocity rage is 0.03 m/s<V<1.50 m/s, this formula applied for the shallow streams. However, the previous formula is calculated for default temperature which 20 C^o, for realistic representation for the stream conditions a temperature correction is needed. The following correction was used:

$$K_{rt} = K_r(1.024)^{t-20} \quad 2.4$$

Where t is the field temperature at each location. The temperature correction coefficient is commonly taken to be in the range 1.024 to 1.025 (Chin, 2013).

Deoxygenation: is a process in which carbonaceous BOD is biochemically oxidized to reduced inorganic compounds. The BOD decay rate traditionally determined in a laboratory might not necessarily be the same as estimated for a natural stream (Bansal, 1975). It difference from the BOD rate constant because there are physical and biological differences between a river and a BOD bottle, this difference recouped by the following modifications:

$$K_d = k_{BOD} + \frac{v}{H}\mu \quad 2.5$$

Where v is the average speed of stream flow, H is the average stream depth, and μ is bed-activity coefficient (from 0.1 to 0.6 or more), the k_{BOD} is rate constant determined in laboratory at $20C^o$. However, the previous formula is calculated for default temperature which 20 C^o, for realistic representation for the stream conditions a temperature correction is needed. The following correction was used:

$$K_t = K_{BOD}(1.135)^{t-20}$$

Where t is the field temperature at each location. The temperature correction coefficient is commonly taken to as 1.135 (Chin, 2013).

Nitrification: is a process in which ammonia is transformed to NO^-_3 nitrogen. The nitrification process is a result of the action of the nitrosomas and nitrobacter bacteria. Stoichiometrically, the oxygen requirement for the overall nitrification reaction is 4.56 mg of O_2 per milligram of NH^+_4 (Chin, 2013). However, since the reaction is autotrophic, oxygen is also produced as a result of bacterial growth, and the overall oxygen requirement for nitrification is less than the stoichiometric value.

Nitrification rate was calculated using a plot for the $\left(\left(\frac{Time}{NBOD}\right)^{\frac{1}{3}}\right)$ Vs. Distance (Hasan et al., 2010), the rate K_{10} was calculating as the following:

$$K_{10} = \frac{\left(\frac{Time}{NBOD}\right)^{\frac{1}{3}} Interception}{Slope\ of\ trend\ line} \qquad 2.7$$

After that the default nitrification rate calculated for temperature of 20 C^o using the following:

$$K_n = K_{10} * 2.302 \qquad 2.8$$

For realistic representation for the stream conditions a temperature correction is needed. The following correction was used:

$$K_{nt} = K_n * (1.1)^{t-20} \qquad 2.9$$

Where t is the field temperature at each location. The temperature correction coefficient is commonly taken to as 1.1(Chin, 2013).

Denitrification: Under anoxic conditions the nitrate-nitrogen ion becomes the electron acceptor in the organic matter oxidation reaction (Schindler, 1985). This process represents a loss of nitrogen from the water since the nitrogen gas produced volatilizes into the air (Chin, 2013).

In this case study no anoxic conditions were exited, so this parameter was excluded from the model calculations.

2.4 Water Quality Models (Catchment Scale)

Large variety of catchment scale models for water quality modeling was developed mostly in the US. The variety probably caused by the different environmental conditions and purposes when the models were developed. Changes and modification must be taken when using a model in Palestine to satisfy and meet the model theories. Several models are described below:

1- AGNPS (Agricultural Non-Point Source) pollution model: is a joint United States Department of Agriculture (USDA) - Agricultural Research Service (ARS) and - Natural Resources Conservation Service system of computer models developed to predict non point source pollutant loadings within agricultural watersheds. It contains a continuous simulation surface runoff model designed to assist with determining Best Management Practices (BMPs), the setting of Total Maximum Daily Loads (TMDLs), and for risk & cost/benefit analyses, it was developed in 1993 (Bragadin et al., 1993).

2- The Swedish Meteorological and Hydrological Institute (SMHI) is a government agency under the Swedish Ministry of the Environment. SMHI's mission is to manage and develop information on weather, water and climate that provides knowledge and advanced decision-making data for public services, the private sector and the general public. SMHI aims to contribute to increased social benefit, safety and a sustainable society. SMHI uses models to study the influence of climate and nutrient loads on the coastal and marine environment, in projects including AMBER, Baltic Way, ECOSUPPORT and INFLOW within the BONUS program, the model was developed in 2001 (Andersson and Arheimer, 2001).

3- The INCA project is based on the INCA (Integrated Nitrogen in Catchments) model, a processed based representation of plant/soil system and in stream nitrogen dynamics. The INCA project aims to use the model to assess the nitrogen dynamics in key European ecosystems, the model was developed in 2002 (Wade et al., 2002).

4- MAGIC (Model for Acidification of Groundwater in Catchments) is a process-oriented intermediate-complexity dynamic model by which long-term trends in soil and water acidification can be reconstructed and predicted at the catchment scale. MAGIC produces long-term reconstructions and predictions of soil and stream water chemistry in response to scenarios of acid deposition and land use. MAGIC uses a lumped approach in two ways, MAGIC was developed in 1985 (Cosby et al., 1985):

1- A myriad of chemical and biological processes active in catchments are aggregated into a few readily described processes.
2- The spatial heterogeneity of soil properties within the catchment is lumped into one set of soil parameters.

5- The Soil and Water Assessment Tool (SWAT) is a public domain model jointly developed by USDA Agricultural Research Service (USDA-ARS) and Texas A&M AgriLife Research. SWAT is a small watershed to river basin-scale model to simulate the quality and quantity of surface and ground water and predict the environmental impact of land use, land management practices, and climate change. SWAT is widely used in assessing soil erosion prevention and control, non-point source pollution control and regional management in watersheds, the model was developed in 1993 (Arnold et al., 1993).
6- MERLIN (Model of Ecosystem Retention and Loss of Inorganic Nitrogen) is a catchment scale model of linked Carbon and Nitrogen cycling in ecosystems. The model is split in to two plant compartments, namely active (plant) and structural (wood) biomass, and two soil organic compartments termed Labile (LOM) and Recalcitrant Organic Matter (ROM). Fluxes in and out of the ecosystem as well as between compartments are regulated by processes such as atmospheric deposition, hydrological discharge, plant uptake, litterfall, wood production, microbial N-

immobilisation, mineralisation, nitrification, and denitrification. The rates of fluxes are controlled by the C/N ratios of organic compartments as well as the inorganic N concentrations in the soil solutions; the model was developed in 1997 (Emmett et al., 1997).

2.5 Case Studies

Several studies and researches have been done to study the field of water quality modeling. Models have been made for rivers, lakes, and catchments. A summary for specific studies related to these topics are presented below:

(Alawneh, 2013) studied the Modeling of Water Quality and Quantity for Faria Streamusing QUAL2Kw to create the model, and to do an assessment of Faria stream quality variations of TKN, TDS, TSS, EC, pH using Microsoft excel, and to create a DO profile for the stream by QUAL2Kw model for summer with high BOD levels and for some critical conditions of minimum DO level with minimum flow. Modeling results showed there is a good correlation of simulated flow, depth, velocity, travel time, DO profile.

(Will et al., 2012) studied the Catchment-Scale Hydrologic and Water Quality Modeling using the Storm Water Management Model (SWMM) to validate lake Tahoe TMDL in South lake Tahoe. Their objective was developing average annual pollutant load estimates for urban catchments, and to simulate summer storm event response. The used tool was Pollutant Load Reduction Model (PLRM), and SWMM. The study utilized a comparison of the modeled storm event results to measured flow and fine sediment particle concentrations allows for evaluation of model performance and parameter refinement.

(Subhi et al., 2012) studied the Anthropogenic trace metals and their enrichment factors in Wadi Al-Qilt sediment, Palestine. The main objective was to delineate the extent of heavy metal pollution from Al-Qilt sediment. The Enrichment Factor (EF) values were determined for heavy and trace metals for the tested sediment samples. The surface sediment samples of the Wadi Al-Qilt catchment were characterized by trace metals that are typical of aquatic environments located in industrial and densely populated areas.

(Iqbal et al., 2010) studied the Development of a Catchment Water Quality Model for Continuous Simulations of Pollutants Build-up and Wash-off in Gold Coast, Australia. Their objective was to estimate of runoff water quality parameters conducted to determine and appropriate water quality management options and practices. They used Runoff Model and Pollutant Model. The developed runoff water quality model was set-up to simulate the build-up and wash-off of Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN).

Rebecca. (2010) studied the water quality modeling for the Kennet and Avon Canal, a navigational canal in an inland catchment in Kennet and Avon Canal in southern England. Her objective was to evaluate of six management scenarios proposed by the Environment Agency to address the water quality problem using Algorithm Model. This project identified the key solids generation and transport processes to be included in a water quality model for inland navigational canals. The model suggested that filtration or other treatment of water in the canal near the confluence with the river is the best management option.

(Saed., 2009) studied the hydrochemical variation in the springs water between Jerusalem–Ramallah Mountains and Jericho Fault, Palestine. His objective was to increase the efficiency of freshwater exploitation in the region. Some precautions, however, should be taken in future plans of artificial recharge of the aquifers or surface-water harvesting in the Wadi. Two zones of recharge are distinguishable. The first zone represented by Fara spring and Al-Qilt spring which was fed directly through the infiltration of meteoric water and surface runoff from the mountains along the eastern mountain slopes with little groundwater residence time and high flow rate. The second zone was near the western border of Jericho at the foothills, which is mainly fed by the under-ground water flow from the eastern slopes with low surface infiltration rate.

(Mazdak et al., 2006) studied the role of watershed subdivision on modeling the effectiveness of BMPs in Raccoon, Iowa, USA. Using the Soil and Water Assessment Tool (SWAT). Their objective was to assess the ability of the SWAT to simulate stream flow and associated movement of nitrogen, phosphorus, and sediment. Results for the study watersheds indicated that evaluation of the impacts of these BMPs on sediment and nutrient yields were very sensitive to the level of subdivision that was implemented in the modeling tool SWAT.

(Romanowicz et al., 2004) studied the Water Quality Modeling in Rivers with Limited Observational Data in River Elbe, Germany. Their objective was to find a derivation of a data-based model that has the minimum number of parameters. Using Data-Based Mechanistic Model (DBM).The result of this analysis was a nonlinear, Multi Input Single Output (MISO) transfer function model that provides a statistical counterpart of the mechanistic algae model.

(Simon and Mohand., 2003) studied the modelling scenarios for south east queensland regional water quality management strategy in Wye catchment, England. Their objective was to examine the spatial distribution of nutrient pollution risk and to assess broad-scale spatial and temporal variability in nutrient fluxes, using a Receiving Water Quality Model (RWQM2).The model was calibrated/verified, and after the development of realistic scenarios within the limitations of the model, the RWQM2 was then used to produce results for the defined management scenarios for dry average and wet years.

Chapter Three

Study Area

3.1 Geography and Topography

Al-Qilt catchment is located in the western side of the Jordan Valley in the West Bank, Palestine with a total area of about 174 km^2 .The catchment extents over parts of Ramallah, Al-Bireh, Jerusalem and Jericho as shown in Figure 3.1. The main stream is 38 km long which starts from Al-Bireh city with upstream elevation of 727 m a.m.s.l, and ending at the vicinity of Jordan River with downstream elevation of 178 m b.m.s.l., passing through Burqa, Mukhmas, Aqbet Jaber Camp, and Jericho (see Figure 3.1). Al-Qilt catchment located in the well-known as Dead Sea Rift Valley. The elevation of the Rift Valley drops to about 350 m b.m.s.l. to the present shores of the Dead Sea in the east, and the west of the Rift Valley in the vicinity of Ramallah and Jerusalem the mountains rise up to elevations over 800 m a.m.s.l. which creates a steep and sharp slopes (ARIJ, 1995).

The catchment includes five major springs, which are: (Ein Jumeiz, Ein Fara, Fawwar, Ras Al-Qilt, and Ru'yan. Al-Qilt catchment is bounded by Nueima drainage basin from north, Soreq and Al Dilb drainage basins from west, Mukallak and Marar drainage basins from south and Jordan River from the east (Ghassan, 2009).

Al-Qilt catchment contains two main tributaries. The first tributary is called Wadi Sweanit which originates from the eastern part of Al-Bireh. Wadi Sweanit contains two water springs, which are Fawwar and Ras Al-Qilt. The second tributary named as Wadi Fara and contains three water springs, which are Ein Jumeiz, Ein Fara and Ru'yan (Subhi et al., 2012). This study focuses on Wadi Sweanit due to its continuous streamflow over the year, unlike Wadi Fara which is only seasonal.

Figure (3.1): General map of Al-Qilt catchment location

3.2 Stream Description

Several field visits were conducted to assess the physical, chemical, and biological characteristics of Al-Qilt stream. Results are listed in Table 3.1, a list of these characteristics with some details; further descriptions are presented in the following chapter 4.

Table (3.1): Factors used in stream survey and assessment

Physical Measures	Chemical Measures	Biological Measures
Size (width, depth)	Dissolved oxygen	Fish
Flowrates, velocity	Nitrogen	
Reaeration rates	Suspended solids	
Slope	Phosphorus	Phytoplankton
Pool, and riffles	pH	
Temperature	Dissolved solids	
Sedimentation		

The average and maximum slope of the stream was 5.3% and max. 20.3%, respectively. The pools and riffles phenomenon was limited and the stream is best described with Owens-Gibbs empirical formulas according to the streamflow velocity, width and depth. From observation during site visits, no considerable sedimentations had accumulated along the stream's bed due to the high flow velocity and high slope.

The stream especially downstream was full of aquatic life with fishes and frogs, with almost no phosphorus nor phytoplankton.

3.3 Population

Many Palestinian communities and Israeli settlements are located within the catchment boundary which affects the environment and the streamwater quality. According to (PCBS. 2007), the Palestinian population in the catchment was estimated to be more than 128,049 inhabitants (see Table 3.2). However, the number of Israeli settlers in six settlements was estimated to be more than 29,250 settlers (see Table 3.3). Palestinian and Israeli built up areas are about 1.7% and 1.5%, respectively (PCBS. 2007). Further information is still needed about the Israeli military bases and industrial zones, since very limited and inaccurate information was available.

Table (3.2): Population of Palestinian communities

Community	Pop.
Beitin	2014
Al-Bireh	35,910
DeirDibwan	4,937
Burqa	1,964
KafrAqab	10,103
Qalandia Camp	7,962
Mukhmas	1,305
Al Ram and Dahyiat Al Bareed	18,356
Jaba'	2,870
Hizma	5,645
Beit Hanina	966
Anata	10,864
EinAduyuk At Tahta	783
Jericho	17,515
Deir Al-Qilt	4
AqbatJaber Camp	6,851
Total	**128,049**

Table (3.3): Population of Israeli settlements

Settlement	Pop.
Psagot	1,333
KokhavYa’kov	3,922
Ma’aleMukhmas	998
Almon	740
Giv’a Binyamin (Adam)	1,988
NevehYa’kov	20,269
Total	**29,250**

3.4 Climate

The climate of the West Bank has no different conditions of the Mediterranean climate. There are two significant seasons: the summer which is dry hot season from June to October, and winter which is cold wet season from November to May. In spite of that West Bank has a small area; there is a significant difference in the climate. Such variations are clear in Al-Qilt catchment. In the western part of the catchment, the climate is influenced by the Mediterranean climate, a rainy winter and dry summer.

While the climate in the eastern part is classified as arid with hot summers and warm winters, (Ghassan, 2009).

In the western part of Al-Qilt catchment, the average temperature ranges between 6–12 °C in the coldest month (January) and between 22–27 °C during the warmest month (August) in the western part of the catchment, while in the eastern part of the catchment it ranges between 7–19 °C during (January) and between 22–38 °C during (August) (PMD, 2012). A map for the mean annual temperature ranges over Al-Qilt catchment is shown in Figure 3.2.

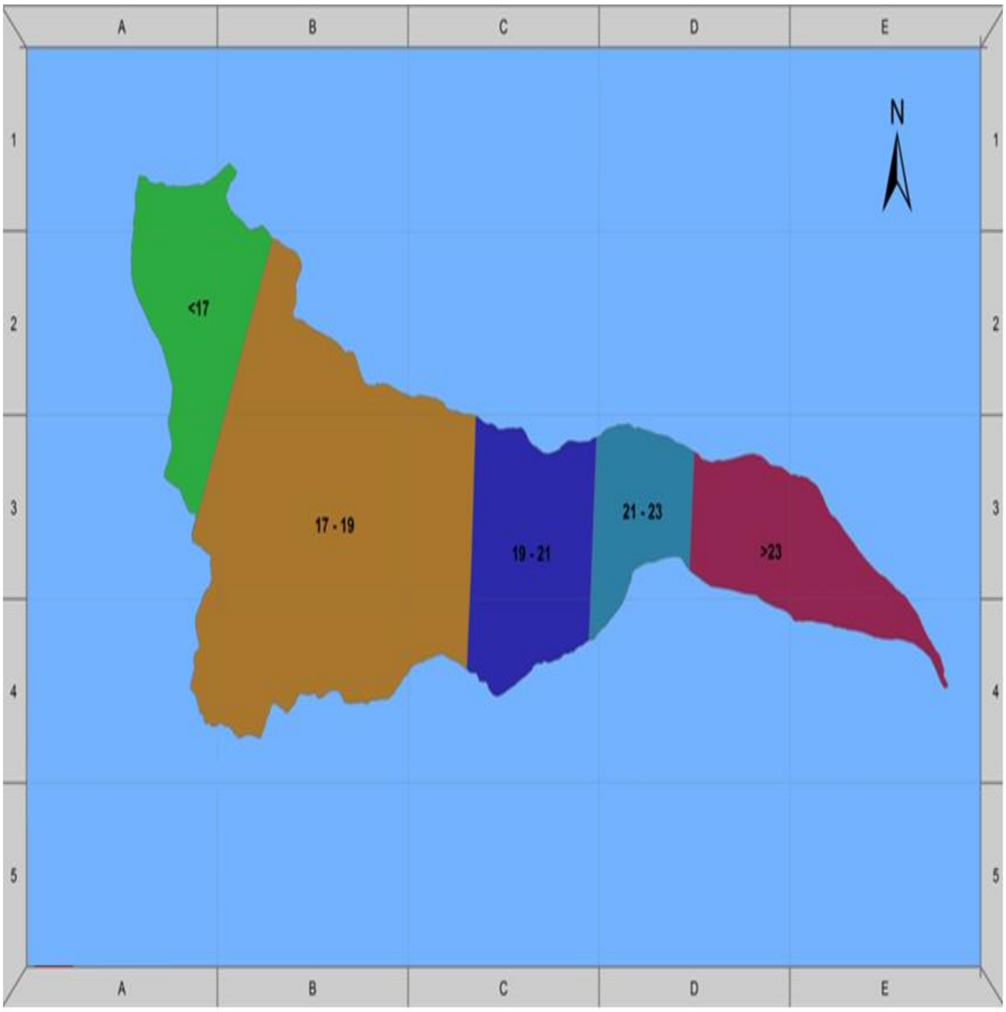

Figure (3.2): Average annual temperature ranges of Al-Qilt Catchment

3.5 Rainfall

Rainfall ranges from 5 to 100 mm in each storm event. Spatial distribution of rainfall also varies strongly. Average annual rainfall in Ramallah and Jerusalem mountains ranges from 400 to 650 mm, whereas in Jericho, the average annual rainfall is about 180 mm, of which approximately 60% falls in the three months of December, January and February. Figure 3.3 shows the average annual rainfall of Ramallah station for the period of (1990 – 2007). In general, Jericho district has the lowest rainfall in the region and short rainy season ranging between 20-25 rainy days per year (ARIJ, 1997; PWA, 2007). Figure 3.4 shows the rainfall contour map for Al-Qilt catchment in 2012.

