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Pollution Aspects of Springs Water in Natuf Catchment (Ramallah area)

Prepared by

Anwar Hassan Atta

1155581

Supervisor

Dr. Marwan Ghanem

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Pollution Aspects of Springs Water in Natuf Catchment (Ramallah area)

جوانب التلوث لمياه الينابيع في حوض الناطوف (منطقة رام الله)

By

Anwar Atta

1155581

Thesis was prepared under the supervision of Dr. Marwan Ghanem and has been approved by all members of the Examination committee.

Dr. Marwan Ghanem .....

Chairman of committee

Dr.Maher Abu-Madi .....

Member

Dr. Saleh Sulaiman .....

Member

Date of Defense:

The findings, interpretations, and conclusion in this study don't necessary express the views of Birzeit University, the views of individual members of the MSc or the views of their respective employees.

Abstract

Natuf drainage basin is considered one of the most important recharge areas for the Western Aquifer Basin (WAB), which is a historical and civilizational site where Natufian civilization was created and man practiced the agricultural activities for the first time. This study was conducted in the summer 2017 where 12 samples of spring water were collected and analyzed to examine the quality of these springs. This study aims to determine the types of pollutants and their sources in addition to evaluating the socio-economic environmental impact on water utilization from local people. The pH values for all samples vary from 6.8 - 7.1 with a temperature mean 22.9C^{o}. The electrical conductivity and total dissolved solids where in the range between 650-1120 µS/cm and 294-642 mg/L, respectively, the cations and anaions were within the WHO guidelines. For biological parameters F.C and T.C. It's resulted that 7 samples out of 12 were contaminated of fecal coliform which suggest the different human activities affect the quality of spring water. Tow samples of Ein Arik Al-tehta and Al-zarka-Beitillu have total organic carbon. The study shows that most of water samples have a water type of Mg- Ca- HCO_3.

50 questionnaires were distributed to the farmers and springs owners in order to study the impact of socio-economic and environmental of spring water utilization. The study shows that 90% of local people using the springs for agricultural purposes. The chemical analysis of water samples are free from industrial pollutants, this refers to the fact that 84% of them are located away from the dumpsites. The existence of water network as well as the absence of the roll of the official authority contributes to the reduction of people's dependence on spring water. The study shows that agriculture is not a basic source of income because agriculture is used for domestic benefits and not for a commercial target. The

existence of Israeli settlements near the agricultural lands and springs have an indirect impact on polluting the springs because there is an apparent lack of studies and statics that show the amount of wastewater and solid waste that are produced from settlements.

الخلاصة

يعتبر حوض الناطوف من أهم مناطق التغذية للحوض الغربي وهو أيضا منطقة ذات طابع تاريخي وحضاري حيث انشأت الحضارة الناطوفية التي مارس فيها الانسان الزراعة للمرة الاولى . نفذت هذه الدراسة في صيف 2017 وتم فيها جمع 12 عينة من مياه الينابيع وتحليلها للتأكد من جودتها ومدى صلاحيتها للاستعمال . تهدف هذه الدراسة الى تحديد أنواع الملوثات ومصادرها التي تؤثر على جودة مياه الينابيع بالاضافة الى تقييم الاثار الاجتماعية والاقتصادية والبيئية لاستخدام مياه الينابيع من قبل سكان المنطقة . الرقم الهيدروجيني لجميع العينات يتراوح بين 7.1 -6.8 مع متوسط درجة حرارة 22.9 c° . الموصلية الكهربائية وكمية الاملاح الذائبة تتراوح بين 1120-650 ميكروسيمنز/ سم و بين 642-294 ملغم / لتر. الأيونات السالبة والموجبة تقع ضمن معايير الصحة العالمية اما التحاليل البيولوجية فقد بينت أن 7 عينات من أصل 12 عينة ملوثة بالبكتيريا القولونية وهذا يدل على تأثير نشاطات الانسان المختلفة على جودة المياه . معظم العينات كانت خالية من المواد الكربونية باستثناء عين عريك التحتا وعين الزرقا –بيتللو أما نوعية المياه للعينات فكانت معظمها من نوع مغنيسيوم بايكربونات $Mg-Ca-HCO_3$

من أجل دراسة الاثار الاجتماعية والاقتصادية والبيئية لاستخدام مياه الينابيع قام الباحث بتوزيع 50 استبيان على المزارعين واصحاب الينابيع في منطقة البحث وتم تحليل النتائج بواسطة برنامج التطبيق الاحصائي وقد بينت الدراسة ان 90% من السكان يستخدمون مياه الينابيع واشارت الدراسة ان الهدف الاساسي من الاستخدام هو للزراعة وليس للشرب . أظهرت نتائج التحاليل الكيميائية للعينات أنها خالية من الملوثات الصناعية والسبب في ذلك يعود الى حقيقة وقوعها بعيدا عن مكبات النفايات العشوائية والمناطق الصناعية . كما وبينت الدراسة ان وجود شبكة للمياه وتراجع دور السلطات المعنية بالاهتمام

باليناببيع الى تقليص اعتمادية السكان على مياه الينابيع . على الرغم من أن غالبية السكان يزرعون اراضيهم بمختلف المزروعات الا انهم يرو أن الزراعة لا تعد مصدر دخل اساسي وان الزراعة تتم بهدف الاستهلاك المنزلي وليس للبيع او التسويق . وقد بينت الدراسة أيضا أن وجود المستعمرات الاسرائيلية يعيق من الوصول للأراضي الزراعية ويساهم في تلويث مياه الينابيع بشكل مباشر أو غير مباشر وذلك لعدم وجود دراسات جدوى واحصاءات تشير الى كمية المياه العادمة او النفايات الصلبة التي يتم التخلص منها من المستوطنات المجاورة .

Dedication

I dedicate my work

To my great parents who strived all their ages to illuminate my life (Hassan & Noora), to my dear sisters and brother who shared me good and bad moments of life (Mohammed, Moneera & Anwar), to my awesome uncles (Yousef, Jalal & Khamees), to all my friends and colleagues.

To all those who love and respect me

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In the final stage of thesis writing, especial thanks from the bottom of my heart to my thesis supervisor **Dr. Marwan Ghanem** who guided and directed me in all steps of thesis preparation. It has been an honor for me to be one of his master students.

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Finally, I would like to thank each and every one who supported me to complete and write this thesis (friends, colleagues and staff of water and environmental institution at B.Z.U)

With best wishes and love for all

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List of Abbreviations

WAB	Western Aquifer Basin
PWA	Palestinian Water Authority
SPSS	Statistical Package for Social Science
L.C.D	Liter per Capita per Day
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
BOD	Biological Oxygen Demand
DO	Dissolved Oxygen
EC	Electric Conductivity
mg/L	Milligram per liter
µg/L	Microgram per liter
C^0	Celsius
µS/cm	Microsiemens per centimeter
SAR	Sodium Absorption Ratio
PHG	Palestinian Hydrology Group
R^2	Square Correlation Coefficient
Km^2	Squared Kilometer
SUSMAQ	Sustainable Management of the West Bank and Gaza Aquifers
Mcm	Million Cubic Meter
B.Z.U	Birzeit University
WB	West Bank
F.C	Fecal Coliform
T.C	Total Coliform
TOC	Total Organic Carbon
ICP	Inductively Coupled Plasma
EPA	Environment Protection Agency
CIA	Capillary Ion Analyzer

Chapter one
Introduction

1.1 Introduction

Groundwater is the major source of fresh water in the West Bank. The continuous supply of high quality water is necessary for quality of life, economic growth, and environmental sustainability. The quality and quantity of potable water varies over time and space, and is influenced by natural and man-made factors, including climate, hydrogeology management practice and pollution. In the West Bank, the demand for potable water for domestic and agricultural uses has increased in the last few decades as a result of rapid increase of population in the West Bank. The Natuf basin, which is a part of the Western Aquifer Basin (WAB) in the West Bank suffers from the scarcity of water like other parts in the West Bank(Ghanem,2008). The scarcity of water, urban extension, the lack of interest in water resources (springs) in the study area have limited land use for agriculture (Ghanem, 2008). Heavy exploitation of groundwater through wells and springs by both Israelis and Palestinians, lack of sewer system, wide distribution of cesspits with inadequate quality control, common practice of grey water disposal into gardens and road ditches and the uncontrolled disposal of untreated municipal sewage into valleys, cause rapid contamination of aquifer system through karstic conduits in the area (Qannam, 1997). lack of previous studies about water quality in the study area, require the need for investigation of pollution aspects in water to determine the type of pollutants and their resources, which will help the concerned authorities to prepare and to implement successful management plan that may reduce the occurrence of pollution to the springs in the study area.

1.2 Problem Statement

Natuf catchment is rich in number of springs located there, it contains about 130 springs distributed in different villages include Jamalla, Deir Ammar, Ein Arik and Beitillu. Natuf also has a civilized and cultural heritage as one of the oldest civilization in the world that should keep on it. The problem of this study lies within determining the degrees and scales of pollutants that affect the quality of springs water which resulted from various resources including raw wastewater, treated wastewater, sewage water, cesspits, dump sites and pesticides. People in the study area dispose wastewater from their household through cesspits which finally infiltrating to the groundwater or by sewage trucks that affect biologically or chemically on the quality of the springs water in the study area. The population centers in the study area dispose from their solid waste randomly in seasonal Wadies or in streets which decomposes and transfer through runoff into the groundwater. Using springs water in agriculture has socio-economic benefits on people in the study area, where some residents depend on agriculture as a main source of income, where noticed that there is various in using springs water for human activities between the past and present, particularly in the presence of internal water network. The most dangerous source of pollution to the Natuf basin is the Israeli settlements surrounded study area, where settlers dispose their wastewater and solid waste in Wadies which finally infiltrate into ground water and contaminate it. Determining types of pollutants and their resources in the study area helps the authorities to find solutions and manage pollution in an appropriate way.

1.3 Objectives of the study

This study mainly aims at determining the types and amounts of pollutants that affect on spring water quality in Natuf Catchment area, in addition to evaluate the socio-economic environmental impact of using spring water from local people in their various activities. The sub targets of the study are as follow:

1. Investigating and defining the impact of wastewater pollution on spring's water quality in Natuf catchment to develop alternate approaches suitable for reducing pollution from this source.
2. Determining the amounts and types of pollutants that affect on the quality of springs water in the study area.
3. Determining the fields of using these springs (household or agriculture) and showing the economic benefits of using spring water in agriculture purpose
4. Determining the types of water harvesting techniques used from people in the study area.

1.4 Questions of the study

1. What are the pollutants that affect the quality of the Natuf spring water?
2. To what extent does the contaminated water of springs in Natuf catchment endanger people and environment?
3. What is the impact of Israeli settlements on water resources and agricultural land in Natuf basin?
4. What are the modern substitutions for the springs water to fulfill the increasing needs from people beside these springs?

1.5 Hypothesis of the study:

Based on previous studies related to subject, many visiting to the springs locations some hypothesis was concluded and they are:

1. The study proposes that pollution sources in Natuf catchment is not only wastewater but also dump sites and agricultural activities.
2. The study proposes that concentration of some parameters such as nitrate (NO_3^-) and fecal coliform are higher than other springs in the study area and this as a result of continuous disposal of treated effluent from AL-Terih wastewater treatment plant near the seasonal Wadi.
3. The study proposes that agriculture is considered as a basic source of income for families in the study area.

