Faculty of Graduate Studies

The Pollution Effects of the Wastewater Flow on the Water Quality in Wadi Sarida Catchment / West Bank

آثار التلوث بمياه الصرف الصحي على نوعية المياه في حوض وادي سريدا / الضفة الغربية

Submitted by:

Waseem Ahmad

Supervisor:

Dr. Marwan Ghanem

A Thesis Submitted in Partial Fulfillment of the Requirement for the Master’s Degree in Water and Environmental Science from the Faculty of Graduate Studies at Birzeit University

May 2015

Dedication

To her kindliness, to my mother "Amal"

To the generations raiser, to my father "Fathi"

To my brothers and sisters who supported me during the study
"Haneen, Yasmeen, Salam and Saher"

To my friends and all those who stand on my side

To every detail related to Aleppo with my wishes for a better future

I Dedicate My Work

Acknowledgment

I would like to express my special thanks to my supervisor *Dr. Marwan Ghanem* who had the primary role in opening my scientific path and inspired me throughout the thesis period, which in turn was not to be completed without his guidance and supervision.

My sincere gratitude goes to the manager who encouraged me, helped me in studding the master's program and was as affectionate father**,** *Mr. Ihsan Rukab.*

And my gratitude to the Institute of Water and Environment Studies with its professors and their recommendations.

I send my special thanks for *Eng. Nadia Affouneh* and *Eng. Mervat Almohammad* who had a role in conducting this research.

I appreciate the support of the friends who accompanied and helped me in field work, and the support of everyone provided me a required data.

Table of Contents

List of Figures

List of Tables

List of Appendices

Acronyms and Abbreviations

°C	Degree Centigrade
µg/L	Microgram per Liter
µS	Microsiemens
µS/cm	Microsiemens per Centimeter
AOPs	Advanced Oxidation Processes
ARIJ	Applied Research Institute – Jerusalem
BOD	Biochemical Oxygen Demand
BOD_5	Biochemical Oxygen Demand (after five days)
CEC	Council of the European Communities
cm	Centimeter
COD	Chemical Oxygen Demand
CSO	Combined Sewer Overflow
EC	Electrical Conductivity
EHD	Environmental Health Department
ESC	Environmental Standard Committee
JMP	Joint Monitoring Programme
km/yr	Kilometer per Year
km^2	Squared Kilometer
L/capita/day	liter per capita per day
L/sec	Liter per Second
LRC	Land Research Center
m	Meter
m.a.s.l.	Meters Above Sea Level
m^3	Cubic Meters
m^3/day	Cubic Meters per Day
MDG	Millennium Development Goal
MEPA	Meteorological and Environmental Protection Administration in Saudi Arabia
mg/L	Milligram per Liter
mm	Millimeter
mm/a	Millimeter per Annual
mm/yr	Millimeter per Year
mS	Millisiemens
nm	Nanometer
NOM	Natural Organic Matter

NTU	Nephelometric Turbidity Unit
OWC	Organic Wastewater Contaminants
PCA	Principal Components Analysis
PCBS	Palestinian Central Bureau of Statistics
pThC	Presumptive Thermotolerant Coliforms
RH	Relative Humidity
RSC	Residual Sodium Carbonate
SAR	Sodium Adsorption Ratio
SPSS	Statistical Package for the Social Sciences
SSP	Soluble Sodium Percentage
SWW	Sarida Wastewater
TDS	Total Dissolved Salts
TH	Total Hardness
UWwS	Urban Wastewater System
WBWD	West Bank Water Department
WHO	World Health Organization
WQI	Water Quality Coefficient
WwTP	Wastewater Treatment Plant

Abstract

This research investigates the wastewater as a pollution source that originate from the Israeli Ara'el colony and Palestinian communities affecting Sardia Wadi, and to determine the quality groundwater in the drainage basin, in order to specify the different pollutants, their possible sources and their impact on the groundwater resources and the socio-economic factors, and to pinpoint the possible measures to improve the situation. Consequently, two rounds of water samples collection have been performed from seven springs in wet season (May) and six springs in the dry season (November) of 2013 and other five wastewater samples have also been collected along the Wadi for each round.

Analyzing the results of wastewater samples showed that the concentration of BOD_5 exceeded the standards in 93% of the samples. The Increase of COD values downstream the Wadi in the dry season may refer to the wastewater discharging from the two villages. Because of the strong correlation between TDS and EC parameters, they acted the same trends with allowable levels. Most of tested samples showed that TSS concentrations exceed the standard (150 mg/l).

Excel and Aquachem software packages were used to analyze springs water results that showed a slight indicators of wastewater pollution. All the physical parameters showed acceptable results according to the WHO. Chemical composition of all samples showed that Ca^{+2} is playing a dominant role, while samples of the dry season exceeded the WHO limits for HCO_3^- levels and Cl^- showed acceptable values compared with guidelines. For NO_3^- content, Al-Matwi is the only spring that exceeded the (45 mg/l) limit.

The microbial data of the study showed a proof of wastewater contamination and has a high content of Fecal Coliforms (FC) and Total Coliforms (TC) compared to Palestinian Water Authority (PWA) microbial data in 2003 which demonstrated the increasing impacts of wastewater during time. All the analyzed trace elements did not exceed WHO guidelines for fresh water, but abnormal value for B in Al-Shalal spring may refer to wastewater contamination. All samples are falling in the earth alkaline water and showed a good and suitable water quality for different for agricultural activities such as irrigation.

Questionnaires data were collected and analyzed by SPSS package showing a confirming indicator for the negative effects on all walks of the people's life that were distinguished into healthy, economic and environmental outputs. As a result of wastewater flow, 92% of respondents confirmed the impact on public health, 47.7 % abandoned their agricultural lands, and 79.1% believed that their land production decreased. In addition, 96.9% of respondents were suffering from the negative implication. The Impact on the aesthetic conditions was negative according to 86% of the respondents.

الملخص

يهدف هذا البحث الى دراسة المياه العادمة القادمة من مستعمرة آرئيل كمصدر لتلوث وادي سريدا من حيث جودة الينابيع في هذا الحوض، كما يهدف إلى تحديد الملوثات المختلفة ومصادرها المحتملة وتأثيراتها الفعلية على مصادر المياه الجوفية وعلى الجوانب الاجتماعية- الاقتصادية لسكان منطقة الدراسة، وتحديد التدابير الممكنة لتحسين الوضع القائم. ولتحقيق ذلك فقد تم جمع عينات هذه الدراسة ضمن جولتين : الأولى وقد ضمت سبع عينات من مياه الينابيع وخمس عينات من المياه العادمة، وهذه تم جمعها في الموسم الرطب (أيار) لسنة 2013 ، أما الجولة الثانية فضمت ست عينات من مياه الينابيع وخمس عينات من المياه العادمة في الموسم الجاف (تشرين الثاني) لسنة 2013.

بعد تحليل نتائج عينات المياه العادمة بواسطة تطبيق (Microsoft Excel)، أظهرت نتائج التحليل وجود تجاوزات في تراكيز ال BOD_5 في عينات المياه العادمة بالإضافة لزيادة في تراكيز ال COD مع تقدم المياه العادمة في الوادي في الموسم الجاف بسبب مساهمة قريتي بروقين وكفر الديك في ضخ المياه العادمة باتجاه الوادي. وبسبب العلاقة المتبادلة بين الناقلية الكهربائية EC والجوامد الكلية الذائبة TDS فإن قيمتيهما قد سلكتا سلوكا متشابها من حيث ثباتها في الجزء الأخير من الوادي، ولم تسجل تراكيز الفوسفات PO_4 ايضا أي تجاوزات عن الحد المسموح. على عكس ذلك فإن معظم قيم الجوامد الكلية المعلقة TSS قد تجاوزت الحد المسموح وهو 150 ملغ/ل. من جهة أخرى فقد تم استخدام تطبيقي Aquachem و Excel من أجل تحليل عينات مياه الينابيع المدروسة في حوض سريدا، وقد أظهرت النتائج وجود دلائل واضحة على التلوث بالمياه العادمة في كلتا الجولتين. فيما يخص المتغيرات الفيزيائية فإن جميع عينات مياه الينابيع المدروسة ظهرت مقبولة اعتمادا على معايير منظمة الصحة العالمية بخصوص المياه العذبة،

أما كيميائيا فقد لعب الكالسيوم Ca^{+2} دور العنصر مع العلم أن هناك عينتان قد تجاوزتا حدود التراكيز المسموحة. أما بالنسبة لتراكيز البيكربونات HCO_3^- حيث سجلت عينات جولة الموسم الجاف تجاوزات عن حدود منظمة الصحة العالمية. أما محتوى النيتريت NO_3^- فلم يشهد أيضا تجاوزات في مياه الينابيع ما عدا نبع المطوي الذي تجاوز حد ال45 ملغ/ل.

بالنسبة للنتائج الميكروبية فقد أظهرت دليلا قويا على تلوث مياه الينابيع بالمياه العادمة، إثر وجود تراكيز عالية من بكتيريا القولونات البرازية FC والقولونات الكلية TC بالمقارنة مع نتائج تحاليل سابقة قامت بها سلطة المياه الفلسطينية PWA لعدد من الينابيع المدروسة عام 2003 ، ولوحظ تزايد كبير وواضح خلال العشر سنوات الماضية ناتج عن زيادة كميات المياه العادمة التي يتم تصريفها الى الوادي. أما فيما يخص محتوى مياه الينابيع من العناصر الكيميائية الصغرى، فقد أظهرت النتائج عدم تجاوز أي تركيز لها للحدود المسموحة من قبل منظمة الصحة العالمية. رغم ذلك فقد ظهرت قيم غير طبيعية خاصة البورون B في نبع الشلال والذي يعتبر دليل على التلوث بالمياه العادمة. من ناحية أخرى فقد صنفت جميع عينات الينابيع لكلتا الجولتين تحت مسمى القلويات الترابية و جيدة وملائمة للأغراض الزراعية مثل الري.

تم جمع نتائج الاستبيانات في منطقة الدراسة وتحليلها بواسطة تطبيق SPSS والتي أكدت الآثار السلبية لمجرى المياه العادمة على جميع مناحي الحياة والتي قسمت إلى صحية واقتصادية وبيئية. فيما يتعلق بالجوانب الصحية فقد كان التأثير السلبي واضحا على الصحة العامة للسكان وفقا ل 92% من عينة السكان المستهدفة، ومن الناحية الإقتصادية فإن حوالي 47.7% من أفراد العينة قد هجروا أراضيهم الزراعية القريبة من مجرى الوادي بسبب تأثيرات المياه العادمة الجارية فيها، إضافة الى قناعة 79% من العينة بانخفاض إنتاجية الاراضي لديهم. بشكل عام فإن 96.9% من العينة المستهدفة يعانون من الآثار السلبية لجريان المياه العادمة في الوادي، وما نسبته 18% قاموا بتغيير مكان سكنهم بسبب ذلك. ووفقا ل 86% من أفراد العينة فقد تأثرت المناظر الجمالية للمنطقة سلبا بجريان المياه العادمة خلال الوادي.

Chapter One

Introduction

1.1 Background

This thesis research is studying the multiple impacts of untreated wastewater flow effluents on the groundwater quality and socio-economic issues of Sarida Catchment. Sarida Wadi locates in Salfit Governorate, and it is one of the main branches of one of the longest Wadis in Palestine.

The study is focusing on two Palestinian communities: Bruqin and Kafr Al-Dik, which currently represent the most environmentally suffering hot spot in the Wadi's catchment, due to wastewater drainage that originates from the nearby Israeli colony called Ara’el and Palestinian communities. According to the Applied Research Institute - Jerusalem (ARIJ) (1999), the quality of flowing wastewater is responsible for the degradation of the receiving water bodies and the creation of critical environmental problems. An environmental survey reveals that there are 363 disposal sites discharging raw wastewater into the environment in the West Bank.

To this extension, Sarida Wadi is used for different types of agricultural and livestock consumption, accordingly the current discharge of contaminates into the Wadi affects the surrounding environment, which is represented by soil, plants, human, animals, as well as groundwater system. This relatively high discharged wastewater quantities by the Israeli side, may be caused by the relatively high wastewater generation rate, that is up to (0.571) Million cubic meter per year for Ara’el colony, and the higher population density with 16,800 person inhabits the colony, compared to Salfit as a wastewater origin (PWA, 2012).

The disposed raw wastewater of Ara’el colony from the sewerage network flows toward a wastewater pretreatment simple plant (WWTP) that in general reduces the severity values of different parameters. Ara'el WWTP is consisting of few sedimentation tanks and discharges the effluent into the nearly two kilometers stream length, which is open to air and polluting the agricultural soils along its path, ending in the joint point where it mixes with effluent and wastewater of Salfit city (PWA, 2012).

On the other hand, Despite its lower wastewater generation rate (0.385 MCM/Y) compared to Ara'el colony due to lower population density (10,477) person and therefore less water consumption (PWA, 2014). Salfit is discharging the collected wastewater without any treatment into the Wadi,

Moreover, Salfit wastewater is collected by a sewage system, and the flow continues through covered pipes with closed manholes for nearly four kilometers length, ending with the joint point where the two streams meet (Ara'el colony and Salfit city streams). Palestinian wastewater in Sarida Wadi is not attributed to Salfit city only, it also includes the discharged quantities of cesspits wastewater and septic tanks of Bruqin and Kafr Al-Dik villages, which dispose the influents into Sarida Wadi, with high pollutants concentrations affecting the wastewater quality downstream the Wadi.

Incontrovertibly, many modifications and adjustments are required to treat the water quality when the two wastewater streams are being mixed at the joint point, in order to balance the different properties of the output wastewater.

1.2 Problem Statement

Pollution and limited access to available water resources are considered major challenges that are facing the Palestinians in the West Bank. The study area of this research (Sarida catchment) has a main Wadi with its branches that is called 'Sarida Wadi', which has the most wastewater flow activity polluting the water resources and the other environmental elements.

Sarida catchment is one of the available groundwater resources, which is supposed to be a part of the water problem solutions for its surrounding area. Current trends represented by discharging of wastewater into the Wadi prevent the population of the nearby villages form the benefit of this natural resource. Accurately, the surface flow of wastewater in the Wadi which is crossing the agricultural lands has been considered as additional polluting factor, resulting in neglecting the cultivation activities in these lands. Moreover, there is a clear decreasing in livestock production for the same reason, where animals are consuming contaminated sources.

In the other hand, wastewater flow may infiltrate downward the groundwater and affect the nearby springs such as Al-Matwi and Al-Fawwar springs, which are supposed to be used by surrounding villagers as primary water resources. However, discharging wastewater into the Wadi -particularly from Israeli side- has duplicated the dangerous effects of contaminated springs' water. Additionally, the flow of wastewater may affect the economic aspect by decreasing the agricultural activities, and livestock production in Bruqin and Kafr Al-Dik villages, and also may affect the environmental, natural and the aesthetic aspects of the Wadi.

Discharging of Israeli raw wastewater towards the Palestinian territories and communities, without an efficient treatment is considered one of the most brutal practices against the Palestinians. With the largest wastewater generation proportion into Sardia Wadi; the Israeli side has the largest wastewater quantitative share, which making it the main cause for such pollution in Sarida catchment.

Moreover, there is a lack of information about the study area, in terms of hydro-chemical parameters as well as the chemical changes in the constituents of near spring's water. The Wadi region currently is suffering from neglecting and lessening by related stakeholders, despite it creates a critical pollution source for the population and the bio-environment. This catastrophic environmental issue requires an urgent assessment, in order to realize the dimensions of the problem, which could create a base for decision makers to rely on. This research study has been conducted in order to assess these problems, fill this gab and open prospects for additional studies that evaluating the environmental status of the rest issues in the catchment.

1.3 The Objectives and Aims

The main objective of the study is to investigate and specify the impacts of the raw wastewater flow on Sarida Wadi and the quality of groundwater and springs in the drainage basin, as well as the socio-economic factors, and to pinpoint on possible measures to improve the situation.

On the other hand, this study aims to:

- fill the gap regarding the lack of the environmental studies about the study area;
- Assist the Palestinian decision-makers to make the right decisions related to the current situation in the region, based on the main results of this study.

Determine the water quality of the springs as well as their hydro-chemical characteristics in the drainage basin will help in introducing the adequate protective approaches to improve the quality of the water sources.

1.4 Methodology

Two data sources have been identified for this research, namely; primary and secondary data resources.

The primary data are extracted mainly from the direct observations from the study area. The primary data used are conceptual and provides visions for the future, it is also informatics and helps to understand the current situation. Meanwhile, the secondary data are built through circulations of the available data in the forms of archived researches, literature reviews, published documents, mapping, and interpretation.

Mainly the methodologies of data collection classified according to the aspects to be investigated in this thesis research are the water quality and the Socio-economic aspects. The methodology of water quality assessment consisted of two samplings campaigns for the study area which are: May round (wet season) that has been conducted in 21 May of 2013, and November round (dry season) that has been conducted in 5 November of 2013, in order to evaluate the different trends of water and wastewater quality during the two periods regarding the chemical, microbial, physical and biological composition. In each round, seven fresh water samples were collected from the catchment, except one spring, that was dry in November round, moreover, five wastewater samples along Sarida Wadi track have been collected in each round with about 2 km distance between each station. After several field visits to the study area, the stations of the wastewater samples have been selected, in such a way that represents the whole Sarida wastewater track. Starting from the wastewater origins: Salfit wastewater discharges (Salfit WW) and Ara'el wastewater discharges (Ara'el WW), and ending with the end of wastewater flow (End point), passing through the other two samples locations (the Joint Point and Bruqin WW). On the other hand, the samples have been collected form the most seven affected springs along the Wadi's track which are: A-Fawwar, Al-Mizrab, Al-Msila, Al-Yanbou', Al-Matwi, Al-Shalal and Al-Adas (Figures 1.1, 1.2).

All the samples of wastewater and springs were analyzed in Birzeit University laboratories. The wastewater samples were collected manually in 1-Liter high density polyethylene, and analyzed for pH, TDS, EC, TSS, COD and BOD parameters by classic analyzing methods, and PO_4 by Spectrophotometer. Moreover, springs water samples of the wet season round were also collected by 1-Leter sterilized glass bottles and analyzed for pH, TDS, EC, TC and FC parameters by classic methods while major cations (Na^+, K^+, Ca^{+2} and Mg^{+2}) were analyzed by (ICP), major anions (NO_3^-, SO_4^{-2} and Cl^-) except HCO_3^- were analyzed by Cooling Ion Analyzer (CIA) while HCO_3^- was analyzed by AOAC titration method. The second round in November had the same sampling procedure and analyzed parameters with additional seventeen trace elements for springs samples which are: Beryllium (Be), Boron (B), Vanadium (V), Iron (Fe), Cobalt (Co), Arsenic (As), Selenium (Se), Barium (Ba), Thallium (Tl), Lead (Pb), Aluminum (Al), Chromium (Cr), Manganese (Mn), Nickel (Ni), Copper (Cu), Zinc (Zn) and Cadmium (Cd).

Figure 1.1: Wastewater sampling from the Wadi

These trace elements were analyzed in Al-Quds University Laboratories by (ICP-MS). The results of major cations and major anions were analyzed by Aquachem software package, the other parameters were analyzed by Excel analyzing software package.

Figure 1.2: Locations of the samples, stations and the communities along Sarida Wadi

Source: PWA, 2015 - Edited

The other part of methodology is statistical; the adopted approach for this assignment based on a written questionnaire that has been designed for this study, seeking for representing most of the life's aspects, it consists of the three following sections:

- Healthy section
- Socio-Economic section
- Environmental section

The survey was conducted for a random sample, which amounted to 50 persons of Bruqin and Kafr Al-Dik citizens; 25 for each locality to ensure the maximum accuracy level of the survey (Appendix 14).

The results have been analyzed through SPSS Statistics application; a software package that is used for statistical analysis. And the survey results were presented by means of tabulations, charts and graphs, by which a clear vision would be created about the significance of wastewater effects on the two localities life's aspects.

1.5 Thesis Structure

This research thesis consists of six chapters, by which the effects of wastewater on water quality and socio-economic aspects will be tested.

- **Chapter One: Introduction**

  This chapter presents the precursory background that introduces for the following contents of the research; it recognizes the scope and level of intervention of the research. Moreover, it clearly identifies the problem statements, the research hypothesis, goals and methodology, and systematically itemized on research theme and context.

- **Chapter Two: Study Area**

  This chapter contains the analysis of the study area (Sarida Wadi), and the specified influenced localities (Bruqin and Kafr Al-Dik) in terms of their physical, geo-political, economic, environmental and other characteristics.

- **Chapter Three: Theoretical Analysis**

  This chapter provides a survey of the existing literature about the subject of the research, it discusses the definition of the wastewater, previous studies about the impact of wastewater on fresh water quality, public health and environment, and finally the possible wastewater treatment processes, based on three hierarchical levels: global, regional and local levels.

- **Chapter Four: Hydrochemistry**

  This chapter uses the adopted methodology to determine the physical and chemical parameters of the surface water, springs and wastewater effluent, and to evaluate the suitability of the water resources for domestic uses. It also studies the changes in the water quality along the Wadi, and evaluates the effect of the wastewater effluent after mixing with spring's water.

- **Chapter Five: Wastewater Effects on Socio-Economic Aspects**

  This chapter clarifies the effect of the wastewater pollution on the socio-economic factors within the study area, divided into three sections: healthy, socio-economic and the environmental sections, based on the results of a structured questionnaire that have been prepared for this study.

- **Chapter Six: Conclusions and Recommendations**

  The closing chapter briefly checks the ability of the research to achieve its goals. It also provides a general policy framework of strategies, for promoting results and methodologies for other polluted Wadis, by identifying the preconditions to initiate such development, through a brief discussion for the generalization ideas and recommendations for policy making.

Chapter Two

Study Area

2.1 Introduction

This chapter introduces the case study area ' Sarida Wadi Catchment', where the research thesis has been performed, including the two localities of Bruqin and Kafr Al-Dik which are located in Salfit Governorate. The analysis includes the main physical characteristics of the study area, as well as the geo-political conditions that affect Sarida Catchment.

2.2 Sarida Wadi and the measured springs

Sarida Wadi is located in Salfit Governorate, and it is one of the main branches of one of the longest Wadis in Palestine (about 12 km) and is classified as a seasonal stream. Sarida catchment is one of the largest catchments area in the West Bank. It's worth mentioning that Sarida Wadi is located over an aquifer that contains abundant groundwater reservoirs and it is considered a strategic resource.

The wastewater of this Wadi originates from two sources; Ara'el colony discharging point after a pre-simple treatment, and Salfit wastewater source. These two sources meet together, making a joint point that is located before Al-Matwi spring and forming Sarida Wadi, leading to much flow and contamination for the surrounding environment (Figure 2.1). This stream continues its way downstream crossing Bruqin village, and passing along Kafr Al-Dik village, ending at the point that is located just after Al-Fawwar spring in Kafr Al-Dik lands.

Moreover, the study area contains seven springs along the Wadi: Al-Fawwar spring which is located next to the end of the wastewater flow, and it is considered as a recreation place, in addition to its relatively high flowing rate, and Al-Mizrab spring that is located in the eastern side of the Wadi and nearby Der Ghassana village, that has an elevated height from the Wadi level, and Al-Msila spring with seasonal flowing. While Al-Yanbou' spring is relatively far from Wadi stream in the contrary of Al-Matwi spring which has the highest flow rate and provide the nearby communities with part of their water needs. Finally, Al-Adas spring is located near Salfit city and provides a small swimming pool for recreation (Figure 2.1) (Appendix 5).

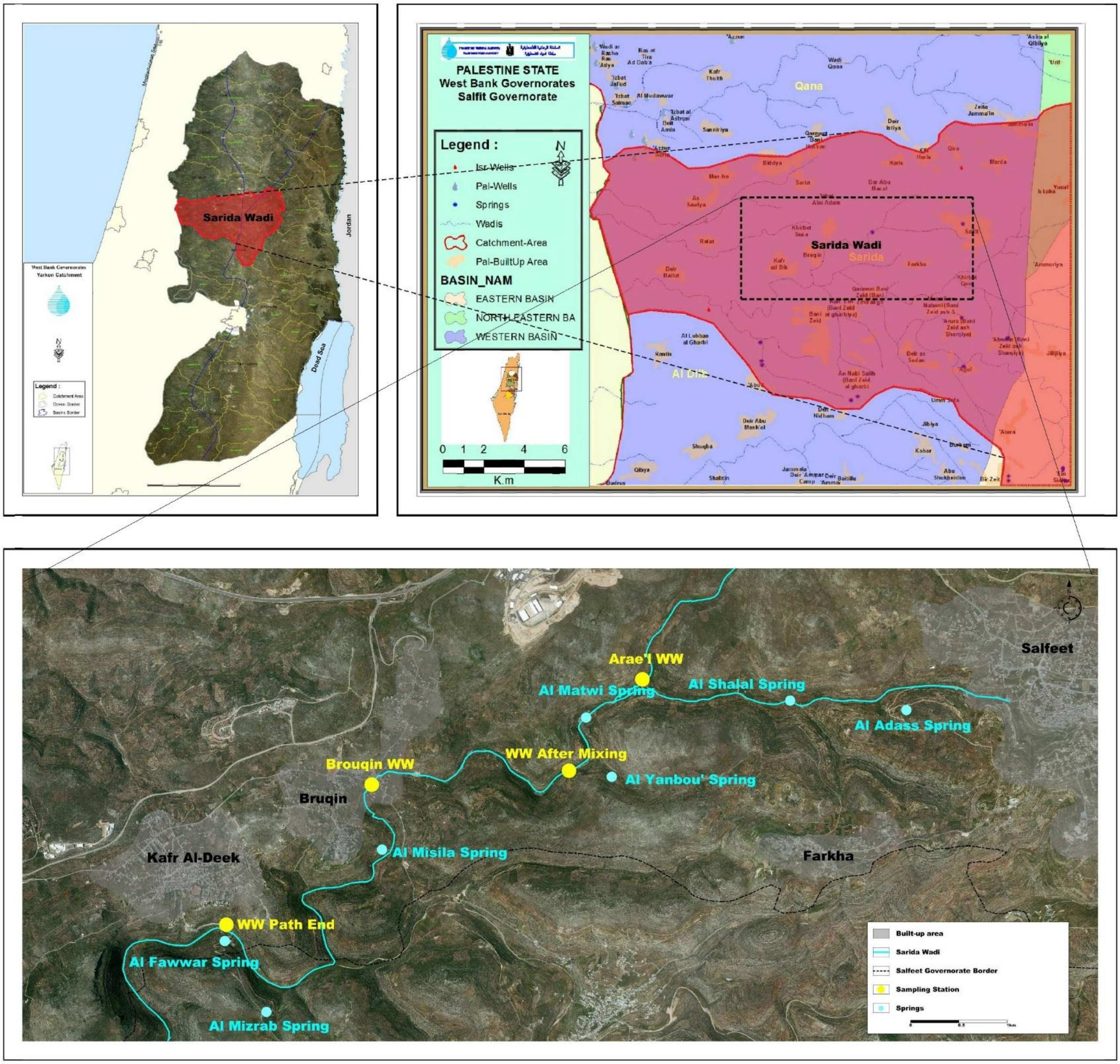

Figure 2.1 : The Location of Sarida Wadi

Source: PWA, 2015 - Edited

2.3 Salfit Governorate

2.3.1 Geographical Location

Salfit Governorate is located in the middle of the northern part of the West Bank, about 20 km to the south-west of the city of Nablus, between latitude of ̊32 degrees, and longitude of ̊35 degrees (LRC, 2008), with an altitude of 570 meters above sea level. Salfit city locates fully within Sarida Catchment, which in turn, its borders are extending from Al-Ahmer and Auja catchments in the east to the green line from the west, and from Qana catchment in the north to Al-Dilb and Al-Qilt catchments in the south. In addition to that, the relatively large Sarida catchment area are divided by the aquifers dividing lines into three parts. (Figure 2.2) illustrates Salfit Governorate location and Sarida Wadi.