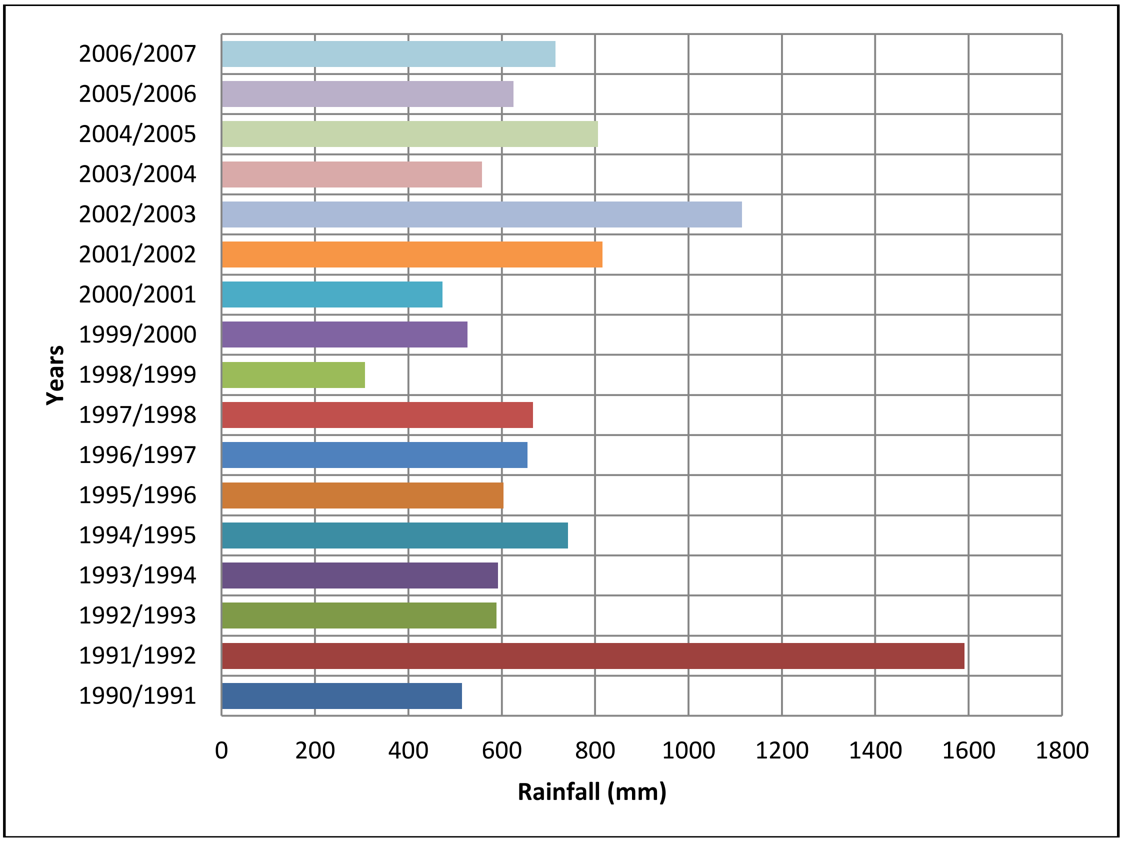

Figure (3.3): Annual rainfall of Ramallah

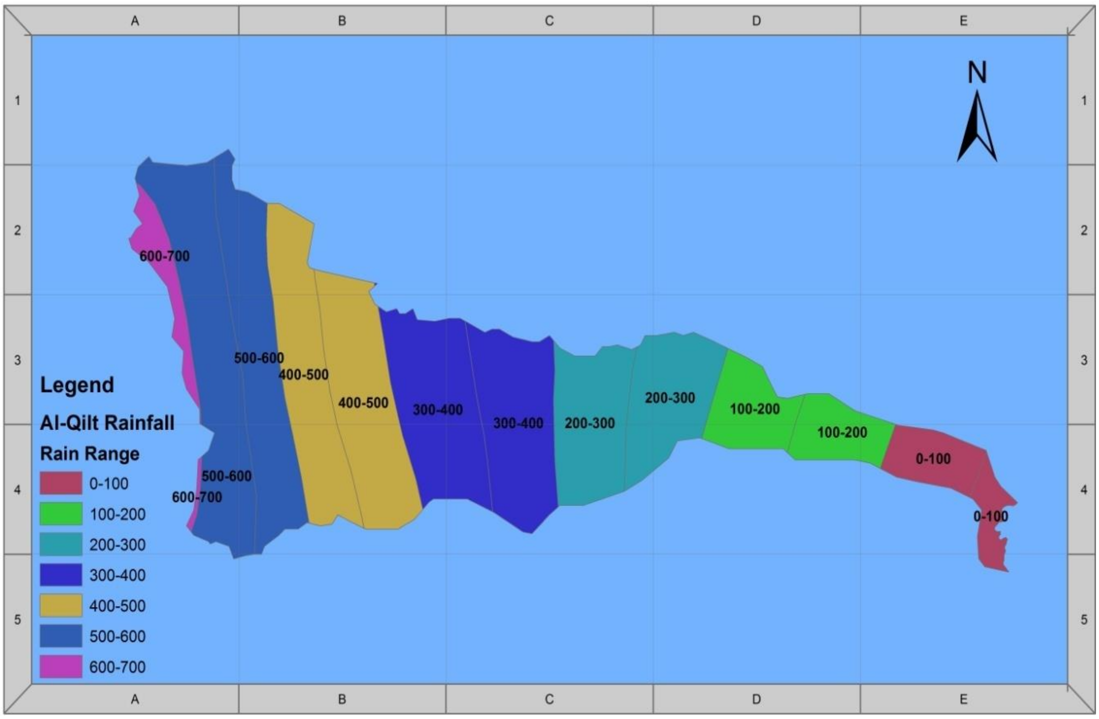

Figure (3.4): Rainfall contour map for Al-Qilt Catchment.

3.6 Streamflow

The long-term observations of the streamflow (runoff) that generating over Al-Qilt catchment ranged from 3.0 to 10.0 MCM/year. Flow measurements are taken for (Al-Bireh, Mukhmas, Fawwar, Ras Al-Qilt, and Murashahat). The total wastewater flow which discharged into Al-Qilt catchment from the Palestinian and Israeli sides could be estimated about 5 MCM/year (Samhan, 2013).

The flow measurements of the five sampling points on the main stream of Al-Qilt catchment are presented in Table 3.4:

Table (3.4): Flow measures for the five sampling locations

Community	Flow (m^3/d)
Al-Bireh	5,000
Mukhmas	3,374
Fawwar	6,726
Ras Al-Qilt	17,458
Murashahat	15,378

These values estimated according the annual averages of streamflow runoff from 2007 to 2012, and not only for wet or dry seasons. The discharges from the five springs depend on the rainfall amount for the corresponding year. From flow measurements it is believed that Al-Qilt spring has the highest discharge quantity which promotes further concern to protect it.

Chapter Four

Methodology

4.1 Introduction

This chapter discusses the scientific approach that was used to build the DO model for Al-Qilt streamwater. The overall research methodology is presented in Figure 4.1.

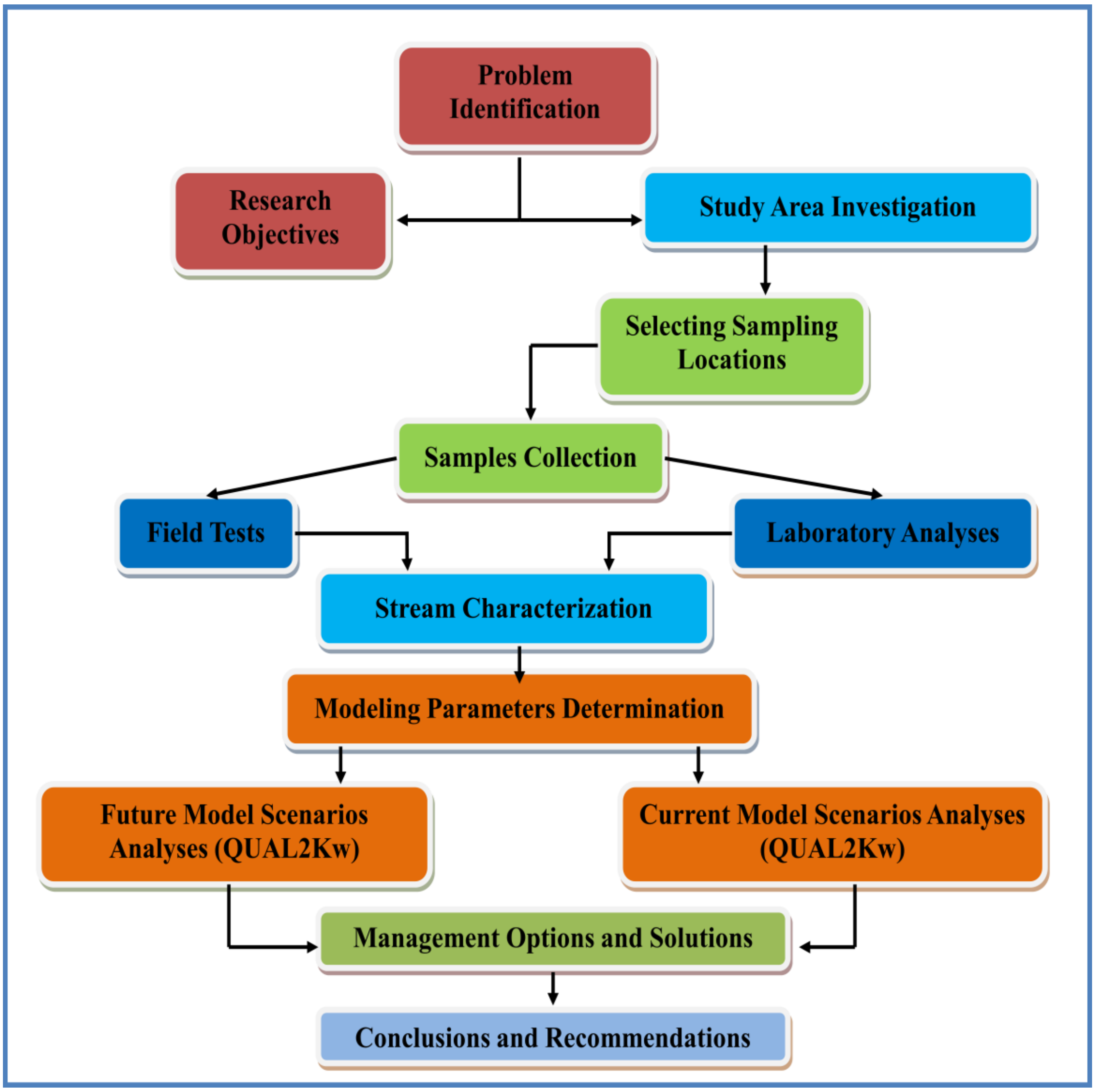

Figure (4.1): Research methodology

4.2 Field and Laboratory Work

4.2.1 Site Investigation and Characterization of the Study Area

A field visit for the study area was conducted on the 6th of March 2013; in which the following sites were visited:

1- Al-Bireh WWTP.
2- Fawwar, and Ras Al-Qilt springs.
3- Mukhmas village.
4- Aqbat Jaber refugee camp.

The potential pollution sources in the area were explored, such as (Israeli military zone, solid waste dumping site, and agricultural zones).

A general view was taken for the terrain of the area, topography, and land cover/use. Using the GIS shapefiles that were obtained from PWA, and Google earth maps. Several detailed maps were created. Also, an elevation profile was created showing (longitudes, altitudes, average slopes, and elevations are shown in Figure 4.2). These maps were used to describe the properties of the catchment, focusing on Al-Qilt main streamwater.

4.2.2 Allocating Sampling Locations

Several considerations and criteria were taken in allocating the sampling locations, such as:

1- Drastic changes in slope or flow.
2- Existence of aquatic growth or pollution sources.
3- Ease of accessibility.
4- Historical data of sampling points.

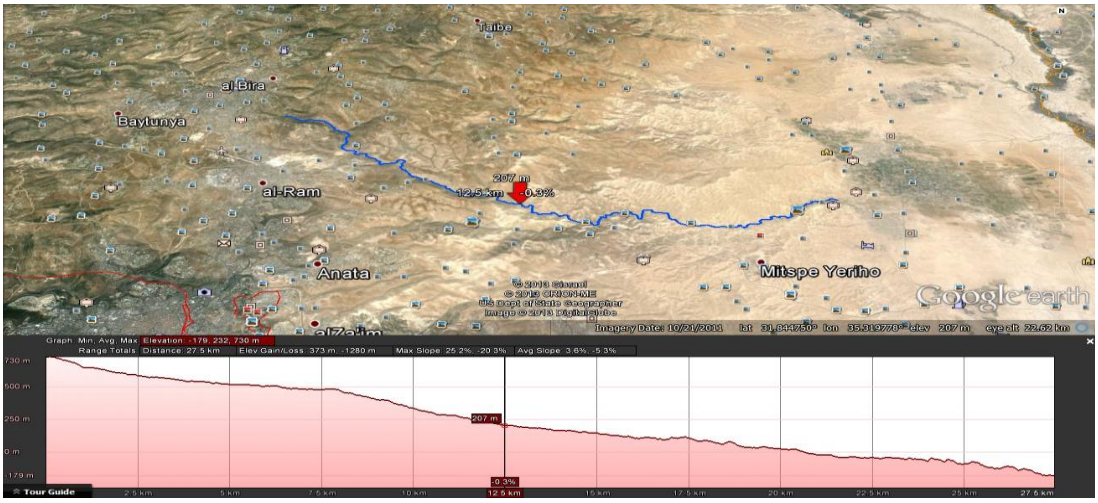

Figure (4.2): Elevation profile of Al-Qilt stream

A description about the sampling points is presented in Table 4.1.

Table (4.1): Sampling locations description

Location	Description	Distance* (km)
Al-Bireh WWTP	Samples were taken exactly after the TP; samples at this location were taken from the treated wastewater effluent. This location considered as reference.	0
Mukhmas	Samples were taken exactly after Mukhmas village; samples at this location were untreated wastewater samples, since the stream running from Al-Bireh merged with raw wastewater coming from Qalandia region.	5.5
Fawwar	Samples were taken exactly at the spring outlet; samples at this location were fresh water.	17
Ras Al-Qilt	Samples were taken exactly at the spring outlet; samples at this location were fresh water.	21.7
Murashahat	Samples were taken before the filtration process; samples at this location were fresh water samples.	27

*Distances are relevant to the discharge at the point of Al-Bireh WWTP to Al-Qilt stream.

The total number of samples that were taken is 15, water and wastewater (treated and untreated) were taken directly from the stream. Samples were collected from both upstream and downstream of Al-Qilt streamwater. The upstream section extends from Al-Bireh WWTP passing through Mukhmas village; with total length of 10.5 km. The downstream section extends from Fawwar spring and ends at Aqbet Jaber camp; with total length of 10.5 km (see Figure 4.3).

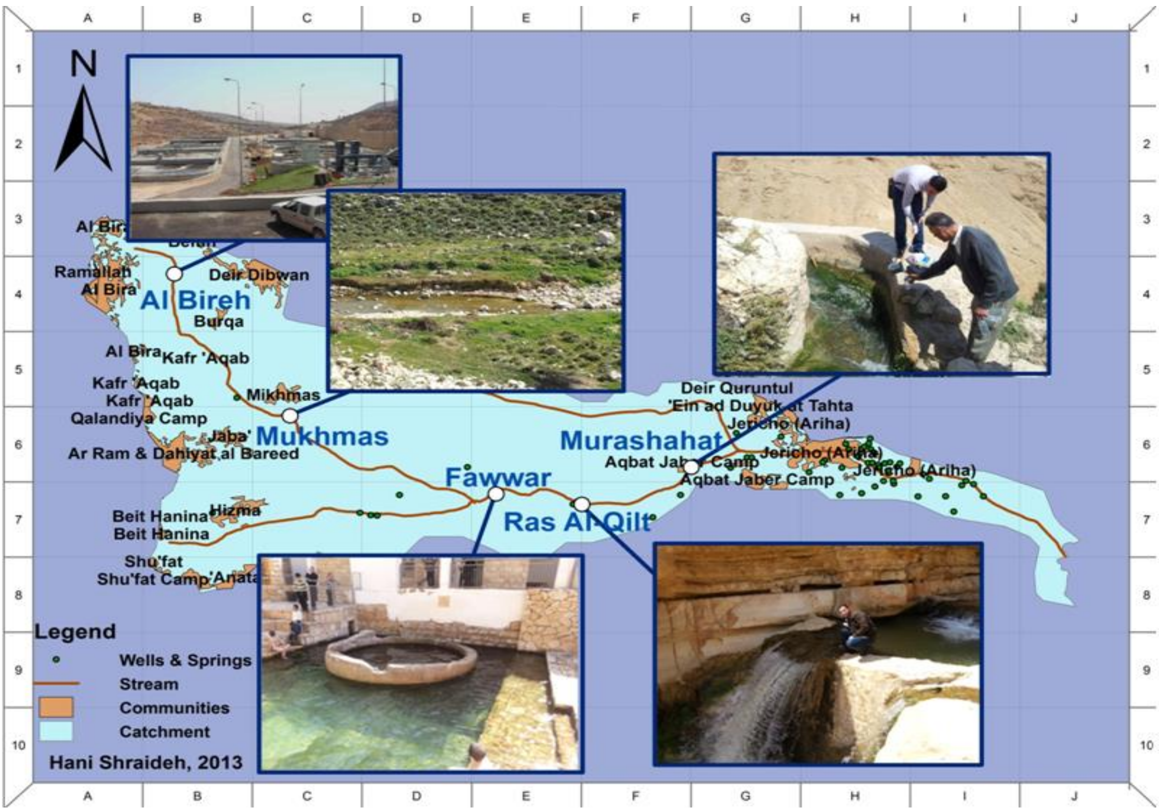

Figure (4.3): Sampling locations map

4.2.3 Sampling Frequency

Samples were collected on monthly basis from the five selected locations. The sampling period covered the dry season of 2013; from April till June of 2013.

4.2.4 Samples Collection

Samples were collected (see Figure 4.4) according to the following procedures:

1- The containers were washed by the stream water at each corresponding location before using each container.
2- The collected volume of each sample was 1 liter.
3- The samples were collected in High density Poly Ethylene (HDPE) bottles with tight caps.
4- The samples were collected by a sampler as shown in Figure 4.4.
5- The numbers of samples and dates had been written on each container.
6- The samples had been cleaned from visible relatively large suspended objects.
7- The samples were preserved during the tour, in a cooled ice container.

Figure (4.4): Collecting samples from Al-Qilt stream

4.2.5 Samples Analyses and Stream Characterization

4.2.5.1 Field Tests

For each collected sample, the following parameters (DO, pH, Temp, TDS and EC) were determined on site.

4.2.5.2 Laboratory Analyses

The following analyses were performed for all the samples in PWA's laboratory in Ramallah: (BOD_5, BOD_{20}, COD, Total Nitrogen (TN), Ammonium, Nitrate, Nitrite, and Total Suspended solids (TSS)).

4.3 Setting up the Model

Three scenarios were simulated for Al-Qilt streamwater; one scenario for the current situation, and two scenarios for suggested future situations.

4.3.1 Current Situation Scenario

The first scenario simulated the current situation without any remediation or reconditioning for the two reaches (upstream and downstream). This case simulated the first three months of the dry season (April, May, and June of 2013) no further extension for the study period included since the stream usually dries up between July and August of every year until the next wet season which starts at late September to mid of October. The simulated condition here represented the worst case scenario with minimum DO level and low quantities of fresh water flow.