1.6 Importance of the study

Despite the fact that there is research conducted about Natuf catchment, there are no studies about whether there are pesticides or total organic carbon (TOC) in the springs of the study area. Therefore, the importance of this study lies within determining if the concentration of heavy metals such as iron and lead complies with the Palestinian international standers, and also determining the reasons behind the differences in the biological, chemical and physical properties among the springs in the study area, even though they are all located in the same area. The study will deal with the socio-economic impact of using the spring's water on people's activities the agricultural aspects, knowing that these area studies possess civilianization and cultural heritage.

Additionally, this study will shed light on the role of Israeli settlements in polluting the springs water in the study area, knowing that the settlements dispose from their wastewater and their solid waste in the Palestinian Wadis which finally reach groundwater and contaminate it.

Chapter Tow
Literature Review

2.1 Previous Studies

(Ghanem et.al, 2017) studied the physico-chemical and biological parameters for 19 springs in Natuf catchment area to assess the quality of these springs and show the convenience of using them for household and farming uses. The study was conducted over three years of (2008, 2010 and 2011) to evaluate the hydrochemical changes that occur in the springs and connect these changes with the surrounding environment. 19 water samples were taken and prepared well for analysis in the lab to examine the quality of each spring. The study showed that springs water is generally good enough for domestic and agricultural purposes related to TDS, EC, SAR, pH and HCO_3^- . However, microbial tests indicated that there is a human impact on the quality of spring's water where some springs were contaminated with fecal coliform. Major ions [Na^+, K^+, Mg^{+2}, Ca^{+2}, Cl^-, SO_4^{-2}, NO_3^-, HCO_3^-] for all samples were within WHO guidelines and Palestinian stander for drinking water. Trace elements of [Fe, Cd, Hg, Cr, As, B, Zn, Mn, Cu, Ni, Al, Pb] were investigated to ensure that their concentrations are less than WHO limits. The tested samples showed that concentration of heavy metals were within the allowed WHO limits with exception of Fe (Ein Abu Zama'a, Ein al-kaikaba in Bietillu and Ein Al-ghazal in Jamalla) springs which exceed the permissible limit, in addition to Al concentration in Ein Abu Esam of 75.49µg/L which surpasses EPA standard limit of 50µg/L.

(Ahmad, 2015) studied the impact of wastewater as a main source of pollution that originate from Israeli Ara'el colony and local Palestinian communities on quality of spring's water in Sarida Wadi. The study carried out through two rounds of water samples collection, samples of seven springs were collected in wet season, while other samples of six springs in dry season of 2013. The researcher concluded that some parameters concentrations exceed the standard limits in most tested samples, such as BOD_5 and TSS, while other parameters showed a concentrations complied with standard and guidelines like Ca^{+2}, HCO_3^- and Cl^-, for NO_3^-, it was complied with standard limits except in Al-Matwi spring that exceed the standerds value of 45mg/L.

As a result of continuous discharge of wastewater into Sarida Wadi the whole tested water samples in the study area showed high content of Total Coliform and Fecal Coliform compared to Palestinian Water Authority (PWA) microbial data in 2003 which demonstrated the increasing impacts of wastewater during time. Trace elements were investigated and their values did not exceed WHO guidelines for fresh water.

The researcher also studied the effects of continues disposal of wastewater in the study area on people's life (healthy, economically and environmental), the study showed that it has a massive negative impacts represent in statics, where 92% of respondent, confirmed the impact on public health, 47.7% abandoned their agricultural lands, and 79% believed that their land production decrease. In addition, 96.9% of respondents were suffering from the negative implication. The impact on aesthetic conditions was negative according to 86% of the respondents.

(Ghanem and Samhan ,2012) studied the hydro chemical parameters for the north part of Auja Tamaseeh basin in Tulkarm area to determine if there is a natural origin or man-made pollution, 22 water samples were taken to be detected. The total number of wells in the study area is 63 wells, 53 of them are irrigation wells which indicates to the importance of study area as an agricultural land, while 10 are using for domestic purpose. Tulkarm area is considered to be highly sensitive area because of the existing of shallow aquifer where pollutants that result from human activities can easily get in to the groundwater system and contaminate it. Large amounts of pesticides are using in the study area, 24% of lands are treated from pesticides while the rest didn't, so pesticides and other pollutants infiltrate to groundwater system which lead to hurtful impacts on people's health weather in direct or indirect way.

The sources of pollution in the study area are various including wastewater, where 70% of houses dispose from their wastewater through cesspits which is one of the main source of pollution to the groundwater, dumping sites, there are 12 known dumping sites in Tulkarm area, these dumping sites are located in agricultural lands and their sites selected randomly without any considerations to the soil properties, topography and climate as well as their locations to groundwater resources.

The researchers concluded after analysis of a certain types of water parameters like nitrate (NO_3^-), trace elements and Fecal Coliform that contaminated wells are located nearby populated areas and higher enclose to agriculture lands (Ghanem and Samhan ,2012).

(Bader, 2011) studied the impact of cesspits on polluting springs water in Natuf catchment (Ramallah area); in addition to types and quantities of pollutants in it. She concluded that there are two main sources of pollution in the study area, the first one is cesspits and the second is randomly dumping sites. The researcher also studied the socio-economic environmental aspects of using springs water in people's activities (domestic and agriculture), she noticed that there was decline in the use of springs water between the past and the present and the reason for this is due to the presence of water distribution network, in addition to the fluctuation in the amounts of rain falling in the study area.

The researcher also focused on the role of settlements that are located in the study area on contaminating springs water, the study showed that settlements have indirect impact on the polluting of springs through randomly disposing of wastewater, solid wastes and industrial waste into the seasoned Wadi (Al- Natuf Wadi) which infiltrate to the groundwater and contaminate it. According to the study, 43%of the springs are located nearby settlement are polluted in wastewater, while 45% of them are polluted with solid wastes (Bader, 2011).

The researcher also studied the chemical, physical and biological changes in springs and the reasons behind these changes. She concluded after analyzing a certain water parameter that some springs are potable and free from pollutants like Ain Twais in Beitillu, while other springs are not and others have high concentration of nitrate (NO_3^-) and Fecal Coliform (F.C) like Ein Qinia springs (Bader, 2011).

(Ghanem et.al, 2011) studied the quantitative effect of pesticides including [2,4-D dichlorophenoxy acetic acid, Atrazin, and paraquat on groundwater quality due to intensive agricultural activities in Jenin and Tulkarm, the north part of the West Bank. This area is considered to be a high sensitive pollution response because of the existing of shallow aquifer where pollutants can easily percolate into groundwater system and contaminate it. There are 123 type of pesticides used in the WB, 14 of which are globally forbidden or banned by WHO, where there is a lack of control, management and monitoring on pesticides quality or quantity used in the agriculture in the WB. 50 water samples were taken from different wells to examine and determine the concentration of pesticides inside these wells. The researchers concluded that wells are contaminated as a result of pesticides and not because of wastewater discharge in the study area, where most of water samples were free from pathogenic indicators which mainly come from wastewater. Researchers recommend residents in the study area not to use some of wells for drinking purposes, as they have a potential health risk on their lives.

The study also highlighted on determining the concentrations of trace elements that come from industrial activity and dump sites including cademium (Cd) lead (Pb) chromium (Cr). The samples were collected and analyzed in the same period of pesticides sample which extending from 2004 to 2005(Ghanem et.al, 2011). The researchers concluded that lead and chromium are complied with WHO standard, while nitrate (NO_3^-) and potassium (K^+) concentrations are exceed it. This is mainly resulted from intensive use of fertilizers in agriculture in the study area.

Rainwater harvesting has become one of the alternatives that people resorted to compensate the shortage of water supply by the local internal water networks in many areas in the West Bank. This water is being consumed directly without any treatment. (Daoud et. al ,2011) studied the quality parameters: Temperature, pH, EC, TDS, Turbidity, NO^{-3}, Cu, Pb. For rainwater which is used as potable water. It is focused mostly on biological parameters of F.C, T.C and further types of bacteria such as Acinetobacter, Aeromonas and many more. The study was carried out during summer (2006) and winter (2007), where 42 water samples collected from (storage tanks and roofs surfaces) and analyzed in labs to investigate that these water are good and suitable for human consumption directly without any treatment. Based on the measured phsio-chemical parameters mentioned above, water in all tested samples is good for human consumption. However, the microbial analysis of water samples, especially stored rainwater samples showed a high contamination with F.C and other types of bacteria such as Pseudomonas which indicate to the fact that this water is not suitable for direct human consumption without any treatment because of their potential health risks on people. The researchers recommend people to make some actions before rainwater collection, these actions include keeping animals away from roofs, cleaning up the birds droppings to reduce these microbes from water and decrease the possible health risks that cause by these pathogens.

There are many issues released by the Palestinian Water Authority about the status of the groundwater and springs water pollution in Palestine show that the wastewater which result from houses, hospitals and factories is considered to be the most danger pollutants that threatens the environment in general and water resources in particular, (PWA, 2009).

According to the Palestinian Statistics Central Bureau of Statics annual report in 2009 about water status, solid wastes production and wastewater disposal method by inhabitants of the West Bank, it shows that 84% of industrial facilities and buildings are not connected to sewer system network rather depending on cesspits and randomly disposal through seasonal Wadis, it also shows people increasing acceptance toward using the system instead of cesspits. The report also shows that the number of people who use the sewer system jumped from 39% in 1992 to 52% in 2002, although this ratio is simple, but it must encourage people depend on the sewer system network mostly to reduce impact of wastewater on groundwater and springs(PSCB,2009).

(Shalash, 2006) studied the chemical, physical and biological parameters for springs water in Natuf catchment (Ramallah area) to determine if they are contaminated or not. A certain number of water samples were collected through different seasons (wet and dry seasons) to detect if pollutants are existing inside the springs. The researcher found that the majority of springs in Natuf catchment area are good for household and farming activities, which means that springs are free from hazardous pollutants. Also, he noticed that there are variations in chemical composition among springs in wet and dry seasons, and from spring to another.

According to the study, some physical parameters such as EC, SAR, pH showed a higher value in springs than others and this refer to their location nearby populated areas and enclose to agricultural activities. These springs which are located in or near populated areas are contain uncountable colonies of Total Coliform (T.C) and Fecal Coliform (F.C), which point to human impact over the quality of springs as in Ein Musbah.

The researcher has detected some heavy metals for some springs in the study area to make sure that the concentrations of these metals don't exceed the Palestinian standard limits. He concluded that cadmium (Cd), Cobalt (Co) and Lead (Pb) are within the Palestinian limits, while concentration of iron (Fe^{+2}) and Zinc (Zn) that were detected for springs located near populated areas were higher than springs located away from population centers, but match with the Palestinian specifications and standards.