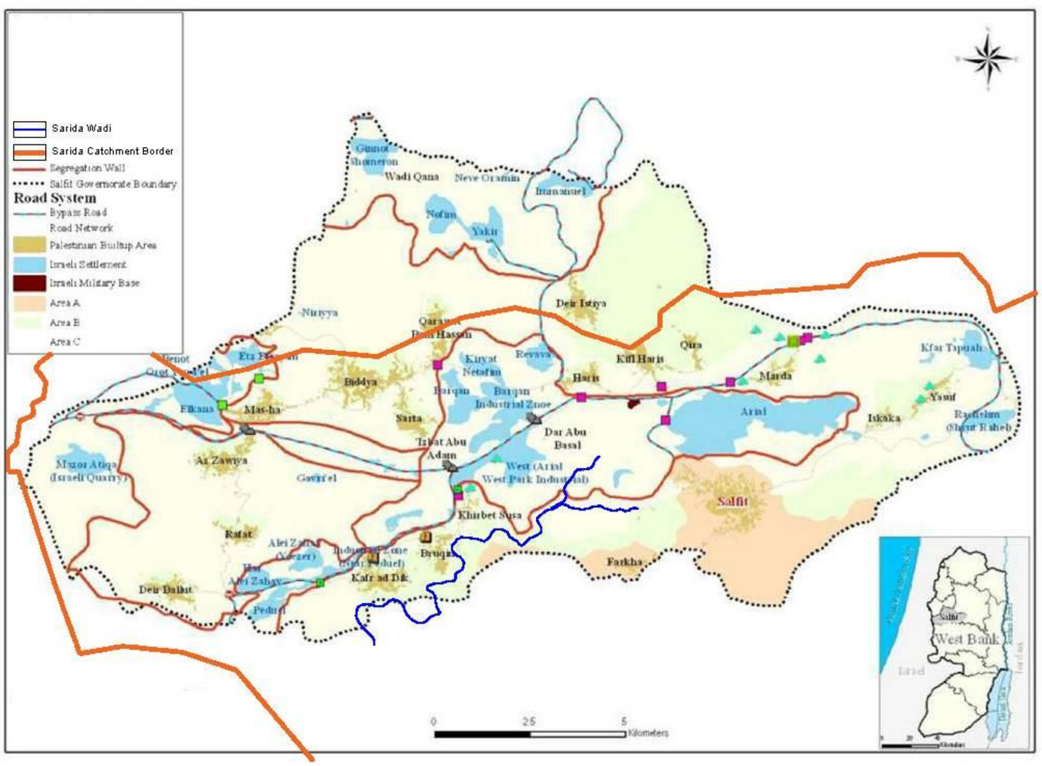

Figure 2.2 : Salfit Governorate Location

Source: ARIJ,2007 - Edited.

2.3.2 Climate

The climate of Salfit governorate is similar to the Mediterranean climate; hot dry summers and mild wet winters. The wind is northwesterly and southwesterly with 237 (km / day) speed average, and the atmospheric pressure is high (ARIJ, 2011).

2.3.3 Temperature

The existence of Salfit Governorate in the northern part of the West Bank affects its climate. In January, the coldest month of the year; the temperature average is (30.1 °C) maximum and (6.2 °C) as minimum. August heats up to higher rates and considered as the highest temperature average with (39.1°C) and the minimum temperature average is (19.5 °C) (Khatib, 2008). These values can be affected by many conditions like the elevation form the sea level, the distance from the coast and the environment of the sample location (Ghanem, 1999).

2.3.4 Relative Humidity (RH) and Rainfall

Expressed by (RH %), the relative humidity increases by moving from east to west towards the coast at the level of the natural Palestine and its average value ranges between 50% in the east regions to 70% in the west. In the study area which is almost located in the middle of this distance, the RH% yearly average is nearly 62% and increases in winter to 67%. The annual rainfall of Salfit governorate is 660 mm. However, in some years the amount increases up to 1000 mm, as in the winter of year 1991/1992 (Khatib, 2008).

2.3.5 Water Sources in Salfit

There are a lot of springs in Salfit; where 5 springs belongs to the public sector, 14 to the private sector, and there are nearly 4011 of collecting rain fell cisterns and it also has more than 60 sub-Wadis (Khatib, 2008). The residents benefit from this water sources for drinking and irrigating their crops and livestock watering, this water availability in abundance provided made-green region (PCBS, 2011).

2.3.6 Area and Population

The total area of Salfit governorate is 204 squared kilometers (LRC, 2008). The population is estimated by 64,614 and make up 2.5% of the total number of West Bank residents, this update refers to an increase by 40% compared to the year 1997 and figure 2.3 illustrates how the growing number of progressive population. This governorate spread over 19 localities and these communities are one city, eight towns and 10 small villages (PCBS, 2011).

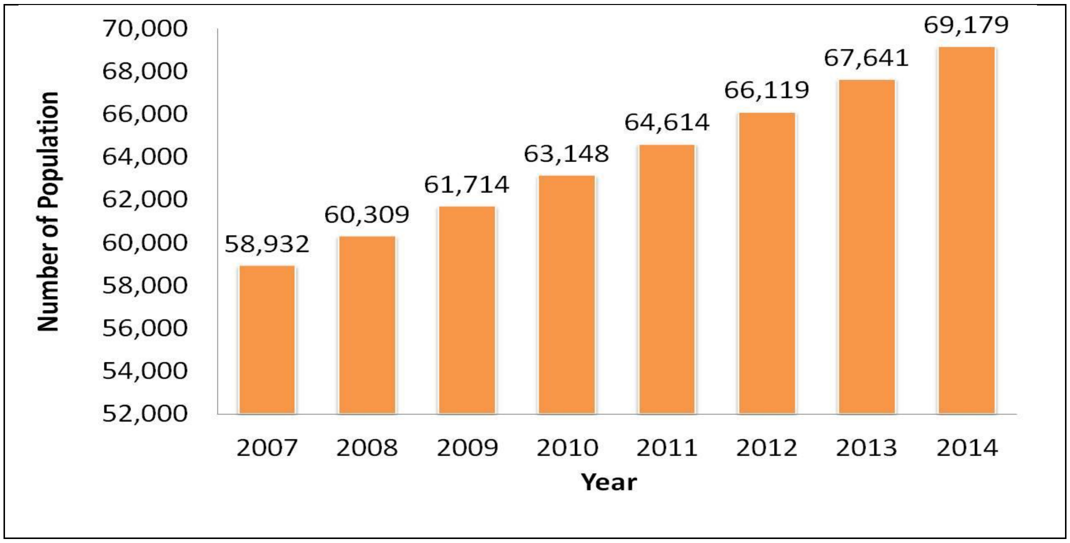

Figure 2.3: The Evolution of Population Number of Salfit Governorate (2007-2014)
Source: PCBS, 2014

2.3.7 Economic Characteristics

The economic activity in Salfit city depends mainly on agriculture, where the cultivated land area is estimated by 46.5 km² which represent nearly 22.8% of the total area of the governorate. Olive trees, grapes, almonds, figs, apricots and apples are the most famous crops that planted (PCBS, 2011). On the other hand, people are sowing many kinds of crops like wheat, barley, lentils, and beans (Al-Dabbagh, 2008).

The Israeli Apartheid Wall which has a part that divide many Palestinians agricultural lands and control them for their benefits for political reasons. This act led to obstruct the work of people and prevented them from a significant part of their agricultural lands. Otherwise, the wastewater had a major role in spreading the waterborne diseases through farmer's animal livestock which is located nearby the Wadi (LRC, 2008).

2.4 Kafr Al-Dik

This locality is considered a rural area according to classification of the PCBS, it is located in the south-west of Salfit and rises 390 meters above the sea level (Figure 2.4).

The total land area of the locality is approximately 20,000 acres, surrounded by several other Palestinians localities such as Bruqin, Bani Zeid, Bedia, Sarta, Rafat and Deir Ballut, it's population is about 4494 people who are sorted as 2,259 males and 2,235 females (PCBS, 2011).

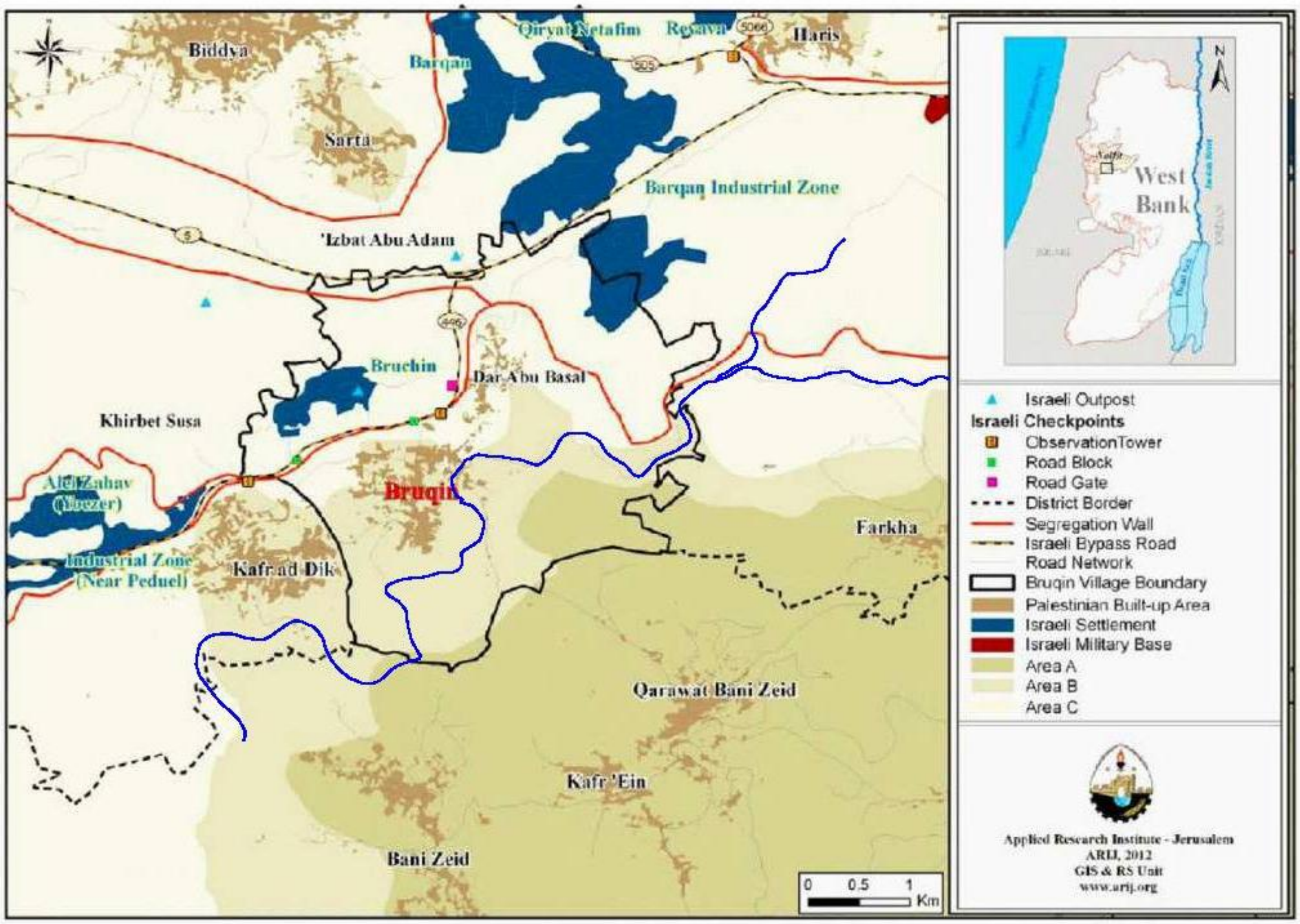

Figure 2.4 : Kafr Al-Dik and Bruqin Villages Location

Source: ARIJ, 2012 - Edited

2.4.1 Economic Situation of Kafr Al-Dik

- **Industry**

According to PCBS surveys in 1997, the number of total economic private plants that operating in Kafr Al-Dik is 40 facilities, 7 of them are industrial where approximately hold 27 workers and the remaining 33 facilities are for trade and vehicles repairing stations holding 34 workers (PCBS, 2011).

- **Agriculture**

Olive planting is the dominant in the agricultural sector, which occupies nearly 1653 acres of land. In addition to olive, this locality plants grains vegetables, fruits trees and raising sheep and cows which are represented 300 acres area (PCBS, 2011).

2.4.2 Infrastructure

Kafr Al-Dik population depends on two ways to secure water for domestic uses, the primary one is the Israeli Water Company (Mekorot) connection point through the West Bank Water Department (WBWD). The secondary choice is the rainwater collecting system which harvests water from houses surfaces, in addition to one main spring for agricultural uses which is called Al-Fawwar, that is located 200 m away of the village. According to the municipality data, there are 600 houses, using (64 m^3) cisterns as an average for the collected rainwater (PCBS, 2011).

The locality has a public electricity network, the main source of electricity is the Israeli side. With regard to wastewater collection, there is no sewerage network serving people. Thus, they dispose the wastewater through emptying septic tanks and cesspits and then discharging it into Sardia Wadi, which is located about (2.5 km) away. There is also an uncontrolled dumping site where the people dispose their solid wastes weekly and burn it frequently, this site is located (3 km) from the nearest residential area.

2.4.3 Nearby Israeli Colonies of Kafr Al-Dik

There are two colonies surround Kafr Al-Dik village; The first one is the Colony of Bdoial , its area is about 106 acres, it had been established in 1984 and classified as a civilian colony. The second one is (Eli Zahav Colony) it had been established in 1982, its area is about 208 acres, and this colony is also civilian.

2.5 Bruqin

This locality is considered as a rural area according to the PCBS, it is located about 8 km to the west of Salfit city, and it is rising 390 m above the sea level, its area is about with 18000 acres. Bruqin village is surrounded by the territories of Salfit city, Haris, Sarta, Kafr Al-Dik, Farkha, Qarawa Banizeid, and kafr Ein (Map 2.4).

The estimated Population is 3,194 residents, divided between males and females (1,643 and 1,551) respectively (PSBC, 2011). There are some archaeological sites that exist in village lands.

2.5.1 Economic Situation of Bruqin

- **Industry**

The number of industrial buildings is 27 according to the survey of 1997, these are distributed as follows: the manufacturing sector has 5 facilities and 25 workers, and the repair of vehicles workshops have 22 facilities and 25 workers.

- **Agriculture**

Bruqin people plants several kinds of crops like wheat, grains and little types of vegetables which are irrigated by spring's water in most cases. About (2974, 255) acres are cultivated with olive trees and fig trees respectively (PCBS, 2011).

2.5.2 Infrastructure of Bruqin

As in the case of Kafr Al-Dik water sector, Bruqin population depends on two ways to secure water for domestic uses, the primary one is the Israeli Water Company (Mekorot) connection point through the West Bank Water Department (WBWD). The secondary source is the rainwater collecting system which is harvesting water from houses surfaces, in addition to two main springs (Al-Matwi and Al-Yanbou) which are used for agricultural purposes, they are located about (1 km) from the village. According to the municipality data, there are 500 houses which are using (45 m^3) cisterns as average for collected rainwater.

The locality has a public electricity network, where the main source of electricity is the Israeli side. With regard to wastewater collection, there is no sewerage network serving the village. Thus, the residents dispose the wastewater through septic tanks and cesspits and then discharge it into Sardia Wadi, which is flowing through the village. There is also an uncontrolled dumping site where the people dispose their solid wastes weekly and burn it frequently , it is located (0.7 km) from the nearest residential area.

2.6 Problems Facing Kafr Al-Dik and Bruqin Residents

People of the localities faces many problems regarding to agricultural sector, industrial sector and other aspects of life which are listed in the following points:

- A general shortage in capital and labors,
- The lack of economic feasibility of the activities,
- The expropriation of the agricultural lands by Israeli forces and classifying them as closed military areas, in addition to the unsuitability lands for cultivation which leads to low agricultural production,
- Regarding the industrial side; people suffers from embarrassment, lack of skilled labors, raw materials and frequent military closures,
- The big problem that related to the wastewater flow and solid wastes disposing, which could lead to health catastrophe, soil contamination and decreasing production.

2.7 Existing Israeli Colonies withinn the Territories of Salfit Governorate

Many colonies were established on the territories of Salfit governorate through time; they are characterized by high-colonial density, compared to the Palestinian population density in the catchment.

Fertility of the soil and the abundance of groundwater represented by springs, led to the Israeli ambitions to exploit and control these resources, by creating many colonies and bring Colonists to live in and wreaking havoc on the lands of the villages. A good example for this situation is Ara'el colony which practice its aggression by discharging its wastewater into Sarida Wadi and contaminates the lands and springs within the Wadi.

The first colony that has been established in Salfit governorate was' Alqana colony' on the lands of the Palestinian village 'Masha' in 1977, which is followed by establishing a lot of other colonies up to 17 Israeli colonies, which in turn occupy about 38,134 acres of the Palestinian lands (LRC,2008) (Table 2.1).

Table 2.1 : Existing Israeli Colonies on the Territory of Salfit Governorate

Colony Name	Classification	Date of Establishment	Municipal Area (acres)	Constructive Area (acres)	Population	Confiscated Palestinian Village Lands
Ara'el	Residential, Educational, Military	1978	13775	2479	16520	Salfit, Kafr Haris, Marda, Iskaka
Immanuel	Residential	1982	1909	328	2585	Der Istia
Bker	Residential	1981	1364	342	984	Der Istia
Nofim	Residential	unknown	331	248	400	Der Istia
Karnei Shomron	Residential, Industrial	1978	7339	1351	6280	Part of Der Istia
Maale Shomron	Residential	1980	1903	216	574	Part of Der Istia
Ginot Shomron	Residential	1985	unknown	608	unknown	Part of Der Istia
Revava	Residential	1991	1540	160	827	Haris
Kfar Tapuah	Residential, Military	1987	414	156	648	Yasouf
Badoeal	Residential	1984	595	171	1113	Kafr Al-Dik, Deir Balout
Kiryat Netafim	Residential	1982	1540	162	438	Qarawa, Haris
Ali Zehaaf	Residential	1982	2003	255	684	Kafr Al-Dik
Alqana	Residential	1977	1198	758	2963	Masha
Shaar Tikva	Residential	1982	1045	915	3709	Masha, Azzon, Atma
Ephraim	Residential	1985	458	184	642	Masha, Beit Ameen, Sineria
Barkan	Residential, Industrial	1981	2720	349	1231	Sarta, Bruqin, Haris
Neve Oranim	Residential	1991	Unknown	153	N/A	Part of Der Istia
Total			38134	8835		
Source: LRC, 2008						

Among those colonies, Ara'el is the biggest, and the main source of polluting Sarida catchment with ongoing wastewater through the Wadi, which extends from the Ara'el passing by Al-Matwi spring and crossing Bruqin village, to the lands of Kafr al-Dik village, producing sever contamination for the vegetation, animals and soil layers in the region.

However, Ara'el colony was established in 1978 over Marda and Salfit lands after signing Camp David agreement between Israel and Egypt followed by sizable expansion of its borders to include and confiscate a lot of nearby Palestinians village's lands, such as Kafr Haris, Iskaka, Marda and Salfit city. Thus, it became a city in short time inhabited by 16,520 capita according to 2005 survey (LRC, 2008).

2.8 The Israeli Colonies Effects on Palestinians Walks of Life in Salfit Governorate

- **Economic Effects**
    - Building the Israeli apartheid wall on Palestinian lands in Masha village west of Salfit governorate, led to destroy the commercial market, which was considered as the main source of many families' income, and affected adversely the economic situation of the region's people. As a result, the unemployment rate is increased and land uses are decreased.
    - The Israeli confiscation of the lands affects directly and negatively the agricultural production, which contributes in 25% of the total production of the governorate. An example for this, is the actual production of olive oil that has been shrunk from (3,000 MT) to (210 MT). In addition to these direct results, there is an indirect negative result related to the animal production, because of the pastures lack and this in turn lead to the incidence of poverty and unemployment rates (LRC, 2008).
    - Another impacts of Israeli apartheid wall are the isolation of several agricultural lands, confiscated them and deprived the owners of their livelihood. For example, what happened in the village of Masha where seven livestock barns were destroyed during the construction of the apartheid wall.

- The isolation of Al-Shilla groundwater well, which is located in Masha and Azoon lands and was the main source for irrigating their crops, this led to water deficiency for agriculture in these villages.

- **Social Effects**
  - The presence of Israeli military checkpoints at village's entrances in the governorate prevents citizens to access to Salfit city and vice versa. A clear example is what is happening in the case of road No. 4775 adjacent to the settlement of Ara'el and connecting to Salfit city from the north-east, which is closed in the face of Palestinian people. Thus, the citizens are forced to choose another longer and bumpy way for (20 km) instead, this increases transportation costs, increases people's discomfort and decreases the social networking between Salfit governorate and other governorates.
  - Building of the Apartheid Wall in the western side of the governorate led to isolate the western villages from the occupied Arab villages in 1948, and created difficulties in communication between each other's.

- **Psychological Effects**
  - Fear and anxiety between the citizens as a result of the ongoing confiscation of lands, and preventing them from exploitation and expansion to meet the requirements of the population increase.
  - As a result of colonists practices of harassment and abuse the rights of citizens on colonies linking roads, the fear and anxiety have dominated citizens and prevent them travelling in the colonies linking roads at evening hours and have affected the nature of their movement in the region.
  - Releasing large number of wild boars by occupation authorities attacking fields and trees and this has led to significant economic damage, in addition to the psychological harm and fear inflicted to children and the elderly.

- **Environmental Effects**

Uprooting plenty of olive trees, confiscation of groundwater, isolation of many agricultural lands and prevent citizens from exploitation of theirs lands led to an environmental disaster and conversing of productive land into the unfit lands for cultivation (LRC, 2008). The following points are the most important environmental impacts of Ariel and nearby colonies on the village of Kafr el-Dik, Bruqin and other nearby communities:

- Air pollution: One of the dangerous impacts that affects air quality of the region is what Burkan industrial locality emit including CO, CO2 and CH4 which released from the factories exhausters.
- Water pollution: This significant impact has a wide range of negative results that affect all of people's life aspects; social, economic, healthy and environmentally. However, it is considered as the main impact of the study because it's huge influence on the main water sources for region which may lead to a serious catastrophe in the water sector. Discharging the wastewater from Ara'el colony and Salfit city to Sarida Wadi represent a direct source of pollution to Al-Matwi spring water which is the main water source for people activities in Salfit city and Bruqin, in addition to affecting many secondary water sources along Sarida Wadi.
- Closeness of the existence springs to wastewater flow could make matters worse, whereas some springs away from the Wadi about 20 meters. And the water quality of these springs could be estimated by analyzing concentrations of some organic, chemical compounds as like Ammonia, Nitrate and others. Which are a good indicating compounds for water contamination and its negative effects like waterborne diseases. Microbial tests are important factor in judging the contamination levels of spring's water. (Table 2.2) represents the main Israeli industries and its healthy impacts on the effected region.
- Increasing in the soil salinity along the Wadi due to the high Sodium concentrations of the wastewater, resulting an agricultural failure.
- Concentrated levels of heavy metals in the pastures grasses along the Wadi because of the industrial wastewater which affected the animal production indirectly by the high doses of the carcinogens.

- Boycotting the animal products like milk that produced from the animal farms along the Wadi and feeding on contaminated pastures, leading to significant losses for farmers.

Table 2.2 : Kinds of Israeli Heavy Industry and its Wastes Discharged to Sarida Wadi and its Healthy Effects.

Industry type	Heavy metals and contaminators	The effects
Petrochemicals	Lead, chromium	Leukemia disease, Affect the digestive system and cause kidney failure
Metallic industry	Lead	Leukemia, kidney failure
Food industry	Preservatives, high conc. of chlorine	kidney failure
Leather tanning	Arsenic	Leukemia, Asthma
Source: EHD - Salfit, 2007		

Chapter Three
Literature Review

3.1 Introduction

This chapter introduces an approach for the concept of the study, the discussion presents reviews about wastewater, which include a general view about wastewater definition as well as its different impacts, followed by the possible treatment methods. Moreover, this chapter provides an approach for previous studies and their results for the same concept. These studies will contribute in creating a general understanding for the problem of the research and adopting the related methods required to answer the research questions.

3.2 Urban Wastewater System

The Council of the European Communities Directive- CEC (1991) defines the urban wastewater as domestic wastewater or that water resulted from mixing domestic with industrial wastewater (and / or) storm water runoff.

In particular, the two expressions “Wastewater” and “Sewage” are perplexing due to 'run-off' entity. The first one (Wastewater) is used in USA; while the second ‘Sewage’ is more common in the UK, but the two expressions are used ultimately as synonyms. Furthermore, the difference between run-off sewage and sanitary sewage is that the latter consists of domestic and industrial wastewater (CEC, 1991).

An Urban Wastewater System (UWwS) is composed mainly of three components; the Sewer Network, the Wastewater Treatment Plant (WwTP) and the Water Receiving System (e.g. Rivers or lakes) as well. The UWwS usually has links with other urban water components such as rural streams, groundwater, drinking water production and supply as well as agricultural runoff (CEC, 1991).

The use of wastewater has the potential both to be used as a good fertilizer, since its considered a source of organic matters and plant nutrients (positive externality), as well as groundwater resources polluter with potentially harmful substances including soluble salts and heavy metals like Cu^{+2}, Fe^{+2}, Pb^{+2}, Zn^{+2}, Mn^{+2}, Cd^{+2} and others (negative externality). Most of these heavy metals such as Cu and Zn contain high concentrations of odor metals and toxicity hazards compared to very low concentrations of required materials for all living organisms (Nouri et.al., 2006).

Using of these heavy metals is undesirable; despite its harmful effects like contamination by heavy metal of soil, crops and different environmental and health negative issues, many farmers using irrigation by wastewater for many reasons like: increasing crop yield, effective way of effluent disposal, low cost source of water, organic matter and nutrient source as well as other reasons (Butt et.al., 2005).

To this extent, the deterioration in water quality is resulted by industrial waste or domestic wastewater, microorganisms in addition to a high concentration of toxic chemical (Khan & Javed, 2007). Other studies reveal that heavy metals resulted from human activities such as industrial activities, automobiles, batteries, tires and wastewater disposal (Miroslav, 2008).

Using wastewater for irrigation contaminates the soil and crops and resulted in plants toxicity and decay of soil (Butt et.al., 2005). One of the most serious polluters that is affecting the fresh water resources is the disposal of domestic and industrial wastewater, it's also affecting human health and agricultural productivity. This problem aggravates in urban and industrial areas, where rapid water quality deterioration may result in different waterborne diseases (Kahlown et.al., 2006).