4.3.2 Future Model Scenarios

The second scenario simulated the effect of adding two artificial weirs in the upstream reach on increasing the DO levels. Figure 4.6 shows the mechanism which was proposed to increase the DO in the stream. The suggested step elevation of the weirs was, h = 1 ft (Butts and Evans, 1983).

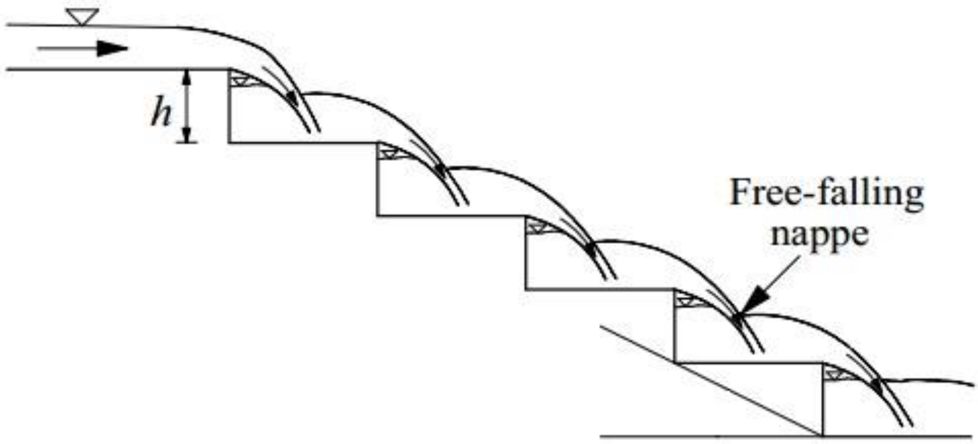

Figure (4.5): Stepped aeration cascades

The predictive relation of the aerated oxygen assumes that saturation concentration (C_s) is constant and determined by the water–atmosphere partitioning. If that assumption is made, C_s is constant with respect to time, and the oxygen transfer efficiency (aeration efficiency), E may be defined by the following equation (Baylar et al., 2009):

$$E = \frac{C_d - C_u}{C_s - C_u} * 100\% \qquad 4.1$$

Where u and d indicating upstream and downstream locations, respectively. The efficiency of the aeration enhancement was set to 85% for all the proposed weirs. The DO concentrations before the proposed weirs were determined from the current situation scenario results and using the efficiency equation, the values of the new generated DO concentrations were calculated and used in building the future model scenarios.

The third scenario, was exactly as the second one, just with the addition of WWTP to treat the raw wastewater flowing from Qalandia region.

The modeling steps for building future model scenarios did not changed from the followed steps in building the current situation scenario model.

Chapter Five

Results and Discussion

5.1 Introduction

This chapter discusses the measured and calculated values of BOD, COD, EC, TS, TSS, TDS, TN, NO^-_3, NO^-_2, Temperature, pH, and constant rates that were used, in order to set up the QUAL2Kw model. This chapter also, presents the results of the three model scenarios that were created for Al-Qilt streamwater.

5.2 Stream Characterization

5.2.1 Physical Characteristics

The physical characteristics of upstream and downstream reaches were specified. Variations of these characteristics at the five allocated sampling locations are listed in Table 5.1. The highest measured flow rate along the stream was at Ras Al-Qilt, this is because of Ras Al-Qilt spring which feeds the stream at this location. While the lowest measured flow rate along the stream was at Mukhmas due to the filtration process. The velocity of the stream ranged between 0.203 m/s at Mukhmas, where the stream is flat and wide; and 1.37 m/s at Murashahat, where the stream is steep and narrow.

Table (5.1): Summary of physical characteristics of Al-Qilt stream

Location	Flow (m^3/s)	Velocity (m/s)	Depth (m)	Width (m)
Al-Bireh WWTP	0.0578	0.35	0.18	1.15
Mukhmas	0.039	0.203	0.2	1.2
Fawwar	0.0778	0.324	0.25	1.2
Ras Al-Qilt	0.202	0.315	0.4	2
Murashahat	0.1779	1.37	0.25	0.65

Al-Qilt streamwater gained and loosed different quantities of water over the study period, in both upstream and downstream reaches (Figure 5.1).

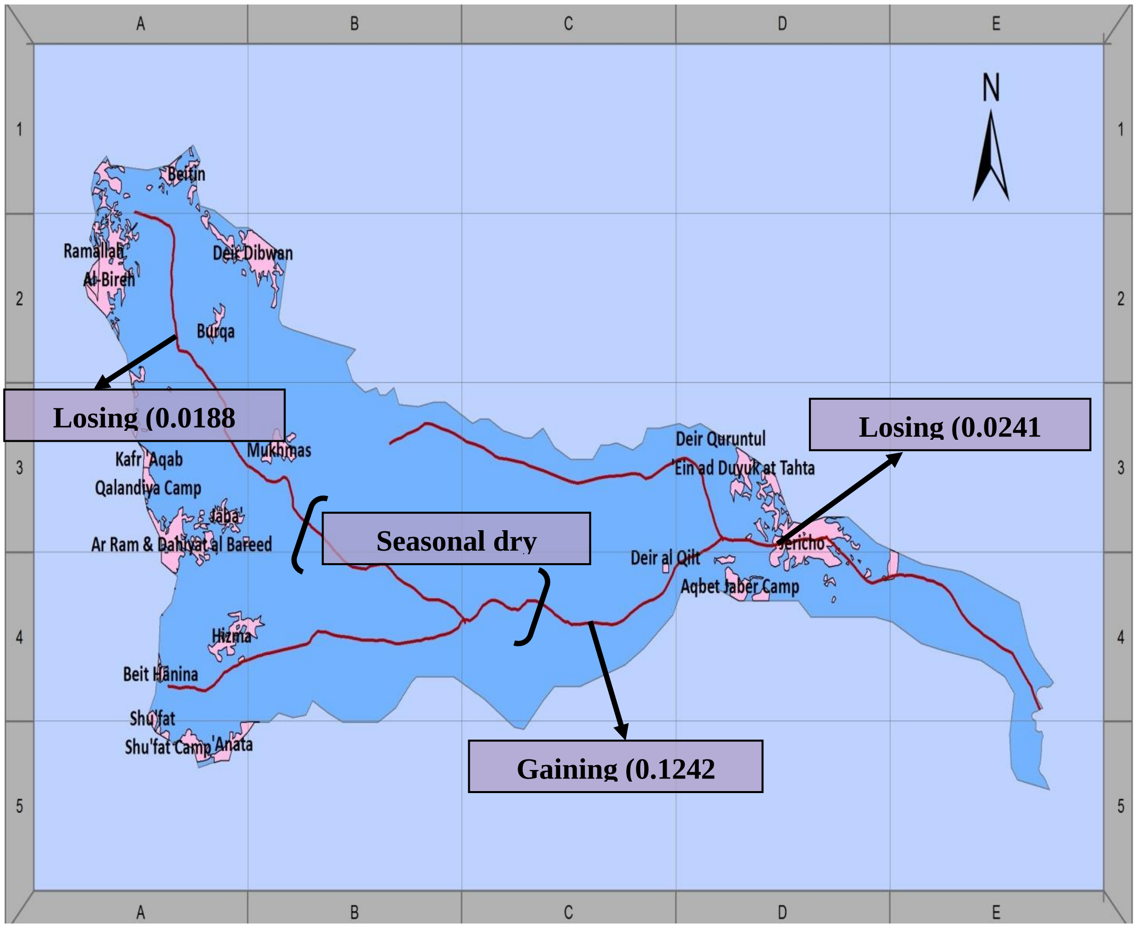

Figure (5.1): Gaining/Losing location sketch along the stream

5.2.2 Field Measured Characteristics

DO – On April, 2013; Do values ranged from 11 mg/L at Murashahat to 3 mg/L at Al-Bireh (Figure 5.2). On May, 2013; Do values ranged from 13.7 mg/L at Ras Al-Qilt to 2.5 mg/L at Al-Bireh (Figure 5.3). On June, 2013; Do values ranged from 12.9 mg/L at Murashahat to 3.6 mg/L at Al-Bireh (Figure 5.4). The reasons of these variations are the different levels of pollution, temperatures, and reaeration process. Each measured value of DO was associated with specific temperature. Temperatures on downstream locations were lower than downstream location; since samples on downstream were taken in the early morning; and samples on upstream were taken in the afternoon.

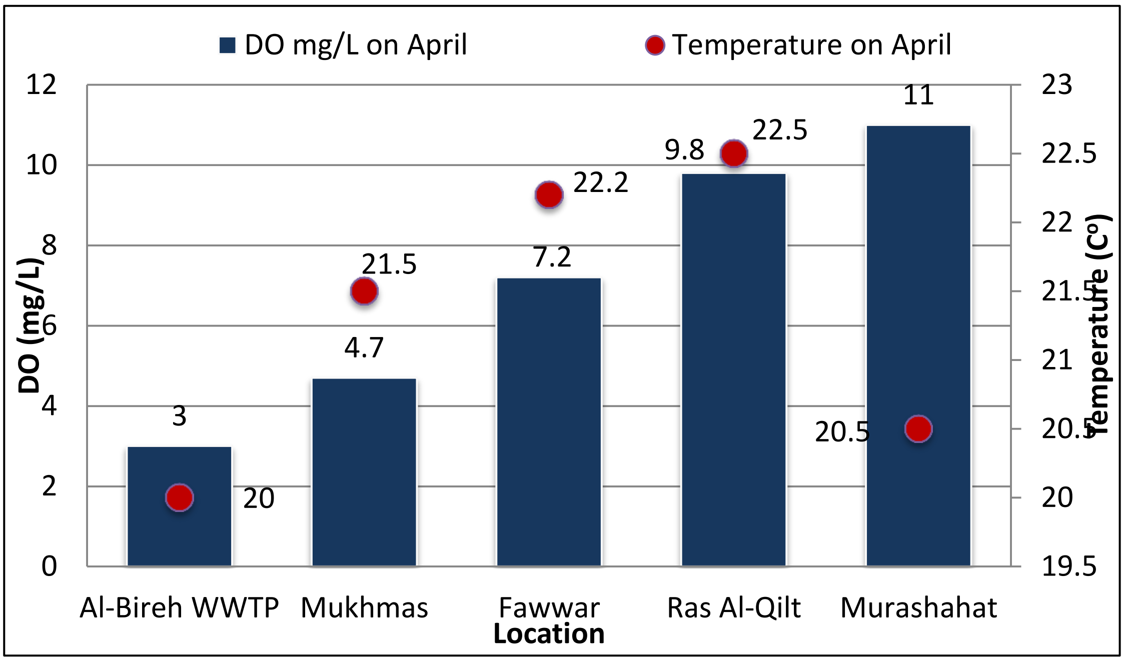

Figure (5.2): Measured DO concentrations with associated temperatures, on April 2013

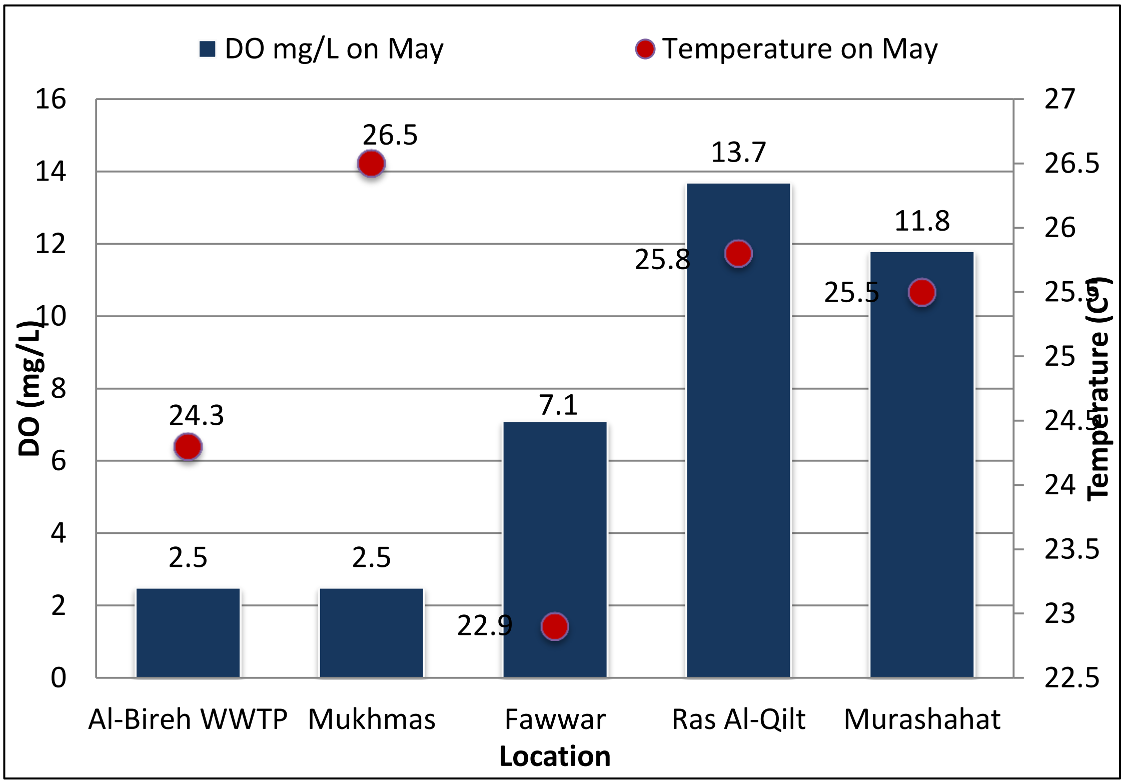

Figure (5.3): Measured DO concentrations with associated temperatures, on May 2013

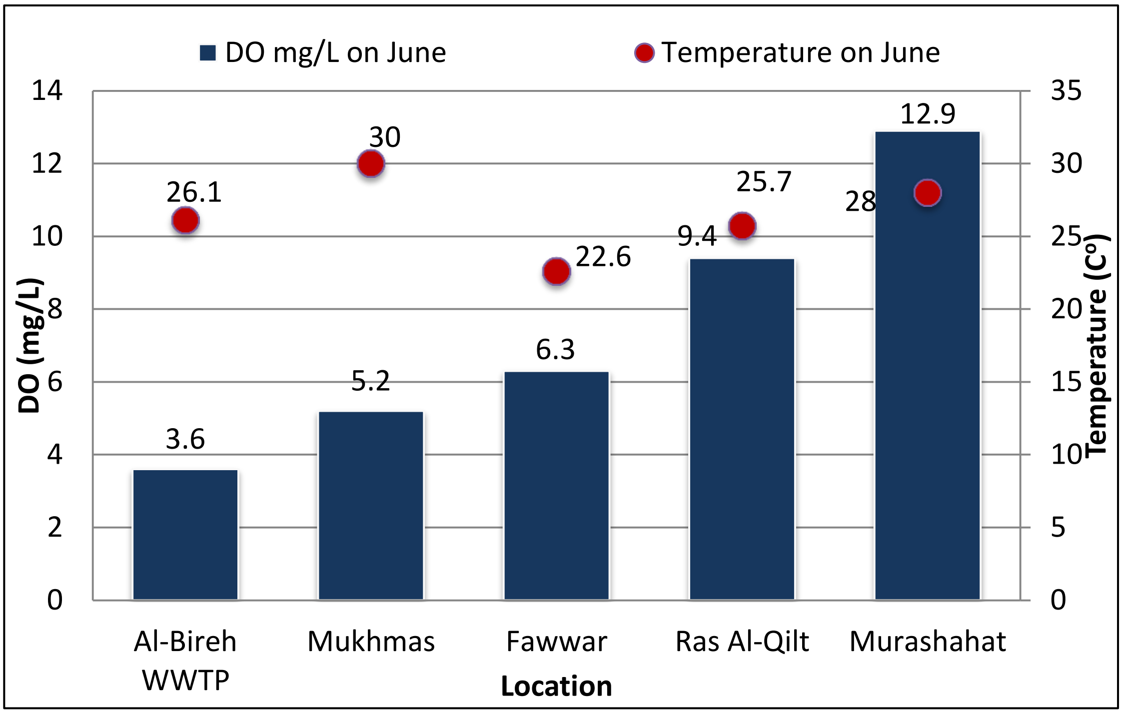

Figure (5.4): Measured DO concentrations with associated temperatures, on June 2013

DO concentrations varied from one location to another. The effluent from Al-Bireh WWTP had the lowest DO concentration along the main stream in both reaches upstream and downstream, with range of (2.5 – 3.6) mg/L. The concentration increased to range of (2.5 – 5.2) mg/L at Mukhmas sampling location which is located approximately 5 km from Al-Bireh WWTP. The DO concentration increased despites of the untreated wastewater from Qalandia region which mixes with Al-Qilt main streamwater.

Murashahat sampling location had high DO concentration with range of (11-12.9) mg/L, and Ras Al-Qilt sampling location had a range of (9.4 – 13.7) mg/L. Oxygen deficits for all the collected water samples are listed in Table 5.2. Springs discharges had higher DO concentrations along the main stream.

Table (5.2): Dissolved Oxygen deficit between measured and saturation concentrations

Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
Samples Collected During April (mg/L)					
DO	3.00	4.70	7.20	9.80	11.00
DO_s	8.29	8.30	8.49	8.62	7.17
Oxygen Deficit	5.29	3.60	1.29	0	0
Samples Collected During May (mg/L)					
DO	2.50	2.50	7.10	13.70	11.80
DO_s	7.67	7.51	8.45	8.07	8.33
Oxygen Deficit	5.17	5.01	1.35	0	0
Samples Collected During June (mg/L)					
DO	3.60	5.20	6.30	9.40	12.90
DO_s	7.38	7.99	8.53	8.14	7.98
Oxygen Deficit	3.78	2.79	2.23	0	0

Each sample location had its related DO_s according to the corresponding temperature (Environmental Services Program, 2013).

pH – From April until June, 2013 values of pH were increasing with range of (1.07 – 1.36). On the other hand, pH vales were almost constant for each location at the same month. More details for pH values in appendix A

TDS/EC – From April until June, 2013 values of the TDS concentrations were extremely close with very limited differences. The same observation for the TDS values applied to the EC values see Table 5.3.

Table (5.3): Measured EC values for samples on April, May, and June 2013

Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
EC (mg/L)	Samples Collected During April				
	1345	1375	635	530	534
	Samples Collected During May				
	1360	1388	635	507	497
	Samples Collected During June				
	1350	1355	654	550	472

5.2.3 Laboratory Characteristics

BOD – On April, 2013 values of BOD in the five sampling locations were roughly three times higher than May and June, 2013 this is due to the cultural habits for the shepherds in the region of washing their sheep in the stream on April of each year, and because of the seasonal visits to this location by the tourists. On the other hand, relatively close match was noticed for the five sampling locations, between BOD values on May and June, 2013 (Table 5.4). Only Ras Al-Qilt and Mukhmas had some differences in the BOD values between May and June, 2013. Values of BOD_{20} and a figure for BOD_5 are listed in appendix B.

Table (5.4): BOD ranges for the five sampling locations

Location	BOD_5 Range (mg/L)	Note	Highest BOD_{20} (mg/L)	Note
Al-Bireh	5 - 20	May values exactly matched June values	35	Highest value on June, 2013
Mukhmas	15 - 35	No match between May values and June values	55	Highest value on April, 2013
Fawwar	5 - 35	May values almost matched June values	35	Highest value on April, 2013
Ras Al-Qilt	0 - 15	No match between May values and June values	20	Highest value on April, 2013
Murashahat	5 - 15	May values exactly matched June values	15	Highest value on April, 2013

BOD_{20} values for Al-Bireh reached up to 35 mg/L on June, 2013 which is reasonable since water flowing at this location was a treated wastewater from Al-Bireh WWTP.