Through Susmaq project in 2005 which was for monitoring and modeling the quality of the groundwater in the Western Aquifer Basin (WAB), as a perfect utilization and administration of the aquifer as a permanent source of fresh water to the Palestinian in the occupied territories. The experts have divided the (WAB) into three sections, the north, the middle and the south parts. The results of modeling indicated that the middle part of the (WAB), which including the study area (Natuf catchment area) has been categorized as the least sensitive part of pollutants responded, and this refers to the geological features of the area as a deep aquifer, unlike the north part of (WAB), which showed a high sensitivity pollution response because this part classified as a shallow aquifer system. Therefore, pollutants enter into aquifer easier than the middle part.

According to (Issac et.al, 1995) study, it shows that the major reason for water scarcity and pollution problems of water resources in the West Bank is the Israeli occupation since 1967. The Israeli occupation control over both surface water that represent in Jordan valley and ground water that represent in the major aquifer basins (Eastern, Western and North-eastern aquifers) which limits the portion of Palestinians in occupied territories to the minimum level or less, where the portion of Palestinian individual is 78 liter per capita (L.P.C) while Israeli individual a portion is about 312 L.P.C, in addition to Israeli monopolizing of the Jordan river water which completely goes to the Israelis.

Another reason for water scarcity and its deteriorating status is the Israeli wastes which they dispose it in the Palestinian seasonal Wadis such as medical wastes, wastewater from settlements solid and chemical wastes result from their industries, which mostly destroy both field of water (surface and ground ones).

Wastewater is considered a major source of pollution that affects the groundwater quality if disposed untreated or partially treated to the environment. The major urban areas in the WB are missing to sewer system, so they depending on cesspits in disposing of their domestic wastewater. Only 40% to 50% of people living in major cities have access to sewer collection networks. Yet, the existing networks are inadequate; many of them are very old and poorly designed which lead to a leakage and flooding of wastewater out of system. The continuous randomly disposal of wastewater especially over the highly permeable areas of the karstic, limestone W.B aquifer will certainly endanger the quality of the groundwater.

2.2 Geographical location of the study area

Natuf drainage basin is considered to be a part of Western Aquifer Basin (WAB), and it is located in the western part of Ramallah city and extends to the coastal plain of historical Palestine covering an area of 204km^2 (Figure. 1)

It has 130 springs, 78 of which are located in Beitillu village only, the water in these springs stems from the mountains and hills of Ramallah city. Natuf catchment area has a cultural and historical significance as the site of the oldest civilization where Man practice farming for the first time ever.

The Natuf basin is surrounded by Quilt and Sarida basins from the East, Sarida basin from the North, Salman and Soreq basins from the South and the Coastal Plain from the West (Abed and Wishahi, 1999). There are more than 90,000 Palestinians inhabitants living in the study area and they distributed over 28 villages and some parts of Ramallah city (PCBS, 2016). This study is limited to the Palestinians controlled sides, while the other parts are excluded related to political and security issues.

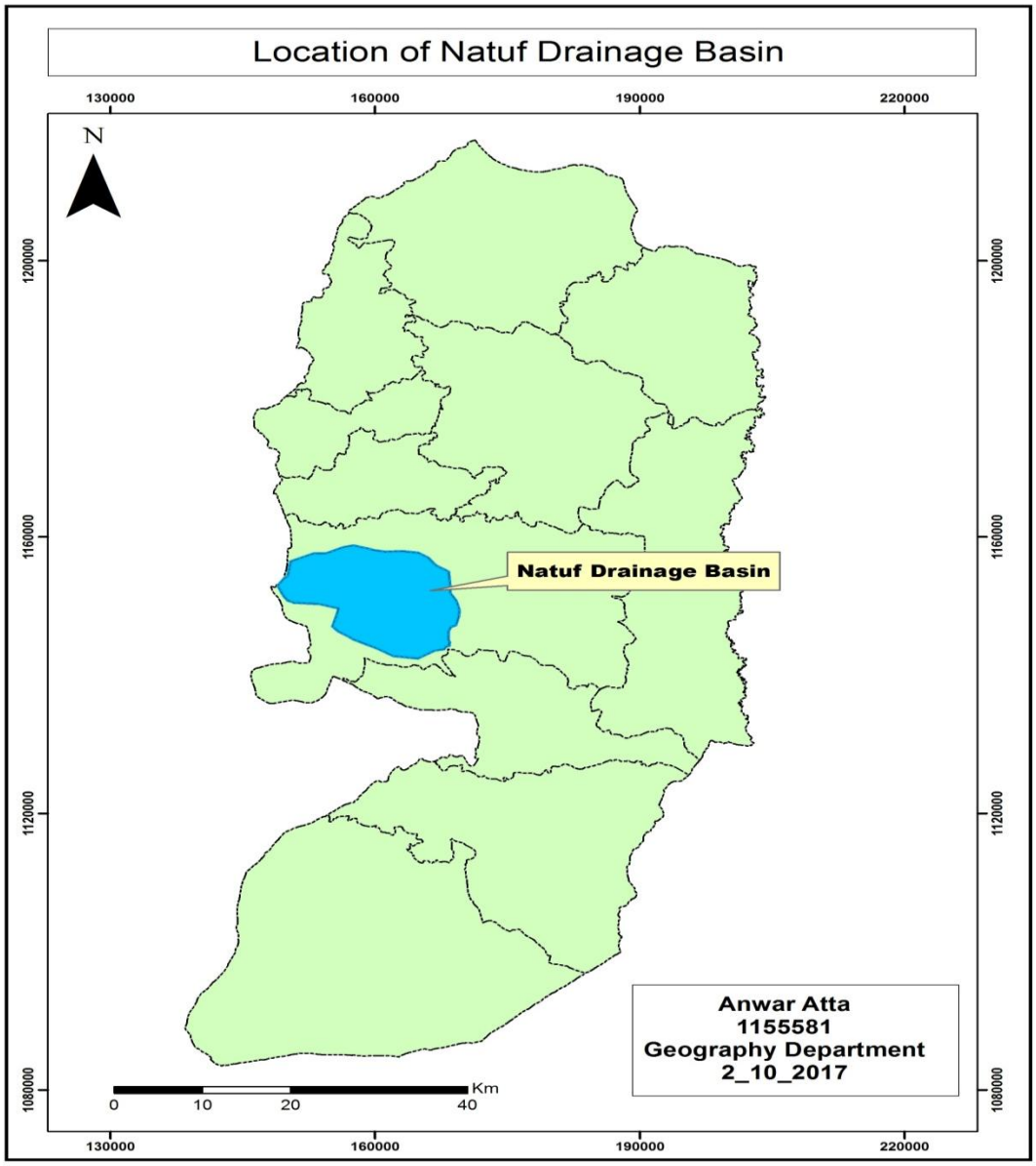

Fig.1: Location map of Natuf drainage basin

There are 12 Israeli settlements have been built in the study area since the year of 1967 until now, the majority of them are located on top of mountains that adding strain on the natural process of the basin and poisoning an existential threat to water resources through which the wastewater that are produced by these colonies. The stellments that are located in the study area are Halmish, Talmon, Talmon B, Talmon C, Dolev, Qiryat Sefer, Mattityaho, Nili, Na'ate and Nevi Tsouf and Nariya.

This study consists of 12 springs from the villages of Ein Arik, Ein Qinia, Beitillu, Der Nidham, Abud, Deir Ibzi and Ras Karkar (Table 1) illustrate names of springs and their locations in the study area. These springs are different in the amount of discharge flow and elevations of the sea level due to the geological formations and intensity of precipitation in the study area. (Figure 2) represent geographic location of springs in the study area

Table 1: The names of springs and their geographical locations in the study area.

Spring's Name	**Location**
Ein Arik Al-tehta	Ein Arik
Ein Arik Al-Fuqa	Ein Arik
Abu-Danfora	Ein Qinia
Om-Al-roman	Ein Qinia
Popin	Deir Ibzi
Ein Ayoub	Ras Karkar
Al-balad	Beitillu
Al-quos	Beitillu
Al-zarka	Beitillu
Wad Al-limon	Abud
Al-zarka	Abud
Wad Reya	Deir Nidham

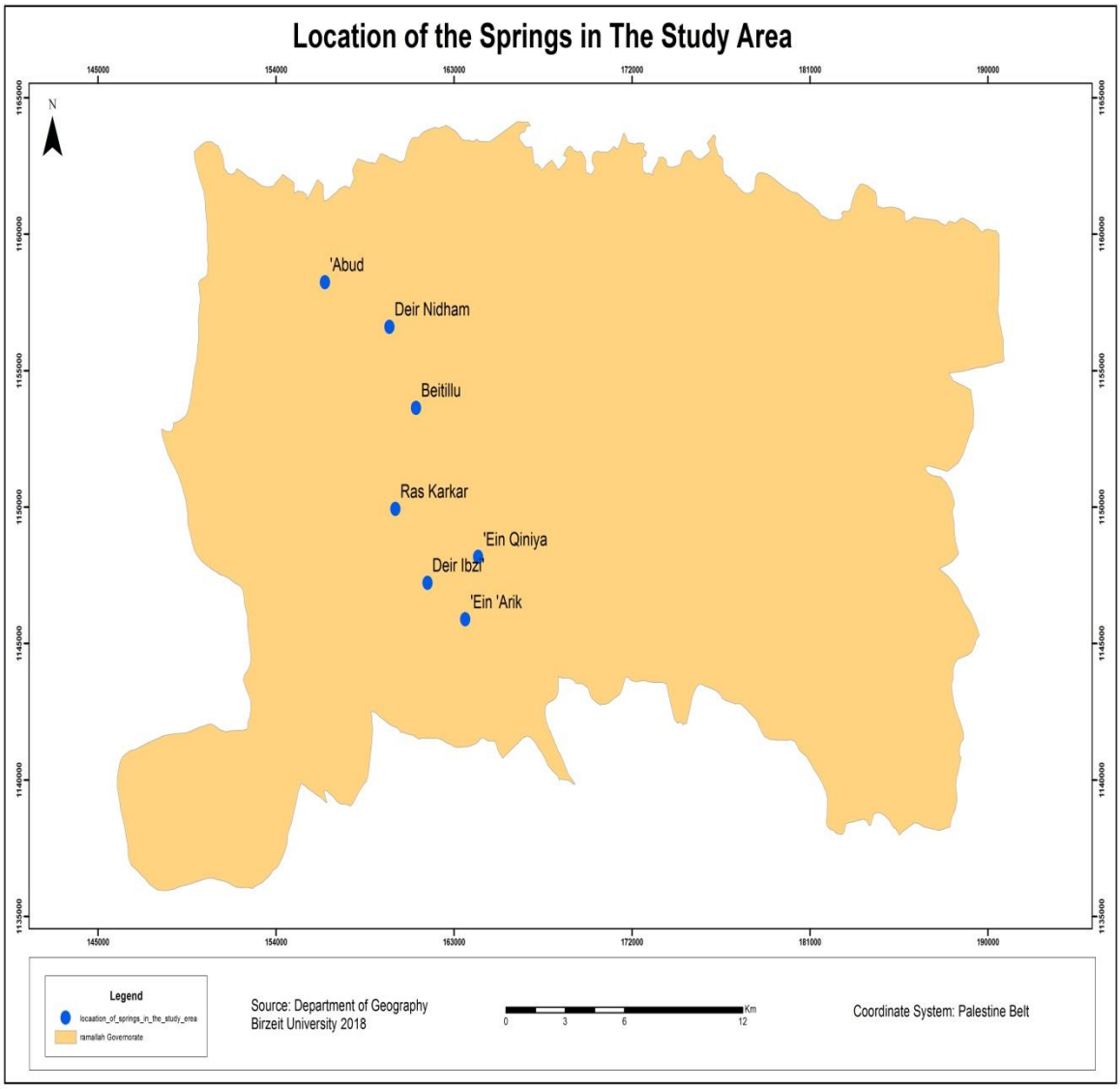

Fig.2: Geographical locations of the studied springs in Natuf area

2. 3 Climate

Palestine is located in the heart of the Middle East and overlooks the Mediterranean one, due to that geographic location the climate is characterized with long hot dry season which starts from the beginning of November until late April, and short wet season which starts from the beginning of May and extends to late December.