The fresh water scarcity has resulted in using wastewater for agriculture and related activities in many countries in the arid and semi-arid region. Irrigation by Sewage effluents goes back to 2500 years ago in Iran (Vojdani, 2006). Currently this practice is common in different parts of the world (Hoek et.al., 2002).

Das & Das (2002) found that the natural treatment process of industrial effluent and municipal wastewater could be an innovative process to meet the growing needs of water. The plants' uptake nutrients (nitrate, phosphate, etc.) while soil adsorb the toxic inorganic/organic substances and microbes, this makes it harmless to some extent. However, soil and vegetation have a limit to absorb these contaminants, thus, waste should be given a primary treatment before its disposal. Septic Tanks are widely distributed creating a potential source of ground water pollution in urban settlements.

Enough safe distance should be maintained between drinking water sources and treatment units, to avoid recontamination by accidental discharge. To decide this distance, both soil types and existing hydrogeological conditions should be taken into consideration (Das&Das, 2002). Despite Actions promoting wastewater reuse are common, there is a clear shortage of human health and the environment protection frameworks in most developing countries (Hanjra et.al., 2011).

3.3 Previous Studies

This section provides summaries about previous studies related to the thesis topic. There are countless number of related studies, the selected researches presented in this chapter classified according to three hierarchical levels; global, regional and local levels.

Taken into consideration the possible impacts of wastewater use on water quality, groundwater, environment, crop production, public health, soil resources, property values, public health, ecology, and social parameters.

3.3.1 Global Studies

- **Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania**

  Warner et.al. (2013) found that the elevated levels of chloride and bromide, combined with the oxygen, strontium, radium, and hydrogen isotopic compositions of the effluents reflect the composition of 'Marcellus Shale' produced waters.

  The discharge of effluent increased concentrations of chloride and bromide above background levels.

  (^{226}Ra) levels in stream sediments (544–8759 Bq/kg) at the point of discharge were (~200) times greater than upstream and background sediments (22–44 Bq/kg), and above the maximum radioactive waste disposal regulations, creating potential environmental risks of radium bioaccumulation.

  Barium and radium were extraordinarily (>90%) reduced in the treated effluents compared to the concentrations in produced water of ' Marcellus Shale' (Warner et.al., 2013).

- **Development of a Low-cost Alternative for Metal Removal from Textile Wastewater**

  In their research ; Parvez et.al., (2013) measured : (the different (Physico-chemical) properties (i.e. pH), alkalinity, electrical conductivity (EC), total hardness (TH), Ca^{+2}, Mg^{+2}, Na^{+}, K^{+}, Cl^{-}, $NO3^{-}$, $SO4^{-2}$, HCO_3^{-}, sodium absorption ratio SAR, total dissolved salts (TDS)) in the groundwater, wastewater irrigated and soil samples.

  They found that wastewater affected the groundwater quality by increasing its EC, TDS and TH. Additionally, they found higher concentrations of heavy metals (i.e. Fe and Pb) in groundwater than the required standards of drinking water, due to the location of their study area near sewage water (Parvez et.al., 2013).

  In soil samples, except Cu and Cd, most of the parameters were within safe limits. The wastewater samples had elevated values of EC, TH, HCO3-, but the concentrations of all heavy metals were within safe limits (Parvez et.al., 2013).

  The study clarified that untreated wastewater polluted the groundwater, but not the soil, since soil particles are negatively charged so they can hold chemical and viruses - positively charged, thereby; soil particles provide a surface for the wastewater to pass over, and accordingly the physico-chemical percentages of soil remained in safe limits (Parvez et al., 2013).

- **Irrigation with Sewage of Effluent - Cooperative Extension Service**

  Chesnin (1996) proved in his study that wastewater contains varying amounts of the Heavy elements for example; the installation of nitrogen ranges between (10.7-74.6 mg / l), while phosphorus proportion was less than (0.1-8.1 mg / l), and magnesium amount ranges between (18-116mg / l), in these values there is a high percentage of the Nitrogen concentration (NO3-N), the increase of Nitrogen above permissible limits can lead to groundwater contamination.

- **Impact of Wastewater from Pig Farm Lagoons on the Quality of Local Groundwater**

  In their study; Beata et al. (2013) aimed to determine the degree of contamination of groundwater and the quality of drinking water, in three pig farms employing liquid manure cleaning systems, in lagoons without hydro isolation for storing wastewaters.

  Ten piezometers were installed in the three pig farms to monitor the quality of shallow groundwater and its level, whereas samples from the local wells were used to test the quality of drinking water (Beata et.al., 2013).

  The significant correlation ($P < 0.001$) between the rainfall amount and the level of water in the piezometers, indicates the possibility of the pollutant's permeation from the earth's surface to the groundwater (Beata et.al., 2013).

  Measuring the three components; (the parameters of wastewater, solid manure, as well as lagoon sediment) show that efficient water treatment occurred in the lagoons under natural conditions, where the overall contamination in the lagoons has been reduced. In more details; organic matter content in the lagoons was reduced by 85–90%, suspended matter by 94–96%, dry matter by 56–69%, total P by 31–50%, Cu by 69–85%, total N by 39–55%, and Zn by 83–89% (Beata et. al., 2013).

  Moreover, the results show that the risk of pollution of surface water and groundwater reduced, due to the fact that most of the metals precipitated in the bottom of lagoon (Beata et.al., 2013).

  The results showed large variations in the groundwater parameters between different locations of the samples. The content of total N in the reference piezometers ranged between (0.14 and 22.4 mg/L), while the same content proportion was up to (90.4 mg/L) in the piezometers near the contamination source (Beata et.al., 2013).

  In the water of the reference piezometers; the concentrations of (NH4+-N) was (0.02 and 1.52 mg/L), compared with (52.6 mg/L) in the piezometers close to the lagoons. Furthermore, the amounts of P and Cl− measured in the piezometers close to the lagoon were (7 - 5) times higher than in the reference piezometer.

Evidently, the relation between electrical conductivity (EC) and (Cl^-, $SO4^{-2}$, Na^+, K^+), between various metals in the shallow groundwater, reflect the common origin from the farm wastewaters (Beata et.al., 2013).

However, the presence of thick clay layer (4–6 m) between the lagoon and the drinking water aquifer, resulted in maintaining the quality of the drinking water in the deeper layers, where the parameters of drinking water quality indicate non-varied results during the research period (Beata et.al.,2013).

- **Wastewater irrigation and environmental health: Implications for water governance and public policy**

  Based on the hypothesis "Wastewater reuse and nutrient capture can contribute in climate change adaptation and mitigation", Hanjra et.al. (2011) examined the potential for wastewater irrigation regarding its benefits and risks. The study also presents a blue-print for future water governance and public policies to protect environmental health.

  Using reused wastewater in irrigation, which resulted in other activates like crop yields and changes in cropping patterns reduces the water footprint of food production on the environment.

  The study recommended a better integration for water reuse by governance polices to grantee environmental health protection during these process.

- **Development of a Low-cost Alternative for Metal Removal from Textile Wastewater**

  Birame (2012) studied the heavy metal pollution found in textile wastewater in Nyabugogo swamp - the study area- a natural wetland located in Kigali City (Rwanda) that receives all kinds of untreated wastewaters from the city.

  The investigation about heavy metals (Cd, Cr, Cu, Pb and Zn) pollution included all environmental compartments of the morass.

The research indicated that (Cr, Cu and Zn) proportions were within the permissible limits by WHO (2008) drinking water quality guidelines, while (Cd and Pb) were above these limits. Except (Cd), all metal concentrations were below the permissible limits for irrigation (Birame, 2012).

The highest metal accumulation found in the sediment represented by: (4.2 mg/kg) for Cd, (68 mg/kg) for Cu, (58.3 mg/kg) for Pb and (188.0 mg/kg) for Zn, followed by accumulation in the roots of *Cyperus papyrus* represented by (4.2 mg/kg) for Cd, (45.8 mg/kg) for Cr, (29.7 mg/kg) for Cu and (56.1 mg/kg) for Pb.

Except Cu and Zn, other heavy metal (Cd, Cr and Pb) concentrations in *Clarias* sp., the *Oreochromis* sp. and the Oligochaetes exceeds the permissible limits.

Finally, he researcher found a real risk on the human health using water and products from the swamp (Birame, 2012).

- **Combination of Advanced Oxidation Processes and Biological Treatments Wastewater Decontamination**

Advanced Oxidation Processes (AOPs) are considered a highly competitive water treatment technology used for the removal of organic pollutants not treatable by conventional techniques due to their high chemical stability.

Oller et.al. (2010) reviews recent research combining AOPs and bioremediation technologies for the decontamination of a wide range of synthetic and real industrial wastewater.

The main conclusions reveal that more work needs to be done on dynamics of the initial attack on primary contaminants and intermediate species generation. Furthermore, better economic models must be developed to estimate how the cost of this combined process varies with specific industrial wastewater characteristics, the overall decontamination efficiency and the relative cost of the AOP versus biological treatment (Oller et.al. 2010).

3.3.2 Regional Studies

- **The relationship between the working efficiency of wastewater treatment plants and water management in Queiq River Basin**

During his study about the effect of irrigation by wastewater on plants, Ali (2009) found that copper, zinc and manganese in all plants analyzes located below the permissible limits, while chromium, lead, Cadmium and nickel percentages were higher than the permissible values. The higher value of chrome and lead found in zucchini (12.02 ppm) and (23.61 ppm) respectively. Cadmium and nickel found in radish (13.23 ppm) and (23.61ppm) respectively. This refers to the use of wastewater contaminated with heavy metals in irrigation operations of these plants (Ali, 2009).

It also found that the most polluted well is the closest well to the hole where contaminated water discarded, compared to other wells in the region, because it was exposed to contaminated water leak more than other wells (Ali, 2009).

- **Incentive Systems for Wastewater Treatment and Reuse in Irrigated Agriculture in The Mena Region: Evidence From Jordan And Tunisia**

In this research; Abu Madi (2004), aimed to analyze the technological, regulatory, institutional, financial, and socio-cultural incentives and disincentives, which influence the use of wastewater treatment and reuse for agricultural irrigation in the MENA (Middle East and North Africa region) region, based on the experiences of Jordan and Tunisia.

Very low rates of wastewater reuse have been observed in most MENA countries, despite of water scarcity, taken into consideration the urgent need for additional water resources, increasing acknowledgment of treated wastewater as a valuable non-conventional resource, and developing new technologies for wastewater collection and treatment.

As a result, the countries of the MENA region (Middle East and Northern Africa) recognize treated wastewater as a non-conventional water resource, and wastewater that still discharged into the sea or water courses without treatment.

- **Impact of Sewage Wastewater on the Environment of Tanjero River and Its Basin within Sulaimani City/NE-Iraq**

  In this study (Mustafa, 2006) addressed the environmental impact of wastewater on the two rivers (Tangero and Kulaiasan), as well as its impact on groundwater, the sediments of drainage wadis and agricultural soils. The study found that the two rivers (Tangero and Kulaiasan) and groundwater in the study area is exposed to different sources of pollution like sulfate and nitrate and nitrite and ammonia and ammonium and rare heavy elements (Cd, Cu, Ni, Pb, & Zn).

  The increase in the physicochemical factors and biochemical demand of oxygen (BOD), and the chemical demand oxygen demand (COD), and the presence of fecal coliform, indicates that surface water and some groundwater models contaminated by wastewater. Agricultural soils in the study area are contaminated soils with rare heavy metals (Cd, Cu, Ni, Pb & Zn), when compared to the international and local standards. The wastewater of the city of Sulaimaniya presents a contamination source for each of the two rivers (Tangero and Kulaiasan), groundwater, the sediments of drainage wadis and agricultural soils as well (Mustafa, 2006).

  Using water quality coefficient for agricultural purposes show that surface water and groundwater characterized by good quality for agriculture , with some risks for specific types of crops. Wastewater, it is not desirable for surface water and groundwater, and it cannot used directly for industries, unless it passes through secondary and tertiary treatment processes (Mustafa, 2006).

- **The Reality of the Use of Wastewater Treatment in Tunisia**

  Rajab (1998), found that irrigated crop production using wastewater equals or exceeds the irrigated crop productivity by using clean water, this refers to the wastewater contents of nutrients - especially nitrogen, where the nutrient ratios in wastewater estimated by (43 mg / l) of nitrogen and (53.4 mg / l) of potassium and (3.4 mg / l) of phosphorus, which can reduce the amount of fertilizer used in agriculture (Rajab, 1998).

Accumulation of cadmium in crop plants and its consequences to human health conversely, chronic diseases may appear on the plant as a result of increased concentration of heavy metals in the foodstuff (Wagner, 1993).

- **Effect of Wastewater Irrigation in "Kwaik River" region in the soil and groundwater contamination - northern Syria Almtkh area**

  Hamou (2003) prepared a study of soils and some irrigated plants by wastewater in the southern plains of Aleppo, the study reported that soil contained high concentrations of nickel and chrome.

  For plants, the study shows that the heavy elements percentages were low in many vegetation samples, while the chrome (Cr) percentages were high in general, and higher than acceptable limits, the Chrome percentages ranged between(1 mg / kg) of wheat, (3.8 mg / kg) of cotton, (6 mg / kg) in the zucchini and (8.8 mg / kg) of potatoes, the same high results have been found for Nickel element percentages, both in plants samples and soil sample, its proportion amounted by (2 mg / kg) in potatoes, and arrived (3.8 mg / kg) in cotton, while the results of the rest of the elements such as copper, lead and zinc were within the permissible limits (Hamou, 2003).

- **Evaluation of Treated Municipal Wastewater Quality for Irrigation**

  Based on the hypothesis that " wastewater reuse is a useful tool to minimize the amount of wastewater in the environment", Abdul Hameed et.al (2010), evaluated of the suitability of Al-Rustamiyah WWTP municipal treated wastewater -Iraq- for irrigation, based on its contents and the international irrigation water quality standards.

  According to standard equations, the researcher measured the three values of ; Sodium Adsorption Ratio (SAR), Soluble Sodium Percentage (SSP) and Residual Sodium Carbonate (RSC), for the purposes of water quality classification , and its suitability for irrigation evaluation, the results were (2.11), (35.67) and (–12.75) respectively (Abdul Hameed et.al., 2010).

Comparing the values of Electrical Conductivity (EC) and sodium absorption ratio (SAR) with the 'US salinity diagram' indicated that most of the samples matches the field (C3-S1), which represents high salinity and low sodium. Thus, the water sample can be used for irrigation without exchangeable sodium risks.

The (RSC) value was negative at all sampling sites, which indicates that there is no complete calcium and magnesium precipitation. However, the results recommended added restrictions on the use of treated wastewater in irrigation due to chloride hazard (Abdul Hameed et.al., 2010).

- **Quality of Wastewater Reuse in Agricultural Irrigation and its Impact on Public Health**

Al-Hammad et.al. (2014), performed a sanitary survey of the largest wastewater treatment plant in Riyadh city - KSA, to examine its effluent quality. By which 12 wastewater samples from the WWTP have been examined by biological and physico-chemical parameters using standard methods.

The physico-chemical analysis indicated that the surveyed municipal wastewater treatment plant contained some parameters which exceed the maximum permissible wastewater limits according to Saudi Standards such as: turbidity, biochemical oxygen demand, total suspended solids, chemical oxygen demand and residual chlorine. However, heavy metal concentrations were found within the recommended standards in all samples (Al-Hammad et.al.,2014).

The biological analysis indicated that fifty percent of all wastewater samples were contaminated with faecal coliforms. In general total and faecal coliform results exceeds the permissible limits which reflects poor sanitation operations, but 'Escherichia coli' were detected in 8.3 % of the samples. Finally, and in order to preserve the environment and public health, the study recommended regular monitoring of microbial and physico-chemical parameters for the quality of treated wastewater which is used for agricultural irrigation (Al-Hammad et.al.,2014).

- **Observation of Pollutants Quantity and Quality in Runways Water and its Effect on Plants, Soil, and Ground Water In fledge of Taldo and Tal El-Zahab-Homs.**

  Essa (2010) found that all wells near water channels were contaminated, and not suitable for drinking. Moreover, the pathogenic microbes exceeded the number of acceptable limits. The pollution refers to pollution as a result of nominated sewage, the same resulted found in shallow wells that used by residents of the area in irrigation and cleaning operations, the irrigated plants found contaminated with wastewater as well.

3.3.3 Local Studies

Most of the generated wastewater in the West Bank and Gaza Strip is discharged untreated in to the surrounding environments.

In the West Bank, only (6.3%) of the generated wastewater is treated in wastewater treatment plants, compared to (93.7%) that is discharged into the environment using septic tanks, cesspits, and sewage collection networks. Whereas, untreated wastewater of Gaza Strip is discharged into the Mediterranean Sea. However, the operation of the vacuum tankers service cannot be considered a real solution to the problem, in addition to be costly service (ARIJ, 2011). Generating a new water resource is an additional benefit of solving the problems of wastewater collection and disposal, this treated water can be used for irrigation purposes (ARIJ, 2010).

The Israeli colonies are considered another source of the Palestinian environment contamination. In 2011 the total number of Israeli Settlement was (144), while the total number of Israeli settlers was (536,932) (PCBS, 2012). More than (90%) of the generated untreated domestic wastewater by settlers is discharged directly into nearby Palestinian lands (Issac, 2007).

Palestinian environment is highly affected by the construction of Israeli “industrial zone” settlements, in the Waet Bank there are 13 industrial zones, occupying an area of 980 hectares (ARIJ, 2007). The settlements of Barqan, Ariel, Atarot, Mishor Adummim and Qiryat Arba, are considered the most important Israeli industrial zones in the West Bank, they host different industries such as; batteries, electroplating, aluminum, electroplating, electroplating, plastic, textile dyeing, fiber glass, rubber, food canning and meet processing (CJPME, 2005; ARIJ, 1998).

Obviously, the Israeli colonies in the West Bank have a high potential for polluting the environment by their solid, liquid and gaseous wastes, where the discharged liquid wastes (industrial wastewater) from Israeli colonies is contaminated by different pollutants such as; organic matter in the form of proteins, fats, solvents, increase the BOD and COD values to toxic trace elements such as Hg and As, Ni and Cr.

The Applied Research Institute-Jerusalem (ARIJ) and the Hebrew University-Jerusalem were carried out an assessment of the impact of Israeli wastewater on the Palestinian lands, in their study : "Environmental Protection of the Shared Israeli-Palestinian West Bank Aquifer". The case study was Barqan Industrial zone (very close to the study area). The study found that the first trace of chloride would reach the water supply wells pumping from the lower layer within 20 years. While the upper aquifer are expected to experience the first trace of the pollutant within 25 (Issac, 2007).

- **Socioeconomic Effects of Israeli Colonies**

The dependency of Israeli colonies, and their impact on the Palestinian lands and resources and the inequality between the two parties are common and clear, this has been promoted by the occupation during the previous forty five years (PWA, 2012).

The last five years have witnessed the growth of illegal Israeli colonies, attached with the expansion of illegal Israeli bypass roads, the strangulation of the Palestinian economy, and the construction of the Israeli Segregation Wall.

Little data is available indeed about the nature and scale of the impact of Israeli colonies on the Palestinian land and water resources, and their aggressive water policy, that are adversely affecting the Palestinians and their environment. The Israeli authorities used different policies to control the maximum amount of water. (Issac, 2005 and PWA, 2012).

The Palestinian consumption of water per capita is considered one of the lowest in the Middle East and North Africa, because of the restrictions of the Israeli occupation and the 1995 Oslo II agreement for water provisions (PWA, 2011). As a result Oslo II agreement, Israel tokes the control over more than 60% of the Palestinian fresh water resources (Issac, 2005). Moreover, untreated wastewater is discharged currently from the main Palestinian centers into the environment due to the lack of wastewater treatment facilities (PWA, 2011).

- **Current Environmental Situation in Salfit Governorate**

In 1999 the Kreditanstalt für Wiederaufbau [kfw][1] had funded the project of establishing a wastewater treatment plant in Salfit governorate, and in Al-Matwi Wadi specifically. This project had been stopped due to Israeli obstacles regarding the WWTP location in Area C, and not giving the required permission for establishment (ARIJ, 2008).

The Israeli side objection on the project was because it had been prepared to treat the wastewater of Salfit city only, while the Israeli side was planning to establish a joint WWTP, that includes the wastewater of Ara’el colony, the Israeli colony that has been established on Salfit governorate lands, and it's wastewater is discharged untreated into the agricultural lands of Salfit, where the wastewater of Ara’el colony and Salfit city meet in Al Matwi Wadi, and the flow continued towards Bruqin And Kafr Al-Dik villages lands, the length of this stream is about 12 km (ARIJ, 2008).

This joint project has been refused by the Palestinians, due to political issues connected with the recognition with the Israeli side. Accordingly, Salfit municipality provided a new location of the WWTP, located in area B, but the project failed again referring to the high cost of the treated water compared with the clean water (ARIJ, 2008).

The wastewater is considered to be the main problem affected Al Matwi Spring, which is located 4 meters only from the wastewater stream flow. This contaminates the spring that covers (30%) of Salfit city needs of water, where the spring pumps about 350 m^3 of water to Salfit city (ARIJ, 2008).

[1] Reconstruction Credit Institute

The biological tests that have been conducted by the Department of Environment and Health in Salfit municipality reflected that there is a significant pollution, and asserted the presence of Fecal Coliform bacteria in the main springs, and this is a clear evidence of wastewater mixing with the spring water. Accordingly, Salfit Municipality has developed a chlorination system for Al Matwi spring water before pumping it to the network of the city (ARIJ, 2008).

This critical situation becomes more dangerous in the winter, where wastewater level increases, and its overflow causes the contamination of Al-Matwi well. Moreover, the residents of the housing units adjacent to the well's region are suffering from a very serious problem, where the population is dependent on rainwater harvesting wells as a main source of water (ARIJ, 2008).

And because the wastewater is discharged a along the Wadi's track, very close to these houses, the assessment of the water quality have improved the contamination of the domestic water. Residents of the two villages of Kafr AL-Deek and Bruqin are also suffering from the same problem, especially neighboring houses to the wastewater stream (ARIJ, 2008).

Additionally, the livestock in the region drink this contaminated water, and feed on the plants that are irrigated by this wastewater, which creates a threat on the health of these animals and to public health as well. Many dermatologists affects the population of Kafr Al-Dek and Bruqin communities, as a result of water contamination. The two villages are suffering from the spread of mosquitoes, insects and rodents, this could be a major environmental and health hazard. The tests of water quality, have shown the pollution of the main source of water in the villages represented by Al-Fawwar Spring (ARIJ, 2008).

- **A case study of urban wastewater balancing to study wastewater pollution loads and groundwater pollution in the city of Nablus-East (Palestine)**

The research aimed to evaluate the pollution resulted by wastewater exfiltration of the sewer networks in Nablus-East region, where the wastewater samples have been collected from the main and sub-main catchment's outlets, for both the water mass balance and the nitrogen (Shaheen, 2013).

The study found out the exfiltration rate, where the daily exfiltration per kilometer was (0.02 m^3/day). Regarding the water mass balance results showed that (82.2%) of the consumed water ends in the sewer network, compared to (17.8%) that is used outdoor. Moreover. The exfiltration wastewater from the sewer network was (12.8%) of the consumed water, while (65.2%) flows to Al-Sajor Wadi, and (4.2%) ends up in cesspits (Shaheen, 2013).

The 'annual urban nitrogen loading' has been found to be 688 (kg N/ha*yr) for Nablus-East region wastewater, which is very high when compared to figures for urban areas in Europe and Africa (Shaheen, 2013).

- **Spatial Quality of Municipal Wastewater Flowing in Wadi Al-Zomar and Infiltrated Through Wadi Bed**

This research aimed to investigate the degree of pollutants in the infiltrated water and their effects on groundwater quality in Wadi Al Zomar Catchment - Tulkarem. Focusing on self-purification in the study area and also pollutants infiltration from untreated wastewater through soil at different sections in the wadi (Al Daraowsheh, 2014).

The quality of wastewater that is discharged into the study area has been evaluated during two seasons, in terms of (COD, BOD, NH_4, PO_4, NO_3, Fecal Coliforms and Heavy Metals), Physical Parameters have also been tested, represented by (TSS,TDS, DO, pH, EC and Turbidity) (Al Daraowsheh,2014).

The study found that the degree of purification in dry season for COD, BOD, PO_4, NH_4 and Fecal Coliforms were (50%, 12%,50%, 34% and 84%) respectively, compared to the results of the wet season; where the percentages of reduction were (53%, 48%, 50%, 48% and 90%), respectively. These differences between dry and wet seasons refer to temperature variation and dilution (Al Daraowsheh, 2014).

Accordingly, self-purification was clear along the wadi. Furthermore, and in terms of dilution effect; the concentrations of pollutants found to be higher in the dry season than in the wet season, where the percentages of the reduction for COD and BOD were (50%), (20%), respectively (Al Daraowsheh,2014).

Moreover, during the dry season the infiltrated wastewater results showed a reduction in the measured pollutants; COD (35-51)%, BOD (31-61)%, NH4-N (9-28)%, Fecal Coliforms (87-100)%. While the Heavy Metals in the infiltrated wastewater decreased for (Zn) and (Fe) by (48-73)% in both seasons, however, the (Mn) concentration increased from (1-fold) up to (6-folds) in the surface wastewater (Al Daraowsheh,2014).

- **Nitrogen and Heavy Metal Fluxes from Cesspits in Palestine - Beit Dajan and Beit Fourik as a Case Study.**

The aim of this research was to evaluate the contamination in Beit Dajan and Beit Fourik villages that are located in Nablus governorate, in terms of total nitrogen and heavy metals from cesspits (Amous, 2014).

The average concentration of heavy metals in the cesspit septage were : (Cu 0.24 mg/l), (Ni 0.03 mg/l), (Pb 0.01 mg/l), (Mn 0.47 mg/l), (Fe 12.56 mg/l), (Cr 0.04 mg/l), and (Zn 1.23 mg/l) (Amous, 2014).

After being moved through soil; the concentrations of heavy metals in the infiltrated septage have been reduced. By which Copper (Cu), Nickel (Ni) and Chromium (Cr) have not been found in the infiltrates, other metals have been reduced dramatically such as manganese (Mn), iron (Fe) and zinc (Zn) (Amous, 2014).

- **Pollution and Water Quality Assessment of Wadi Al Qilt**

This study aimed to assess the water quality of Wadi Al Qilt drainage basin, for this purpose five sampling stations were located along the Wadi's path, between November (2004) and July (2005), where chemical, physical, biological and hydrobiological studies have been analyzed (Daghrah, 2005).

Results detected major trends in most of measured parameters; where higher concentrations of lead and cadmium have been found in three samples. However, five samples have been polluted by fecal coliform, which indicates the presence of contamination in the springs sources. Additionally, results showed that three samples were contaminated with aluminum, lead and cadmium (Daghrah, 2005).

Finally, the study found that the dilution process that is resulted from spring's discharge that ends up in the wadi's which are forming Wadi Al Qilt, is the reason behind decreasing the concentration of parameters when water is flowed in the open transportation canal (Daghrah, 2005).

- **Hydrochemistry and Isotopes of the Spring Water in Soreq Catchment/ Ramallah / West Bank.**

This study aimed to identify the various pollutants and their environmental impacts on the groundwater in Soreq catchment, by assessing the hydrochemical and isotopes studies (Jebreen, 2014).