BOD_{20} values for Mukhmas reached up to 55 mg/L on April, 2013 this value shows that the flow contains unacceptable concentrations of raw wastewater and it exceeds the limits of Palestinian standards for treated wastewater.

BOD_{20} values for Fawwar reached up to 35 mg/L on April, 2013 where theoretically it must be zero since the streamwater on this location is fresh water, but it is a strong indicator for an underground pollution source form Mukhmas region causing this significant BOD level.

BOD_{20} values for Ras Al-Qilt reached up to 20 mg/L on April, 2013 where theoretically it must be zero since the streamwater on this location is fresh water, but it was due to the tourist’s visits to this location by this time of the year. The zero value here was due to inaccurate analysis process.

BOD_{20} values for Murashahat reached up to 15 mg/L on April, 2013 where theoretically it must be zero since the streamwater on this location is fresh water, but due to the sheep cleaning activities, BOD values had increased.

COD – From April, 2013 to June, 2013 COD values ranged from 200 mg/L to 380 mg/L, these results were in the upstream reach which is considered as treated and mixed raw wastewater (Figure 5.12). Such values are considered as moderate, comparing them to the values of COD in Palestinian wastewater which could reach more than 1000 mg/L in some cases. Downstream reach had one odd value of COD, at Ras Al-Qilt which was (323 mg/L) this might be due to the human tourism activities on that location at this time of the year.

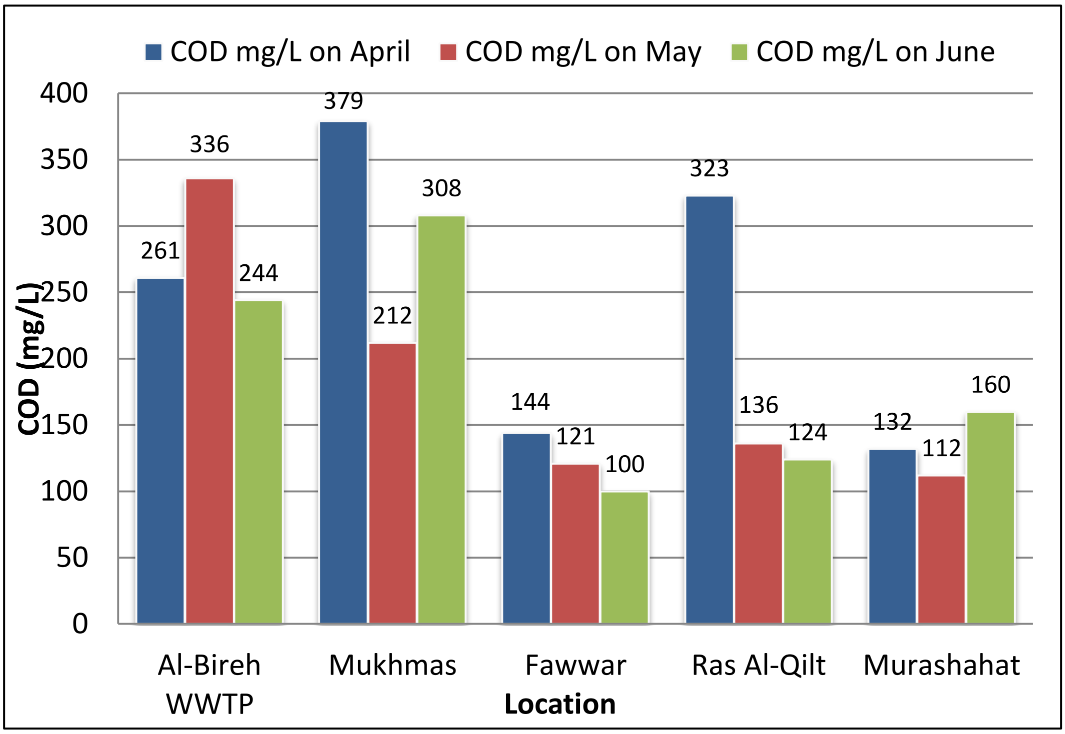

Figure (5.5): COD for the five sampling locations on April, May, and June 2013

Nitrogen (TN, TKN, NO^-_3 and NO^-_2)

TN – Values of TN were very reasonable. Comparing the highest value which was almost 42 mg/L on April, 2013 at Mukhmas (see appendix C) with the typical value of TN in residential untreated wastewater which is 40 mg/L, showed close proximity. High values appeared at locations which considered as fresh water on April due to the human activities at this time of year.

TKN – The maximum value of the TKN was 16.4 mg/L on April, 2013 at Fawwar (see appendix C), which is significantly lower than the typical values of TKN in residential untreated wastewater which is 50 mg/L.

NO^-_3 , NO^-_2 - Theoretically NO^-_3 and NO^-_2 must be zero in the untreated wastewater. However, because of the considerable aeration that occurred along the Al-Qilt streamwater, NO^-_3 and NO^-_2 appeared due to nitrification.

Values of NO^-_3 and NO^-_2 were the lowest on June for all the sampling locations (see Appendix C).

Table 5.5 lists the levels of (total nitrogen, TKN, NO^-_3, and NO^-_2) for the period from April 2013 to June 2013.

Table (5.5): Nitrogen levels for Al-Qilt stream on April, May and June 2013

Nitrogen levels during April					
Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
TN	17.6	41.7	40.2	28.5	38.7
TKN	7.4	11.1	16.4	3.7	11
NO^-_3	6.6	11.6	20.4	22.1	19.2
NO^-_2	3.6	19	3.4	2.7	8.5
Nitrogen levels during May					
TN	39.3	39.6	34.8	24.9	33.1
TKN	14.1	10.1	2.2	4.3	7.9
NO^-_3	21.2	18.3	30.6	17.6	15.2
NO^-_2	4	11.2	2	3	10
Nitrogen levels during June					
TN	22.88	34.93	15.57	18.68	28.88
TKN	15.18	14.63	3.07	8.08	14.08
NO^-_3	5.4	17.9	6.2	9.4	13.3
NO^-_2	2.3	2.4	1.3	1.2	1.5

TSS – Values of the TSS for the five sampling locations showed significantly high values on April (Figure 5.17), that exceeded approximately five times the typical value of TSS in residential untreated wastewater which is 220 mg/L, especially at the upstream reach, since it contains treated and mixed raw wastewater.

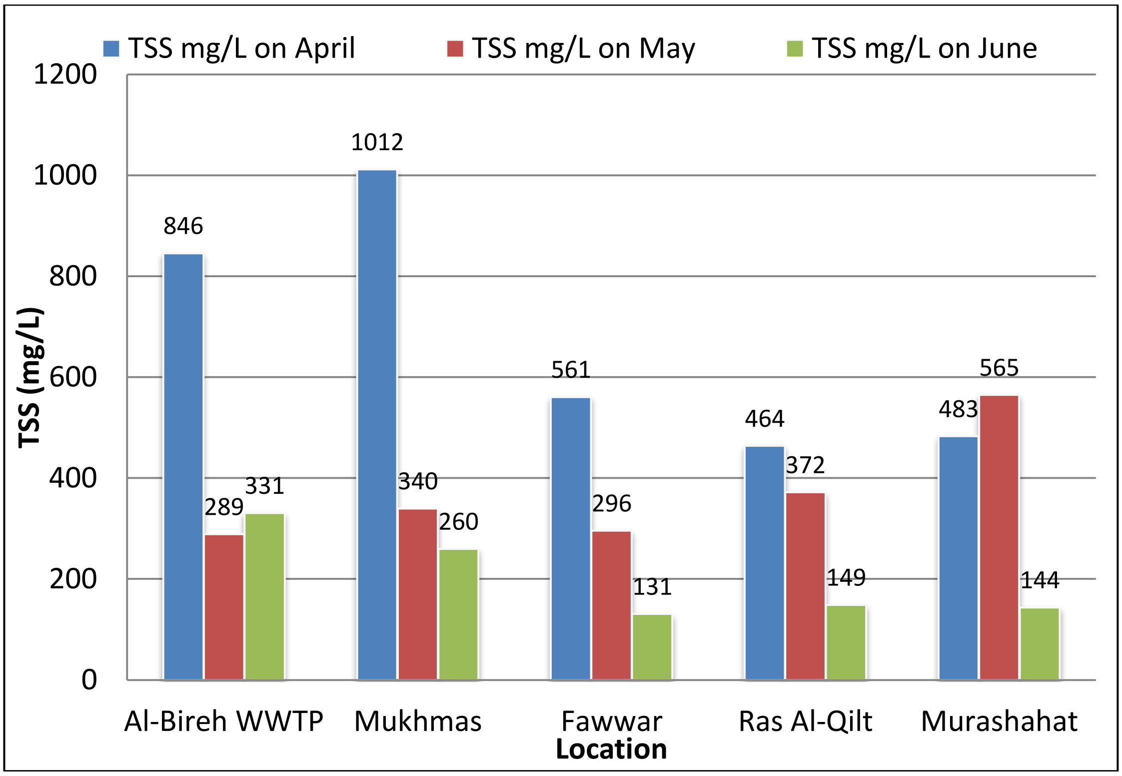

Figure (5.6): TSS for the five sampling locations on April, May, and June 2013

5.3 Modeling Scenarios

5.3.1 Rate Constants

Three key water quality rate constants were calculated (reaeration rate, deoxygenation rate, and nitrification rate).

Reaeration

Values of the calculated reaeration rates exceeded the typical range of reaeration which is from 0.1 day^{-1} for small ponds and backwaters, to 1.15 day^{-1} for rapids and waterfalls (Tchobanoglous and Schroeder, 1985). The range of the calculated reaeration rate was (14 – 103) day^{-1} (Table 5.6). The maximum value was at Murashahat, since Murashahat has the steepest section of the stream with significant air mixing. In addition, that Murashahat had the highest velocity of all locations with 1.37 m/s.

Table (5.6): Reaeration rate and temp. correction for Al-Qilt stream on April, May and June 2013

Reaeration rate during April					
Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
kr_{20}	62.832	35.894	32.492	13.364	85.373
kr_t	62.832	37.194	34.233	14.181	86.392
Reaeration rate during May					
kr_{20}	62.832	35.894	32.492	13.364	85.373
kr_t	69.578	41.877	34.806	15.335	97.269
Reaeration rate during June					
kr_{20}	62.832	35.894	32.492	13.364	85.373
kr_t	72.612	45.501	34.559	15.299	103.210

Deoxygenation

Values of the calculated deoxygenation rates exceeded the typical range of deoxygenation which is from 0.05 day^{-1} for untreated wastewater, to 0.7 day^{-1} for unpolluted river (Thomann and Mueller, 1987), (Kiely, 1997), (Davis and Masten, 2004) .The range of the calaculated deoxygenation rate was (0.96 – 9.7) day^{-1} (Table 5.7). The maximum value was at Murashahat, since Murashahat has the steepest section of the stream. In addition, that Murashahat had the highest velocity of all locations with 1.37 m/s. BOD rate constant (K_{BOD}) parameter controlled the deoxygenation rate. Values of K_{BOD} are listed in Table 5.8.

Table (5.7): Deoxygenation rate and temp. correction for Al-Qilt stream on April, May and June 2013

Deoxygenationrate during April					
Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
kd_{20}	1.396	0.959	1.007	0.702	0.959
kd_t	1.396	1.159	1.331	0.964	1.159
Deoxygenationrate during May					
kd_{20}	1.396	0.959	1.007	0.702	0.959
kd_t	2.407	2.184	1.454	1.464	2.184
Deoxygenationrate during June					
kd_{20}	1.396	0.959	1.007	0.702	0.959
kd_t	3.023	3.402	1.400	1.445	3.402

Table (5.8): K_{BOD} rate constant and temp.correction for Al-Qilt stream on April, May and June 2013

BOD rate constant during April					
Location	Al-Bireh	Mukhmas	Fawwar	Ras Al-Qilt	Murashahat
k_{BOD20}	0.230	0.350	0.230	0.230	0.230
k_{BODt}	0.230	0.374	0.254	0.257	0.235
BOD rate constant during May					
k_{BOD20}	0.230	0.350	0.23	0.230	0.230
k_{BODt}	0.280	0.471	0.262	0.300	0.296
BOD rate constant during June					
k_{BOD20}	0.230	0.350	0.230	0.230	0.230
k_{BODt}	0.304	0.554	0.259	0.298	0.332

CBOD Hydrolysis Rate

The CBOD hydrolysis constant rate was assumed to be equal to 0.1 day^{-1}, as an approximate value since the typical range is (0.02 – 10) day^{-1} (Tech, 2009). Literature values were used as a first approximation and their value fine tuned through the process of calibration.

Nitrification

Values of the calculated of the nitrification rates exceeded the typical range which is from 0.1 day^{-1} to 15.8 day^{-1}(Ruane and Krenkel, 1975), the calculated range of the nitrification rate was (24.4 – 133.6) day^{-1}. Nitrification rates were calculated using a plot for the $\left(\left(\frac{Time}{NBOD}\right)^{\frac{1}{3}}\right)$ Vs. Distance. K_{10} rate was calculating, using Eq. (2.7), values of K_{10} were determined by the division of the curve intersection with the Y axis over the curve slope. The used figures are presented in appendix D.

Nitrogen Hydrolysis Rate

The organic nitrogen hydrolysis constant rate was assumed to be equal to 0.2 day^{-1}, as an approximate value since the typical range is (0.001 – 1) day^{-1} (Tech, 2009). Literature values were used as a first approximation and their value fine tuned through the process of calibration.

Denitrification

The constant rate for the denitrification was not used since in this case study the coditions were aerobic along the whole stream, no anoxic nor anaearobic conditons existed, so no denitrificationwould occurr.

5.3.2 Current Situation (S1)

This case represented the first three months of the dry season (April, May, and June of 2013). No further extension for the study period included since the stream usually dries up between July and August of every year till the next wet season which starts at late September to mid of October.

DO (**Upstream)** – Results from the simulation for the upstream showed an incremental behavior in the DO concentrations over April, May. And June, 2013 (Figures 5.18, 5.19, and 5.20). The behavior had limited distortion between Al-Bireh and Mukhmas locations; this is due to the model trying to approximate the simulated values to the measured values of DO concentrations. However the model at this point failed in some how to match the simulated and measured values. On April, 2013 the value of simulated DO concentration was 6.93 mg/L which is 47% higher than the measured value that was 4.7 mg/L. On May, 2013 the value of simulated DO concentration was 6.9 mg/L which is 76% higher than the measured value that was 2.5 mg/L. On June, 2013 the value of the simulated DO concentration was 6.1 mg/L which is 17% higher than the measured value that was 5.2 mg/L.

Values of the simulated DO concentrations after Mukhmas location showed significant increase that almost reached the saturation levels. The cause of the significant increase of the DO concentrations after Mukhmas is the absence of pollution sources at these locations. The area is rural which gave the stream the chance to self remediates.

The saturation DO curve showed slight incremental behavior with distance over the three time steps, almost 0.45 mg/L. This is due to the fact that water holds more DO in lower altitudes.

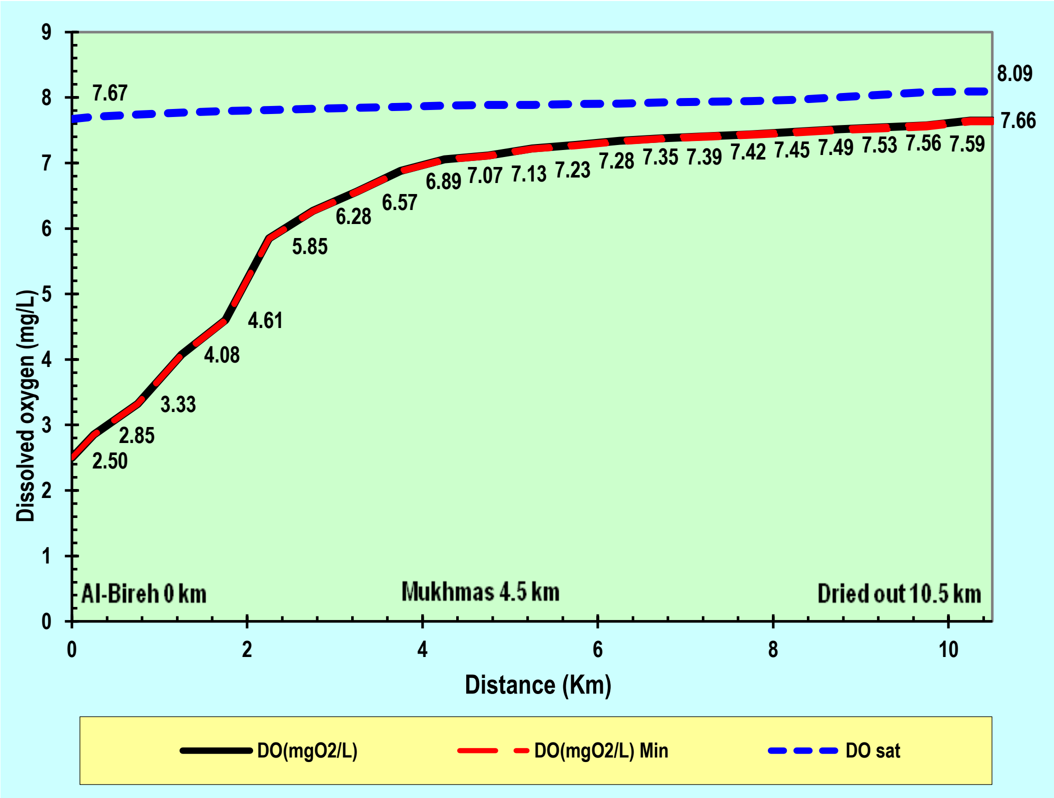

Figure (5.7): Simulated DO levels for current situation in the upstream reach on April 2013

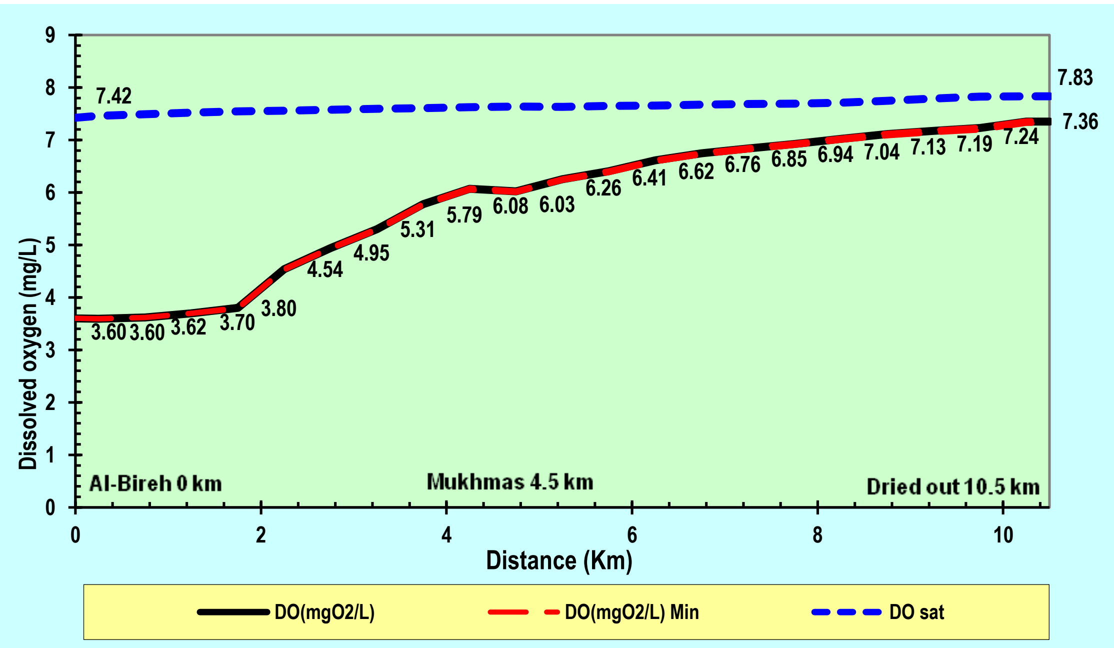

Figure (5.8): Simulated DO levels for current situation in the upstream reach on May 2013