The annual average of rainfall in the study area ranges between 400-700 mm\year, while the long-term annual average in the West Bank is about 450 mm (PWA, 2014). Approximately 5-15% of rainfall amounts return to sea as surface runoff, 20-25% infiltrated to groundwater aquifers system and the rest is lost by evapotranspirations (PHG, 2017).

The study area is located in the mountainous area of the West Bank. Therefore, the study area is characterized with lower temperatures than other places of the W.B, particularly in the winter season. The coldest month of the year is January, the temperature ranges between 6-14^{o}C, while August is the hottest one and temperature ranges between 23-30^{o}C. The lowest temperature was recorded is -3^{o} in January, while the highest was recorded is 40^{o}C in August. (Ghanem, 1999).

2 .4 Rainfall in the study area

Rainfall is the main source of groundwater and surface water in the occupied territories. Rainfall exhibits large degrees of spatial and temporal variation, with long-term annual average rainfall of 450 mm\year. In the study area, which is located in the central part of the W.B the average rainfall ranges between 400-700 mm/year. The amounts of rainfall decreases from eastern slopes of (Ramllah and Berzeit) to western slopes of western villages such as Nelin. The highest value of the amount

of rainfall in the study area was 840 mm, it was recorded by station of Birzeit University (B.Z.U) in 2004.

2.5 Geological features of the study area

The Natuf basin is located in the Western Aquifer Basin (WAB), which is a part of Auja-Tamaseeh catchment area. It considers one of the main recharge areas for the WAB. The Natuf basin is composed of thick layered limestone, dolomite, chalk and marl. The majority of springs are located in the central part of the study area near union's villages (Beitillu, Deir Ammar and Jamalla), where Yatta formation exists as an Aquiclude (marl and marl limestone layered in between). There are two groundwater wells well in the study area located in Shibteen village, downstream of Wadi Al-Natuf. They are completely controlled by Israeli Water Authority (Mekarot) and classified as productive wells. In the past, Shibteen's wells were supply water for villages of Shuqba, Deir Abu Meshal, but today they are out of service and don't supply water for surrounding villages as in the past and people get their water from Beit Nuba station. Figure 3 illustrate geological settings of Natuf area

These study springs of the study were found on the remnants of perched aquifers. Water naturally surfaces from the aquifer is due to the karstified nature of the dolomite and limestone outcoppings. The main outcrop formations belong to formations of the Albian and Turonian age, Table 2 illustrate the geological formation for each spring in the study area (Susmaq, 2003).

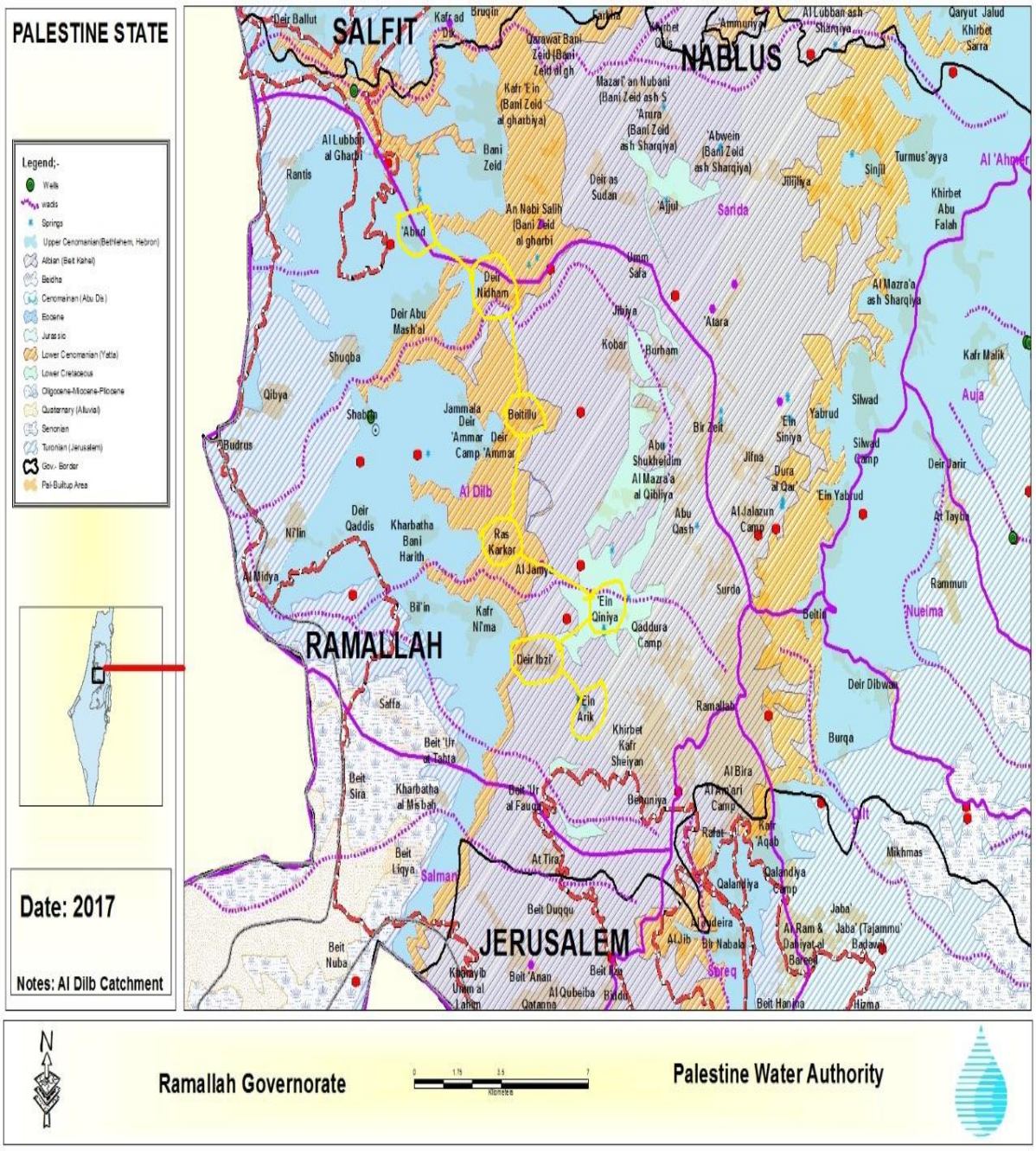

Fig.3: Geological features of the study area

Table 2: Geological formations of springs in Natuf catchment

Spring's Name	Geological formation
Ein Arik Al-tehta	Lower lower Beit Kahel
Ein Arik Al-Fuqa	Lower lower Beit Kahel
Abu-Danfora	Lower Ein Qinia
Om-Al-roman	Upper Ein Qinia
Popin	Hebron
Ein Ayoub	Hebron
Al-balad	Bottom lower Yatta
Al-quos	Lower Upper Beit Kahel
Al-zarka	Lower Yatta
Wad Al-limon	Jerusalem
Al-zarka	Jerusalem
Wad Reya	Lower Yatta

The geological formations that are found in the Natuf drainge basin are classified from recent to old, as follows (Abed and Wishahi, 1999, Susmaq, 2003).

1. Senonian:

The surface rocks of these layers are a part of Abu Dis formation and it is found in the western part of the study area (Natuf catchment). This formation is related to Eocene- Senonian ages. It is composed mainly from a chalk and chert which makes it aquiclude.

2. Turonian:

Jerusalem Formation is considered to be a hard white creamy limestone which makes it suitable for constructions materials. It is widely found in many places in the W.B mostly near Beit Fajar village.

3. Cenomanian:

This age is divided into two eras:

A. Upper Cennomanian.

1. Bethlehem Formation. The upper and lower rocky layers are found in the different areas of the W.B such as Nablus, Ein Qinia and other places. The chalky limestone and chalk composition of this formation made it a good aquifer.

B. Lower Cennomanian. The surface rocks of this formation are divided into two eras:

1. **Hebron formation**. It is found mostly in Hebron, Jerusalem Mountains and in the northern parts of the W.B. It is composed of sequences of tough limestone and dolomite. Its karstic and conduits nature gives it a high permeability and make it a good aquifer.

2. **Yatta formation**: The rocks of this formation are found in different areas of the W.B near the Dead Sea, Nablus and some parts of Ramallah city.it is to be considerd an aquiclude because it is composed mainly from marl layers with some limestone in between.

3. **Albian formation**: The rocks of this age are divided into two eras:

A. Upper Beit Kahil formation. This formation is found in the north and the middle parts of the W. B. It is composed of layers of limestone with marl layers in between.it is an aquiclude layer because of the presence of marl and chalk.

B. Lower Beit Kahil Formation:

The rocks of this layer are found in Ein Qinia in the Natuf area in the west and in Surif in the south, and Beit Forik in the north parts of the West Bank. The main composition of this formation is dolomitic limestone with few marl and marly limestone which makes it act like an aquifer.

4. **Lower Cretaceous (Albian- Abtian):**

The rocky layers of this age that are found in the Natuf catchment area are divided into two parts:

A. Qatanna rocks, which are composed of marl and clay, and they act as Aquitard.

B. Ein Qinia rocks, wich are composed of marl and marly limestone, they act as an Aquitard.

2.6A Spring Definition and Formation

Springs are one of the major water resources in the W, B, especially in the eastern part of Jericho and Dead Sea areas. A spring is a place on the earth's surface where groundwater naturally stems from aquifer system to that place. It is formed when a side of a hill, a valley bottom or any other excavation intersects a flowing body of groundwater at or below the local water table, below which the subsurface material is saturated with water.

2.7 springs Discharge

The amount of water that flows out from springs is related to many factors, including the size of cracks within the rocks, water pressure in the aquifer system, size and type of basin and the amount of rainfall.

In the study area, springs of this research and other springs of the area flow with an average annual discharge ranges between 0.3 – 0.6 million cubic meters (Mcm) of fresh water, which is mainly used for agriculture activities and sometimes for drinking purposes when there is discontinuous supply of water through the pip-line system. (Shalash, 2007).