The results indicate that the groundwater in most samples of Soreq catchment is contaminated by Fecal Coliform and Total Coliform. While the concentration of nitrate shows values below the WHO limits. Moreover, the groundwater of the study area springs is contaminated by heavy metals such as (Zn^{+2}, Mn^{+2}, Cd^{+2}, Co, As^{+2}, Cu, Ni, Al, Pb, Fe^{+2}, and V) as their concentrations were higher than the permissible limits according to WHO standards of 2007 (Jebreen, 2014).

Chapter Four

Hydrochemistry

4.1 Introduction

The main aim for this chapter is to determine the most important geochemical reactions that control groundwater and springs water composition in the semi-arid aquifer where the tested springs are located. These reactions with the aquifer's chemical components - that are classified as natural influential factors- could affect groundwater quality in terms of major ions content. On the other hand, the main anthropogenic factor in the study is the direct pollution of the raw discharged wastewater that infiltrates thorough soil and rocks layers downward to the aquifer affecting groundwater quality, which is represented by spring's water quality.

Chemical analysis for each spring could indicate the general properties and the quality of the water spring for many purposes like domestic or agricultural uses. Thus, water quality variations between the springs could be explained and guessed based on the circumstances and activities that surround the concerned springs which are clarified in this chapter.

4.2 Qualitative Comparison between the Both Wastewater Sources

Despite the importance of quantitative factor for each of wastewater sources which showed significant difference between the two sources with 1.6 MCM/year of wastewater for Ara’el colony and 0.3 MCM/year for Salfit city (PWA, 2012), the qualitative factor is not less important and even it is more important than the quantitative, due to its sever effects when it exceeds the standards levels. For this, a simple comparison has been conducted between the two origins in order to determine the reasons behind the different qualities between the both sources.

The average values of the two rounds parameters for Salfit wastewater and Ara’el wastewater were calculated and analyzed in order to indicate the quality difference between the two wastewater sources. The results showed slightly higher values for Salfit wastewater in terms of pH (7.3, 7), Total Dissolved Solids (TDS) (817, 778 Mg/l) and Electrical Conductivity (EC) (1633, 1556 µs/cm) - for Salfit and Ara’el respectively. These nuances could be justified by the pretreatment plant for Ara'el colony that decreased the measured values (PWA, 2012) (Appendixes 8, 9).

The rest parameters (TSS, COD and PO_4) except (BOD_5) showed significantly lower values for Ara'el wastewater sample compared to Salfit wastewater, such variation could be referred to the strong role of pretreatment plant. The abnormal variation belongs to BOD_5 values for two sources, unlike the previous parameters, BOD_5 played an opposite trend that showed a higher values for Ara'el wastewater compared by Salfit wastewater with (232 mg/l) and (156 mg/l) respectively. The unusual trend may be justified by the exposed uncovered wastewater path for other natural organic source such as; dead plants, animal wastes, soil organic content as well as others (Figure 4.1).

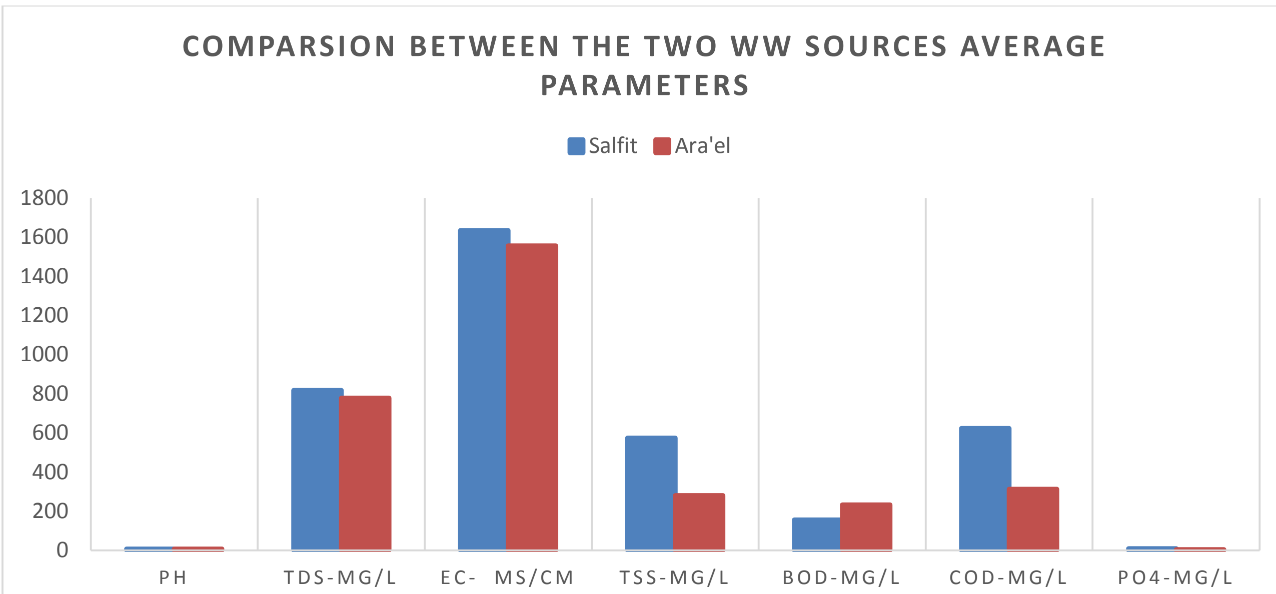

Figure 4.1 : The Difference between the Wastewater Quality of the Two Sources, Salfit and Ara'el for some Average Values for Both Rounds

4.3 Variation of Parameters along Sarida Wadi

In order to understand the quality situation of the wastewater flow of Sarida Wadi, a clear understating framework is required to clarify all elements that affect directly and indirectly- the Wadi from its origins (Salfit and Ara'el) to its end point (Al-Fawwar spring). Each of the affecting parameters had been analyzed and discussed separately in the following sections.

4.3.1 Organic Parameters

The BOD_5 refers to organic load in any water body (wastewater in this case), and has been defined as a 'five days incubation standard' and considered the best parameter to estimate the water quality relating to the presence of organic matter either suspended form or dissolved (Ahipathy & Puttaiah, 2006). Whenever the organic matter content increased in wastewater, the microorganisms' activity increases in order to oxidize the organic matter biochemically which increase the BOD_5 values.

Almost all samples of the study exceed the standard of the raw wastewater, which is (25 mg/l) except the 'End Point' sample of the wet round (May) according to MEPA (1992). This particular value which is (19 mg/l) is justified by the high dilution activity of Al-Fawwar spring that locates just close to the (End Point) station (Appendixes 8, 9).

However, there are opposite trends between the wet season round results and dry season round results related to BOD_5 values which showed a better results for the wet season (May) by time with more springs flow rates after direct recharging season than the dry season (November), which was conducted within a dry winter in the first two months (November and December) of the season and after a dry summer. Therefore and rationally, the increasing in BOD_5 values downstream the Wadi in November period (Figure 4.2), due to the effect of the wastewater contribution of Bruqin and Kafr Al-Dik communities. Another reason for such increasing is represented by organic wastes of livestock activities that is disposed into Sarida Wadi body between (Bruqin WW) station and (End Point) station (Figure 4.2).

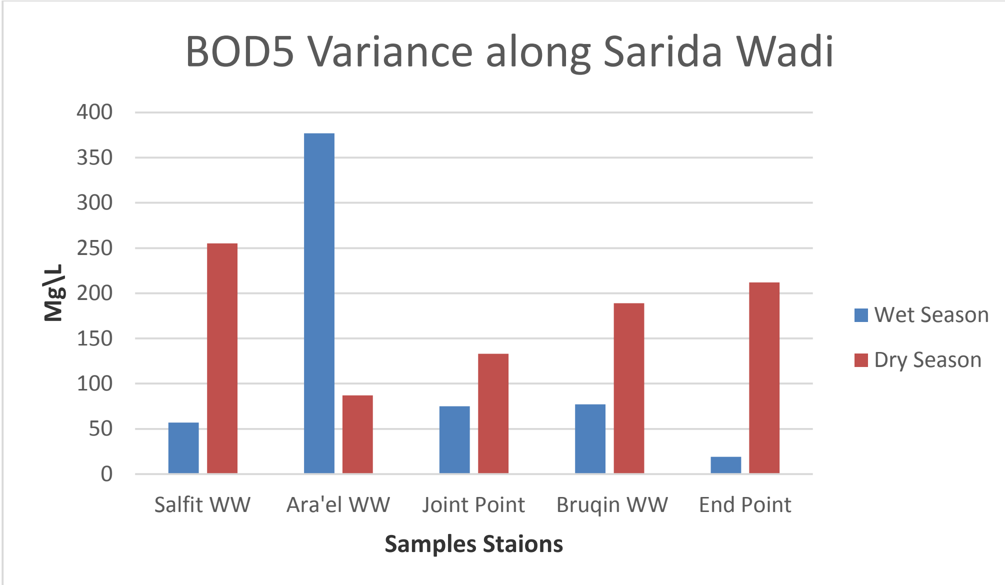

Figure 4.2 : The BOD5 Variance Trend of wastewater along Sarida Wadi

On the other hand, the wet season results indicated and confirmed the significant role of the spring's dilution effect. There is abnormal high value of BOD_5 in (Ara'el WW) sample of the wet round (May) which may be attributed to runoff act of the surrounding organic materials such as livestock animal wastes or dead plants towards the Wadi, which in turn, increase the organic content in the wastewater, particularly in the case of such open channel. This justification can seem logical when regarded to May because of the precipitation activity compared to the dryness of November in this year (Figure 4.2).

Another abnormal values related to (Salfit WW) sample which recorded an opposite trend of Ara'el, where BOD_5 of the dry season sample is higher than the wet season, this may be explained by the high usage of water for domestic uses just after wet season in May, thus, a higher dilution rate for wastewater resulting lower BOD_5 concentration in the sample of the wet round (May) compared with the dry round (November) whom people are suffering from water scarcity.

The Chemical Oxygen Demand (COD) content could also indicates the water pollution, which originates from many sources, such as domestic and industrial wastewater or agricultural and animal activities. Because the proportion of the substances which can be oxidized chemically exceeds the biologically oxidized. COD values generally are higher than BOD values (Bartram and Balance, 1996).

Similarly to for the BOD_5 trend for both rounds, the trend of COD values along the Sarida Wadi acted the same manner for all samples (Figure 4.3). the lower COD concentration for Ara'el may be attributed to the stable water usage in all seasons of the year including November, while Salfit people decreases their water usage because of the lack of water resources in dry season including November which was dry this year. This lead to Ara'el wastewater dilution comparing to Salfit wastewater which is affecting the COD concentrations.

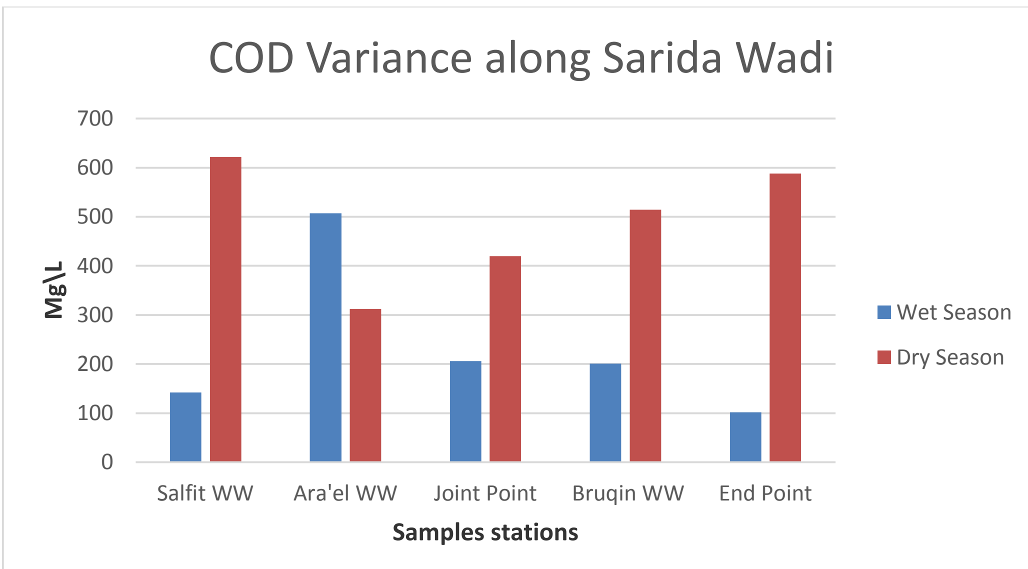

Figure 4.3 : The COD variance trend along SWW in both Rounds

The growing COD levels downstream the Wadi from (Joint Point) station ending with (End Point) is may because of the adverse wastewater sharing of Bruqin and Kafr Al-Dik population who discharges their wastewater into the Wadi body (Figure 4.3).

4.3.2 Physical Parameters

One of the important quality parameters of wastewater is pH (Gelman, 2003) and it's suitability for many purposes such as agriculture (Ahipathy and Puttaiah, 2006). This parameter could be affected by many components of the wastewater such as sodium content represented by detergent presence. Comparing with the optimum range of pH for wastewater (6.5-9.5) that is identified by WHO (2006), all samples taken from different places along the Wadi showed reassuring results and did not exceed the standard value of WHO.

Ara'el wastewater sample in the wet round is the only sample that indicated an acidic behavior, which may return to the open flowing channel and rainy season where the runoff can gather different decaying organic material including organic acids such as humic acids, fulvic acids, phenolic acids and other organic acidic materials, leading to acidic effect in the wet season (May) comparing with the dry season (November) that has no runoff effects in such dry year (Figure 4.4) (Appendixes 8, 9).

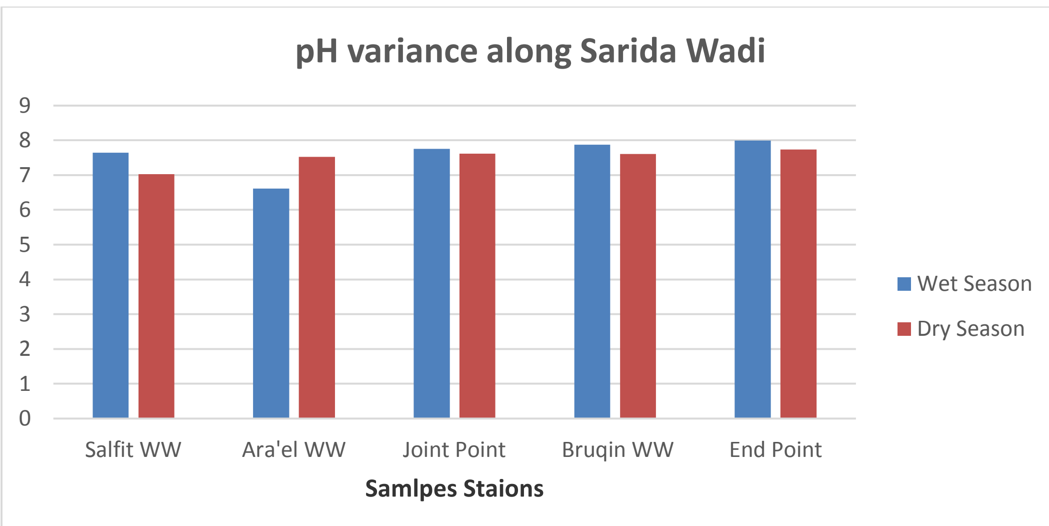

Figure 4.4 : The pH Variance of Wastewater Along Sarida Wadi wastewater

However, due to the continuous discharging of the raw wastewater by Bruqin citizens along the Wadi, carrying potential basic load of pollutants, there is a slightly higher pH values of wastewater in (Bruqin WW). In addition to Bruqin station, another rise in pH has been found in the 'End Point' station, this might be caused by the presence of stone quarries on the stream's track. The same trend has been found in the two seasons rounds, which somewhat confirms the described reasons above (Figure 4.4).

Electrical Conductivity (EC) is another physical parameter that affects wastewater quality, it indicates indirectly the measurement of salinity (Harivandi and Beard, 1998). There is a strong relationship between the two parameters (Total Dissolved Solids (TDS) and EC) that affect each other, and the (EC) is considered an evaluation of the concentration of TDS (Anzecc and Armcanz, 2000).

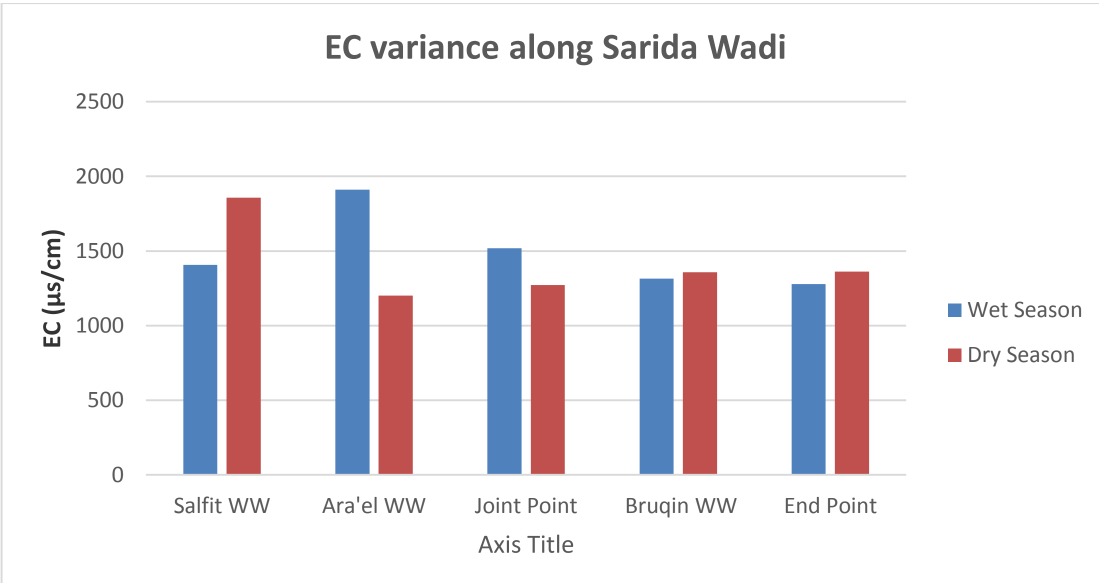

Figure 4.5 : EC Trend for Wastewater along Sardia wastewater Wadi for the Two Rounds

A wide range of EC was resulted for the two rounds (1200-1900 µs/cm) which is considered with medium strength. The EC values indicated a stable and straight trends as illustrated in (Figure 4.5), especially after about 5 kilometers from the (Joint Point) station by which the value stabilized between (1270-1370 µs/cm). Relating to the abnormal values of EC in Ara'el samples in both rounds, the runoff may act the most influencing factor for such trend where clays and soluble salts are directed towards the Wadi body from surrounding mountains and lands, these sediments with high ion exchange rates and salts content can raise EC levels of uncovered Ara'el wastewater in the wet season compared to the low EC level of the dry season (November). This difference is reflected in the case of (Joint Point) sample of EC levels, which has higher values in the wet season with 1518 µs/cm compared to the dry season with 1271 µs/cm.

4.3.3 Chemical Parameters

The Total Dissolved Solids (TDS) varies between samples according to several factors, one of them; is the solubility minerals differences for the geological region in the study area (WHO, 2006).

An important second factor is a seasonal effect, which is represented by the temperature difference between the two seasons which lead in turn to evaporating, and concentrating the wastewater accordingly (Dreyer, 1982). (Figure 4.6) shows a similar trend to the EC parameter, referring to the strength relationship between them, by which they initiated with irregular values due to the mixing operation, and ending with a steady trend.

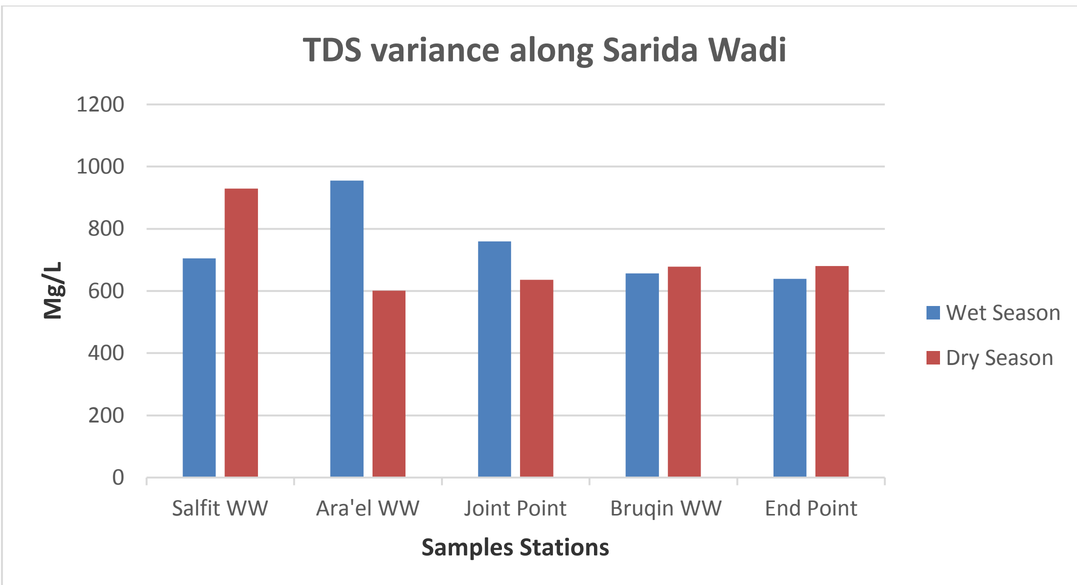

Figure 4.6 : The Wastewater Trend for TDS along Sarida Wadi

Obviously, springs activities contributes the chemical parameters values. The dry round (November) represent more TDS value which equals (680 mg/l) because of delayed rainy season in (2013-2014) winter. Which refers to limited spring's activity and their dilution effect.

On the other hand, the wet round (May) showed less TDS value represented, by (640 mg/l) due to the same previous reason which refers to continuation of the springs flowing activities even after May, which in turn diluting the wastewater (Figure 4.6).

The relatively high flow rate of the Sarida Wadi Wastewater (SWW) in the wet season sampling round, refers to the rainy season delay combined with great spring's contribution; this led to significant dust and soil erosion, as well as larger friction with rocks, more than the dry season, which resulted in high Total Suspended Solids content (TSS) in the wastewater, and increased downstream along the Wad, according to ESC (1996).

All of the study samples results (except Ara'el WW, Joint Point and Bruqin WW) in the wet round (May), exceed the typical TSS concentration which is (150 mg/l).

The clear difference of TSS content between (Ara'el WW) and (Salfit WW), is a strong evidence of pretreatment process significance, this can be seen obviously in (Figure 4.7) that illustrates the relatively lower content of TSS in Ara'el in the two rounds, which running a simple sedimentation method.

Another noticeable observation in (Figure 4.7) is the sudden rise of TSS content in the last station in the two lines. This may be justified by the presence of the stone cutting processes for a road construction project, just before the sampling station which produce such content of TSS.

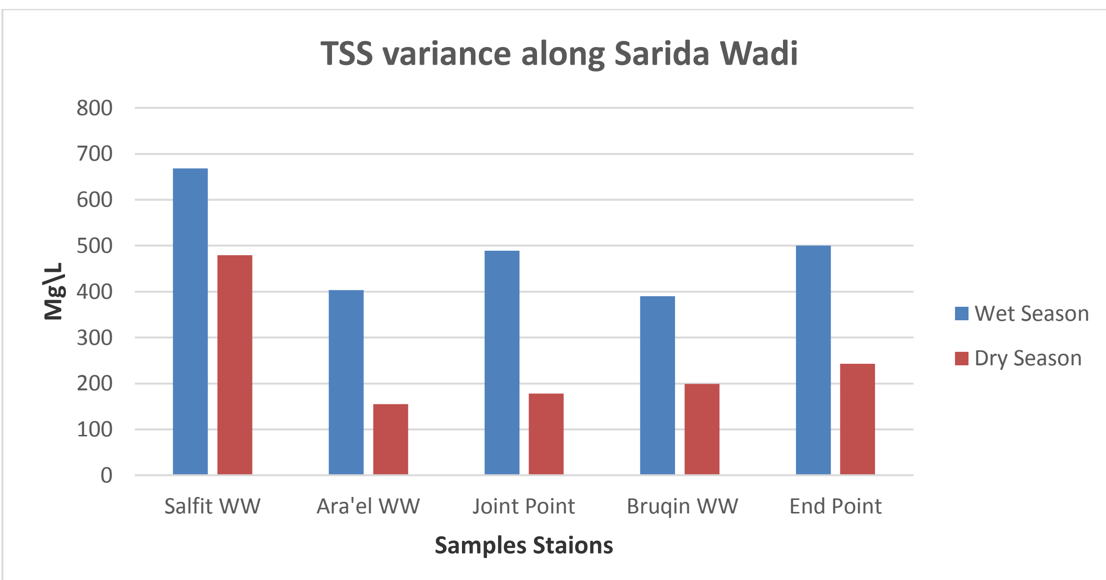

Figure 4.7 : The Variance Trend of the TSS along Sarida Wadi

The eutrophication process is considered one of the side effects for phosphorus compounds such as PO_4, which in turn enhances the algal growth in the wastewater bodies. Its sources in the wastewater are detergents, industrial wastes and rain run-off (Bartram and Balance, 1996).

Although the phosphorus level of the effluents is (5-50 mg/l) for local water uses according to Pescod (1992), (Figure 4.8) shows a low content of PO_4 in all samples of the raw wastewater for the dry round (November) (3.5-8 mg/l).

It is obvious that there is a relatively big difference in PO_4 content between the two rounds, which was caused by dilution effect of the springs in the wet season (May) compared to the dry season (November). However, the increase in concentration of PO_4 in Bruqin WW station can be explained by discharged wastewater from the two villages of (Kafr- Aldik and Bruqin) (Appendixes 8,9).