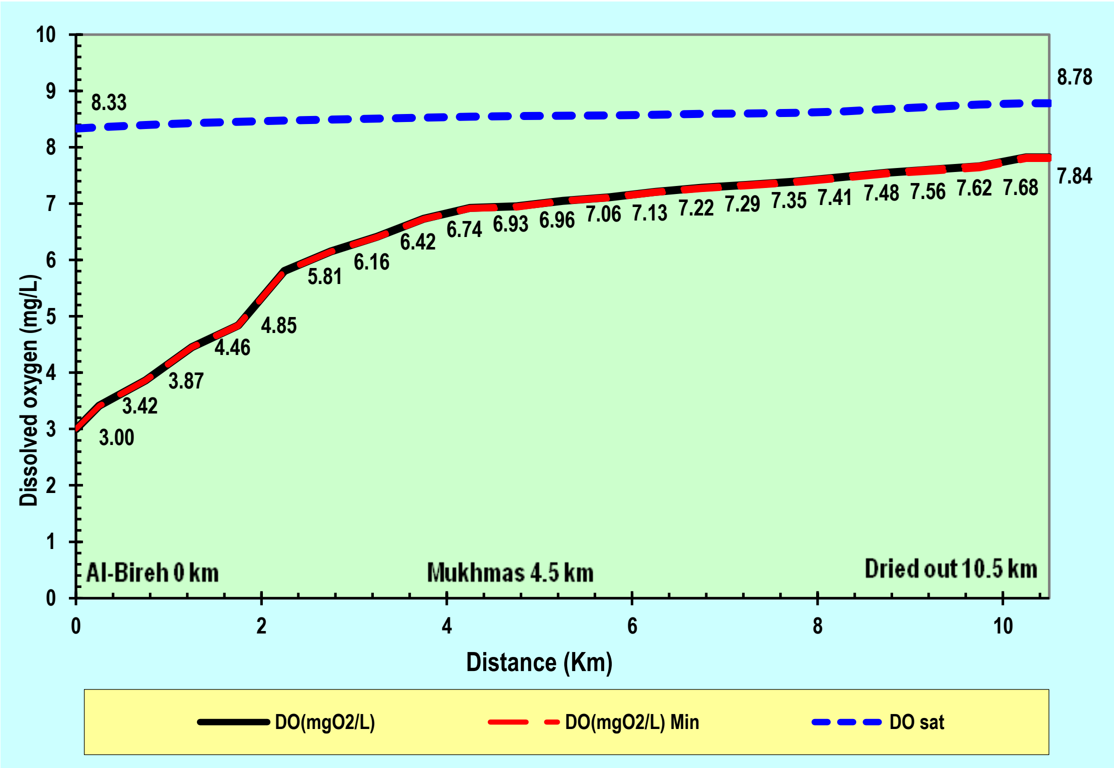

Figure (5.9): Simulated DO levels for current situation in the upstream reach on June 2013

DO (Downstream) – Results from the simulation for the downstream reach showed a deflection point at Ras Al-Qilt with significant rise of the DO concentration (Figures 5.21, 5.22, and 5.23); this was due to the increased aeration occurring at this location because of its stepped terrain. However on April, 2013 the DO concentrations did not reached the saturation because of some temporary pollution sources such as citizens' recreation visits and cleaning the sheep in the stream which occurs usually at this time of the year. On May and June, 2013 the simulation curves reached the saturation curve at Ras Al-Qilt since the pollutions sources stopped.

For Ras Al-Qilt the simulated DO concentration on April, 2013 was 9.8 mg/L which is 19% higher than the measured value that was 8.22 mg/L. On May, 2013 the value of the simulated DO concentration was 13.7 mg/L which is 24% higher than the measured value that was 11 mg/L. On June, 2013 the value of simulated DO concentration was 9.4 mg/L which is 9% higher than the measured value that was 8.61 mg/L.

The saturation DO curve showed slight incremental behavior with distance for the three time steps, almost 0.3 mg/L. This is due to the fact that water holds more DO in lower altitudes.

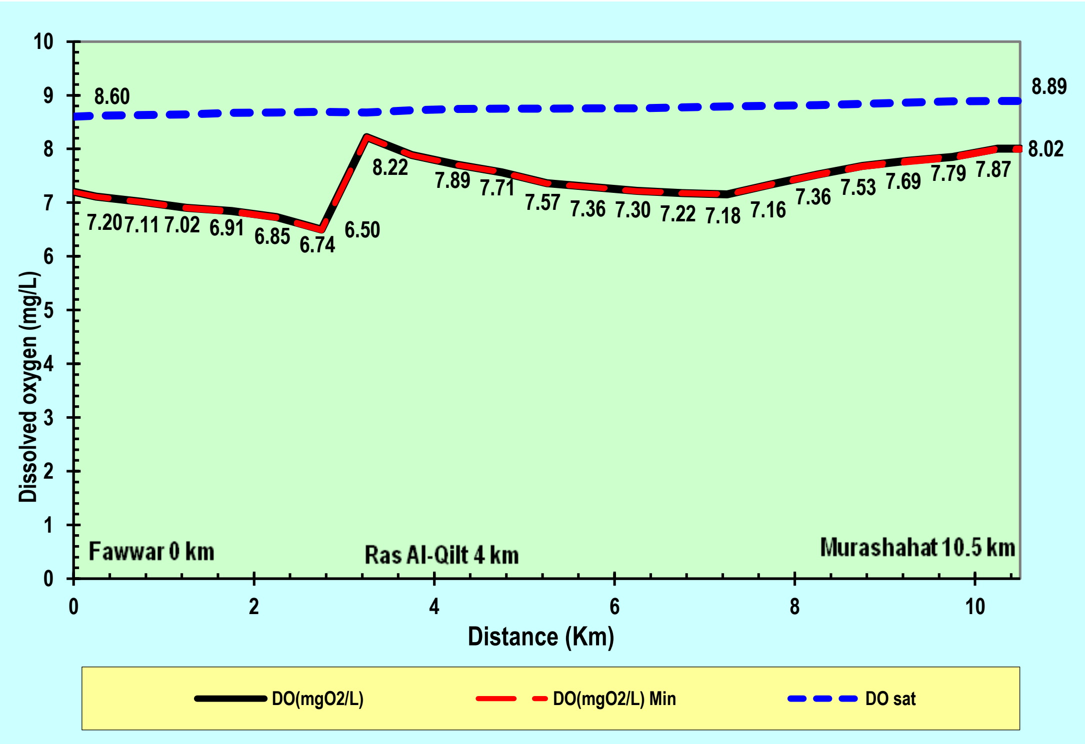

Figure (5.10): Simulated DO levels for current situation in the downstream reach on April 2013

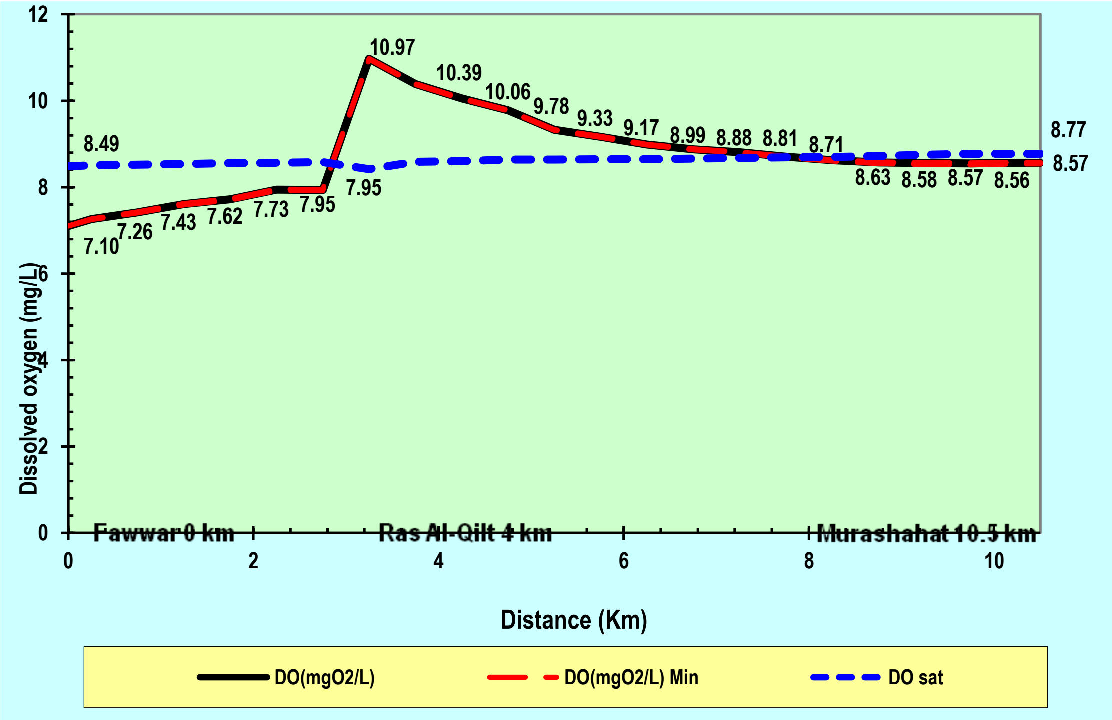

Figure (5.11): Simulated DO levels for current situation in the downstream reach on May 2013.

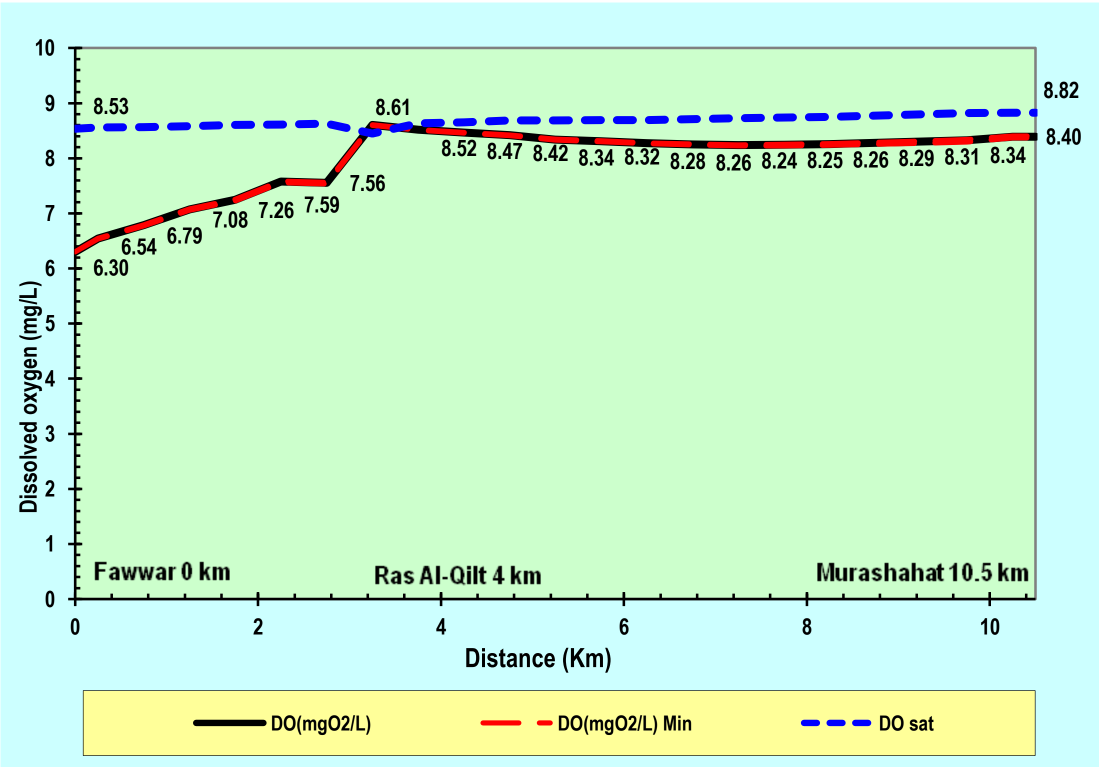

Figure (5.12): Simulated DO levels for current situation in the downstream reach onJune 2013

5.3.3 Future Scenario (S2)

This case represented the simulation of the same time period as in scenario one (April, May, and June, 2013) but with different conditions. The simulated condition here represented one of the management options that could possibly applied easily to enhance the quality of Al-Qilt stream. This scenario simulated the DO of the stream after the addition of two stepped weirs on the upstream reach, at (Al-Bireh and Mukhmas) which increased the DO concentration levels in this reach of the stream. Al-Bireh and Mukhmas locations were selected since DO deficits were the highest between all of the five locations.

The expected DO concentration levels after using artificial aeration by the stepped weirs with proposed efficiency of 80%; are listed in Table 5.9.

Table (5.9): DO concentrations using weirs in the upstream reach on April, May and June 2013

Stepped weirs efficiency during April		
Location	Al-Bireh	Mukhmas
DO $_{(Before)}$, mg/L	3	4.7
DO $_{(After)}$, mg/L	7.86	8.03
Stepped weirs efficiency during May		
Location	Al-Bireh	Mukhmas
DO $_{(Before)}$, mg/L	2.5	2.5
DO $_{(After)}$, mg/L	7.22	6.9
Stepped weirs efficiency during June		
Location	Al-Bireh	Mukhmas
DO $_{(Before)}$, mg/L	3.6	5.2
DO $_{(After)}$, mg/L	7.18	7.87

DO (Improved Upstream) – Values of the simulated DO concentrations at this reach showed (Figures 5.24, 5.25, and 5.26) relatively high initial concentrations followed by immediate drop due to the deoxygenation and nitrification.

For Mukhmas the simulated DO concentration on April, 2013 was 7.1 mg/L which is 13% lower than the calculated value that was 8.03 mg/L. On May, 2013 the simulated DO concentration was 7.2 mg/L which is 4% higher than the calculated value which was 6.9 mg/L. On June, 2013 the simulated DO concentration was 6.2 mg/L which is 26% lower than the calculated value that was 7.87 mg/L.

The saturation DO curve showed slight incremental behavior with distance for the three time steps, almost 0.3 mg/L. This is due to the fact that water holds more DO in lower altitudes.

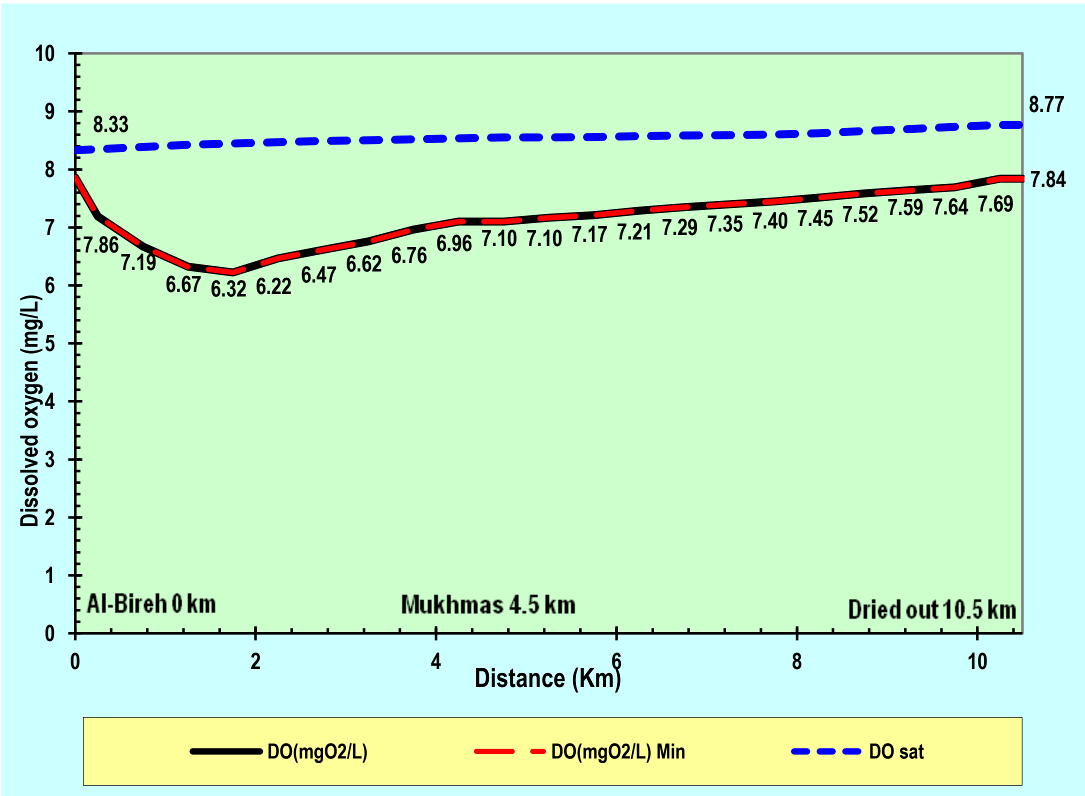

Figure (5.13): Simulated DO levels for future scenario 2 in the upstream reach on April 2013

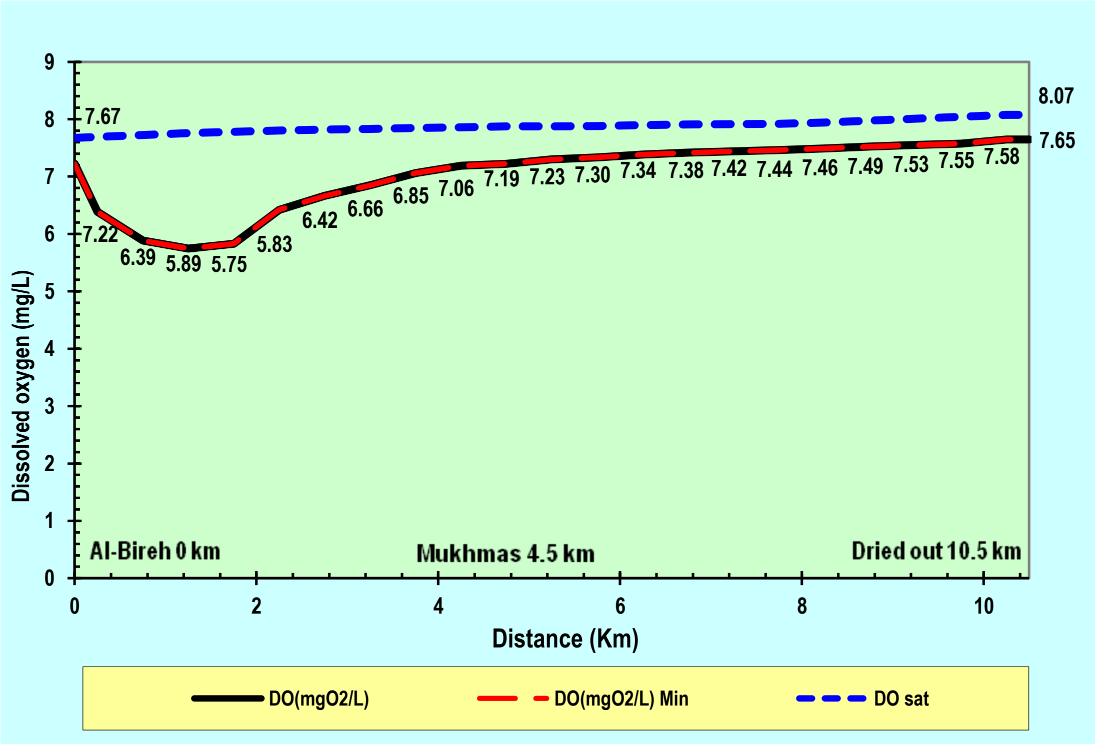

Figure (5.14): Simulated DO levels for future scenario 2 in the upstream reach on May 2013