2.8 Groundwater Resources in the W.B

Groundwater basins in the West Bank and Gaza strip provide the Palestinians with more than 90% of their water needs. The main aquifer systems of the W.B consist of several rocky deep layers from the lower cretaceous to the recent age. The quantity, quality and the extraction cost

of groundwater are determined by the spatial and vertical hydrological variety of the mountain aquifers in the W.B. The three main Palestinian aquifer basins are in the W.B are controlled and run by the Israeli occupation and they are classified as follow:

Western Aquifer Basin: It is considered to be the biggest and the most significant among the aquifer basins of the W.B. This basin has a sustainable yield estimated at 362-400Mcm. However, it is intensively exploited by the Israelis at variable rates of 340-430Mcm yearly. The Israelis provide the Palestinian with the least amount for their essential needs estimated by 32.23Mcm. In good rainy years, the recharge amount of water to the basin may reach to 520Mcm (PWA, 2014). The main aquifer system in this basin is the upper and lower Cenomanian aquifers.

North-eastern Aquifer Basin: This basin has a sustainable yield estimated at 100-145Mcm. Although majority of recharge areas are of it are located within the Palestinian boundries which run by the Palestinian authority. Nevertheless, The Israelis are heavily exploit it with amount estimated at 103Mcm, and this quantity is mainly taken from the springs of Galbou area. for Palestinians, they are only utilizing a quantity reach to 13Mcm through wells and springs which doesn’t cover all their needs. The aquifer system of this basin includes the shallow Eocen aquifer.

Eastern Aquifer Basin: It has a sustainable yield estimated at 145-185Mcm. It is divided into three sub aquifers, and they are the Jordan Valley, the Mountainous Heights and Northern-eastern Tip. The Israelis exploit an amount estimated by 150Mcm, 50Mcm through wells and 100Mcm from springs of the Dead sea that completely controlled by them, while they supply the Palestinians with a quantity estimated at 30Mcm only through wells and springs.

2.9 Villages of the study Area

Beitillu

Beitilllu is a Palestinian village located 12 km of north-west of Ramallah City with about 4500 inhabitants living in it on an area estimated with 455 donom of total area 22,000 donom. (PSCB, 2016) It is about 428 m above the sea level and surrounded with other villages such as Jamalla, Deir Ammar, Deir Nidham. The village has got 78 springs of the total number of springs in the study area, some of them are seasonal and others are durable like Ein Albalad, Ein Alqus which are a part of this study. Because of the plenty of the springs, it's considered an agricultural village, since there are 2000 donoms planted with trees of olives, citrus and field plants. Beitillu is missing for sewer system network and people use the usual way to dispose of their wastewater which is through Cesspits and septic tanks or by tankers into the near Wadis that may threat the quality of springs water, especially that located close to populated areas. (Beitillu Local Council, 2017).

Ein Arik

Ein Arik is a small Palestinian village located 7 km west of Ramallah city with about 2005 inhabited living in it. Its area is about 5934 donom, with inhabited area of about 150 donom. It's 550 m above the sea level and surrounded by villages of Deir Ibzi, Ein Qinia and Beitunia town, no Israeli settlements are surrounding the village like the other villages of the study area. The village has got many springs, but the main two springs are Ein Arik Al-Tehta and Ein Arik Al-Fuqa with abundant amount of fresh water used in agriculture and drinking purposes. Agriculture area is planted with nuts, citrus and pomegranate (Ein Arik local Council, 2017).

Abud

Abud is a Palestinian village located 35 km north-west of Ramallah City with about 2668 inhabitant living on about 250 donom with an average 1500 donom of the whole area. Its elevation ranges between 300-450 m above sea level, and annual rainfall is range from 300-650 mm\year. There are two major springs involve Ein Wad Al-limon and Ein Al-zarka, before pip-lines system in the village, people were depending on these two springs in drinking, while these days there are used for agricultural and recreational purposes.

Abud is surrounding by two Israeli settlements, Ofarim which was built in 1982 and Beit Aryah that established in 1980, some residents of Abud village unable to reach their lands because of these settlements. (Abud Local Council, 2017).

2.10 Al-Tirah Wastewater Treatment Plant

Al-Tirah (WWTP) is a wastewater treatment unit was established in 2012 by funding of Ramallah municipality designed and supervised by DURAVOM CONTRACTING CO- The capacity of this facility is about 2000 m^3 \d and serves about 25000 inhabitants in the area. It's operated and managed by the Palestinian company (Global Environmental Services), this facility uses the membrane bioreactor technology (MBR) in treating process, which has the advantage of producing high quality treated water.

The administration of the plant (GES) company performs durational tests of major wastewater parameters including BOD, COD, TSS and Nitrate

(NO_3^-) to ensure and monitor the efficiency of the plant. Also, the administration of the plant dispose of treated effluent into surrounding seasonal Wadies which may cause problems for springs water and farms, especially in Ein- Qinia. (Table 3) shows measurements of a certain wastewater parameters in both of outlet and inlet cases during the years 2015-2016 (GES, 2017).

Parameter's name	BOD mg/L	COD mg/l	TSS mg/L	Total nitrogen	Nitrate-N	Amonia-N
Inlet	375	685	340	177	Bellow detection limit	76.56
outlet	7.8	17.4	2	11.49	-	Below detection limit

Chapter Three

Methodology

To achieve the objectives of this research, different methods and tools are used and they are divided into two main approaches:

1- Descriptive approach.
2- Analytical approach.

3.1 Descriptive approach

This approach is used to describe the study area (geographic location, climate, populations) based on previous studies and people interviews

3.2Analytical approach: This approach is based on fieled work including samples collection, lab tests, lab analysis and questionnaire analysis.

3.3 Sampling and samples procedures

12 samples of water were collected from 12 springs of the villages mentioned in Table1 for dry season only. Samples were taken directly from the emerging source of the springs using 1- liter polyethleen bottles for preservation.

Physical parameters including temperature, electric conductivity EC, dissolved oxygen DO, PH and total dissolved solids were measured onsite using Hana Field Multimode Meter.

Hydrochemical parameters (Cations) involve Na^{+} K^{+} Mg^{+2} and Ca^{+2} were carried out in the labs of Al-Quds University by ICP\Ms device, while (Anions) were conducted at the water lab of Birzeit University. HCo_3^{-} was determined by titration with $H_2SO_4^{-}$ acid, NO_3^{-} -by water Capillary Ion Analyzer (CIA) device, Cl^{-} by titration with silver nitrate and SO_4^{-2} is measured calorimetrically using the turbid metric method.

The following trace elements [Li Cd Ba TI Bi B Fe Pb Cu Ni Zn Al Cr Mn Ag Mo and Co] were investigated in the labs of Al-Quds University by ICP\Ms, a 100 ml of each collected sample was acidified with Avistar

Concentrated 69% Nitric acid (14.4 M HNO_3) and stored at $4C^o$ before testing process. A 100 ml of sterile glass bottles were used in collecting samples for microbiological tests of Total coliform (T.C) and Fecal coliform (F.C), after collection.

Samples stored in iced-box and transferred to the water and environmental lab at Birzeit University B.Z.U in the same day of sample's collection. Total organic Carbon (TOC) was performed in the lab of pharmacy faculty at B.Z.U by titration.

3.4 Questionnaire Analysis

The study involved 50 samples of questionnaire were distributed randomly to the landowners and the farmers. The questionnaire implied 4 main parties; the first one is personal information such as age, educational level, sex and job. The second part is related to the frequent use of springs water and the dangers that affect them. The third part is about the effects of farm land reclamation on the quality of the springs through using fertilizers and pesticides and the last part is about rainfall harvesting and springs water management. Data of questionnaires were analyzed by Al-amer center for students services. The main results of questionnaire analysis represent in frequencies and percentages. Moreover, Chi square test is used to study the relation between the farming and source of income for people in the area.

Chapter Four
Results and Discussion

4.1 Hydrochemistry

4.1.1 pH

pH is a significance water parameter and it is used to measure the acidity and alkalinity of a solution. It should be taken in consideration in water quality assessment. It is a way of expressing the hydrogen ion – concentration. pH values of springs water in Natuf Catchment ranges between 6.8 – 7.1 with a mean 6.9 which shows that all inorganic carbon are exist as bicarbonate (HCO_3^-). pH has no measurement unit and it was measured for all samples onsite using Hana field Multimode meter.

4.1.2 Temperature

Temperature is physical water parameter expressing how hot or cold water is, it's measured in degree Celsius (C^o). It's a parameter for monitoring groundwater quality because the majority of physical and chemical properties of groundwater affect by the temperature like DO, EC, pH, TDS and mineralization process.

The measured temperatures of all springs water were in the range of 21.6 -24.6 C^o with an average 22.9 C^o. This indicates that there was no difference between the surrounded atmospheric temperature and springs water temperature in the study area at that time.

4.1.3 Dissolved Oxygen (DO)

DO is essential for all living organisms that live in water and It's measured in mg\L. DO refers to the amount of free-non compound oxygen dissolved in water, DO concentrations are influenced by several factors including temperature, elevation, pressure and salinity, as temperature increase, the amount of DO decrease and vice versa, while when pressure increases, the amounts of DO increase, which reveals that concentration of DO in water α with pressure and irreversibly with temperature.

The measured concentration of DO for springs water in the study area was carried out onsite by Hana Field Multimode meter. The concentration of DO were in the range between 5.25 -7.6 mg\L with a mean 6.4 mg\L.

4.1.4 Electric Conductivity (EC)

EC of water is the measure of water capability to carry an electrical current or to pass electrical flow. It's measured in micro- or millisiemens per centimeter µs\cm or MS\cm, the standard unit for freshwater is MS\cm.

The ability of water to conduct electrical current depends on the type and number of ions dissolved in water. These conductive ions come from dissolved salts and inorganic materials such as alkalie, Chlorides, Sodium, Potassium and Carbonate Compounds. Most of dissolved salts and inorganic substances present in water one in ionized form (Cl^-, Na^+, K^+, SO_4^{-2}, HCO_3^-, NO_3^-, Fe^{2+}). (EC) can be used as a rapid measure replacing total dissolved solids (TDS) concentration, where EC measurements give a practical estimate of the variation in dissolved minerals. The measurements of EC conducted in this range between 650-1120µS\cm. The maximum value of EC was recorded in Abu Danfora spring and the minimum value was recorded in Ein Arik Al-fuqa spring.

The variation in EC values for springs water is resulted from variation of the total dissolved solids (TDS) for these springs. The possible cause of high EC for Abu Danfora spring of 1120µS/cm is due to the interfering mixing of treated effluent that come from Al-Tirah (WWTP), in addition to the location of spring near agricultural area. The relationship between EC and mineralization process indicates that springs water can be classified as highly mineralized.