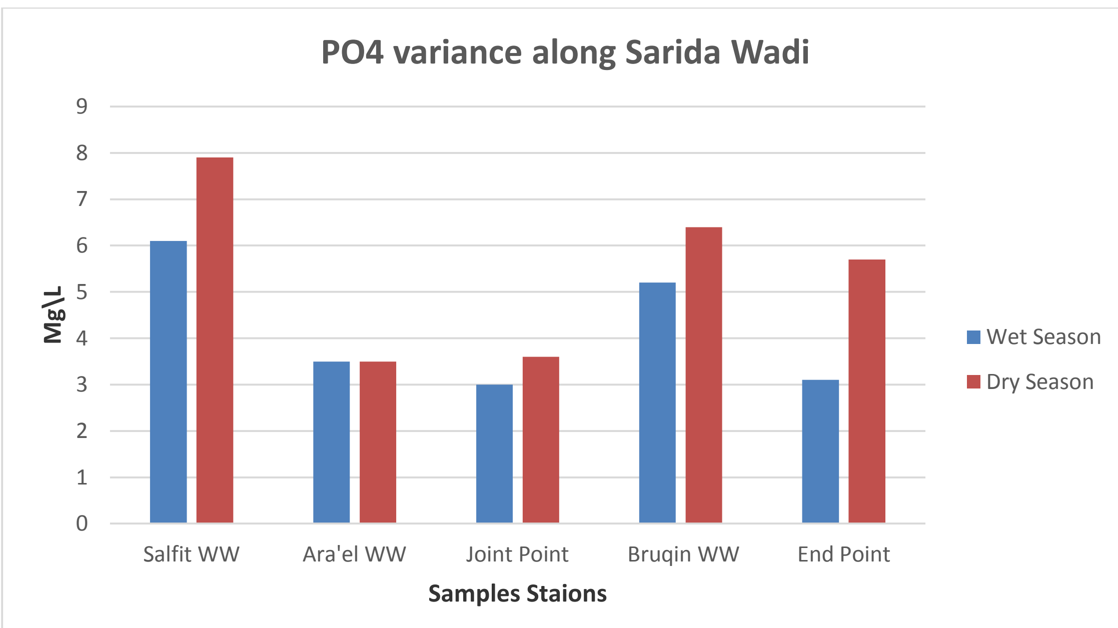

Figure 4.8 : The Variance Trend of PO_4 of Spring's Water of Sarida Catchment in both rounds

4.4 Springs of Sarida Catchment

Sarida catchment is considered to be the major raw wastewater discharging area for the two largest communities; Salfit city and Ara'el colony. This stream continues its way downstream crossing Bruqin village, then it passes next to Kafr Al-Dik village, and ending at a location just after Al-Fawwar spring which belong to Kafr Al-Dik village.

However, the citizens of these two villages are suffering from the pollution effects of Sardia Wadi wastewater, which contaminate the adjacent agricultural lands, animal production, and people life aspects as shown in chapter 5 and groundwater of the region. This chapter is mainly an analysis of the impacts of Sarida Wadi wastewater on the groundwater within the study area, since it is considered one of the most important sources of fresh water. Because of the absence of groundwater wells in the study area, then the best indicator for groundwater quality are the springs.

Sarida Wadi basin contains seven main springs flowing the fresh water towards the Wadi and diluting the wastewater within the Wadi, the next section discusses the quality of these water springs and the effects extent of wastewater.

4.4.1 Interpretation of the Analyzed Parameters

4.4.1.1 Physical properties

Temperature is an important factor that's affecting the chemical and geochemical reactions and physical parameters such as pH and EC (Saether and Caritat, 1997; Skidmore at.el., 2003). The temperature of the two sets were measured in Celsius (C^0) and ranged between 21-25 C^0 with a slight difference up to one degree between November (dry) and May (wet), there was no abnormal temperature values recorded for the spring’s water during the study period.

pH values of springs varied according to reactions occurring underground surface such as dissolution of CO_2 into groundwater under pressure, and dissolving HCO_3^- derived from carbonate rocks (Ghanem, 1999). Depending on WHO guidelines, all of measured pH values for samples show acceptable values (7.39 to 7.8) and did not exceed the standards limits (6.5-8.5).

As for TDS in springs' water and according to the classification of Todd (1980), all the samples records classified as fresh water, and devoid of abnormal values that ranged between (207-339 mg/l). The dissolved solids can significantly affect the electrical conductivity of water because of close association between both parameters. Hydro-Chemical Prosperities (Appendixes 1, 2).

4.4.1.2 Chemical Properties

- **Major Cations**

From the fact that Ca^{+2} is abundant component in the study area rocky structure of dolomite and limestone, the groundwater which contact theses rocks continually, causes the Ca^{+2} to play a dominant role in all of study samples.as shown in Figures (4.9, 4.10) which are representing a consecutive arrangement of the springs, Calcium values ranged between (53-90 mg/l) with the maximum value recorded in Al-Adas spring for the two seasons, with average of (85 mg/l), this may refers to the long contact with carbonate rocks. It is worth mentioning that the only two springs which are Al-Adas and Al-Matwi exceeded the WHO guidelines (70 mg/l).

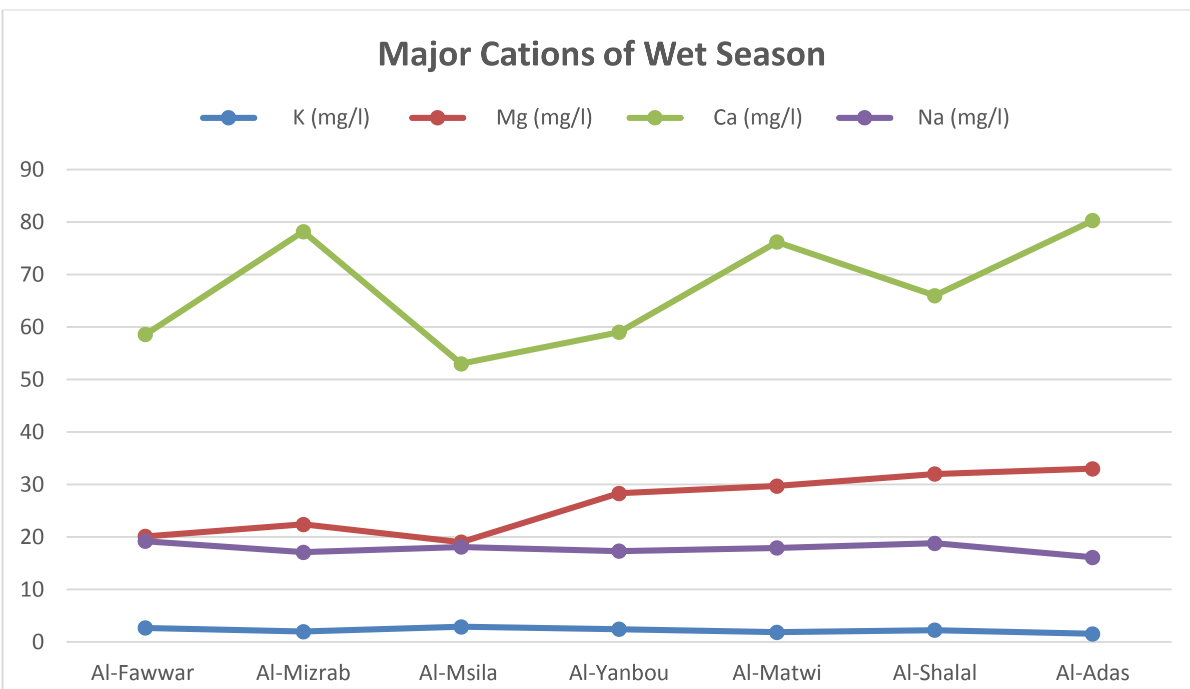

Figure 4.9 : The Major Cations Concentrations of Spring's Water of Sarida Catchment in the Wet Round (May)

The joint role played by Magnesium (Mg^{+2}) and Calcium (Ca^{+2}) in hardening the water, is a source of interest because of its importance in affecting the water quality.

The high concentration of Mg^{+2} in spring's water indicates the presence of dolomite or magnesium-rich limestone, which contacts the groundwater.
Based on Langmuir (1997) classification, the typical groundwater must not exceed (7 mg/l) of Mg^{+2} while all of the analyzed samples showed values higher than permissible level up to (19-38 mg/l), but they did not exceed the WHO (2007) guidelines.

The Mg^{+2} concentrations values recorded within the study area were similar to the previous Ca^{+2} values, which showed that Al-Adas spring had the maximum value in the two rounds with (38 mg/l) (Figures 4.9, 4.10). In the spite of mineral deposits and sewage effluents factors, that contribute the quantities of sodium (Na^{+1}) to water (WHO, 2006).

The high doses of the fertilizers that contain Na^{+1} and is used in intensive agriculture around the Al-Fawwar spring, play the most important role for such increase of Na^{+1} concentration in the two rounds periods, and overcoming the rest factors (Figures 4.9, and 4.10).
On the contrary, the springs that are located far from human activities, recorded the lowest values of Na^{+2} such as Al-Adas, Al-Yanbou and Al-Mizrab. However, none of the values exceeded the WHO limits for Na^{+1} content.

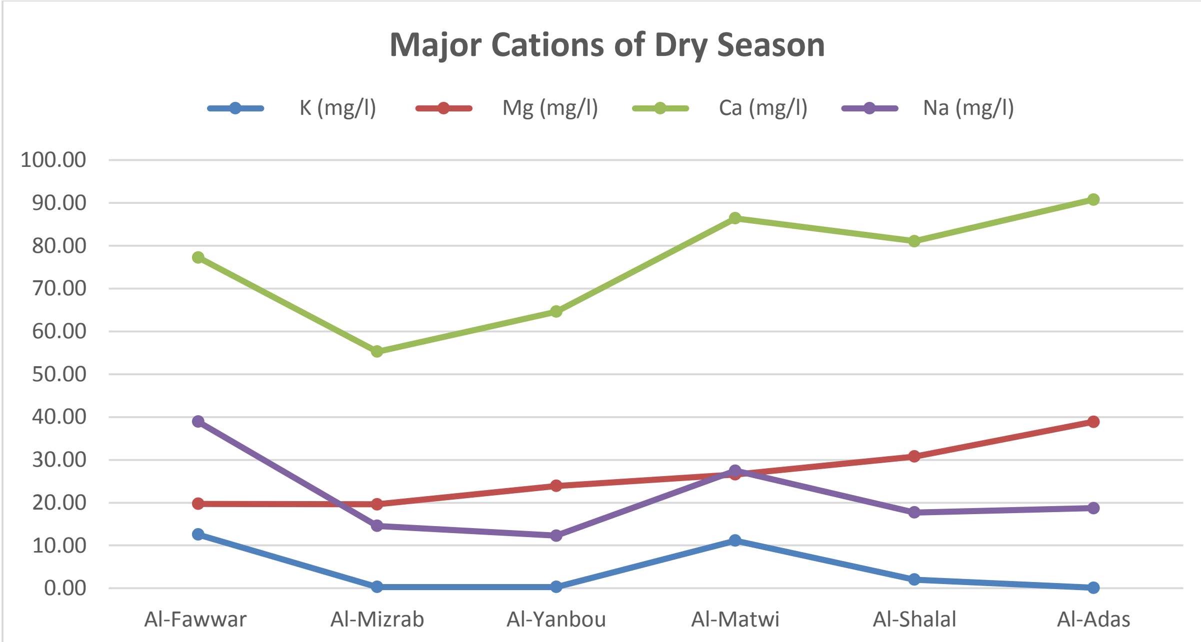

Figure 4.10 : The Major Cations Concentrations of Spring's Water of Sarida Catchment in the Dry Round (November)

Similar to the trend of Na^{+1} with regard to agricultural activities and its impact on Na^{+1} content, the evaluation of potassium (K^{+1}) showed results that's confirming the negative impact of the potassium-rich fertilizers on water quality, especially in Al-Matwi and Al-Fawwar springs, where the intensive agriculture exists and even exceeding the WHO limits (12 mg/l). This variant trend occurred only in the dry round (November), due to dilution effect of rain recharging, which was low because of the rain season delay, as it had already been explained. Except for these two samples, all the tested results were acceptable according to WHO guidelines (Appendixes 3, 4).

- **Major Anions**

According to Langmuir (1997) conclusions, the groundwater natural content of Bicarbonate (HCO_3^-) concentration, depends on solubility extent of the carbonate rocks that dissolving the soil CO_2, and weathering process of silicate minerals, making it the strongest factor for water alkalinity.

The big variations of HCO_3^- values between the two rounds, can be explained by the recharging impact on diluting the parameter concentration, and leading its values tend to balance as in the wet round (May), and the opposite happened in the dry round (November), where all of tested samples showed exceeding the WHO limits (200 mg/l).

Based on the study's major goal, which evaluate the SWW effects mainly on groundwater; represented by springs of the study area, Chloride (Cl^-) is considered to be a good indicator groundwater contamination by sewages (Pacheco et.al., 2001). The study samples for the two rounds recorded acceptable values, which ranged between (24-64 mg/l) compared to WHO levels (2006), which is (250 mg/l) (Figures 4.11 and 4.12).

Furthermore, it is obvious that Al-Matwi spring had a relatively high Chloride concentration, because it is surrounded by the wastewater flow and fertilizer-amended farmlands, and the same found for Al-Mizrab spring, which is related to sewage-source pollution by surrounding cesspits of Der Ghassana village (Appendixes 3, 4).

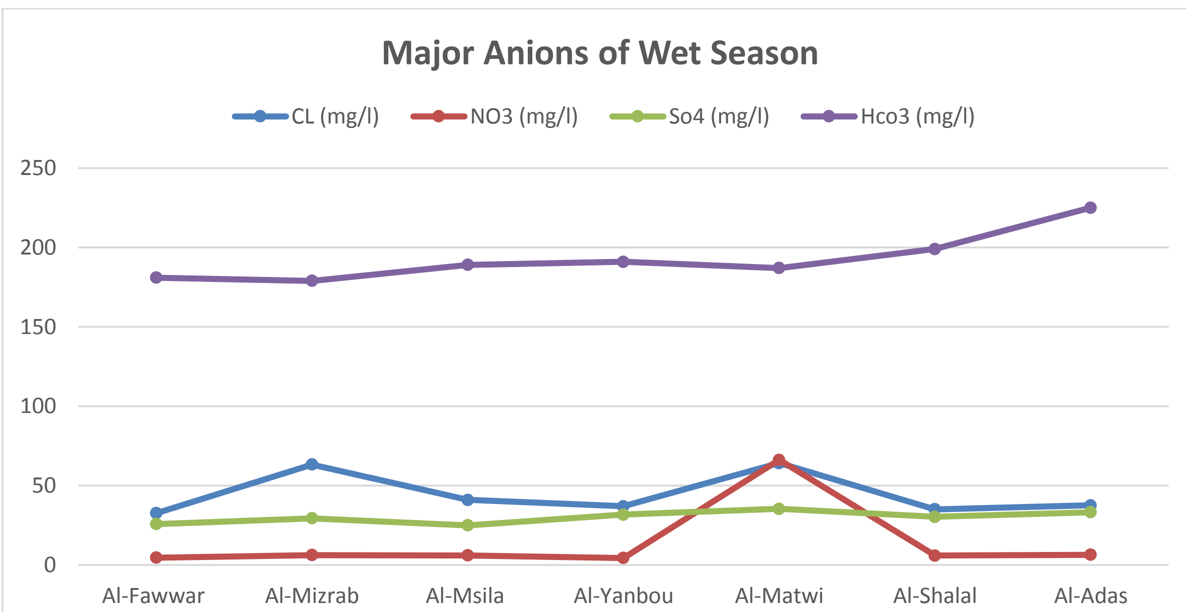

Figure 4.11 : The Major Anions Concentrations of Spring's Water of Sarida Catchment in the Wet Round (May)

Usually the groundwater contain low concentrations of Nitrate (NO_3^-) which is considered as a strong evidence for sewage pollution source (WHO, 2006). By examining (Figures 4.11 and 4.12) and looking at each NO_3^- value for all samples, we can notice that there are no abnormal values exceeding the WHO limits for spring's water which is 45 mg/l except

Al-Matwi spring in the wet round (May). It can be justified by the springs emerging formation lies within the effect of wastewater flow according to the layers slope in the study area.

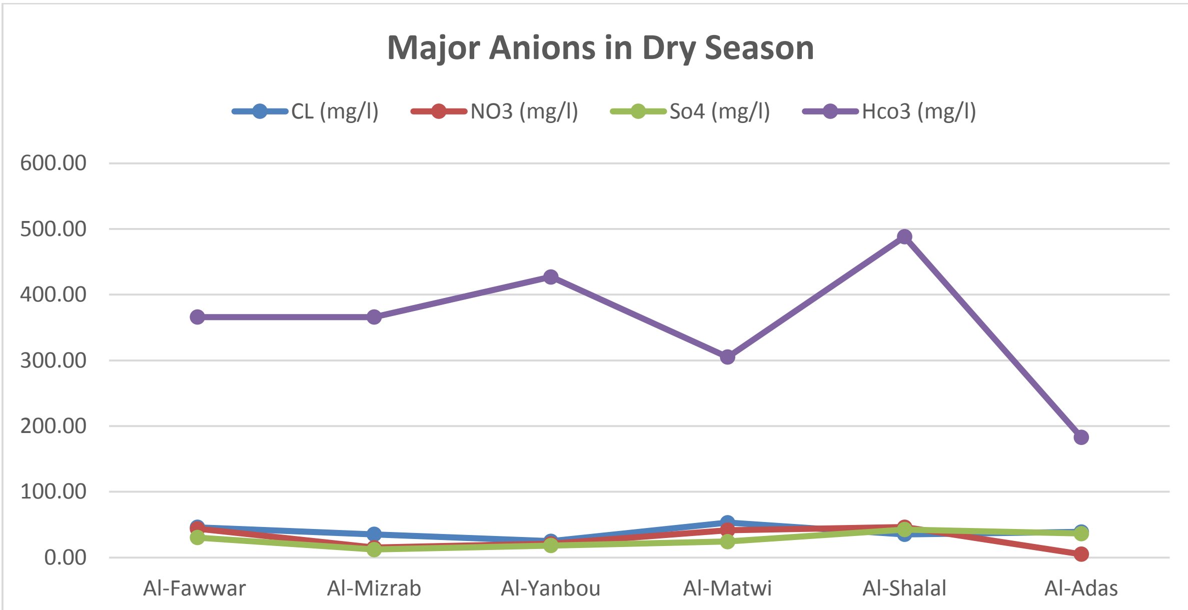

Figure 4.12 : The Major Anions Concentrations of Spring's Water of Sarida Catchment in the dry round (November)

The possibility of sulfate (SO_4^{-2}) existence in groundwater is more than any other water resources and must not exceed the 250 mg/l limit according to (WHO, 2006). The related figures showed no exceeded values and no significant variations between the two rounds which ranged between 12 mg/l and 42 mg/l with mean of 29 mg/l. A relatively slight increase in SO_4^{-2} concentration at Al-Shalal spring sample with 42 mg/l at the dry round (November) because of its closeness to the wastewater stream, a similar case and justification regarding Al-Matwi sample at the wet round (May) with 35 mg/l.

4.4.1.3 Microbiological Analysis

In this study two microbial parameters were measured which are: Total Coliforms (TC) and Fecal Coliforms (FC). Consequently, the routine tests for the water samples showed a significant variation for the two parameters between the two rounds. The wet round (May) samples recorded high contamination levels according to (Figure 4.13), and lower levels for the dry round (November). From the WHO guidelines which determined the TC and

FC limits to zero, all analyzed samples revealed sewage contamination source particularly in Al-Shalal and Al-Mizrab springs (Appendixes 6, 7).

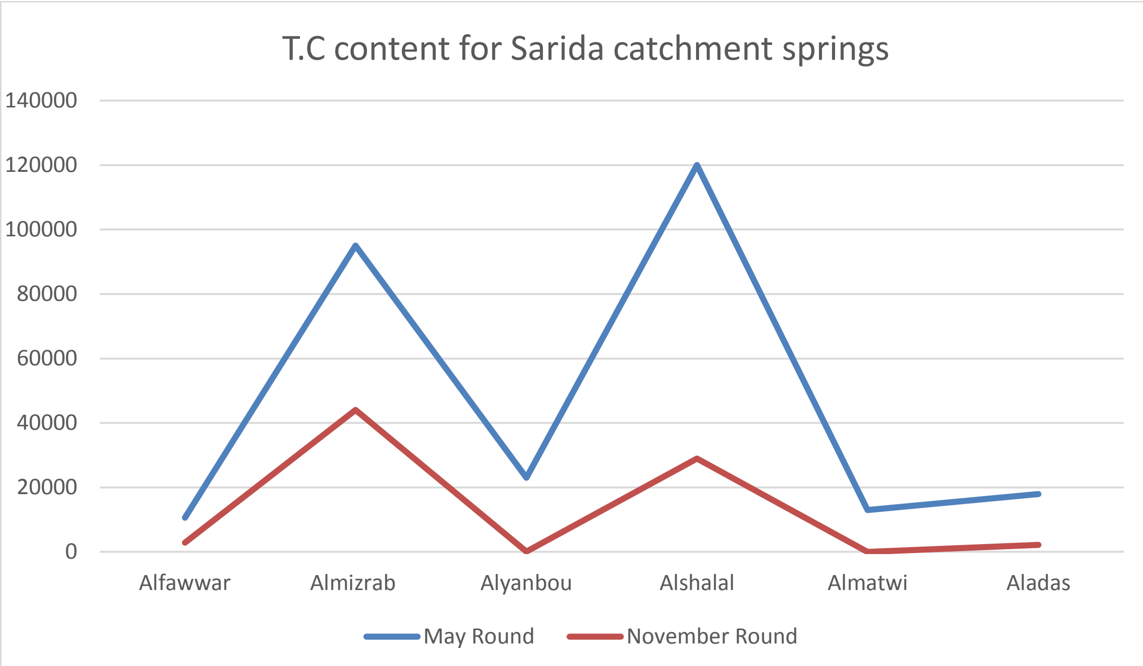

Figure 4.13 : Variations of Total Coliforms Content for springs of Sarida Catchment between May and November Rounds

For Al-Shalal spring, the reason for such significant contamination due to wastewater direct mixing with maximum of (120,000 cfu/100ml) for TC and (12,000 cfu/100ml) for FC, On the other hand, a lower contamination observed in Al-Mizrab but still high with (95,000 cfu/100ml) for TC and (34000 cfu/100ml) for FC and Justified by intensive presence of cesspits surrounding the spring (Figure 4.13 and Table 4.1).

Table 4.1 : Fecal Coliforms in (cfu/100ml) in Springs of Sarida Catchment at May and November Rounds

Rounds Names	Springs Names					
	Al-Fawwar	Al-Yanbou	Al-Shalal	Al-Matwi	Al-Mizrab	Al-Adas
May	1000	1300	12000	500	34000	1200
November	28	Nil	60	Nil	45	15

In addition to the previous analyzing for current situation, a microbial data was collected from the Palestinian Water Authority (PWA) about the water microbial quality situation in December of 2003 for Al-Matwi, Al-Fawwar, Al-Shalal and Aladas springs and compared them with the observed data in this study. the dry round (November) data is more suitable for such comparison because of its availability, however, a significant difference between the two sets of samples relating the TC and FC contents, which showed that the dry round (November) of 2013 is much more contaminated than December of 2003. A justification for such difference would be the increasingly wastewater discharges by Israeli and Palestinians communities during the last ten years, which affecting adversely the water quality (Figure 4.14 and 4.15).

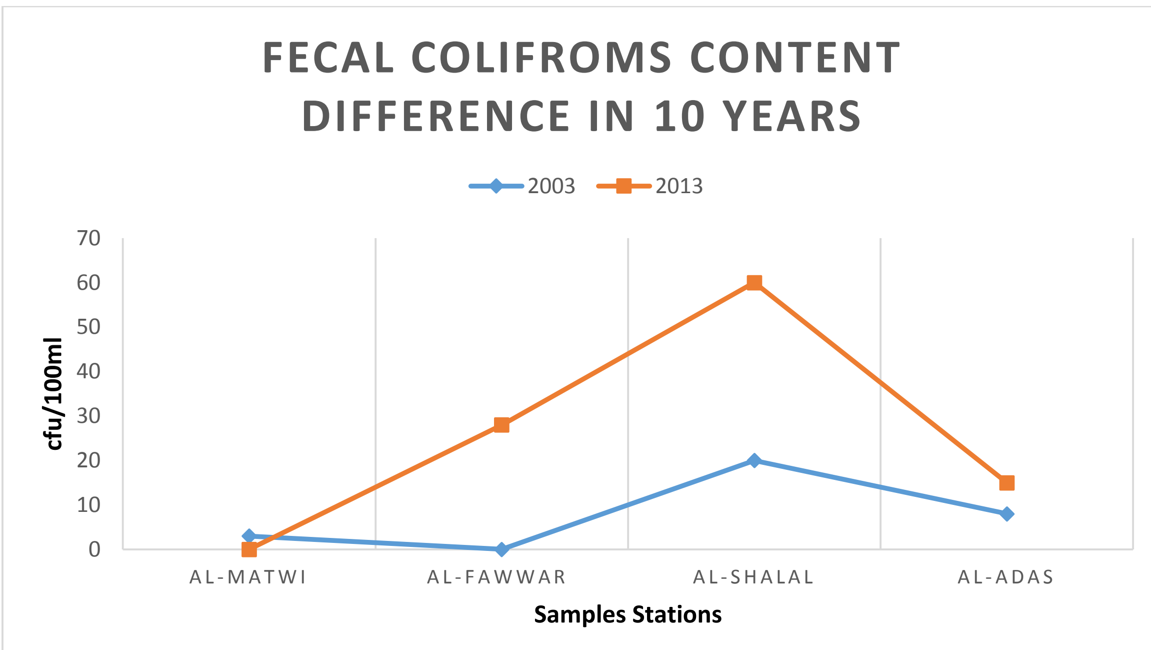

Figure 4.14 : The Fecal Coliforms Content in Some Springs of Sarida Catchment in November - 2013 and December - 2003 and the Quality Difference During Ten Years

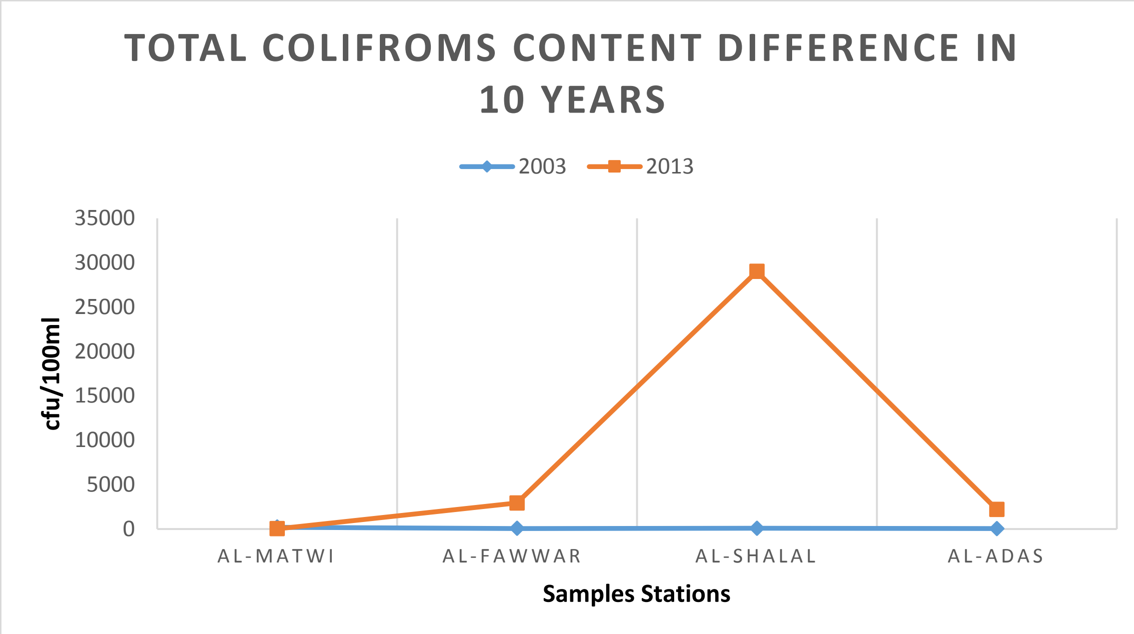

Figure 4.15 : The Total Coliforms Content in Some Springs of Sarida Catchment in November - 2013 and December - 2003 and the Quality Difference during Ten Years

This comparison confirmed a clear observation regarding the critical contamination levels of Al-Shalal spring in all samples of all analyzed rounds. This abnormal values can be explained only by the existence of the spring in the wastewater path, which in turn, contact the spring water directly (Appendix 12). And additional results of microbial analysis are in appendixes (Appendix 13)

4.4.1.4 Trace Elements

Heavy metals have stiff resistance for degradation in nature, thus are classified as a persistent (Arnason and Fletcher, 2003). Each element has certain effects on public health which are depending on its dose, bio-availability, and chemical composition. The occurrence of trace elements in groundwater can be attributed to natural sources dissolution of minerals that contain traces in the aquifer and soil or to mankind activities such as industrial sewage and heavy industries wastes etc., nevertheless, these traces naturally exist in low concentrations.