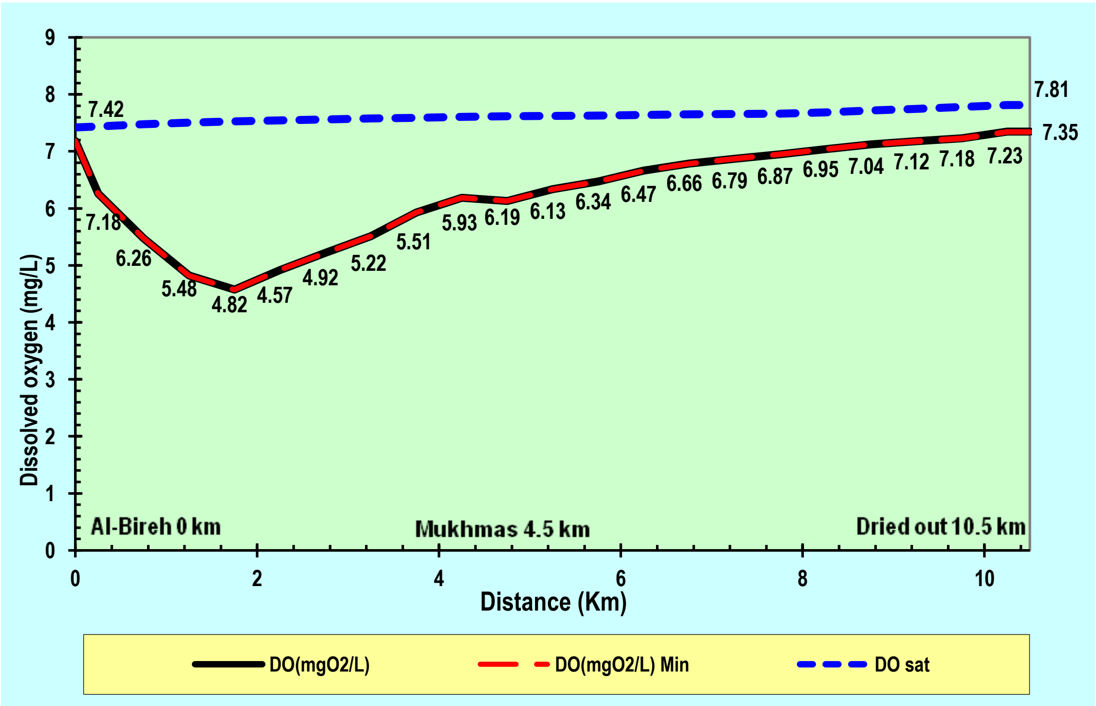

Figure (5.15): Simulated DO levels for future scenario 2 in the upstream reach on June 2013

5.3.4 Future Scenario (S3)

This case represented the simulation of the same time period as in scenarios one and two (April, May, and June, 2013) but with different conditions. The simulated condition here represented a second option of the management options that could possibly be applied to enhance the quality of Al-Qilt stream. This scenario simulated the quality of the stream after constructing WWTP at Qalandia region to treat the raw wastewater flowing from that area. The water quality parameters and characteristics were assumed to be the same as the water quality generated from Al-Bireh WWTP. A comparison between the results from this simulation of this scenario (S3) and the results from previous scenario (S2) are in (Figures 5.27, 5.28, and 5.29).

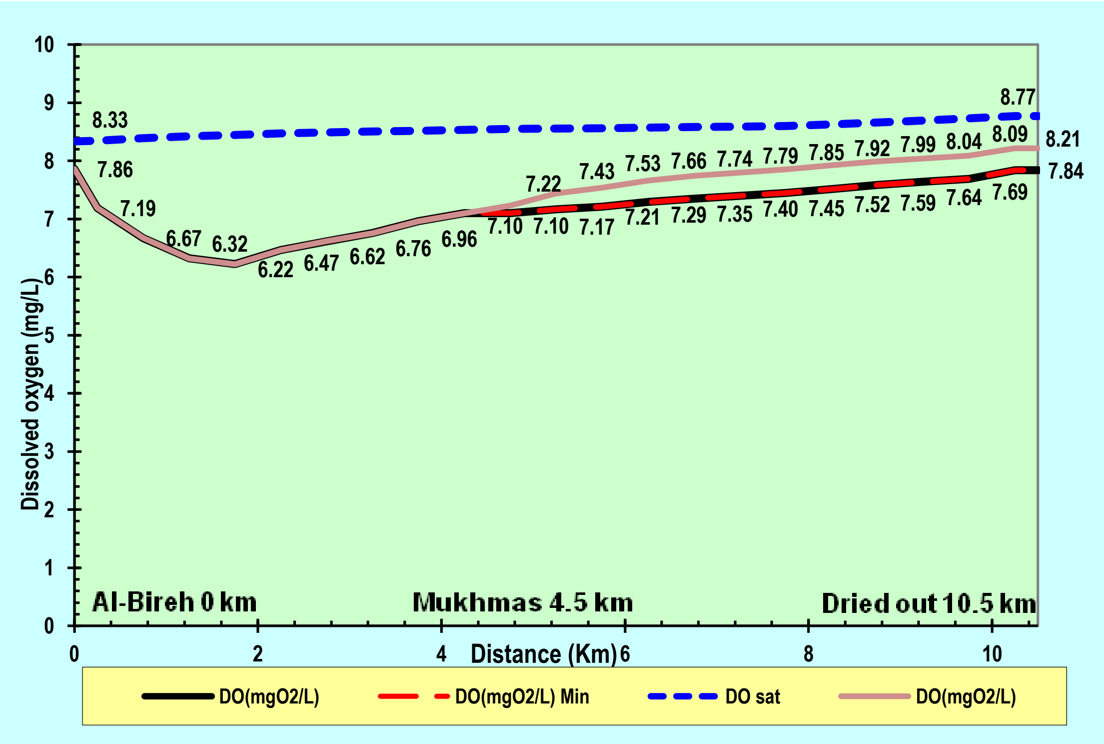

Figure (5.16): Simulated DO levels for future scenario 3 in the upstream reach on April 2013

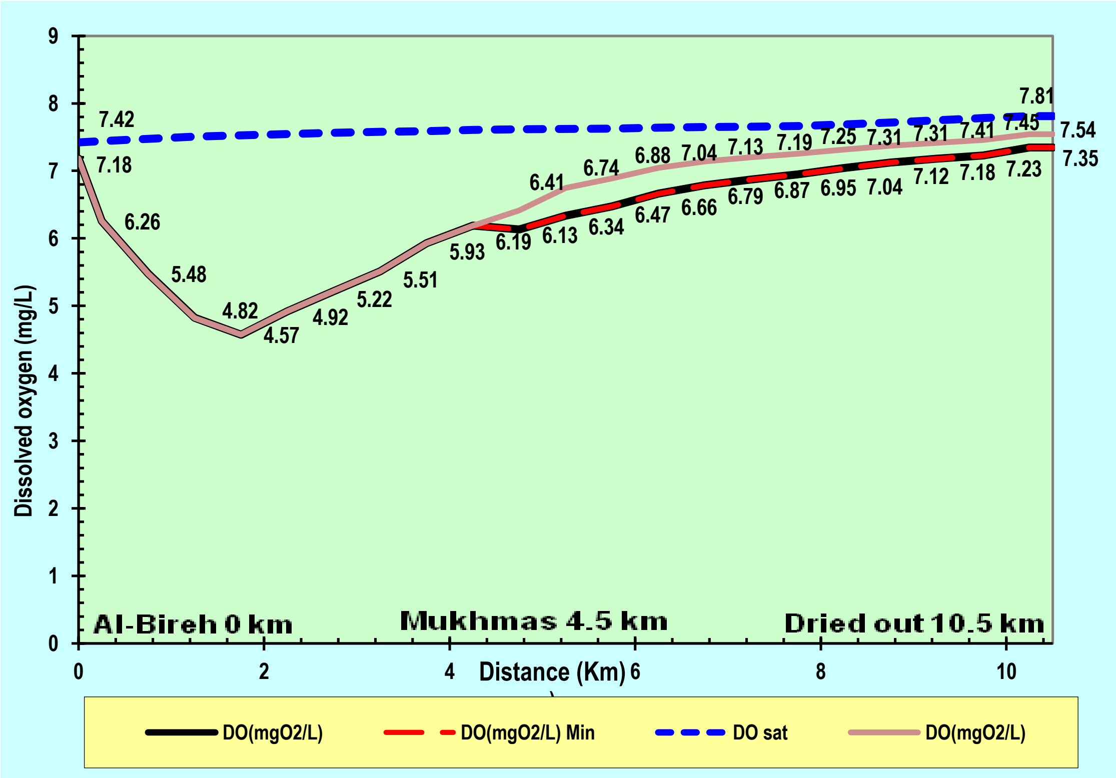

Figure (5.17): Simulated DO levels for future scenario 3 in the upstream reach on May 2013

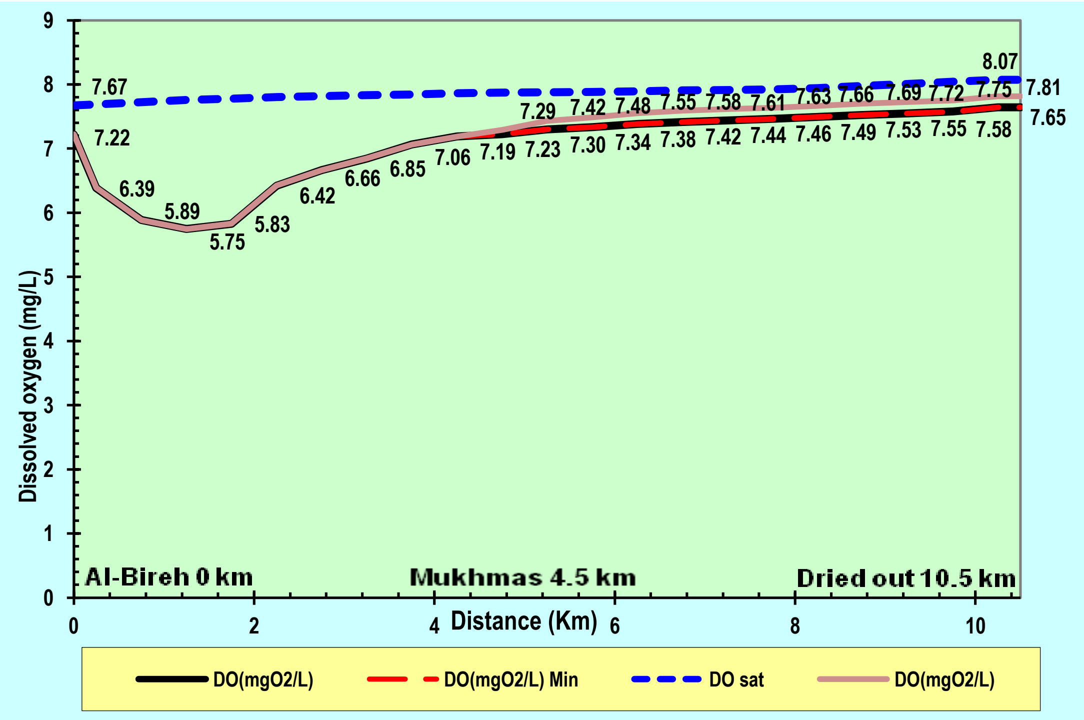

Figure (5.18): Simulated DO levels for future scenario 3 in the upstream reach on June 2013

The conditions in this scenario were the same as in the previous one (S2) (i.e. the construction of two artificial aeration weirs), but with the addition of the effects from the WWTP at Qalandia. The modeling rate constants (e.g. reaeration, deoxygenation, and nitrification) were assumed to be the same for the flow running form Al-Bireh.

Values for the DO concentration on April, May and June, 2013 were identical with the values of the DO concentration in the second scenario (S2), until the flow reached near Mukhmas where the new conditions for the third scenario apply.

In this scenario, no significant improvements on the DO levels existed. For April, 2013 only 4.7% of the DO had increased with a raise of 0.37 mg/L. For May, 2013 only 2.1% of the DO had increased with a raise of 0.16 mg/L. For June, 2013 only 2.6% mg/L of the DO had increased with a raise of 0.19 mg/L.

Chapter Six

Conclusions and Recommendations

6.1 Conclusions

The following are the main conclusions:

1- Pollution levels were higher in the upstream reach (from Al-Bireh WWTP till the distance of 10.5 km), this was due to the effluent flowing from Al-Bireh WWTP and from the raw wastewater from Qalandia region.

2- Highly suspected connection between the pollution sources in the springs downstream (Fawwar and Ras Al-Qilt) and the raw wastewater running upstream. Underground connection might exist in the dry segment of the stream (7 km) between the upstream reach and downstream reach.

3- Pollution in the downstream reach on April, 2013 was higher than May and June, 2013 due to the recreation visits to the stream.

4- The stream showed ability of self remediation regarding the DO concentration, in several locations levels almost reached the saturation concentration.

5- The values of the key simulation rates (Reaeration, deoxygenation and nitrification) for Al-Qilt stream exceeded the typical ranges; this was expected since the used theory was originally derived for large scale rivers. However, the simulation of Al-Qilt stream which was considered as small scale stream that showed very reasonable results.

6- Raises of the saturation DO curves were noticed in all of the model simulations range. These raises ranged from 0.28 to 0.45 mg/L, this was due to the fact that water absorbs more oxygen at lower altitudes which was the case in this study, since the altitude changing from elevation of 727 m a.m.s.l to 178 m b.m.s.l. In addition to the effect of the increased temperature which help the water in absorbing more oxygen.

7- The suggested stepped weirs in the upstream reach increased the DO concentrations almost to the saturation levels which indicate that such low cost solution could improve the stream quality significantly.

8- The construction of a WWTP to treat the raw wastewater flowing from Qalandia region, had limited effects on the DO levels with too much high costs. The maximum raise in DO concentration from this option was only 0.37 mg/L.

6.2 Recommendations

Based on results of this research, the following are the set of recommendations:

1- Studying the effect of stepped weirs on the aeration coefficient.

2- The construction of the stepped weirs in the upstream reach, at least two weirs with 1 ft for each step and with 80% designed efficiency.

3- The major pollution source in the stream was the raw wastewater flowing from Qalandia region, this source of pollution must be solved with any possible solution.

4- Further studies on water quality modeling on Al-Qilt stream with longer time periods to cover the wet season are recommended for the purpose of achieving an integrated water quality management for the catchment.

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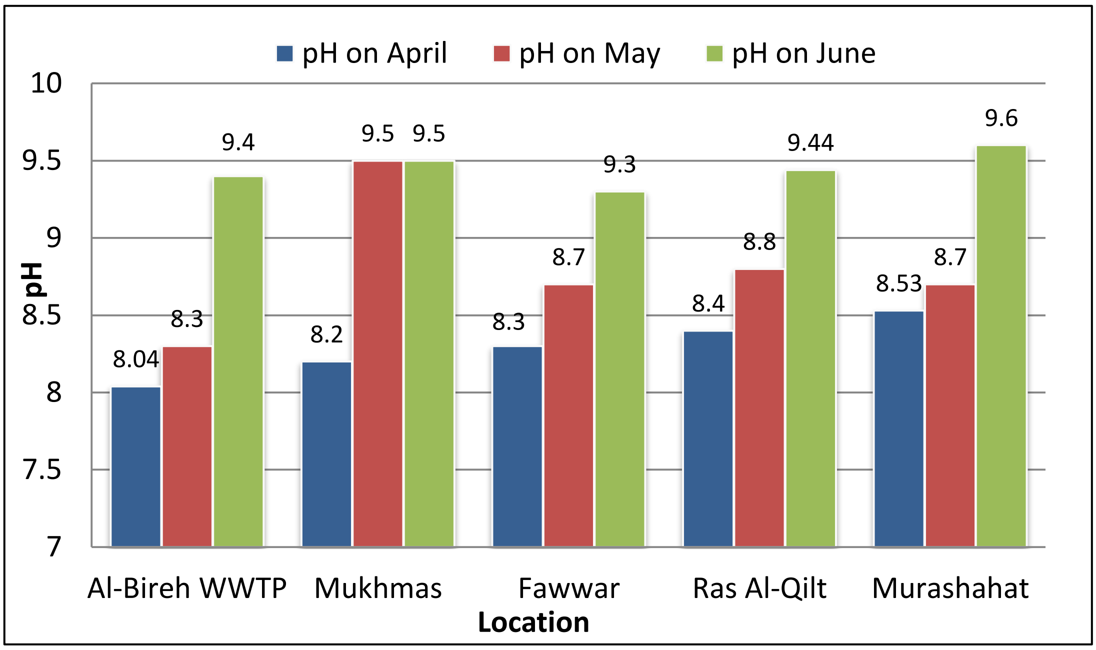
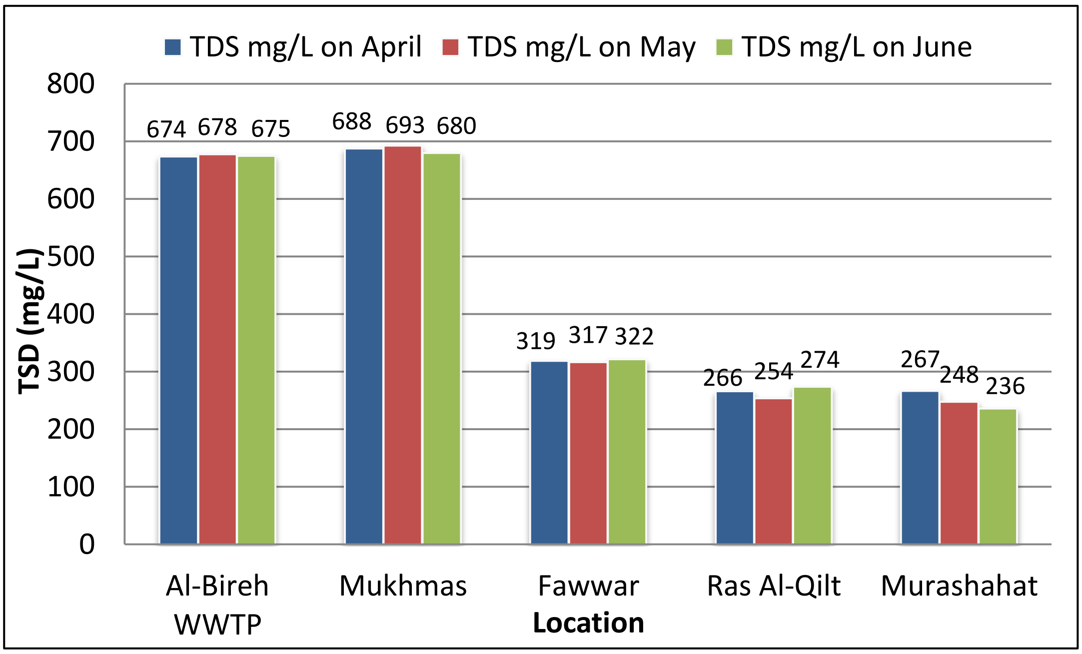
Appendices

Appendix A

On site measured values from April to June, 2013 at the five locations.