4.1.5 Total Dissolved Solids (TDS)

TDS represents all inorganic salts dissolved in water, basically chloride, sulfide, bicarbonate, calcium, magnesium, nitrate and some small amounts of organic matter in polluted water is measured in mg\L. The acceptable level of TDS in drinking water should be less than 1000 mg\L according to WHO guidelines and Palestinian students. High levels of TDS may impart an objectionable taste to drinking water; also it has irrigation effects where high levels of salts limit the growth of plants. TDS measurements help in determining the suitability of springs water for household and farming targets. All water of springs samples in the study area showed a TDS values less than 1000 mg\L, which indicated that these springs water can be classified as a fresh water according WHO guidelines as shown in Table 4. TDS measurements for 12 springs of Natuf

The maximum value of TDS was recorded in Abu Danfora spring with 642mg/L and the minimum value was in Ein Arik Al-fuqa with 294mg/L

Generally, water can be classified based on TDS into fresh, brackish, saline and brine water. The relationship between EC and TDS in the springs water of the study area is strong and the TDS versus EC values showed that the value of the linear correction coefficient R^2 is close to one according equation ($TDS=0.71EC-175.0$ $R^2=0.90$) as shown in Figure 4

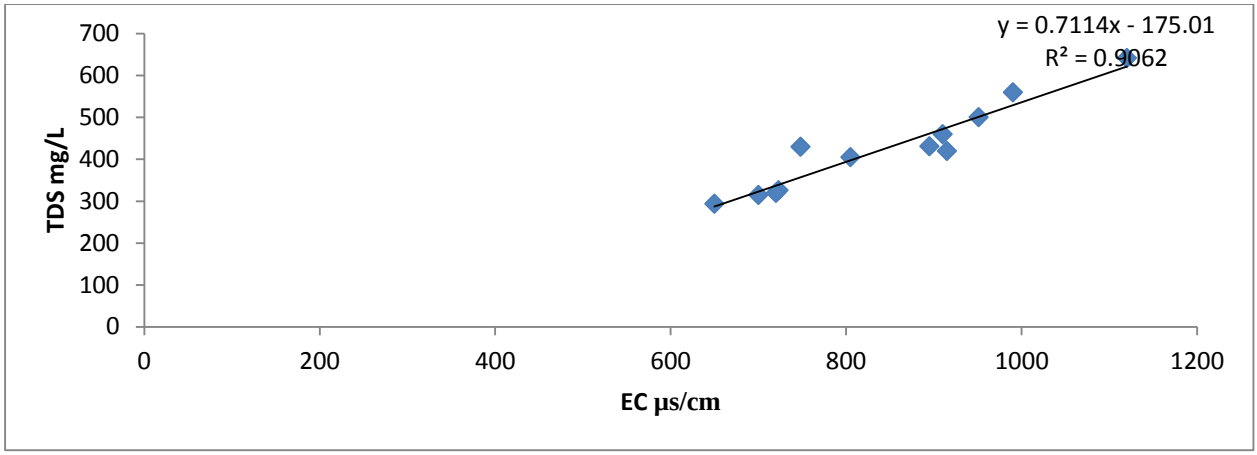

Fig. 4: Relationship between TDS and EC for springs water in the study area

Table 4: The classification of springs water according to (TDS) concentration (Todd, 1980**)**

Water Class	**TDS (mg\L)**
Fresh	< 1000
Brackish	1000 – 1000,0
Saline	10,000 – 100,000
Brine	>100,000

Table 5: The statistical values of physical parameters for springs water samples in the study area.

Spring's Name	**TDS mg\L**	**EC µS\cm**	**DO mg\L**	**T C°**	**PH**
Wad Reya	501	951	6.8	21.6	6.95
Al-zarka, Beitillu	420	915	5.7	24.6	6.89
Ein Arik Al-tehta	405	805	7,05	22.6	6.92
Ein- Arik Al-Fuqa	294	650	7.6	22.2	7.05
Ein Ayoub	460	910	6.4	21.9	6.99
Al-zarka, Abud	430	748	5.9	22.6	7.08
Al-balad	431	895	7.6	24.3	6.81
Al-qus	320	720	7	24	6.93
Popin	326	723	6.5	22	7.01
Wad Al-limon	560	990	6.2	22.7	6.77
Om Al-roman	315	700	5.25	23.2	6.84
Abu Danfora	642	1120	5.30	24	6.79

4.1 .6 Calcium and Magnesium (Ca^{2+}, Mg^{2+})

Calcium is one of the major cations that almost exist in all natural waters. It's measured in mg\L. It originate from dissolution process of minerals of limestone ($CaCO_3$), dolomite ($Ca.Mg(CO_3)_2$ and gypsum ($CaSO_4.2H_2O$) through the percolation of rainfall water. The acceptable levels of Ca^{2+} concentration is 100 mg\L according to Palestinian standard and WHO guidelines.

Concentration of Ca^{+2} in the springs water samples ranges between 5.29 mg\L in Al-qus spring to 19 mg\L in Abu Danfora spring with an average 9,7 mg\L. Calcium concentration level for all water samples was below the WHO guidelines, the higher concentration of Ca^{+2} in Abu Danfora spring is refer to long water contact time with minerals and continuous weathering process of soil and bed rocks.

Magnesium (Mg^{+2}) is also a major cation in natural waters and measured in mg\L. The presence of Mg^{2+} in ground water refers to dissolution process of dolomite ($Ca.Mg\ (CO_3)_2$ mineral. Concentration level of Mg^{2+} for water samples of springs in Natuf Catchment area varies from 11.35 mg\L in Wad Al-Limon spring to 19.72 mg\L in Ein Ayoub, analysis of Mg^{+2} by ICP\MS shows that there was no significant difference among Mg^{2+} concentrations of concerned springs water samples.

Calcium and Magnesium (Ca^{2+}, Mg^{2+}) are the two common minerals dissolved in water that responsible for water hardness phenomena. The degree of hardness becomes greater as the concentration of both (Ca^{2+}, Mg^{2+}) increases. Hardness of water refers to Calcium and Magnesium present in water and is expressed as an equivalent concentration as Calcium carbonate ($CaCo_3$), waters with less than 75 mg\L $CaCo_3$ are

generally considered soft, those with between 75-150 mg\L $CaCo_3$ are considered to be moderately hard, those with 150 – 300 mg\L are hard and waters with more than 300 mg\L are classified as very hard. Springs water of Natuf catchment area can be classified as a soft water because the total of Mg^{2+}, Ca^{2+} for all samples were less than 150 mg\L and much more less than WHO guidelines of 300 mg\L $CaCo_3$. (Gloria et al, 2005)

Hard water is not health hazard, but it has negative effects that limit its uses for domestic and industrial purposes. High levels of Ca^{+2}, Mg^{+2} ions in water lead to form insoluble salts with anions in soap, forming a scum in wash water, also Ca^{2+}+Mg^{2+} ions cause mineral build up in sinks, tubes which may close them.

4.1.7 Sodium and Potassium (Na^+, K^+)

Sodium is a naturally constituent of drinking water. It comes from dissolution process of rocks and minerals of Halite (NaCl). Standard level concentration of Na^+ is 200 mg\L, so concentration of Na^+ above 200 mg\L may lead to high-blood pressure disease (hypertension) for humans. Concentrations of Na^+ for samples of springs in Natuf basin range from 9.99-31.80 mg\L except Abu Danfora spring which recorded the highest value concentration of 76 mg\L, the reason behind that is due to the weathering process and mixing of the treated effluent that comes from Al-Tirah (WWTP) with spring water leads to add considerable amount of Na^+ to the spring. Based on previous data measurements of Na^+ concentrations for springs in the study area, it's clearly that concentration of Na^+ increases in the dry season as a result of evaporation and low flow rate, while it decreases in the wet season as consequence of dilution process by rainfall.

The occurrence of Potassium (K^+) in ground water comes from dissolution process of mineral of sylvite (KCl) and sometimes from decaying of plants, especially leaves. The acceptable level concentration of K^+ is 50mg/L according to WHO standards. The concentration of K^+ in water samples varies from maximum of 5 mg\L in Ein Arik Al-Tehta to a minimum value of 0.53 inWad Reya spring, which reveals that there is no outsource (anthropogenic) that may increase concentration of K^+ in springs of Natuf catchment. Figure 5 illustrate the different cations concentrations of springs in Natuf area.

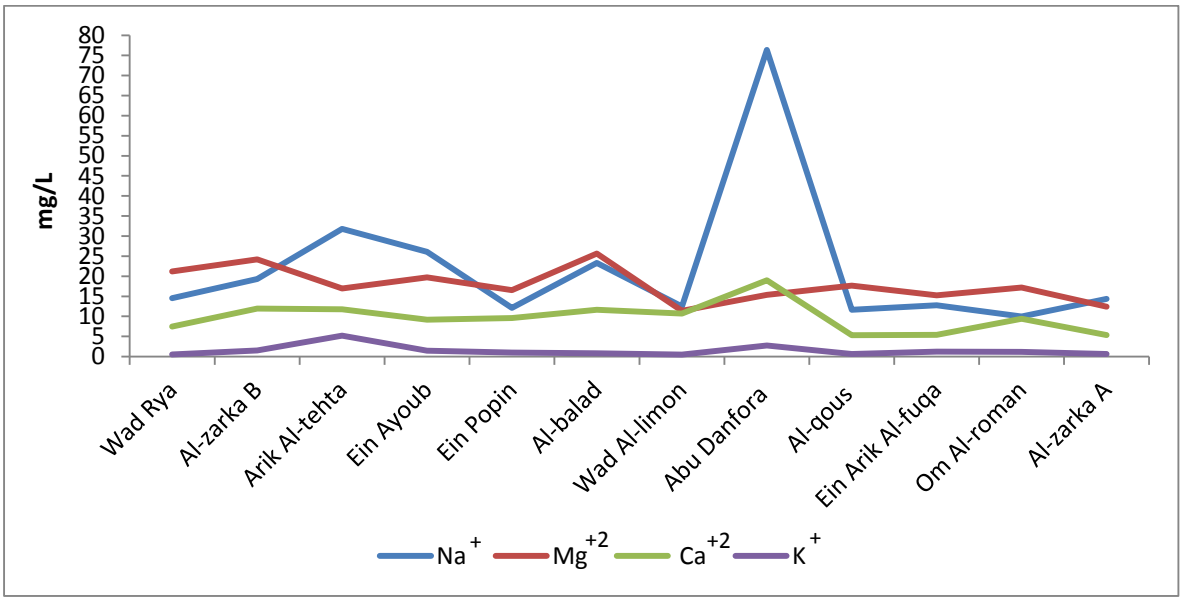

Fig.5: Concentrations of cations for springs water samples in the study area.

Table 6: Concentrations of cations for springs water samples in the study area

Spring's Name	**Ca^{+2} mg/L**	**Mg^{+2} mg/L**	**Na^{+} mg/L**	**K^{+} mg/L**
Wad Reya	7.47	21.16	14.51	0.53
Al-zarka, Beitillu	11.96	24.18	19.32	1.50
Ein Arik Al-tehta	11.76	16.96	31.80	5.17
Ein- Arik Al-Fuqa	5.37	15.21	12.78	1.23
Ein Ayoub	9.18	19.72	26.10	1.42
Al-zarka, Abud	5.34	12.39	14.34	0.63
Al-balad	11.67	25.63	23.33	0.78
Al-qus	5.29	17.64	11.64	0.64
Popin	9.57	16.54	12.14	0.97
Wad Al-limon	10.69	11.35	12.47	0.49
Om Al-roman	9.39	17.21	9.99	1.16
Abu Danfora	19	15.35	76.40	2.72

4.1.8 Nitrate (NO_3^-)

Nitrate is considered one of the major anions in natural water. Cesspits, agricultural activities (fertilizers) and animal manure contribute in increasing NO_3^- concentrations in natural water (Widory et.al, 2004). Concentration of NO_3^- in water above WHO standard of 45mg/L could be toxic for both humans and Cattle. For humans, it causes methemoglobinemia (blue babies' syndrome) in infants and certain susceptible segments of the adult population. Blue babies occur due to conversion of nitrate (NO_3^-) to nitrite (NO_2^-) by nitrate – reducing bacteria in the gastrointestinal tract. (Bitton, 2005).