The identification of health hazards of several heavy metals on animals had been confirmed, for example, the sequential accumulation of these traces in different organisms' bodies through the food chains may lead to Physiologic diseases and cancers. The healthy catastrophe regarded to Bangladesh arsenic-pollution of groundwater that has been occurred is an obvious example for critical impacts of hazardous trace elements concentrations.

Depending on the WHO (2007) guidelines for trace elements concentrations limits for drinking water which are listed in the attached (Table 4.2), it can be noticed that there are no exceeding value for all the measured elements in Sarida springs which indicate that there is no significant heavy metal-source contamination influencing the groundwater of Sarida catchment such as industrial wastes involving in Sarida Wadi.

Table 4.2 : Comparison between the Observed Values of Trace Elements with WHO 2007 Guidelines at the dry round (November)

Parameter	Average Conc. (ppb)	WHO 2007 Guidelines	Exceeding Limits	Parameter	Average Conc. (ppb)	WHO 2007 Guidelines	Exceeding Limits
Fe	45.42	500	Not exceeded	Pb	0.35	10	Not exceeded
Co	0.22	50	Not exceeded	Be	0.01	4	Not exceeded
Ni	3.53	20	Not exceeded	B	74.83	1000	Not exceeded
Cu	0.86	1000	Not exceeded	As	0.17	50	Not exceeded
Zn	6.89	3000	Not exceeded	Se	0.40	50	Not exceeded
Cd	0.00	3	Not exceeded	Ba	18.79	1000	Not exceeded
Mn	4.48	100	Not exceeded	Tl	0.02	2	Not exceeded
Al	50.15	200	Not exceeded	Cr	5.50	50	Not exceeded

Despite the absence of any exceeded value for measured heavy metals which are seventeen different element (Fe^{+2}, Cd^{+2}, Pb^{+2}, Zn^{+2}, Mn^{+2}, B, As^{+2}, Be, Tl, Cr, Al, V, Co, Cu, Ni, Se), Figures 4.16 and 4.17 show that there are some abnormal elements recorded a various values from rest of elements. One of these traces is Nickel (Ni) in Al-Fawwar and Al-Shalal springs where two times of Ni concentrations existed compared with other springs, one reason for such increase may be presence of sewage wastewater nearby the springs (Sujatha et al,. 2001). Moreover, Al-Mizrab spring showed a similar Ni values which has been exposed to wastewater infiltrated by the nearby cesspits and polluting the groundwater where this spring originate. Boron (B) comes to confirm this analysis which recorded a significantly and relatively higher concentration in Al-Fawwar compared with other springs caused by the heavy use of fertilizers and sewage-related irrigation.

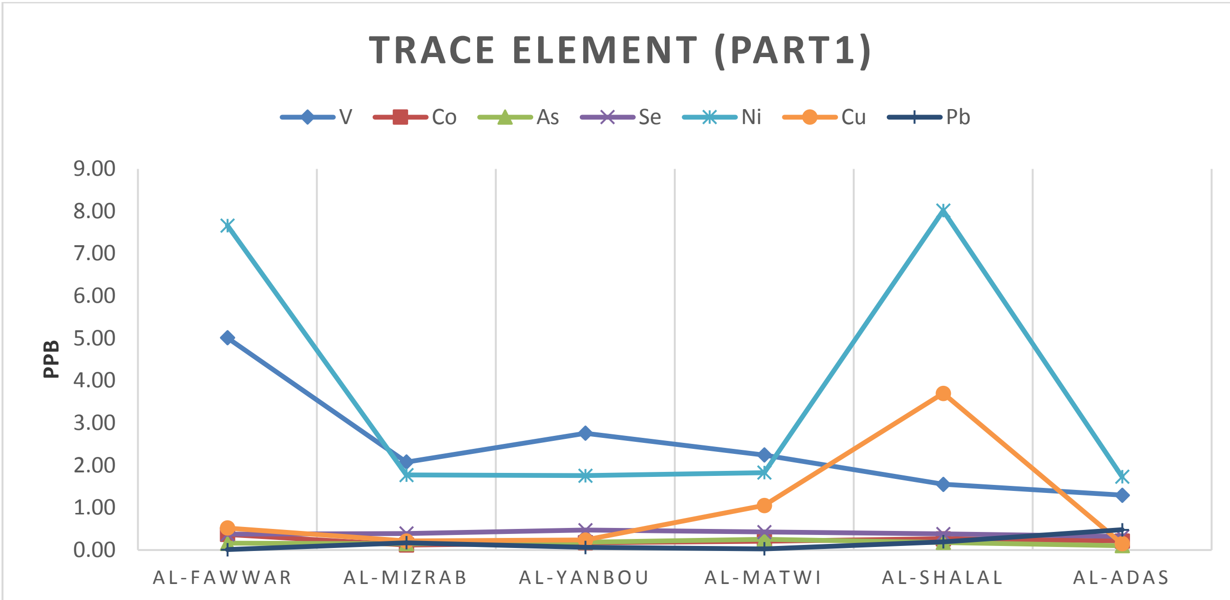

Figure 4.16 : Trace Elements (V, Co, As, Se, Ni, Cu and Pb) Concentrations in Springs water of Sarida Catchment

Al-Fawwar got the lion's share of contamination by heavy elements among the springs of Sarida catchment, in addition to above traces, (Figure 4.17) shows that this spring has several times concentration of Chromium (Cr) compared with the rest. Although Chromium present naturally in water from the erosion of chromium deposits found in rocks and soils, pesticides and insecticides containing chromium used in agricultural activities can influence Cr levels of surrounding groundwater by infiltration process in the case of Al-Fawwar spring water. In addition to the above, the same trend of Cr happened to Vanadium (V) levels in the spring which prove man's activity negative effects represented by urban sewage sludge, and certain fertilizers,in the region (Byerrum et al. 1974).

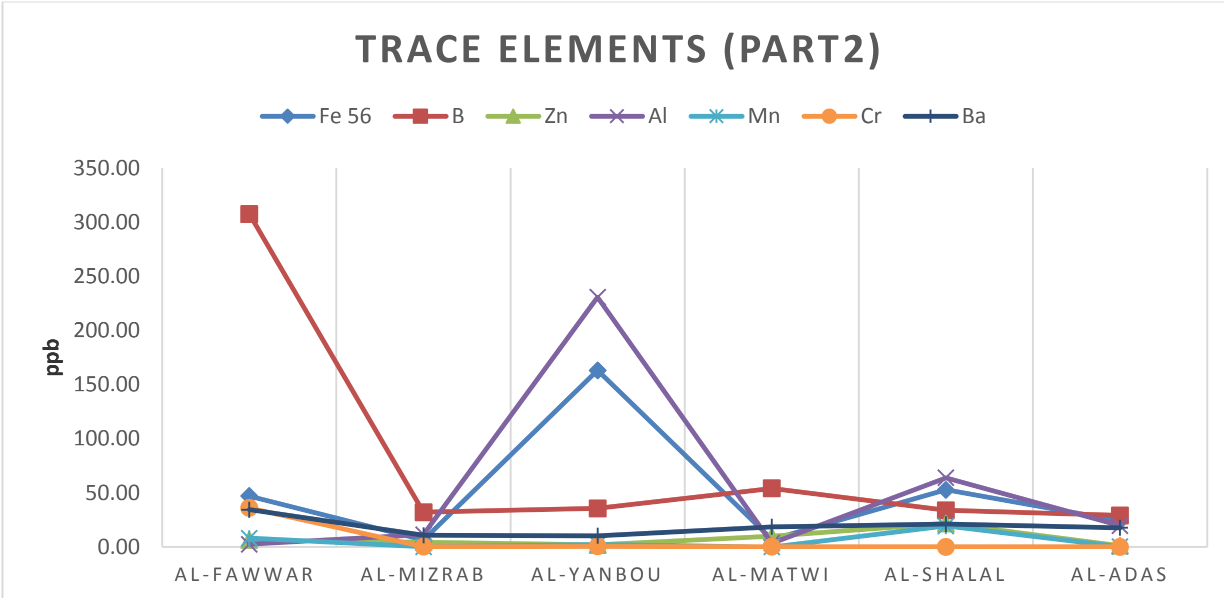

Figure 4.17 : Trace Elements (Fe, B, Zn, Al, Mn, Cr, and Ba) Concentrations in Springs of Sarida Catchment

The last observation that deserve mentioning is: according to (Figure 4.17) is Al-Yanbou spring containment of Aluminum (Al^{+3}) and Iron (Fe^{+2}) which is relatively higher levels than the other springs, because (Al^{+3}) and (Fe^{+2}) may originated by its natural sources which are the rocks and clays such as bauxite forming the aquifer by dissolution process (Appendixes 10, 11).

4.4.2 Water Origin and Classification

4.4.2.1 Piper Diagram

Major cations (Na+1, K+1, Ca+2 and Mg+2) and major anions (Cl-, HCO3- and SO4-2) are represented in the Piper trilinear plots which is an analyzing tool for evaluating water samples with regard to their hydrochemical type and hydrological interrelations. In this case, a windows software called Aquachem (2011, 1) was used for plotting the chemical results of Sarida catchment springs and resulted that the springs water samples are plotted using Piper diagram and all samples are falling in the earth alkaline water with prevailing bicarbonate in the two rounds (Figure 4.18).

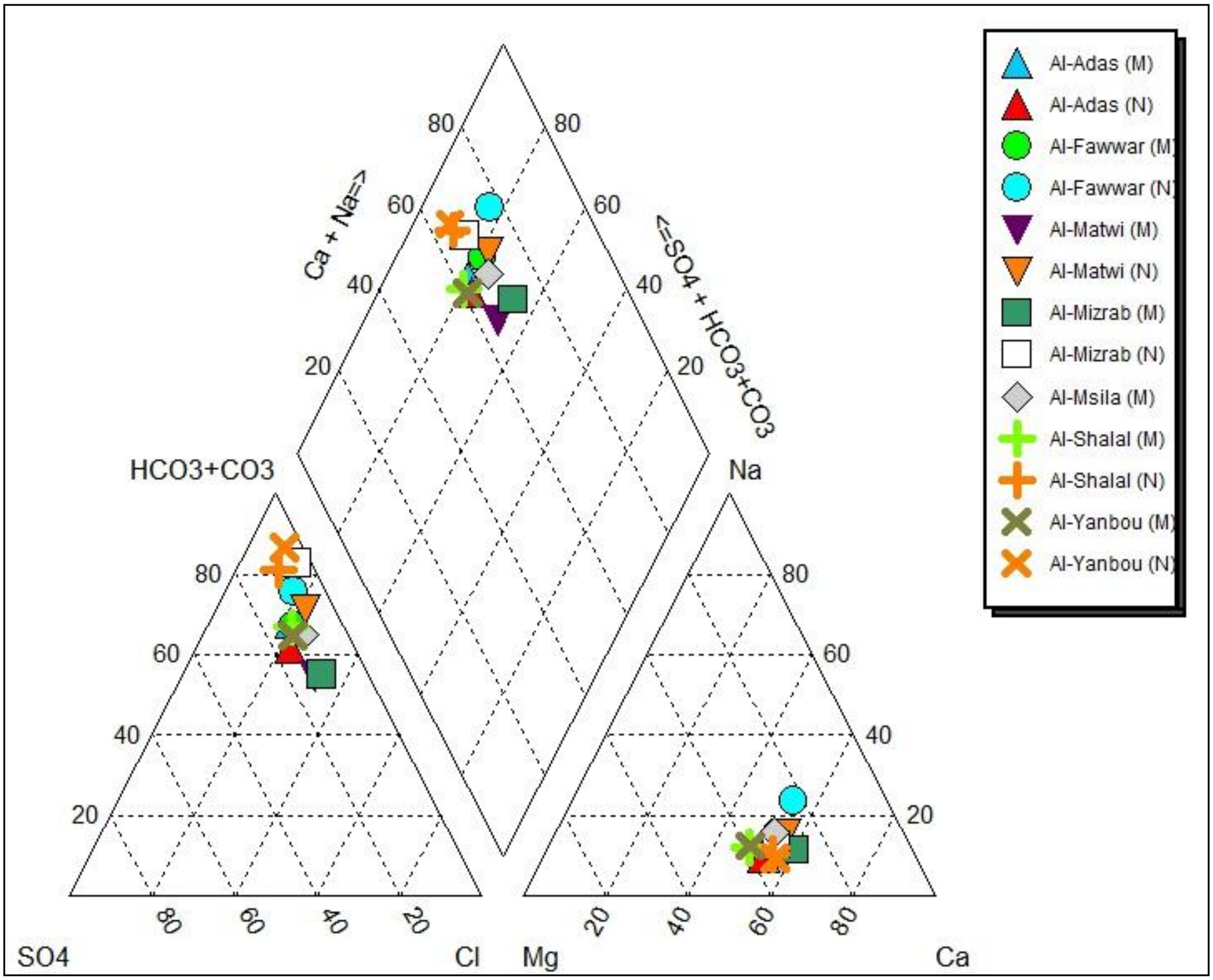

Figure 4.18 : Piper Trilinear Plot for Springs of Sarida catchment for May and November Rounds Combined

4.4.2.2 Water Type

The spring water samples are plotted using Durov diagram and 92% of all samples are falling in the domain of Ca – Mg – HCO_3, which frequently recharging water in limestone and dolomite aquifers. 8% of the measured samples showed the water type Ca-Na-Mg-HCO_3 which is represented by Al-Fawwar spring water in the dry round (November). This abnormal Na containing in water type may justified by using of Na-contained fertilizers in surrounding the spring and infiltrating to the groundwater (Figure 4.19).

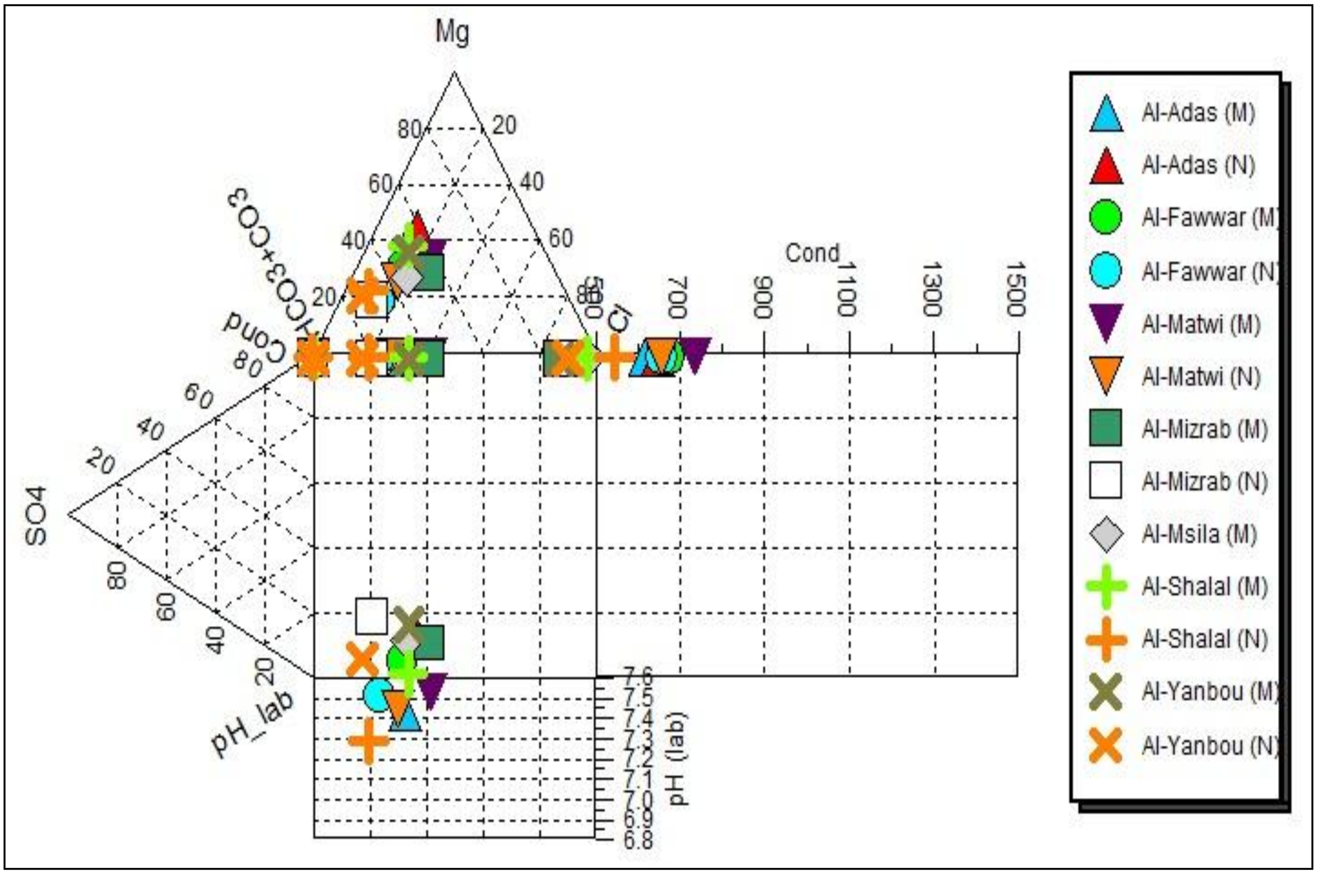

Figure 4.19 : The Durov Diagram for Measured Spring's Water Samples of Sarida Catchment in May and November Rounds Combined

4.4.3 **Spring Water Quality for Different Purposes**

4.4.3.1 EC

Choosing the proper growing crops or trees in the agricultural activities relating to conductivity of irrigation water depending on a certain classification that conducted by Todd (2007) which is one of the most popular in the field. By plotting the EC (μS /cm) values for both rounds springs water in Todd classification table (Table 4.3), the results showed that all springs are suitable to irrigate all kinds of Fruit, Vegetable and Field crops because they presented in the first row of classification which is (Low Salt Tolerance crops) and contain lemon, strawberry, green beans, field beans as well as others (Table 4.3).

Table 4.3 : Classification of Todd (2007) for the Tolerance of Different Types of Crops by Using Conductivity Values

Crop Division	Low Salt Tolerance crops EC (µS /cm)	Medium Salt Tolerance crops EC (µS /cm)	High Salt Tolerance crops. EC (µS /cm)
Fruit Crops	0 - 3000 Limon, Strawberry, Peach Apricot, Almond, Plum Orange, Apple, Pear	3000 - 4000 Cantaloupe, Olive, Figs, Pomegranate	4000 - 10,000 Date palm
Vegetable Crops	3000 – 4000 Green beans, Celery, Radish	4000 - 10,000 Cucumber, Peas, Onion Carrot, Potatoes, Sweet Corn, Lettuce, Cauliflower, Bell pepper, Cabbage, Broccoli, Tomato	10000 - 120,000 Spinach, Garden beets
Field Crops	4000 – 6000 Field beans	6000 - 10,000 Sunflower, Corn (field) ,Rice, Wheat	10,000 - 16,000 Cotton, Sugar beet.

4.4.3.2 Salinity

All the samples were plotted in the Wilcox diagram which is describing the relationship between SAR and Conductivity. The classification of Wilcox diagram is divided into four salinity hazard columns in vertical (C1-C4) and four Sodium hazard sections horizontally (S1-S4) (Figure 4.20). The results of Wilcox analyzing put all the samples in medium salinity (C2) and low sodium (S1) in the two rounds, this zone indicate it’s suitability for agriculture (Wilcox, 1955).

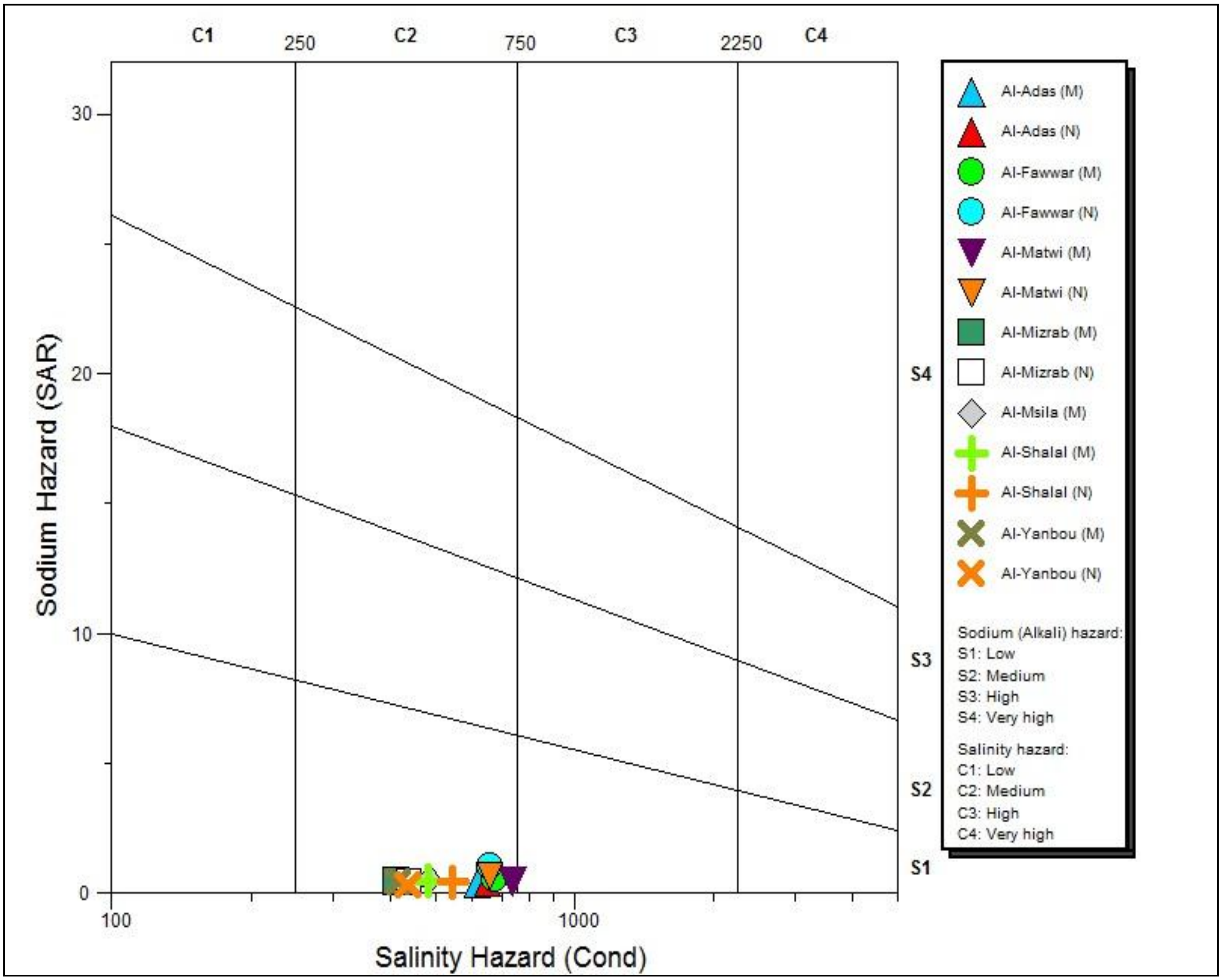

Figure 4.20 : Wilcox diagram showing the correlation between SAR and Conductivity For the measured springs in Sarida catchment in May and November round

4.4.3.3 SAR

In order to judge the quality of water resources for irrigation, we need some indicators that show the suitability of water quality. One of the most popular indicators is Sodium Adsorption Ratio (SAR) which is evaluating based on the water content of Na^{+}, Ca^{+2} and Mg^{+2} by applying a special equation (Table 4.4).

$$S.A.R = \frac{Na^+}{\sqrt{\frac{1}{2}(Ca^{2+} + Mg^{2+})}}$$

Table 4.4 : The average concentrations of Na^+, Ca^{+2}, Mg^{+2} and SAR values for the projected springs

Spring Name	Na^+		Ca^{+2}		Mg^{+2}		SAR
	(mg/l)	meq/l	(mg/l)	meq/l	(mg/l)	meq/l	
Al-Fawwar	19.2	0.83	58.6	2.93	20.1	1.67	0.45
Al-Msila	18.1	0.79	53	2.65	19	1.58	0.54
Al-Yanbou	17.3	0.75	59	2.95	28.3	2.36	0.46
Al-Shalal	18.8	0.82	66	3.3	32	2.66	0.47
Al-Matwi	17.9	0.78	76.2	3.81	29.7	2.47	0.44
Al-Mizrab	17.1	0.74	78.2	3.91	22.4	1.86	0.43
Al-Adas	16.1	0.7	80.3	4.01	33	2.75	0.38

Depending on the previous equation, the calculated SAR value for each spring sample was plotted in a certain table that classify it's suitability for irrigation according to SAR. This classification is relating to USDA (1954) who classify the SAR into four ranges (Table 4.5).

Table 4.5 : Classification of water for irrigation Suitability based on SAR (USDA, 1954)

SAR value	Irrigation Suitability
<10	Excellent
10-18	Good
18-26	Fair
>26	Poor

By applying the required parameters of all spring's samples to SAR equation, the results showed that all water springs in both rounds situated in Excellent class for irrigation suitability which had SAR values below ten referring to the relatively low salinity effects on the studied area.

Chapter Five

Wastewater Effects on Socio-Economic Aspects

5.1 Introduction

This chapter presents an analysis for the socio-economic effects of wastewater in the study area, to achieve this purpose the research based on a field survey by which a questionnaire prepared and filled by a random sample of the study area residents.

5.2 Questionnaire Main Components

The questionnaire questions have been classified according to four main components, affected by wastewater within the study area, which could be listed as follows:

- The effects of wastewater on livestock and agricultural production (economic)
- The effects of wastewater on natural and aesthetic wealth (environmental).
- The effects of wastewater on socio-health aspects (social and health).
- The effects of wastewater on used nearby water springs.

5.3 Results and Discussions

This part of the chapter clarifies the analysis of the questionnaire results, divided into four sections: General, health, socio-economic and the environmental sections.

5.3.1 The General Section

- **Geographical Distribution**

The total number of questionnaires divided equally among the two agglomeration, so that each has approximately equal number of questionnaires, which could guarantee homogeneous covered area (Table 5.1).

Table 5.1 : Geographical Distribution of Respondents

Community	No. of Questionnaires	Percentage (%)
Bruqin	25	50.0
Kafr AL-Dik	25	50.0
Total	50	100.0

- **Age Structure**

Regarding the distribution of the respondents across age categories, the results varied between the two communities. In Bruqin, the sample captured respondents from all age groups, while in Kafr Al-Dik the majority were older than 36 years old, the distribution of age groups is presented in (Figure 5.1).