Measured pH values on April, May and June 2013



Measured TDS values on April, May, and June 2013

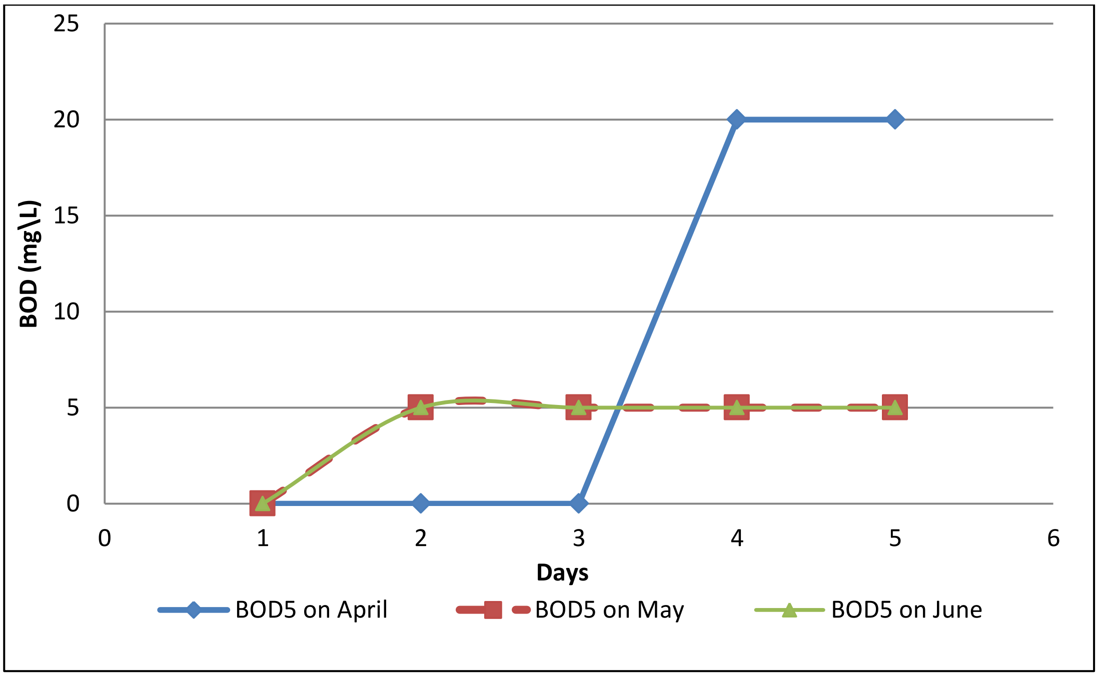
Appendix B

BOD_{20} values from April to June, 2013 at the five locations

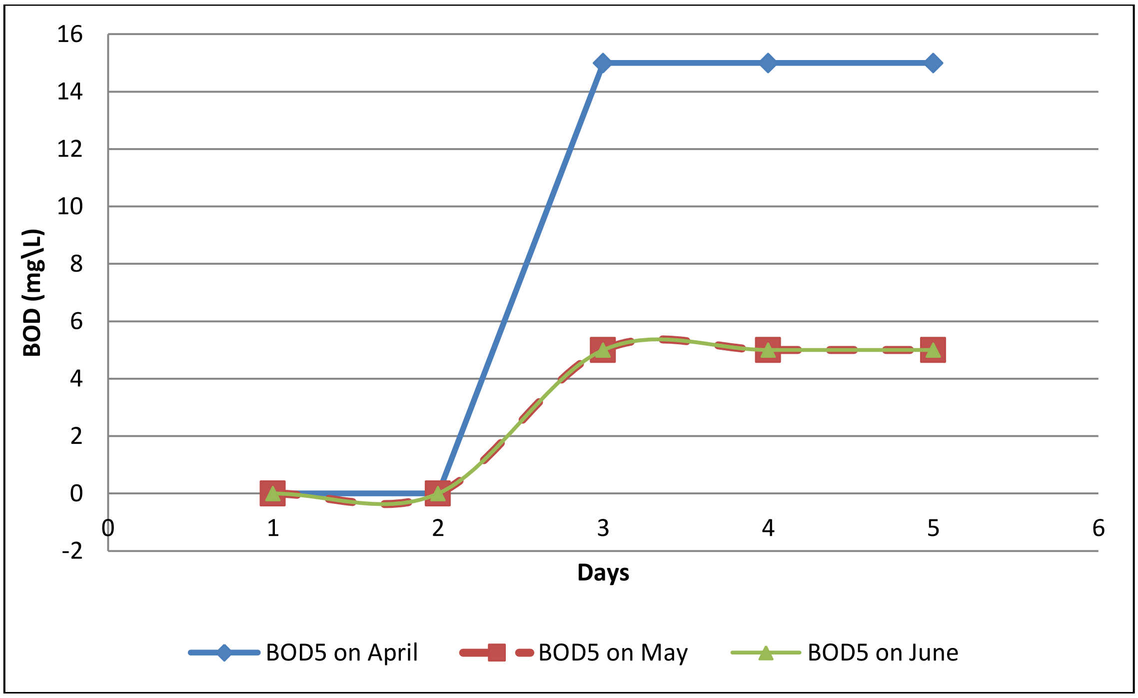
BOD Readings (Round one. Taken 16 April, 2013)					
Dates	**Al-Bireh**	**Murashahat**	**Ras Al-Qilt**	**Fawwar**	**Mukhmas**
18-Apr	0	0	0	0	0
19-Apr	0	0	0	15	15
20-Apr	0	15	15	15	15
21-Apr	20	15	15	15	15
22-Apr	20	15	15	35	35
23-Apr	20	15	15	35	35
24-Apr	20	15	15	35	35
25-Apr	20	15	15	35	35
26-Apr	20	15	15	35	35
27-Apr	20	15	20	35	35
28-Apr	20	15	20	35	35
29-Apr	20	15	20	35	35
30-Apr	20	15	20	35	35
1-May	20	15	20	35	35
2-May	20	15	20	35	35
3-May	20	15	20	35	35
4-May	20	15	20	35	55
5-May	20	15	20	35	55
6-May	20	15	20	35	55
7-May	20	15	20	35	55

BOD Readings (Round Two Taken 20 May, 2013)					
Dates	**Al-Bireh**	**Murashahat**	**Ras Al-Qilt**	**Fawwar**	**Mukhmas**
20-Jun	0	0	0	0	0
21-Jun	5	0	0	5	15
22-Jun	5	5	0	5	15
23-Jun	5	5	0	5	20
24-Jun	5	5	0	5	25
25-Jun	5	5	5	5	25
26-Jun	5	5	5	5	25
27-Jun	5	5	5	5	25
28-Jun	5	5	5	5	30
29-Jun	10	5	5	10	30
30-Jun	10	5	5	10	30
1-Jul	10	5	5	10	35
2-Jul	10	5	5	10	35
3-Jul	10	5	5	10	35
4-Jul	10	5	5	10	35
5-Jul	10	5	5	10	35
6-Jul	15	10	5	10	40
7-Jul	20	10	10	15	45
8-Jul	20	10	10	15	45
9-Jul	25	10	10	15	45

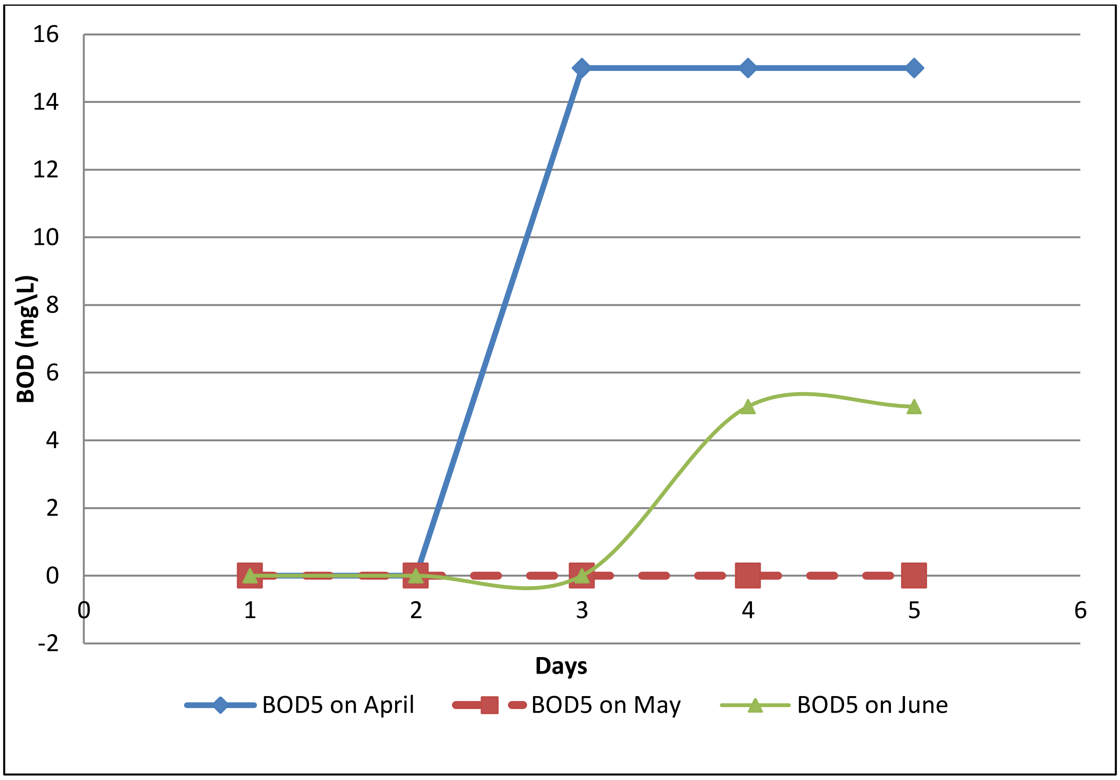
BOD Readings (Round Three. Taken 20 June, 2013)					
Dates	**Al-Bireh**	**Murashahat**	**Ras Al Qilt**	**Fawwar**	**Mukhmas**
20-Jun	0	0	0	0	0
21-Jun	5	0	0	5	5
22-Jun	5	5	0	5	10
23-Jun	5	5	5	5	10
24-Jun	5	5	5	10	15
25-Jun	10	5	5	10	15
26-Jun	10	5	5	10	20
27-Jun	15	5	5	10	20
28-Jun	15	5	5	10	20
29-Jun	15	5	5	10	25
30-Jun	20	5	5	10	25
1-Jul	20	5	5	10	30
2-Jul	20	5	10	15	30
3-Jul	25	5	10	15	30
4-Jul	25	10	10	15	35
5-Jul	30	10	10	15	35
6-Jul	30	10	10	15	40
7-Jul	35	10	15	15	40
8-Jul	35	10	15	15	45
9-Jul	35	10	15	15	45



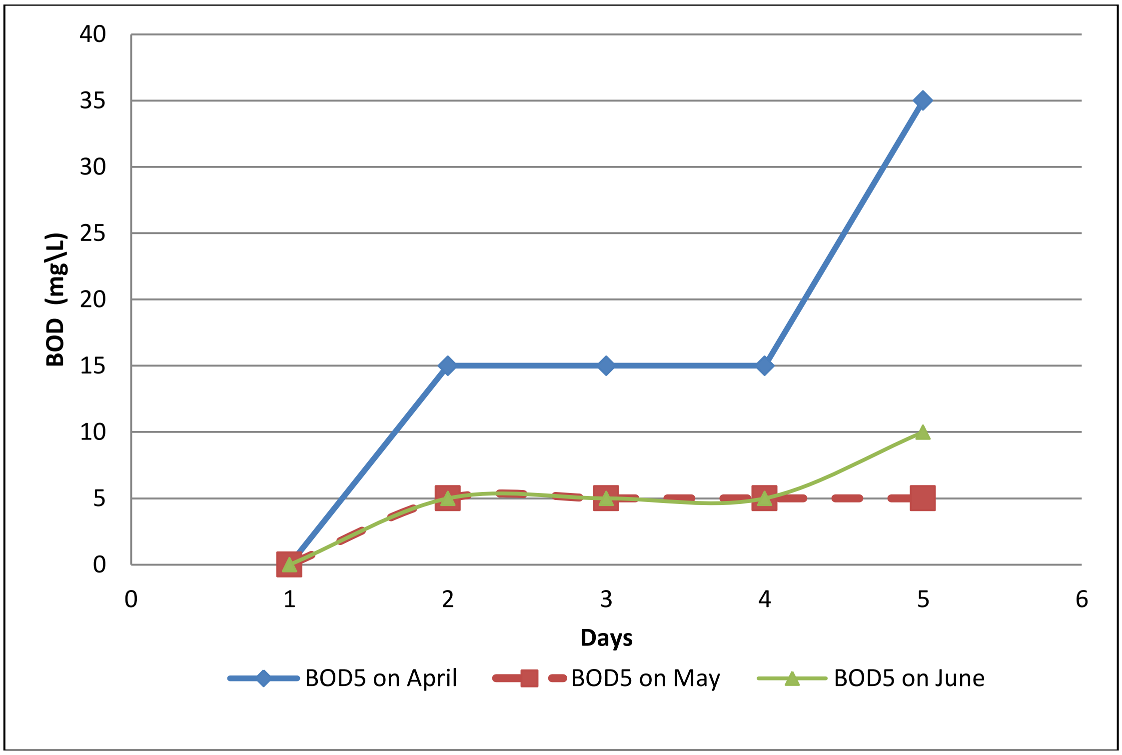
BOD_5 for Al-Bireh sampling location from April to June, 2013



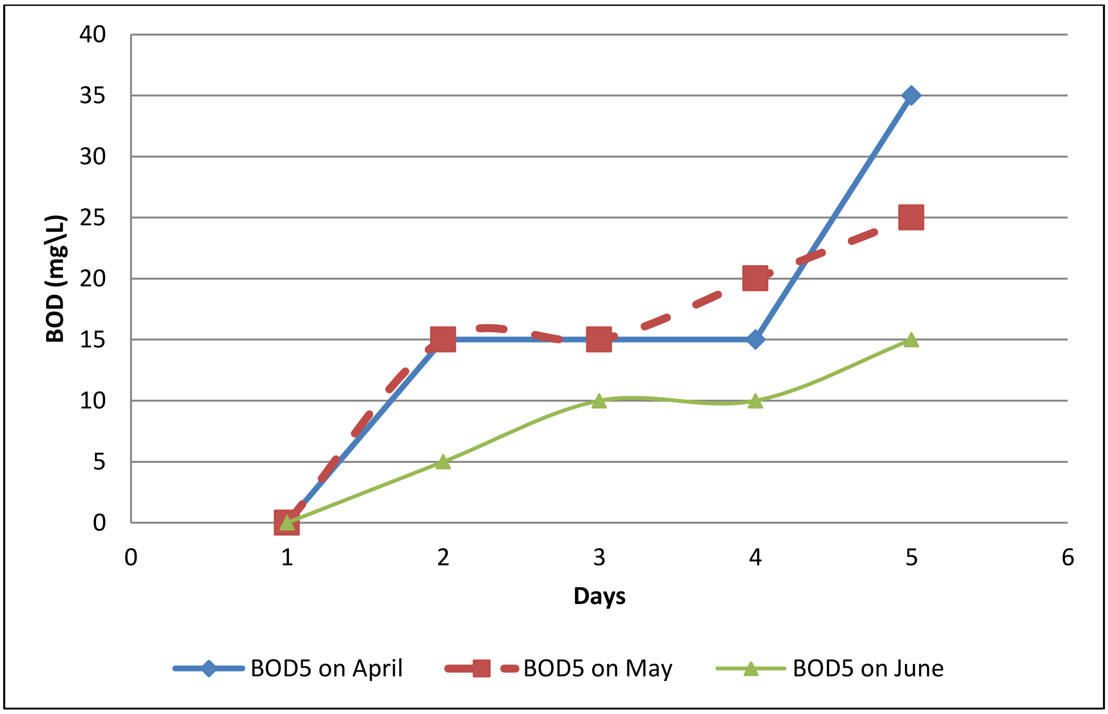
BOD_5 for Murashahat sampling location from April to June, 2013



BOD_5 for Ras Al-Qilt sampling location from April to June, 2013



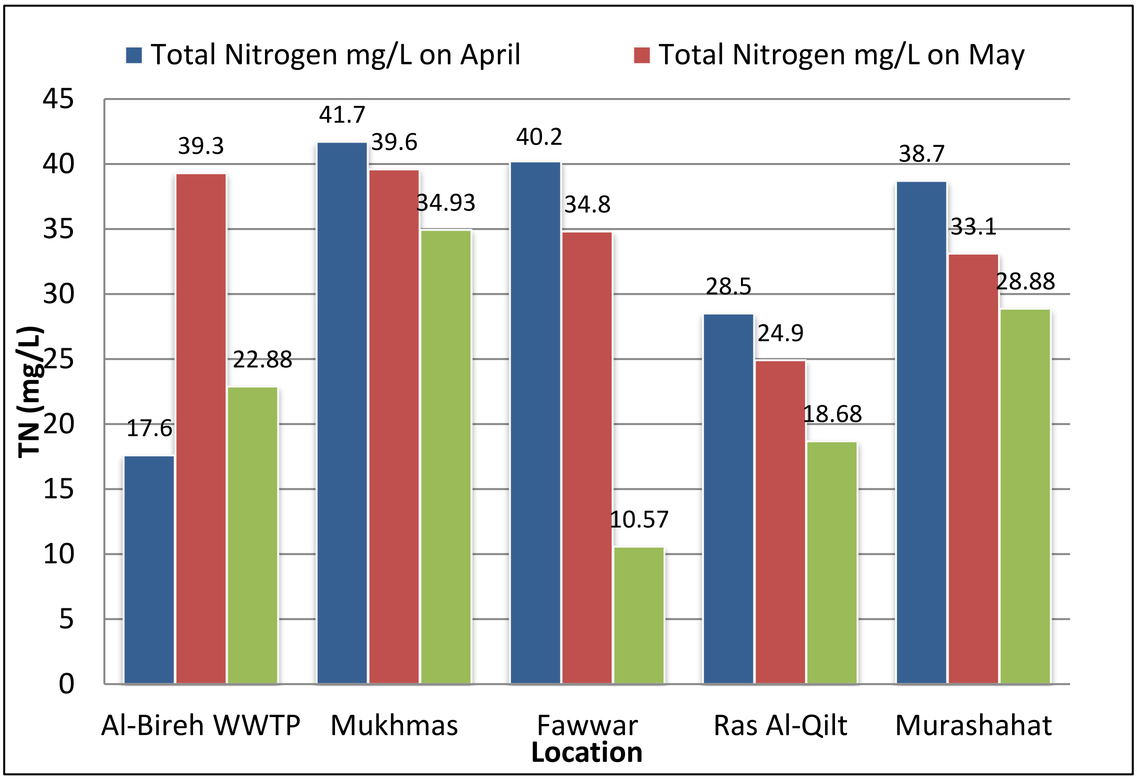
BOD_5 for Fawwar sampling location from April to June, 2013