The concentrations of NO_3^- for all samples were in the range 6.1 – 8.7 mg\L with a mean 7.4 mg\L. The results of analysis for NO_3^- indicate that all samples are not contaminated with nitrate and all concentrations of NO_3^- for all samples were much more less than the WHO standard limit of 45mg/L as shown in figure 6

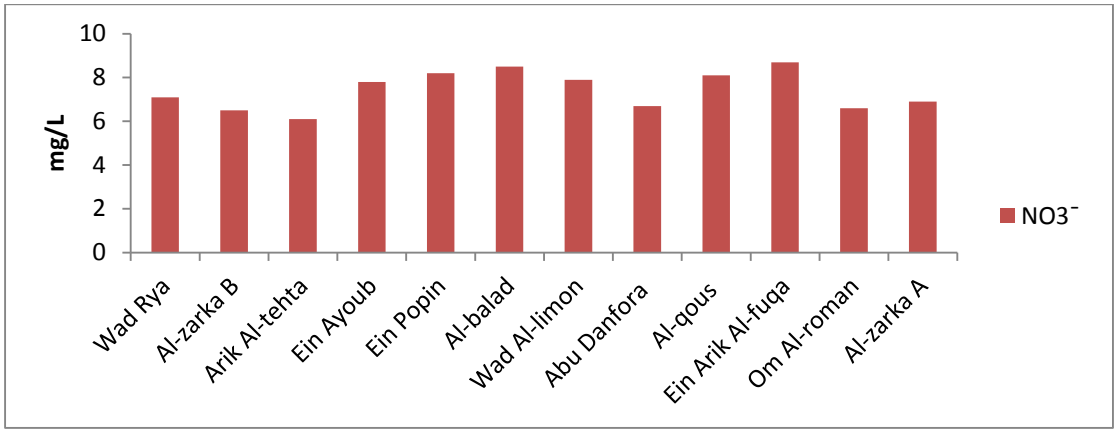

Fig. 6: Nitrate concentrations for springs water samples in the study area.

3.1.9 Sulfate (SO_4^{2-})

Sulfate is a naturally anion in drinking water. It comes from dissolution process of minerals of gypsum ($CaSO_4.H_2O$). Industrial wastes disposal that contain sulfur, agricultural activities (fertilizers) and decomposition of organic materials contribute to rise the concentration levels of SO_4^{2-} into groundwater reservoirs. (Ghanem, 1999). The allowed concentration of SO_4^{-2} in groundwater is up to 250 mg\L. (Todd, 1980).

High concentrations of SO_4^{-2} in drinking water give a better taste and may cause transitory diarrhea, also high level of SO_4^{-2} in industrial water is not favorable, it forms with Ca^{+2} and Mg^{+2} a layer of sediments that prevents heat exchange in heaters (Todd, 1980).

The concentrations of Sulfate in all samples in the springs of the study area were in the range 16.8-29.8 mg\L with a mean 22.8 mg\L.

The highest value was recorded in popin of 29.8 mg\L and the lowest value in Ein Arik Al-tehta of 16.8 mg\L. The measured concentration of SO_4^{-2} for 4 samples of Al-zarka (Beitillu), Wad Reya, Abu Danfora and Ein Arik Al-Tehta almost have the same concentration of 23 mg\L. Concentrations of SO_4^{-2} for all samples were much more less than WHO standard.

4.1.10 Chloride (Cl^-)

Chloride is abundant element occurring in natural waters. In groundwater, it originates from dissolution of minerals of Halite (NaCl) and sylvite (KCl). Cl^- concentrations in groundwater can be elevated due to continuous discharge of raw or not fully treated wastewater which comes from human urine (Sawyer et. al, 1994). Most of pesticides that use in agriculture domain contain Chloride which contributes in increase of Cl^- into groundwater through biodegradation process.

Standard level of Cl^- is 250 mg\L. Concentration of Cl^- above 250 mg\L gives a salty taste of water which makes it objectionable for both domestic and irrigation uses. The concentrations of Cl- for all samples in the Natuf catchment area were in the range 33.1-49.8mg\L with a mean

37.9 mg\L. The measured concentration of Cl^- varies from maximum value of 49.8 mg\L in Wad Al-Limon spring to minimum value of 33.1 mg\L in Al-Zarka (Beitillu Village), which are below WHO standards.

4.1.11 Bicarbonate (HCO_3^-)

Bicarbonate is a common anion in groundwater; it's usually associated with Ca^{+2} and Mg^{+2} concentrations. The occurrence of HCO_3^- in springs water is refer to the reaction between Carbon dioxide (CO_2) and water droplets from the atmosphere to form carbonic acid ($H_2CO_3^-$, which reacts with soil particles and carbonate rock to produce HCO_3^- according to the equation

$$\mathbf{H_2\,CO_3 + Ca\,CO_3 \rightarrow H^+ + 2HCO_3^-}$$

Concentration of bicarbonate in groundwater is acceptable by the value of 500 mg\L (Todd, 1980). It's obvious from the analysis of HCO_3^- that the measured values for all samples of springs water in the study area were less than 500 mg\L, which indicates to the suitability of using springs water for drinking purposes. The highest concentration of HCO_3^- was recorded in Om Al-roman spring of 209 mg\L, and the lowest one of 166mg/L in Ein Ayoub as shown in Figure 7.

The highest values of HCO_3^- in the springs are recorded in dry season due to the longer residence time of water with dolomite and limestone formations (Shalash, 2006). Figure 8 and Table 6 show the concentration of anions for all water samples in Natuf area.

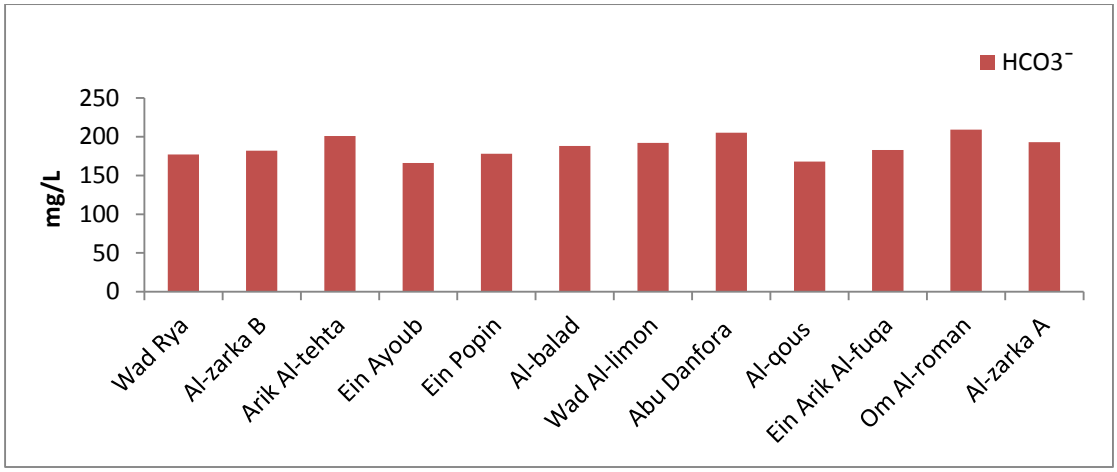

Fig.7: Bicarbonate concentrations for springs water samples in the study area

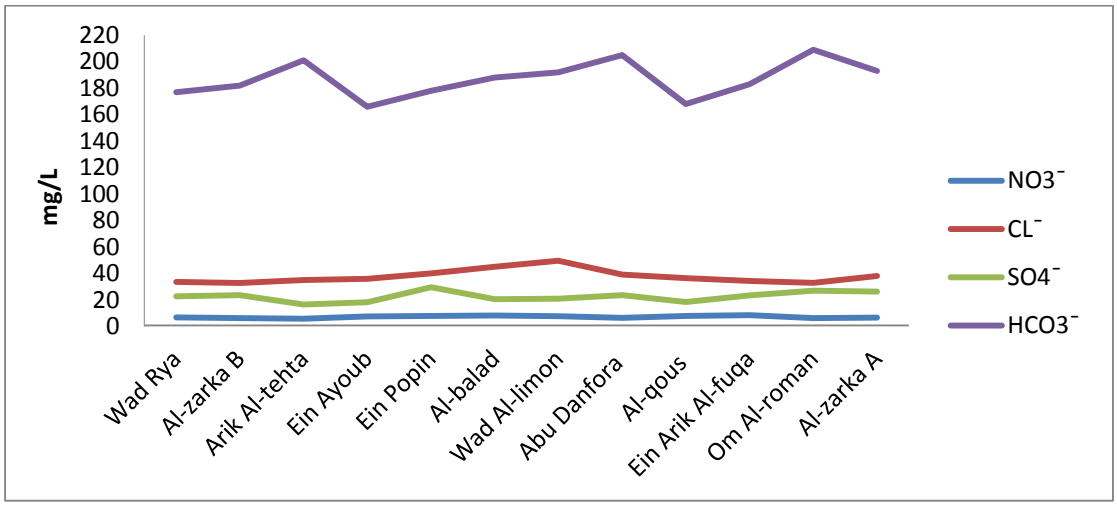

Fig.8: Concentrations of anions for springs water samples in Natufe area

Table 7: Concentrations of anions for springs water samples in Natufe area

Spring's Name	HCO_3^- mg/L	Cl^- mg/L	SO_4^{-2} mg/L	NO_3^- mg/L
Wad Reya	177	33.8	23	7.1
Al-zarka, Beitillu	182	33.1	23.8	6.5
Ein Arik Al-tehta	201	35.2	16.8	6.1
Ein- Arik Al-Fuqa	183	34.5	23.7	8.7
Ein Ayoub	166	36.2	18.5	7.8
Al-zarka, Abud	193	38.3	26.5	6.9
Al-balad	188	45.2	20.8	8.5
Al-qus	168	36.7	18.7	8.1
Popin	178	40.2	29.8	8.2
Wad Al-limon	192	49.8	21.2	7.9
Om Al-roman	209	33.2	27.3	6.6
Abu Danfora	205	39.4	23.9	6.9

4.1.12 Trace Elements

Trance elements can be naturally found in groundwater from bedrocks, climate, soil and dissolution of some minerals, but most commonly they introduce to groundwater from industrial and agricultural activities such as chemical industries, cars, solid wastes disposal and wastewater.

The following trace elements including (Fe^{+2}, Li, D, Sr, Ba, Ti, Pb, Bi, Al, Cr, Mn, Co, Ni, Cu, Zn, Mo, Ag and Cd) were analyzed by ICP\MS, the results of analysis were compared with WHO standards to make sure that the selected samples of springs water in Natuf catchment are not contaminated with these elements and exist with the allowable limits of WHO.