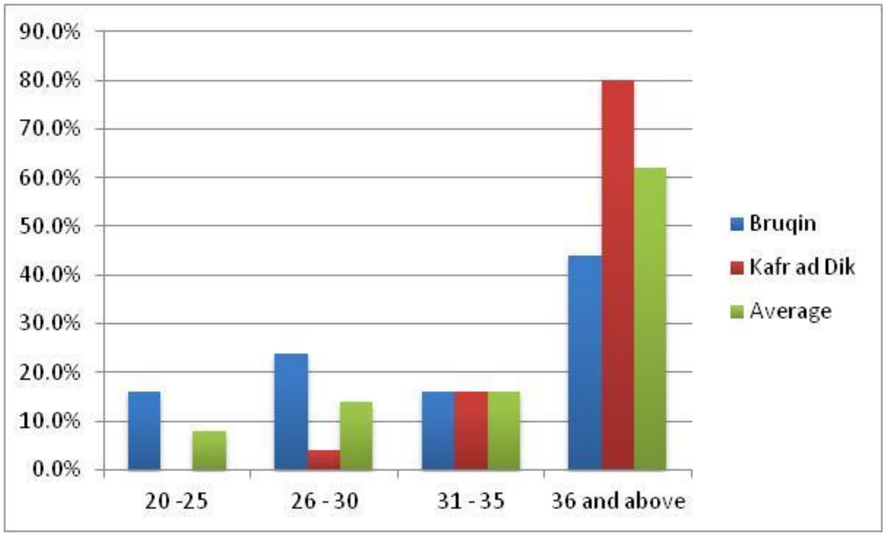

Figure 5.1: Distribution of Age Categories

- **Gender Composition**

Although Palestinian women play an important role in the management of their household water resources, only 30% of the respondents were females (Figure 5.2).

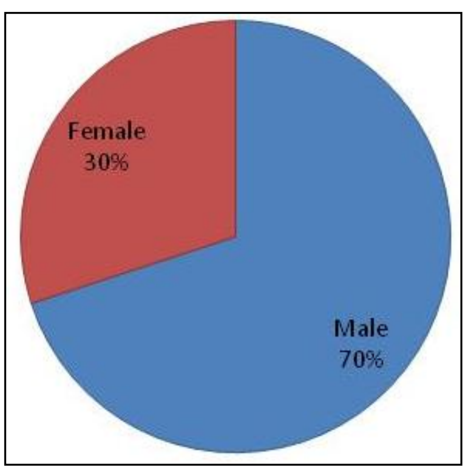

Figure 5.2 : Gender Distribution of the Respondents

- **Academic Achievements**

Educational levels were classified to three levels; Primary, secondary and University - college levels. Comparing the felid survey samples results to this classification shows that 44% of Bruqin village sample get a university - college Degrees, compared to 25% from Kafr Al-Dik Sample, whereas 50% of Kafr Al-Dik sample had a secondary school education (Figure 5.3).

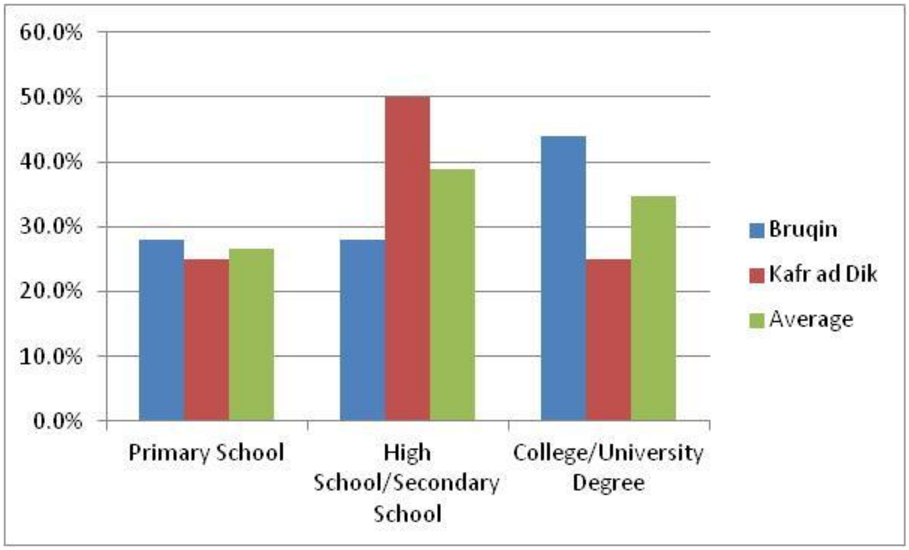

Figure 5.3 : Academic Achievements of the Respondents

- **Occupation Type**

(Table 5.2 and Figure 5.4) clearly indicate that a large proportion of the population (about 68%) do not have fixed jobs. Comparatively, 32 percent of the overall sample are employed by the governmental or the private sectors.

Table 5.2 : Occupation of the Respondents

Community	Occupation				Total
	Governmental sector Employee	private sector Employee	Skilled work	Other	
Bruqin	24.0%	12.0%	40.0%	24.0%	100.0%
Kafr Al-Dik	28.0%	4.0%	36.0%	32.0%	100.0%
Average	26.0%	8.0%	38.0%	28.0%	100.0%

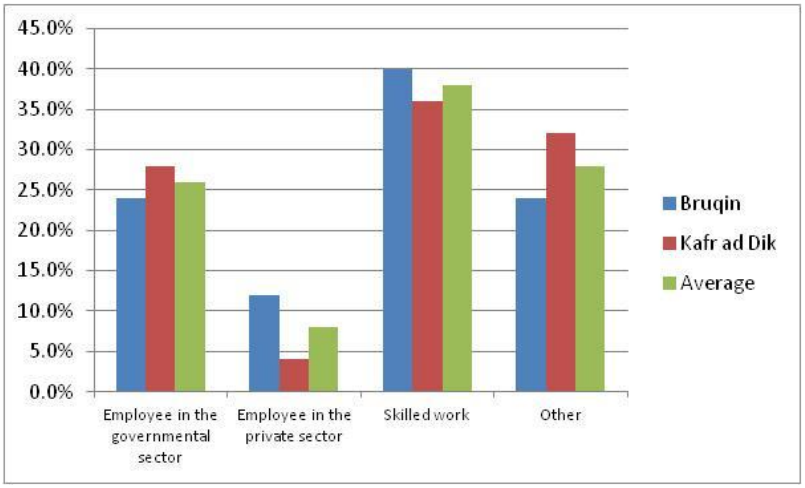

Figure 5.4 : Occupation of the Respondents

5.3.2 Health Section

The majority of the respondents in both communities believe that raw wastewater has negative influences on public health. More than half of the respondents from Bruqin village reported having been infected by a waterborne/sanitation disease as a result, while 33 percent reported the same in Kafr Al-Dik. Most common health implications mentioned include skin infections, Leishmania, Amoeba and Respiratory problems (Figure 5.5).

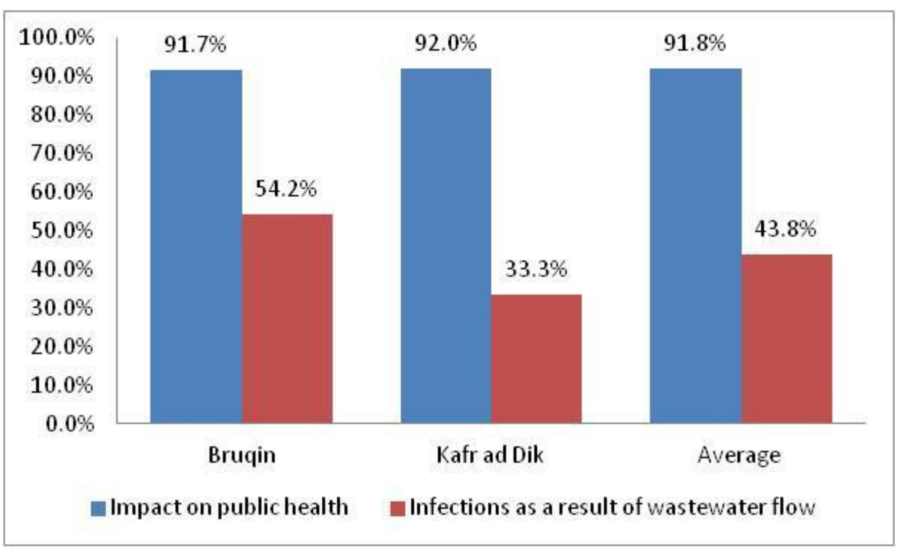

Figure 5.5 : Public Health Impact of Sarida Wadi Flow and Infections Proportions of Raw Wastewater Flow

In terms of public awareness, the questioner clarifies that much male respondents believe that the wastewater has a negative impact on public health (Table 5.3).

Table 5.3 : Gender Perceptions on Negative Impact of Wastewater Flow

Community	Impact on Public Health	Diseases as a Result of Wastewater Flow
Male	94.1%	51.5%
Female	86.7%	26.7%
Average	91.8%	43.8%

5.3.3 Socio-Economic Section

- **Land Ownerships and Cultivated Lands Proportions**

(Figure 5.6) shows that about 80% of the research sample, own land parcels adjacent to the wastewater flow channel in Sarida Wadi. The average area of land owned by the respondents adjacent to Wadi Sarida is 21 Dunums (ranging between 1 to 205 Dunums), and 8 Dunums (ranging between 1 to 30 Dunums) in Bruqin and Kafr Al-Dik respectively.

A very high percentage of the respondents of the study area used to cultivate their lands in the past. However, they prevented from agricultural activities concurrently due to Israeli practices against local people, represented by land confiscation, (About 40% of the respondents reported owning land that has been confiscated by the Israeli Authorities), Wastewater pollution, as well as other unfair practices.

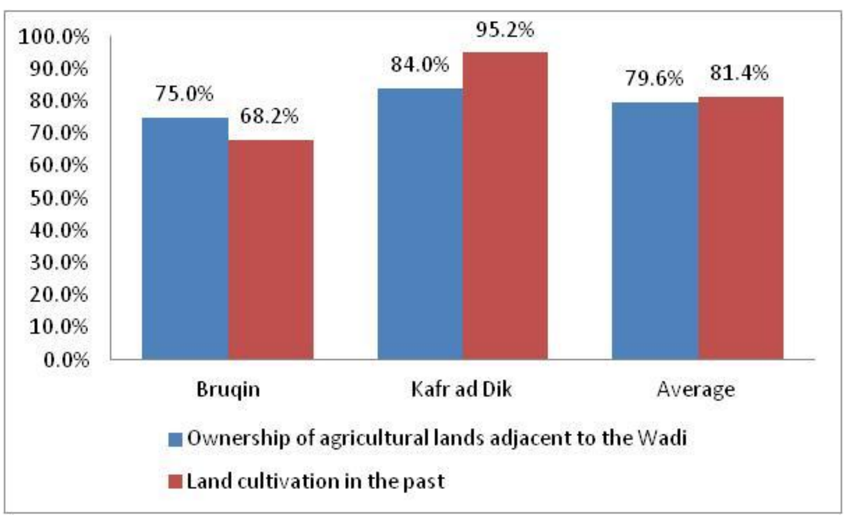

Figure 5.6 : Represents the Proportions of the Cultivated Land Areas and the Land Ownership Adjacent to Sarida Wadi

- **Land Production and Soil Quality**

Almost 80 percent of the respondents reported the decrease of their land production rates because of the spread of Plant Pathology, resulting by wastewater flow in the region. Moreover, 48 percent said that they had abandoned their land cultivation as a result of the negative impacts of the wastewater flow. Furthermore, 68 % of the sample agreed that wastewater impact on the soil, make it unsuitable for cultivation, it may justified by contaminated by heavy metals or pathogens (Figure 5.7).

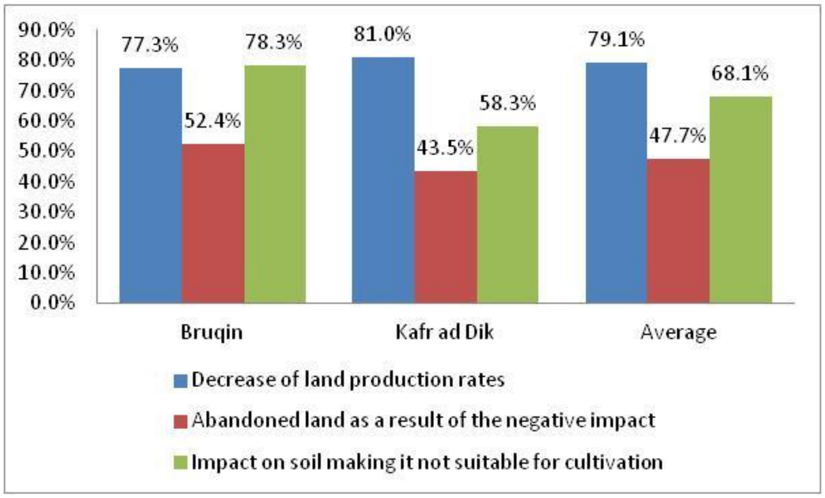

Figure 5.7 : Impact of Sarida Wadi Flow on Land Producion and Activities

- **Agricultural and Livestock Production**

(Table 5.4) clarifies the extent of the Wadi's flow impact of agricultural production rates and livestock on the study area. The results varied between the two agglomerations, with a clear negative effects on Bruqin lands because of the village location near the Wadi’s flow.

Table 5.4 : Extent of Impact of Sarida Wasdi Flow on Agricultural and Livesock Activities

Community	Extent of Impact of Agricultural Production Rates and Livestock in the Area			Total
	Decrease by a 0 - 50% rate	Decrease by a 50 to 95% rate	The land has been abandoned	
Bruqin	36.0%	28.0%	36.0%	100.0%
Kafr ad Dik	41.7%	45.8%	12.5%	100.0%
Average	38.8%	36.7%	24.5%	100.0%

- **Impact on the Social Dimension of the Region**

The social dimension has been measured by the quality life in the dwellings near the Wadi. In Bruqin, most of the sample currently live within Wadi Sarida region, comparatively 28 percent of Kafr Al-Dik sample are living near the Wadi (Figure 5.8). (Figure 5.9) shows that the majority of the research sample have negatively affected directly or indirectly by the wastewater, such as bad odors. However, about 18% of the respondents have decided to change their dwellings locations to avoid negative impacts of the Wadi and this might refer to two reasons; the first is to stay near their lands, and the other is to avoid the costs of new residential units.

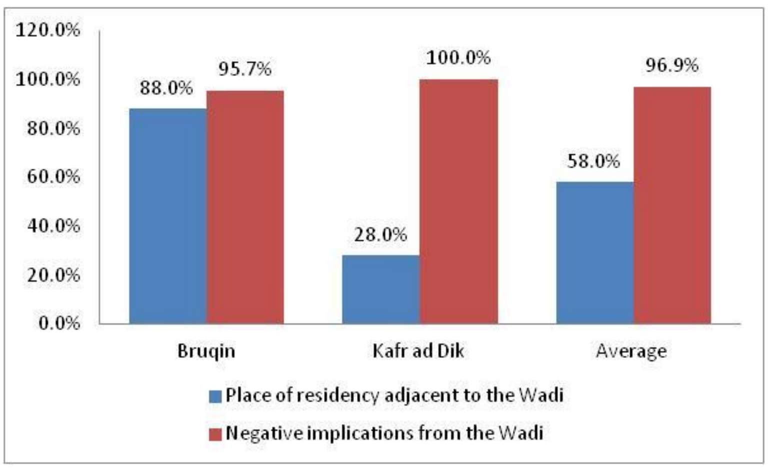

Figure 5.8 : Impact of Sarida Wadi Flow on Residency Quality

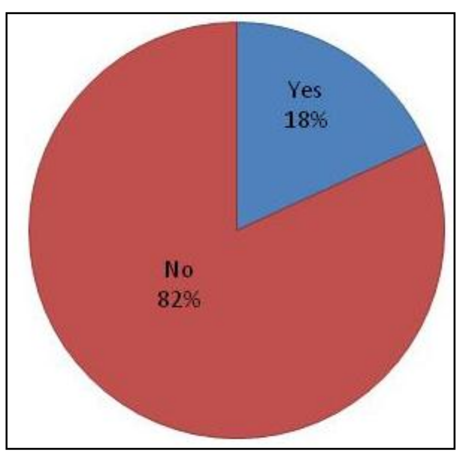

Figure 5.9 : Impact of Sarida Wadi Flow on Place of Residence

- **Impact on the Use of Water Resources and it's Purposes**

Around 38 percent of the respondents use the springs in the area basically for agricultural purposes including irrigation and for livestock. Most of the respondents do not use the water of near springs due to the bad water quality, especially for domestic uses (Figures 5.10 and 5.11).

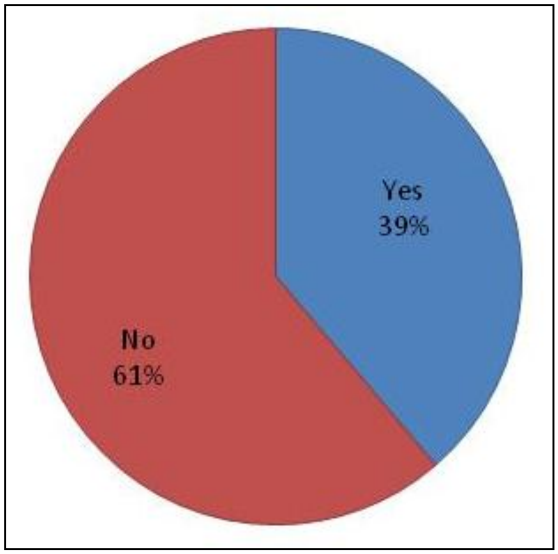

Figure 5.10 : Use of Springs in the Study Area

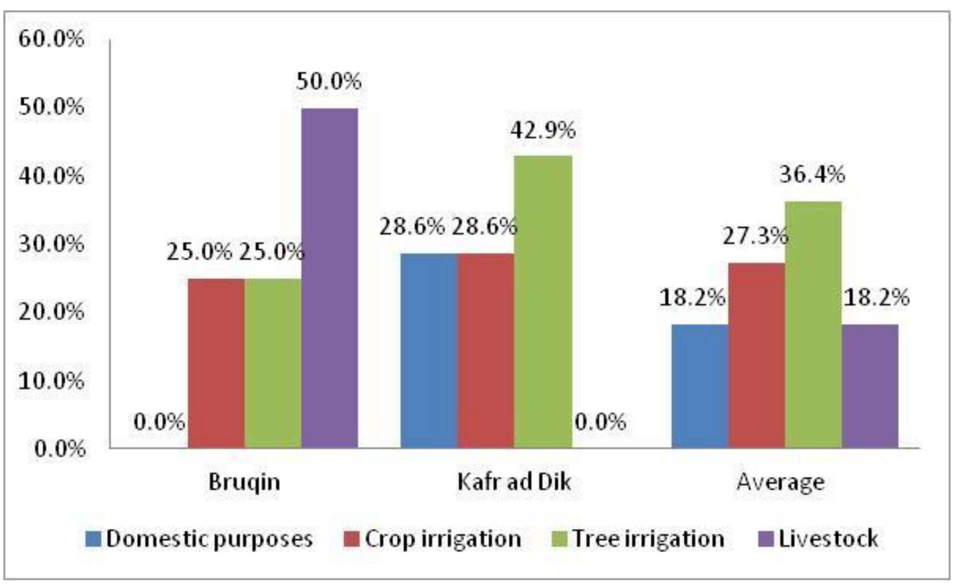

Figure 5.11 : Purpose of Springs Water Use

5.3.4 The Environmental Section

The majority of the respondents in the communities believe that the raw wastewater has negative impacts on the aesthetic conditions of the surrounding environment (Table 5.5).

Table 5.5 : Impact of Sarida Wadi Flow on Aesthetic Condition

Community	**Impact on the Aesthetic Conditions of the Study Area**		**Total**
	Yes	**No**	
Bruqin	80.0%	20.0%	100.0%
Kafr Al-Dik	92.0%	8.0%	100.0%
Average	86.0%	14.0%	100.0%

With regard to the wildlife including animals and plants, the majority of the respondents also believe that the wastewater has negative impact on both the wild mammals, birds, insects and the wildlife in the area. Many of the respondents noticed the decrease in wild animals that used to be common to the area including birds such as the European Goldfinch and Dears, while other animals such as wild hogs increased (Table 5.6).

Table 5.6 : Impact of Sarida Wadi Flow on Wildlife

Community	**Impact on the Wildlife**
Bruqin	80.0%
Kafr Al-Dik	87.0%
Average	83.3%

Chapter Six

Conclusion and Recommendations

6.1 Conclusions

The research showed that the main source of the raw wastewater flowing in Sarida Wadi is the Israeli side where Ara'el colony is discharging the wastewater with large quantities up to 1.3 MCM/year, which is considered as a real threat to all walks of life in Sarida catchment. However, Kafr Al-Dik village is less susceptible to the adverse effects of the discharged raw wastewater due to its farther distance from the Wadi, while Bruqin village people are more suffering from these significant impacts as a result of the presence of the Wadi through an apart of the village itself.

An important negative result of the flow of the wastewater thorough the region is distortion of the aesthetic view of the local nature, which was a recreation area where people were spending their time on the banks of the Wadi enjoying the beauty of nature before discharging a huge amounts of raw wastewater into the Wadi's body and increasing the wastewater proportion against spring's water within the flow. The springs affected the wastewater quality along Sarida Wadi. In the wet season of the year, the completed recharging season leads to strengthen springs' flow rate, which in turn dilute the wastewater and decreasing most of pollutants concentrations. On the other hand, the dry season suffered from delayed rain season and a contrary effects of the wet round (May) happened.

Unexpectedly, some physical parameters such as pH were increasing whenever wastewater were going toward the end point station. This can be explained by the serious contribution of wastewater discharging by Bruqin and Kafr Al-Dik citizens who may increase in alkaline pollutants, thus, increase the pH. In addition, a compatible trend for EC and TDS changing through the Sarida Wadi wastewater because of the strong correlation that connect them together.

With regard to springs' waster analyzing, TDS levels for the sampled sprigs of Sarida Catchment are considered as fresh water and suitable for all kinds of irrigation activities.

Moreover, the measurement of Major Cations showed that the Ca^{+2} is playing a dominant role in all of samples which reflects the structure formation of the groundwater aquifer, which are dolomite and limestone. The relatively high concentrations of NO_3^-, Cl^-, Na^+ and K^+ in Al-Matwi and Al-Fawwar springs may be attributed to the intensive agricultural activities using fertilizers and pesticides that contain these elements surrounding the two springs.

The closeness in distance of the springs' locations to the wastewater flow is proportional to the microbial contamination content of TC and FC, Al-Shalal spring is a good example for that. Moreover, a microbial analysis of 2003 for some springs showed lower content of TC and FC than 2013 due to the significantly increase of wastewater discharging during time which is the main source of contamination.

It is noticeable that there are no exceeding values for all the measured elements in Sarida springs which indicate that there is no significant heavy metal-source contamination influencing the groundwater of Sarida catchment such as industrial wastes involving in Wadi wastewater or excessive using of pesticides of insecticides of agricultural activities containing heavy metals. 92% of all samples are falling in the domain of Ca-Mg-HCO_3, which frequently recharging water in limestone and dolomite aquifers. 8% of the measured samples showed the water type Ca-Na-Mg-HCO_3. On the other hand, using EC test, Wilcox and SAR equation for all springs showed a good and suitable water quality for different for agricultural activities such as irrigation.

A relatively large proportion of the two villages population have underground cesspits that have not impermeable layers, thus could lead for leaking the wastewater downwards the groundwater and pollute it. Moreover, there is a strong contribution of each villages Kafr Al-Dik and Bruqin in increasing the flow volume of the wastewater in the Wadi where people are discharging their cesspits.

According to people's evaluation and field interviews, ruining the soil quality is may due to the penetration of the wastewater flow towards the agricultural lands, and may play an important role in by increasing or decreasing the proper elements concentrations as like increasing the heavy metals concentrations in the soil, thus may influence directly and negatively the agricultural production either crops or trees. As result of the conducted socio-economic survey, The large wastewater flow that cross Bruqin and Kafr Al-Dik villages have adverse effects on health, socioeconomic and environment aspects. In addition, ruining the soil quality is due to the penetration of the wastewater flow towards the agricultural lands.

The spread of waterborne diseases and the diseases transmitted by mosquitoes such as leishmaniasis and rashes in Bruqin and to a lesser extent in Kafr Al-Dik because of its distance from the stream. As a result, there has been little desire for residents of the same area to buy the agricultural and animal products as like dairy products or crops, and have begun finding out another alternative source. All of this leaded to a significant economic losses.

In general, the analyzed results for many parameters such as chemical, physical and microbial as well as the socio-economic survey showed a strong correlation between the wastewater flow in the Wadi as pollution source and the quality of surrounding springs water in the drainage basin, in addition to the adverse impacts on life's aspects of study area population. As previously mentioned, these evidences fulfilled the developed hypothesis as well as the main and secondary goals of the study relating to the pollution sources and their effects on water quality and life's aspects in Sarida catchment.

6.2 Recommendations

Building on the main findings of this research which were extracted directly from the observations, the following key recommendations are proposed within namely outlined interventions according to some gaps that must be studied and some steps that could reduce the risk of the hazardous raw wastewater:

- Building up a proper wastewater treatment plant in order to mitigate the catastrophic effects of the wastewater in the Wadi's basin, as a result, this can help in applying the sustainable development concept and converting these negative effects of the wastewater into water reuse and other purposes.

- The municipalities of Kafr Al-Dik and Bruqin have to adopt a policy to control and manage empting the wastewater of the near villages into the Wadi.

- The Ministry of Health must work to ensure the safety of underground cesspits structure in the two mentioned villages to be impermeable through the development of specialized monitoring programs.

- The competent authorities should do the necessary health measures to reduce the diseases borne by mosquitos and waterborne diseases, by covering the open wastewater channels, indeed, it began to be covered by the competent authorities in Bruqin village. Pest control is also an effective way for such situation.

- The Multi-source pollution issue that affect groundwater must be taken into account in the future studies, such as the random waste dumps and it’s leachates in the study area.

- Rational use of fertilizers and pesticides containing pollutants and planning for frequently agricultural extension to regulate their uses with the correct concentrations.

- Further similar researches are required in order to study the industrial wastes of Burkan colony.