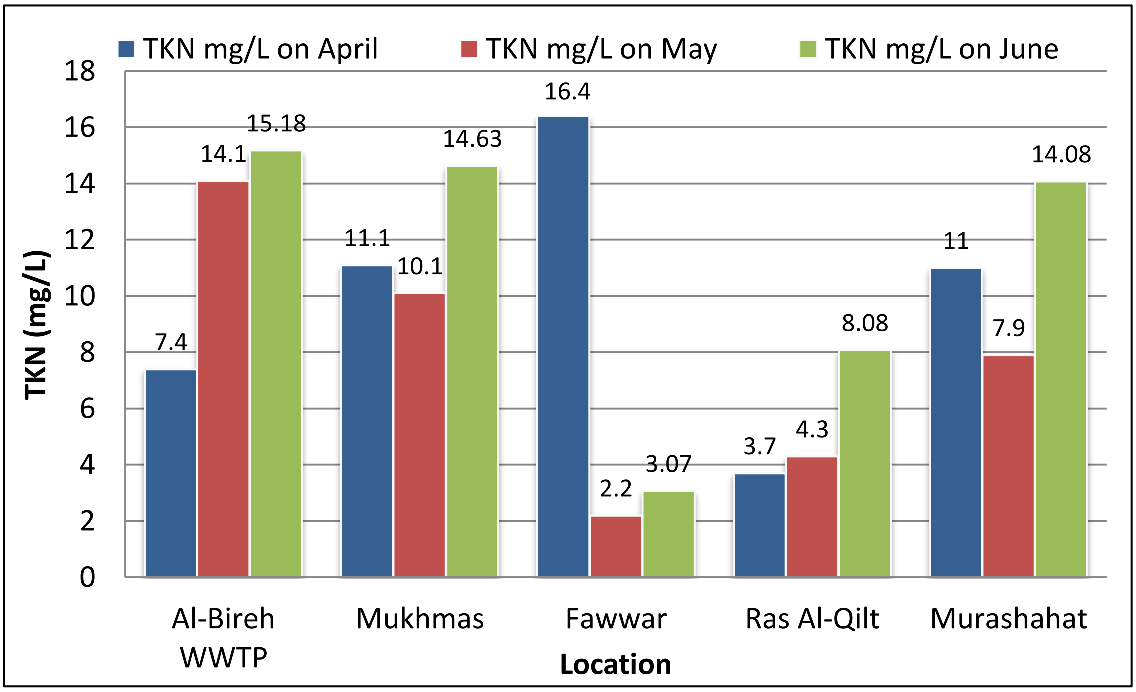
BOD_5 for Mukhmas sampling location from April to June, 2013

Appendix C

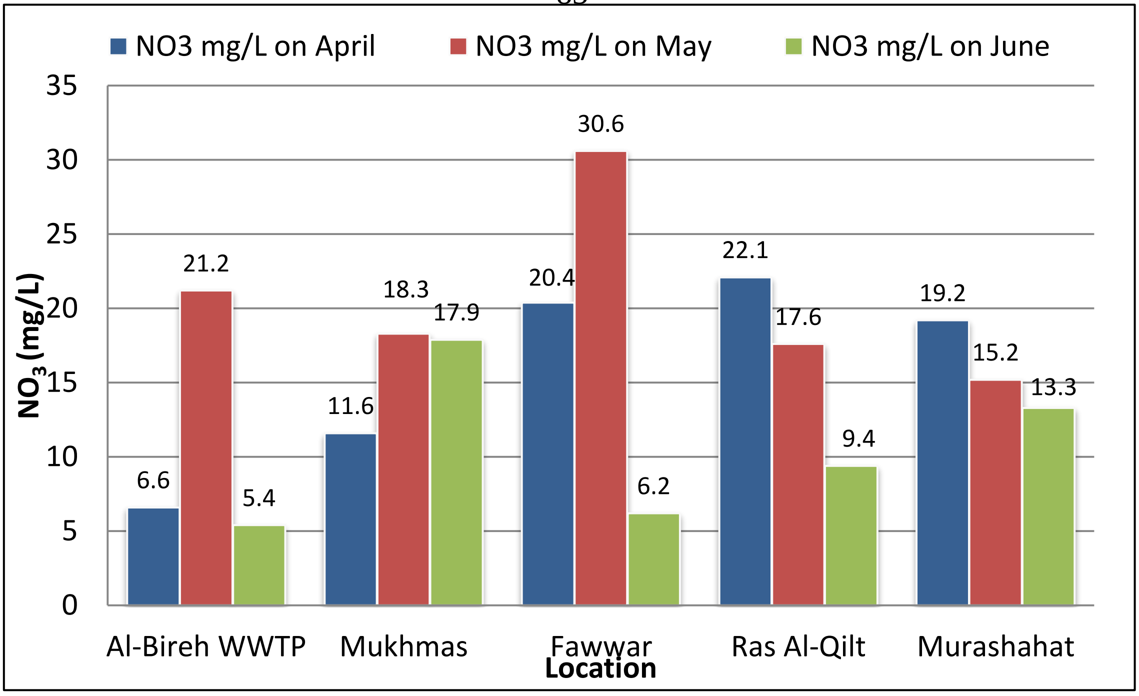
Nitrogen values from April to June, 2013 at the five locations



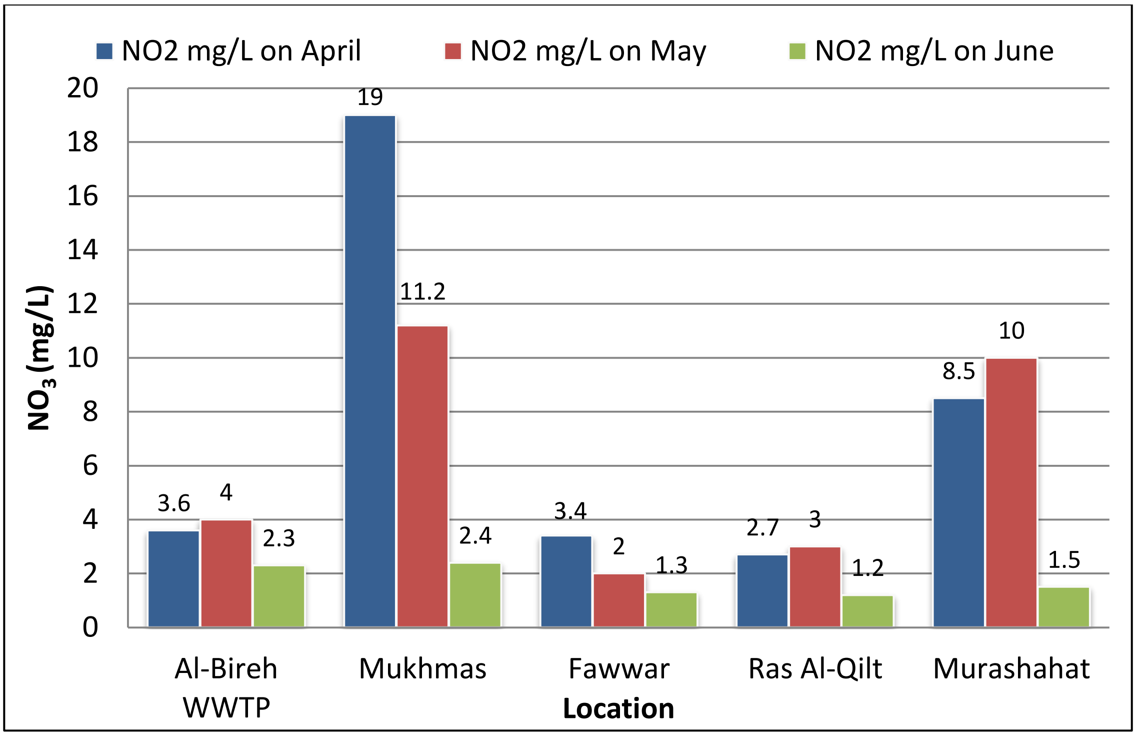
TN for the five sampling locations on April, May, and June 2013



TKN for the five sampling locations on April, May, and June 2013



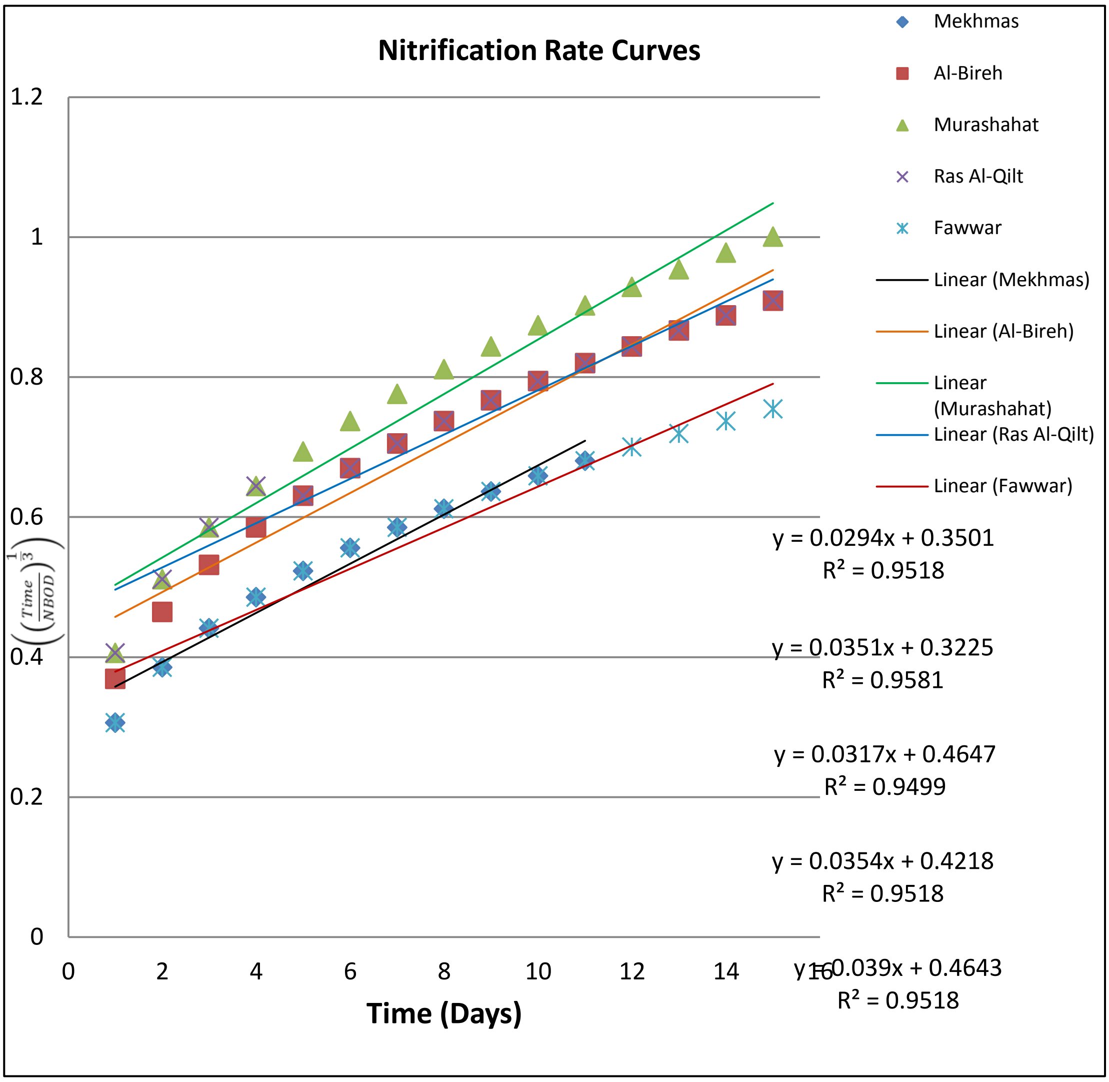
NO^-_3 for the five sampling locations on April, May, and June 2013



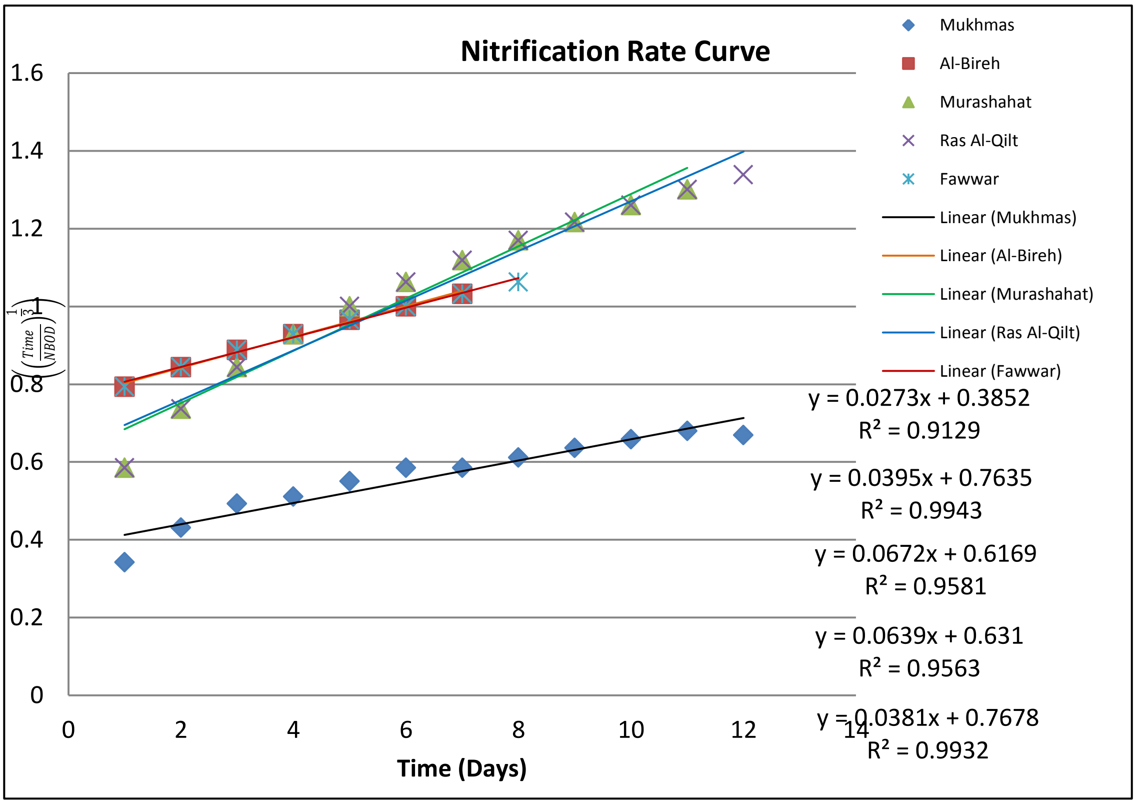
NO^-_2 for the five sampling locations on April, May, and June 2013

Appendix D

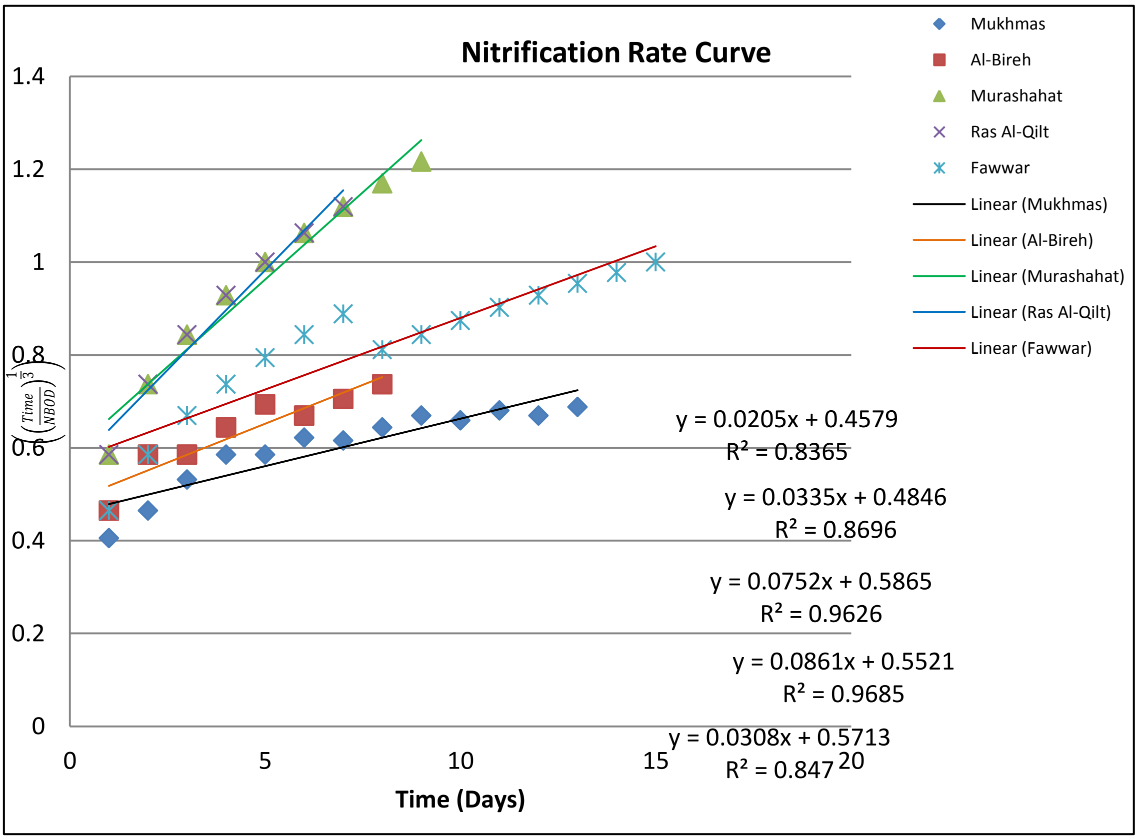
Curves that were used to calculate the Nitrification rate for the five sampling locations.



Nitrification rate curves for all the five sampling locations on April 2013



Nitrification rate curves for all the five sampling locations on May 2013



Nitrification rate curves for all the five sampling locations on June 2013

جامعة النجاح الوطنية
كلية الدراسات العليا

نمذجة نوعية المياه في وادي القلط

إعداد
هاني عادل أحمد شريدة

إشراف
د. عبد الفتاح حسن
د. سمير شديد

قدمت هذه اللأطروحة إستكمالا لمتطلبات الحصول على درجة الماجستير في هندسة المياه والبيئة بكلية الدراسات العليا في جامعة النجاح الوطنية في نابلس – فلسطين.

2014

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الملخص

المياه السطحية محدودة جدا في المناطق الفلسطينية، لذا فإن اهتماما خاصا يجب أن يسلط على نوعية هذه المصادر المائية المتوفرة. المياه السطحية في حوض القلط تعتبر مصدر مائي لا غنى عنه. نوعية المياه في وادي القلط عرضة لملوثات عديدة وهذا يحد الإستخدام الكامل لهذا المصدر المهم. لذا التركيز في هذه الأطروحة كان على بناء نموذج لنوعية المياه في وادي القلط مع إعتبار الأكسجين المذاب كمعيار أساسي لنوعية المياه في الوادي. لقد تم بناء نموذج لنوعية المياه بإستخدام برنامج (QUAL2Kw) وتم محاكات عدة ظروف محتملة لتوقع سلوك الأكسجين المذاب ومستوياته على مدى الوادي في الظروف الحالية أو في ظروف محتملة مثل إستعمال مدرّجات في مواقع معينة لتحسين عملية التهوية أو بناء محطة معالجة للمياه العادمة المتدفقة من منطقة قلنديا. النتائج التي ظهرت أكدت القدرة العالية والمميزة للوادي على التنقية الذاتية التي أدت إلى إرتفاع مستويات الأكسجين المذاب إلى مستويات وصلت لحد الإشباع الكامل، وفي بعض المواقع التي تتمتع بقدرة على التهوية الجيدة، قد تجاوزت المستويات الأكسجين المذاب حد الإشباع إلى أن وصلت إلى (11 mg/L). لقد أثبتت النتائج أن الحلول المقترحة المتمثلة في مدرجات التهوية تمثل حلا مناسبا لتحسين نوعية المياه في الوادي وقد رفعت مستويات الأكسجين المذاب من (2.5 mg/L) إلى (7.5 mg/L). من ناحية اخرى فإن تأثير محطة المعالجة القترحة في منطقة قلنديا، كان تأثيرا محدودا بفعالية فقط 4.7% في زيادة الأكسجين المذاب.