Sources and Bibliography

- Abdul Hameed M, Alobaidy, J, Al-Sameraiy ,M.A, Kadhem,A & Abdul Majeed,A. (2010). *Evaluation of Treated Municipal Wastewater Quality for Irrigation*. Environmental Research Center, University of Technology, Baghdad, Iraq.
- Abu Madi, M. (2004). *Incentive Systems For Wastewater Treatment And Reuse In Irrigated Agriculture In The Mena Region: Evidence From Jordan And Tunisia*. Delft, The Netherlands.
- Ahipathy, M.V, & Puttaiah, L.T. (2006). *Ecological Characteristics of Vrishabhavathy River in Bangalore*. India. Environ Geol, 49: 1217-1222.
- Al Daraowsheh, A. (2014). *Spatial quality of municipal wastewater flowing in wadi Al-Zomar and infiltrated through wadi bed*. Thesis research. Institute of Environmental and Water Studies, Birzeit University, Palestine.
- Al-Dabbagh, M. (2008). *Our land Palestine*. Volume 2.
- Al-Hammad, B, Abd El-Salam, M & Ibrahim, S. (2014), Q*uality of wastewater reuse in agricultural irrigation and its impact on public health.* Biology Department, College of Science and Humanity Studies, Salman bin Abdulaziz University, Al-Kharj, Saudi Arabia.
- Ali, M. (2009). *Relationship between the working efficiency of wastewater treatment plants and water management in Queiq River Basin* - Master Degree Thesis. Renewable Natural Resources and the Environment, College of Agricultural Engineering, Aleppo, Syria.
- Amous,B. (2014). *Nitrogen and heavy metal fluxes from cesspits in Palestine Beit Dajan and Beit Fourik as a case study*. Thesis research. Institute of Environmental and Water Studies, Birzeit University, Palestine.
- ANZECC [Australian and New Zealand Environment and Conservation Council] & ARMCANZ [Agriculture and Resource Management Council of Australia and New Zealand]. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. *National Water Management Strategy*. Paper No.4.
- ARIJ [Applied Research Institute – Jerusalem]. (1998). *Monitoring Israeli Colonization Activity in the Palestinian Territories, Assessment of the environmental impact of Jewish industries in the West Bank*. Bethlehem, Palestine.
- ARIJ [Applied Research Institute – Jerusalem]. (1999). *Environmental Protection Of The Shared Israeli-Palestinian West Bank / Mountain Aquifer*. Bethlehem, Palestine.
- ARIJ [Applied Research Institute – Jerusalem]. (2007) .*Israeli Violations against the Palestinian Environment*. Bethlehem, Palestine.
- ARIJ [Applied Research Institute – Jerusalem]. (2008). *Current environmental situation in Salfit Governorate*.

- ARIJ [Applied Research Institute – Jerusalem]. (2010). Biodiversity and agriculture Department (BARU) , Bethlehem, Palestine.
- ARIJ [Applied Research Institute – Jerusalem]. (2011). *The Status of Environment in the oPt – A Human Rights Based Approach*. Bethlehem, Palestine.
- ARIJ [Applied Research Institute – Jerusalem]. (2012). Bruqin *Village Profile*. Bethlehem, Palestine.
- Arnason ,G & Fletcher, B. (2003). *A 40+Year Record of Cd, Hg, Pb, and U Deposition in Sediments of Patroon Reservoir, Albany Country, NY, USA*. Environmental Pollution, Vol. 123, No. 3, pp. 383-391.
- Bartram, J. & Ballance, R. (1996). *Water Quality Monitoring. A Practical Guide to the Design and Implementation of Fresh Water Quality Studies and Monitoring Programs*. UNEP/WHO. Chapman & Ha11, P.383.
- Beata, F, Dejan, K, Božo, D, Jelena, M, Vesna, P, Marijana ,K & Nataša, V. (2013). *Impact of wastewater from pig farm lagoons on the quality of local groundwater*. University of Novi Sad Faculty of Sciences, Trg Dositeja Obradovića 3, 21000 Novi Sad, Serbia.
- Byerrum, R.U., Eckardt, R.E., Hopkins, L.L., Libsch, J.F., Rostoker, W., Zenz, C., Gordon, W. A., Mountain, J.T., Hicks, S.P., Boaz, T.D., 1974. Vanadium: National Academy of Sciences, vol. 18, pp. l–117. Washington, D.C
- Birame, C. (2012). *Development of a low-cost alternative for metal removal from textile wastewater*. Wageningen University and the Academic Board of the UNESCO-IHE Institute for Water Education. Delft, the Netherlands.
- Butt, M.S, Sharif, K & Bajwa, B.E. (2005). *Hazardous effects of sewage water on the environment*. *Focus on heavy metals and chemical composition of soil and vegetables*. Management of Environmental Quality, 16: 338-346.
- CEC [Council of the European communities]. (1991). *Council of the European communities directive concerning urban wastewater treatment* (91/271/eec)", In Official Journal of European Communities, L135: pp 40.
- Chesnin,L. (1996). *Irrigation with sewage of effluent. Cooperative extension service*. Institute of agriculture and natural resources-University of Nebraska-Lincoln-USA. Circ.969, Washington, D.C.,19 pp.
- CJPME [Canadians for Justice and Peace in the Middle East] .(2005). *Fact sheet: Industrial Zones and Israeli colonies strategy*, Fact sheet No. 10, October, 2005.
- Daghrah,G. (2005). Pollution *and Water Quality Assessment of Wadi Al Qilt*. Thesis research. Institute of Environmental and Water Studies, Birzeit University, Palestine.
- Das, R & Das, S.N. (2002). *Impact of Wastewater Discharge on Soil and Groung Water- A Case Study*. Regional Research Laboratory (CSIR). Bhubaneswar 751013. Journal of Scientific& Industrial Research.

- Dreyer, J.I. (1982). *The Geochemistry of Natural Water*. Prentice-Hall, USA, P.338.
- EHD [Environmental Health Department] of Salfit. (2007). Health ministry of Palestine.
- ESC [Environmental Standard Committee]. (1996). *National Environmental Quality Standards for Municipal and Liquid Industrial Effluents*, P.16.
- Essa, B. (2010). *Observation of pollutants quantity and quality in runwaus water and its effect on plants, soil, and Ground Water In fledge of Taldo and Tal El-Zahab-Homs*. College of Agricultural Engineering in the Department of Soil Science and land reclamation. Syria.
- Gelman, E.F. (2003). *pH and its Role in Water Quality*. Nature, 2(4): 22-34.
- Ghanem, M. (1999). *Hydrology and Hydrochemistry of the Faria Drainage Basin West Bank*. Ph.D Thesis, Technische Universitat Bergakademie Freiberg. Freiberg, Germany.
- Hamou, N. (2003). *Effects of Wastewater Irrigation "Kwaik River" in the soil and groundwater contamination in northern Syria - Almtkh area*. Aleppo University-Agricultural Faculty.
- Hanjra, M , Blackwell, J, Gemma, C, Fenghua, Z & Jacksona,T. (2011). *Wastewater irrigation and environmental health: Implications for water governance and public policy*. Charles Sturt University, Wagga Wagga Campus, NSW 2678, Australia, b: Future Directions International, Perth, WA, Australia, c : Centre for Water Resource Systems, Vienna University of Technology, d : Austriad Shihezi University, Shihezi City 832003, Xinjiang, China. Online 16 November 2011. Elsevier (International Journal of Hygiene and Environmental Health).
- Harivandi, D. & Beard. C, (1998). *How to Interpret a Water Test Report*. Golf Course Management, P.49-55.
- Hoek, W, Hassan, M, Ensink, J, Feenstra ,L, Sally,S, Munir, R. Aslam, N, Ali, R. & Mastuno, Y. (2002). *Urban waste water: A valuable resource for agriculture. A case study from Haroonabad*, Pakistan. Research Report 63, International Water management institute.
- Issac, J. (2007). *Israeli Violations against the Palestinian Environment*, ARIJ.
- Issac, J. (2005). *A Critical Analysis of the Israeli Palestinian Water Relations*, ARIJ.
- Jebreen, H. (2014). *Hydrochemistry and Isotopes of the Spring Water in Soreq Catchment/ Ramallah / West Bank*. Thesis research, Institute of Environmental and Water Studies, Birzeit University, Palestine.
- Kahlown, M, Ashraf, M, Salam, A & Bhatti, Z. (2006). *Impacts assessment of sewerage and industrial effluents on water resources, soil, crops and human health in Faisalabad*.

- Khan, F.J, & Javed,Y. (2007). *Delivering access to safe drinking water and adequate sanitation in Pakistan*. Pakistan Institute of Development Economics. PIDE Working, pp: 30.
- Khatib, R. (2008). *The impact of Israeli settlements on ruban expansion of residential agglomerations in Salfit Governorate*. An-Najah National University, Unpublished Master Thesis.
- Langmuir, P. (1997). *Aqueous Environmental Geochemistry*. Prentice-Hall, USA, P.600.
- LRC [Land Research Center]. (2008). *Geopolitical Situation in Salfit Governorate*.
- MEPA [Meteorological and Environmental Protection Administration in Saudi Arabia]. (1992) *Performance Standards for Direct Discharge*. Riyadh, Saudi Arabia.
- Miroslav. R. (2008). *Statistical Perspective and Pollution Indicator in Mengkabong,* Campus Modern Applied Science. Vol 2 No (4) 131-143.
- Mustafa, O. (2006). *Impact of Sewage Wastewater on the Environment of Tanjero River and Its Basin within Sulaimani City/NE-Iraq*. Council of the college of science, university of Baghdad. Iraq.
- Nouri, J, Mahvi, A.H, Babaei, A.A, Jahed, G.R. & Ahmadpour, E. (2006). *Investigation of heavy metals in ground water.* Pakistan Journal of Biological Sciences, 9: 337-384.
- Oller, S. Malato, J.A & Sánchez, b. (2010). *Combination of Advanced Oxidation Processes and biological treatments wastewater decontamination*. Plataforma Solar de Almería (CIEMAT), Carretera Senés, Km 4. 04200 Tabernas & Department of Chemical Engineering, University of Almería, Crta de Sacramento s/n, 04120 Almería, Spain. Science of the Total Environment. Journal homepage: www.elsevier.com/locate/scitotenv.
- Pacheco, J, Marin, L, Cabrera, A, Steinich, B & Escolero, O. (2001). *Nitrate Temporal and Spatial Patterns in 12 Water-supply Wells*. Yucatan, Mexico. Environ Geol, 40: 708-715.
- Parvez, M, Mehmood, K & Akram, M. (2013). *Evaluating the Wastewater Impacts on Groundwater and Irrigated Soil*. Department of Chemistry, the Islamia University of Bahawalpur, Pakistan. And University College of Agriculture and Environmental Sciences,. Submitted: May 2, 2013; Accepted: Jun 13, 2013; Published: Sep 11, 2013e Islamia University of Bahawalpur, Pakistan. World Applied Sciences Journal 24 (9): 1184-1191, 2013 ISSN 1818-4952. DOI: 10.5829/idosi.wasj.2013.24.09.922.
- PCBS [Palestinian Central Bureau of Statistics]. (2011). *Salfit Governorate Statistical Yearbook*. Ramallah, Palestine.
- PCBS [Palestinian Central Bureau of Statistics]. (2012). *Palestinian Expenditure and Consumption Survey 2011*.

- PCBS [Palestinian Central Bureau of Statistics]. (2014). *Residential agglomerations in Salfit governorate, and population predictions*. Available: http://www.pcbs.gov.ps/Portals/_Rainbow/Documents/salfta.htm.
- Pescod, M.B. (1992). *Wastewater Treatment and Use in Agriculture*. FAO Irrigation and Drainage Paper No.47, Rome, P.146.
- PWA [Palestinian Water Authority]. (2003). (unpublished).
- PWA [Palestinian Water Authority]. (2011). *Request for proposals for monitoring and measurement of flow and loads of the Hebron City wastewater outfall*. PWA, Ramallah, Palestine.
- PWA [Palestinian Water Authority]. (2012). *Analysis of Problem with Waste Water Treatment in Rural Areas /remote areas Different Typical Israeli Settlements in West Bank*, (unpublished).
- PWA [Palestinian Water Authority]. (2014). *Water and Sanitation Improvement Projects for Salfit District - West Bank, Draft Sanitation Master Plan Report*. (Unpublished).
- PWA [Palestinian Water Authority]. (2015). GIS UNIT, Ramallah, Palestine.
- PWA, [Palestinian Water Authority]. (2012). *Analysis of Problem with Waste Water Treatment in Rural Areas /remote areas Different Typical Israeli Settlements in West Bank*, (unpublished).
- Rajab,S. (1998). *National Study about the reality of the use of wastewater treatment in Tunisia*, chemical pollution of the plants estimation-Workshop on the uses that of water. Tripoli.
- Saether, O.M, & Caritat, P.D. (1997). *Geochemical Processes, Weathering and Groundwater Recharge in Catchments*. Rotterdam, P.400.
- Shaheen,O, (2013). *A case study of urban wastewater balancing to study wastewater pollution loads and groundwater pollution in the city of Nablus-East (Palestine).* Thesis research. Institute of Environmental and Water Studies, Birzeit University, Palestine.
- Skidmore. L, Van, D & Simon, E. (2003). *Measurement and simulation of wind erosion, roughness degradation and residue decomposition on an agricultural field*. Earth Surface Processes and Landforms 28:10.1002/esp.v28:11, 1243-1258. Online publication date: 1-Oct-2003.
- Sujatha, S.D.; Sathyanarayanan, S.; Satish P.N and Nagaraju, D., 2001: *A Sewage and Sludge Treated Lake and its Impact on the Environment, Mysore, India.* Envrion Geol, 40: 1209-1213.
- Todd, K, (2007). *Groundwater hydrology third edition, Jhon Wiley and Sous*,Third Reprint. Inc. India. 535p.
- Todd, K. (1980). *Groundwater Hydrology*. 2nd ed., John Wiley & Sons. USA, P.535.

- USDA Salinity lab. (1954). *Diagnosis and improvement of saline and Alkali soils*,Agriculture and Drainage Lab.Tech. Report, U.S.A.
- Vojdani, F. (2006). *Waste water reuse, an alternative water supply resource*.
- Wagner, G.J. (1993). *Accumulation of cadmium in crop plants and its consequences to human health*. Adv.Agron, 51,173-212.
- Warner, N, Christie, C, Jackson, R, & Vengosh, A. (2013). *Impacts of Shale Gas Wastewater Disposal on Water Quality in Western Pennsylvania*. Division of Earth and Ocean Sciences, Nicholas School of the Environment, Dukes University, Durham, North Carolina 27708, United States. Environ. Sci. Technol., 2013, 47 (20), pp 11849–11857 .Publication Date (Web): October 2, 2013 (Article) DOI: 10.1021/es402165b.
- WHO [World Health Organization]. (2007). *Guide fine for drinking water quality Recommendation*. Vol.4th ed. 36p.
- WHO [World Health Organization]. (2006). *Guidelines for Drinking-Water Quality*. 3rd ed., Vol.1, Recommendations, Geneva, P.515.
- Wilcox, V. (1955). Classification *and use irrigation waters*. US Dep. Ag .

Appendices

Appendix 1 : Physical Parameters of Some Sarida Springs in the Wet Round (May)

Station Name	Date	pH	TDS (mg/l)	EC (µs/cm)	Temperature (c)	pH in situ
Al-Fawwar	21/05/2012	7.68	336	673	25	7.51
Al-Msila	21/05/2012	7.78	243	485	22.5	8.06
Al-Yanbou	21/05/2012	7.86	208	416	23	7.65
Al-Shalal	21/05/2012	7.62	241	482	21.8	7.37
Al-Matwi	21/05/2012	7.53	367	734	24.4	9.32
Al-Mizrab	21/05/2012	7.77	207	413	23.2	7.1
Al-Adas	21/05/2012	7.43	309	617	21.9	7.42

Appendix 2 : Physical Parameters of Some Sarida Springs in the dry round (November)

Station Name	Date	pH	TDS (mg/l)	EC (µs/cm)	Temperature (c)	pH in situ
Al-Shalal	11/10/2013	7.29	298	546	22	7.2
Al-Fawwar	11/10/2013	7.51	339	657	21.6	7.66
Al-Matwi	11/10/2013	7.45	318	655	23.7	7.53
Al-Yanbou	11/10/2013	7.69	251	436	22.9	7.88
Al-Mizrab	11/10/2013	7.9	234	440	21	8.2
Al-Adas	11/10/2013	7.79	333	649	22	7.7

Appendix 3 : Chemical Parameters (Major Cations and Major Anions (mg/l)) of Some Sarida Springs in the Wet Round (May)

Station Name	Cl	NO3	SO4	HCO3	Mg	Ca	Na	K
Al-Fawwar	32.5	4.5	25.7	181	20.1	58.6	19.2	2.66
Al-Msila	40.9	5.9	24.9	189	19	53	18.1	2.86
Al-Yanbou	36.9	4.3	31.6	191	28.3	59	17.3	2.41
Al-Shalal	35	5.8	30.2	199	32	66	18.8	2.22
Al-Matwi	64.1	66.1	35.3	187	29.7	76.2	17.9	1.83
Al-Mizrab	63.2	6.1	29.3	179	22.4	78.2	17.1	1.95
Al-Adas	37.5	6.3	33.1	225	33	80.3	16.1	1.52

Appendix 4 : Chemical Parameters (Major Cations and Major Anions (mg/l)) of Some Sarida Springs in the dry round (November)

Station Name	Cl	NO3	SO4	HCO3	Mg	Ca	Na	K
Al-Shalal	35.4	46.3	42.7	488.1	30.7	81.0	17.7	2.0
Al-Fawwar	46.0	43.8	30.5	366.1	19.7	77.2	38.8	12.5
Al-Matwi	53.1	41.7	24.4	305.1	26.5	86.4	27.4	11.1
Al-Yanbou	24.8	20.9	18.3	427.1	23.8	64.6	12.2	0.3
Al-Mizrab	35.4	15.1	12.2	366.1	19.5	55.2	14.5	0.3
Al-Adas	38.9	5.2	36.6	183.0	38.8	90.7	18.6	0.1

Appendix 5 : The Geographical Coordinates (meters) of the measured springs

Station Name	X	Y	Height
Al-Fawwar	697094	3548824	278
Al-Msila	698738	3549802	307
Al-Yanbou	700991	3550625	410
Al-Shalal	702733	3551408	429
Al-Matwi	700730	3551233	382
Al-Mizrab	697608	3548156	343
Al-Adas	703825	3551335	480

Appendix 6 : The Microbial Content in Some Springs of Sarida Catchment (cfu/100ml) in the Wet Round (May)

Spring Name	F.C	T.C
Al-Fawwar	1000	10600
Al-Msila	7200	80000
Al-Yanbou	1300	23000
Al-Shalal	12000	120000
Al-Matwi	500	13000
Al-Mizrab	34000	95000
Al-Adas	1200	18000

Appendix 7 : The Microbial Content in Some Springs of Sarida Catchment (cfu/100ml) in the dry round (November)

Spring Name	F.C	T.C
Al-Shalal	60	29000
Al-Fawwar	28	2914
Al-Matwi	Nil	16
Al-Yanbou	Nil	109
Al-Mizrab	45	44000
Al-Adas	15	2200

Appendix 8 : Different Parameters of Sarida Wastewater along the Wadi in the Wet Round (May)

Stations names	**PH**	**TDS (mg/l)**	**EC (μs/cm)**	**TSS (mg/l)**	**BOD_5 (mg/l)**	COD-mg/l	PO4-mg/l
End Point	7.99	639	1279	500	19	102	3.1
Bruqin WW	7.87	657	1314	390	77	201	5.2
Joint Point	7.75	759	1518	489	75	206	3
Salfit WW	7.64	705	1408	668	57	142	6.1
Ara'el WW	6.61	955	1911	403	377	507	3.5

Appendix 9 : Different Parameters of Sarida Wastewater along the Wadi in the dry round (November)

Stations names	**PH**	**TDS-mg/l**	**EC-μs/cm**	**TSS-mg/l**	**BOD-mg/l**	COD-mg/l	PO4-mg/l
End Point	7.74	680	1361	243	212	588	5.7
Bruqin WW	7.61	678	1357	199	189	514	6.4
Joint Point	7.62	636	1271	178	133	420	3.6
Salfit WW	7.03	929	1858	479	255	622	7.9
Ara'el WW	7.52	601	1201	155	87	312	3.5

Appendix 10 : Trace Elements Concentrations (ppb) in Springs of Sarida Catchment in the dry season (Part 1)

Spring Name	Boron	Vanadium	Iron-56	Iron-57	Cobalt	Arsenic	Selenium	Barium
Al-Shalal	33.92	1.55	52.83	1078.50	0.27	0.18	0.38	21.25
Al-Fawwar	307.49	5.01	47.01	1037.16	0.37	0.16	0.37	34.48
Al-Matwi	54.15	2.24	7.02	1093.42	0.20	0.25	0.43	18.73
Al-Yanbou	35.68	2.76	163.17	987.19	0.17	0.19	0.47	10.34
Al-Mizrab	32.20	2.08	6.45	736.72	0.12	0.15	0.39	10.77
Al-Adas	29.21	1.29	24.16	1173.86	0.21	0.10	0.32	17.84

Appendix 11 : Trace Elements Concentrations (ppb) in Springs of Sarida Catchment in the dry season (Part 2)

Spring Name	Lead	Aluminum	Chromium	Manganese	Nickel	Copper	Zinc	Thallium
Al-Shalal	0.19	63.96	0.19	19.42	8.01	3.70	21.82	0.01
Al-Fawwar	0.01	2.59	36.13	8.20	7.66	0.52	6.58	0.00
Al-Matwi	0.03	3.53	0.27	0.07	1.83	1.05	9.91	0.01
Al-Yanbou	0.06	230.81	0.70	2.42	1.75	0.24	1.98	0.00
Al-Mizrab	0.17	11.45	0.40	0.21	1.77	0.21	4.48	0.01
Al-Adas	0.48	19.67	0.18	0.41	1.73	0.15	1.20	0.10

Appendix 12 : Microbial Data About Some Sarida Springs Catchment in the Wet Season of 2003 Conducted by PWA

Spring Name	Sampling date	TC (cfu/100ml)	FC (cfu/100ml)
Al-Fawwar	02/12/2003	41	0
Al-Shalal	02/12/2003	71	20
Ein-Asafeer	02/12/2003	79	8
Al-Adas	02/12/2003	33	0
Al-Matwi	07/01/2003	185	3

Appendix 13 : Results of Microbial Test (Total Count) for Al-Matwi Spring Water before and after Chlorination

Sample source	Sampling Date	Chlorine detection mg/L	Results counts
Before chlorination			
Al-Matwi source	December 2007	0	TNTC / Contaminated
Al-Matwi main	December 2007	0	TNTC / Contaminated
Al-Matwi secondary	December 2007	0	TNTC / Contaminated
After chlorination			
Al-Matwi (Water distribution network)	December 2007	2.8	NIL / Not Contaminated
Al-Sika (Water distribution network)	December 2007	0.5	NIL / Not Contaminated
Reservoir (Water distribution network)	December 2007	0.4	NIL / Not Contaminated
Source: EHD - Salfit, 2007			

Appendix 14 : Copy of the Distributed Questionnaires on Bruqin and Kafr Al-Dik Citizens in Arabic Language.

الاستبانة

تهدف هذه الدراسة الى معرفة المشاكل التي تسببها المياه العادمة الجارية في وادي صريدا في منطقة كفر الديك وبروقين وهذا الجزء مهم في الدراسة التي اجريها، وفي هذه الاستبانة سنراعي السرية التامة في حماية المعلومات ولن تستخدم الا في مجال البحث ولن تعرض للنشر او التوزيع.

1- حدد مكان سكنك الحالي :

( ) بروقين   ( ) كفر الديك

2- حدد الجنس :

( ) ذكر   ( ) انثى

3- حدد الفئة العمرية :

( ) 20-25   ( ) 26-30   ( ) 31-35

( ) 36- فما فوق

4- حدد المستوى العلمي :

( ) ابتدائي   ( ) ثانوي   ( ) جامعي

5- حدد مهنتك :

( ) موظف في قطاع حكومي   ( ) موظف في قطاع خاص

( ) مهنة حرة   ( ) غير ذلك

6- هل تعتقد ان المياه العادمة في وادي صريدا قد أثرت بشكل مباشر او غير مباشر على الصحة العامة للسكان :

( ) نعم   ( ) لا

7- هل عانيت من مرض نتيجة المياه العادمة الجارية في وادي صريدا :

(   ) نعم   (   ) لا

8- اذا كانت اجابتك نعم عن السؤال السابق، اذكر الاجراءات التي قمت بها من من حيث زياراتك للعيادة الطبية واذكر اسم المرض او الامراض التي اصبت بها او غير ذلك:

9- هل تمتلك أراضي زراعية مجاورة لمجرى المياه العادمة في منطقة وادي صريدا :
(   ) نعم   (   ) لا

10- اذا كانت اجابتك على السؤال السابق بنعم، فكم عدد الدونمات التي تمتلكها:

11- هل تمت زراعة هذه الاراضي في القديم :
(   ) نعم   (   ) لا

12- هل ادى تصريف المياه العادمة ووصولها الى الاراضي الزراعية الى تقليل انتاج الاراضي من الزراعة :
(   ) نعم   (   ) لا

13- هل قمت بهجرة ارضيك الزراعية نتيجة للاثار السلبية الناجمة عن المياه العادمة في وادي صريدا :
(   ) نعم   (   ) لا

14- هل اثرت المياه العادمة على التربة ونتيجة لذلك اصبحت غير صالحة للزراعة :
(   ) نعم   (   ) لا

15- هل تم مصادرة أراضي تمتلكها من قبل الإحتلال الاسرائيلي :
(   ) نعم   (   ) لا

16- اذا كانت اجابتك على السؤال السابق بنعم فكم عدد الدونمات التي تم مصادرتها:

17- هل تسكن الان او سكنت سابقا بجوار مجرى المياه العادمة في وادي صريدا :
(   ) نعم   (   ) لا

18- اذا كانت اجابتك نعم عن السؤال السابق، هل تأثرت بشكل مباشر او غير مباشر من الاثار السلبية للمياه العادمة في وادي صريدا كالروائح الكريهة مثلا :
(   ) نعم   (   ) لا

19- هل اضطررت لتغيير مكان سكنك نتيجة الاثار السلبية للمياه العادمة في الوادي:
(   ) نعم   (   ) لا

20- اذا كانت اجابتك بنعم عن السؤال السابق، وضح مكان اقامتك السابقة والحالية :

21- هل أثرت المياه العادمة في وادي صريدا سلبيا على البعد الجمالي للطبيعة :
(   ) نعم   (   ) لا

22- هل الأثار البيئية الملوثة التي تركتها المياه العادمة في وادي صريدا أثرت على الحياة الحيوانية من حيث الانتاجية في المنطقة :

( ) نعم ( ) لا

23- هل أثرت المياه العادمة في وادي صريدا على الحياة البرية في المناطق المحيطة بها :

( ) نعم ( ) لا

24- اذا كانت اجابتك بنعم عن السؤال السابق، حدد بشكل مختصر انواع الحيوانات البرية المتأثرة بشكل مباشر او غير مباشر بالاثار السلبية للمياه العادمة في :

25- هل تستخدم مياه الينابيع المجاورة لمجرى المياه العادمة في الوادي :

( ) نعم ( ) لا

26- اذا كانت اجابتك بنعم عن السؤال السابق، ما هو نوع الاستخدام لمياه هذه الينابيع:

( ) لاغراض منزلية ( ) لري المحاصيل ( ) لري الاشجار المثمرة

( ) لسقاية الحيوانات

27- اذا كانت اجابتك ب لا، ما هو السبب في ذلك :

( ) بسبب تردي جودة المياه ( ) لسبب اخر

28- باعتقادك الى اي مدى اثرت المياه العادمة في وادي صريدا سلبيا على انتاجية الاراضي الزراعية والثروات الحيوانية في المناطق المجاورة للوادي:

( ) تناقصت بنسبة 0-50 % ( ) تناقصت بنسبة 50-95 % ( ) تمت هجرة هذه الاراضي

انتهى الاستبيان