Trace elements such as Cobalt, Iron, Lead, Cadmium, Chromium and Arsenic are toxic and harmful for both living organisms and humans if they the surpasses the permissible limits of WHO standards. Results of analysis for all trace elements mentioned above showed that their concentrations were within the allowable WHO standard for drinking water or even some of them were below the detection limits(Table7). Some trace elements were recorded as the highest concentrations more than other elements in water samples, these elements including Fe^{+2}, Ni, Al, Cu and Zn, but within the allowable limits. The highest concentration of Zn was recorded in Alqus spring in Beitillu with 246µg/L (Figure 9) and this can be attributed to the presence of cans and materials contain zinc surrounding the spring.

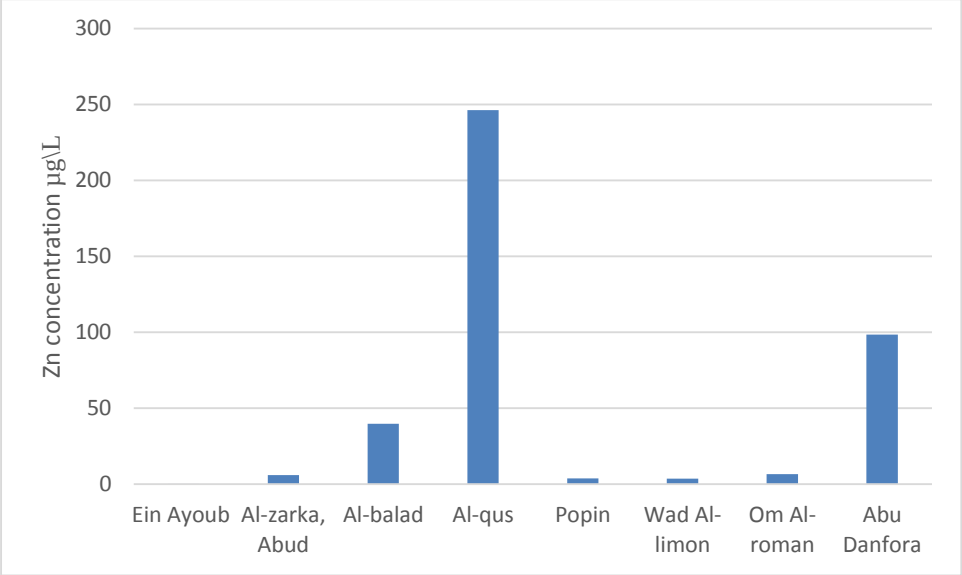

Fig.9: Concentrations of Zn of springs water samples in the study area

Table 8: Concentrations of trace elements for springs water sampes in the study area

Spring's Name	**Zn µg/L**	**Ni µg/L**	**Al µg/L**	**Fe^{+2} µg/L**
Wad Reya	8.14	0.46	5.81	2.91
Al-zarka, Beitillu	67.9	4.03	2.62	1.95
Ein Arik Al-tehta	6.10	4.00	5.13	1.62
Ein- Arik Al-Fuqa	<0.00	16.9	2.85	1.29
Ein Ayoub	0.12	5.55	6.47	2.08
Al-zarka, Abud	5.93	2.42	2.16	2.88
Al-balad	39.82	2.65	2.86	2.31
Al-qus	246.19	4.21	6.57	1.38
Popin	3.87	13.3	6.85	1.49
Wad Al-limon	3.57	0.69	7.68	6.63
Om Al-roman	6.59	6.06	1.37	2.43
Abu Danfora	98.53	3.44	4.84	0.79

4.1.13 Total Organic Carbon (TOC)

Organic compounds in groundwater derive from different sources including the breakdown of naturally occurring organic materials such as leaves of trees and man-made chemicals from domestic, commercial and agricultural activities. These man-made organic chemicals enter to groundwater through wastewater, agricultural activities and urban runoff which make groundwater polluted and has a potential health effects on people's life. The test of (TOC) was applied in pharmaceutical labs of B.Z.U where traditional method of analysis (titration) was used to determine if the tested samples have (TOC) or not. Determination of (TOC) can provide valuable diagnostic evidences of the extent of groundwater contamination by organic compounds. The results of analysis showed that most of water samples were free of (TOC), two samples of (Ein Arik Al-tehta and Al-zarka Bietillu) have (TOC), the source of these materials could be attributed to wastewater from cesspits, particularly these two springs that are located so close to cesspits.

4.1.13 Microbiological Analysis

Fecal coliform bacteria are that type of bacteria which usually live in the digestive tracks of warm blooded animals. Despite they are not harmful and a part of normal digestive system of warm blooded animals. Nevertheless, some of them are pathogenic to humans and may cause different diseases for them such as cholera and hepatitis.

Pathogenic microorganisms don't naturally exist in water; rather they enter the water through feces and urine of humans and animals, as a result of continuous supply of raw or partially treated wastewater from domestic houses, local municipalities and bio industry. Analysis of microbiological parameters of water samples in Natuf area showed that the springs of (Wad Reya Al-zarqa in both Bietillu and Abud Ein Arik Al-tehta and Al-fuqa, Popin and Albalad) are contaminated in fecal coliform bacteria which reveals a leaking of wastewater from cesspits or animal feces into these springs while other springs in the study are free of fecal bacteria which make them good for drinking purposes. The highest concentration of fecal bacteria was recorded in Ein Arik Al-tehta with 42 CFU/100ml and the lowest one recorded in Al-zarqa Bietillu with 7 CFU/100ml. Table8 and Figure10 show the concentrations of fecal and total coliform bacteria in all water samples in the study area.

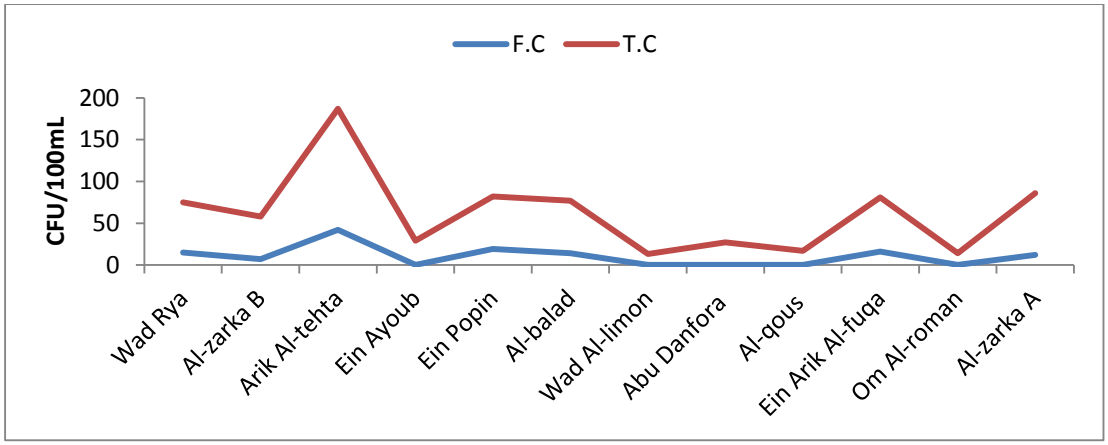

Fig.10: Concentrations of F.C and T.C bacteria for springs water samples in the study area

Table 9: Concentrations of F.C and T.C bacteria for springs water samples in the study area

Spring's name	**F.C CFU/100ml**	**T.C CFU/100ml**
Wad Reya	15	75
Al-zarka Bietillu	7	58
Ein Arik Al-tehta	42	187
Ein Ayoub	0	29
Popin	19	82
Albalad	14	77
Wad Al-limon	0	13
Abu Danfora	0	27
Al-qus	0	17
Ein Arik Al-Fuqa	16	81
Om Al-roman	0	14
AL-zarka Abud	12	86

4.2Socio-economic Environmental Analysis

4.2.1 Introduction

Water is the most precious thing on the earth for all living organisms without any exceptions, not for living only, water nowadays has strong ties to social, economic and political life. So every drop must be accounted for, especially in regions suffering from water scarcity. The occupied Palestinian territories represent water resources deficiency which arise greater interest to clarify the main aspects of the problem and its suggested solutions on both popular and governmental level. To evaluate the socio-economic environmental impact of spring water utilization on people's life, they have been asked through questionnaire about these aspects in the study area.

This questionnaire aims at showing the social, economic and political effects of exploiting the springs water in the study area on its residents' life, and the obstacles that limit their utilization of the springs water weather they are environmental or political obstacles related with status quo.

4.2.2 Sample Characteristics

50 questionnaires were distributed to farm land owners who are mostly utilized from the springs water in the Natuf catchment area. The sample included both males and females, with 80% males who form the highest rate related to farming career or interest and 20% females as shown in Figure 11.

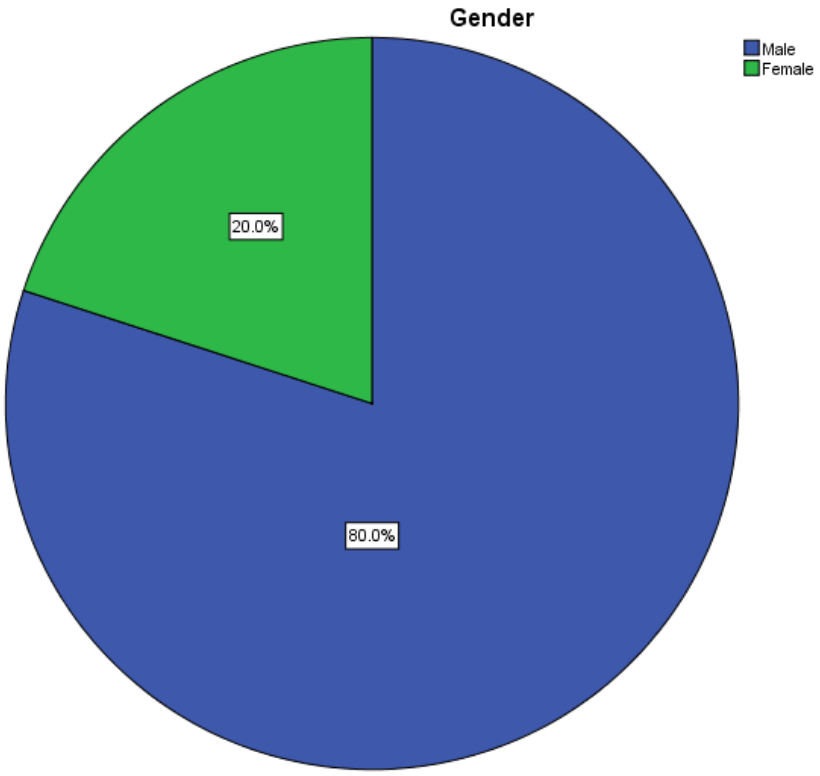

Fig.11: Percentage distribution of sex sample in Natuf area

The study shows the age categories who are the most and the least interested in farming i.e.; people aged between 15-25 formed 32%, while people aged between 26-35 10%, and people aged between 36-45 are 20%, 46-55 are 32% and people who pass 55 are 6% (Figure12). The questionnaires show that all age categories practical farming and farming is not specialized to a certain age.

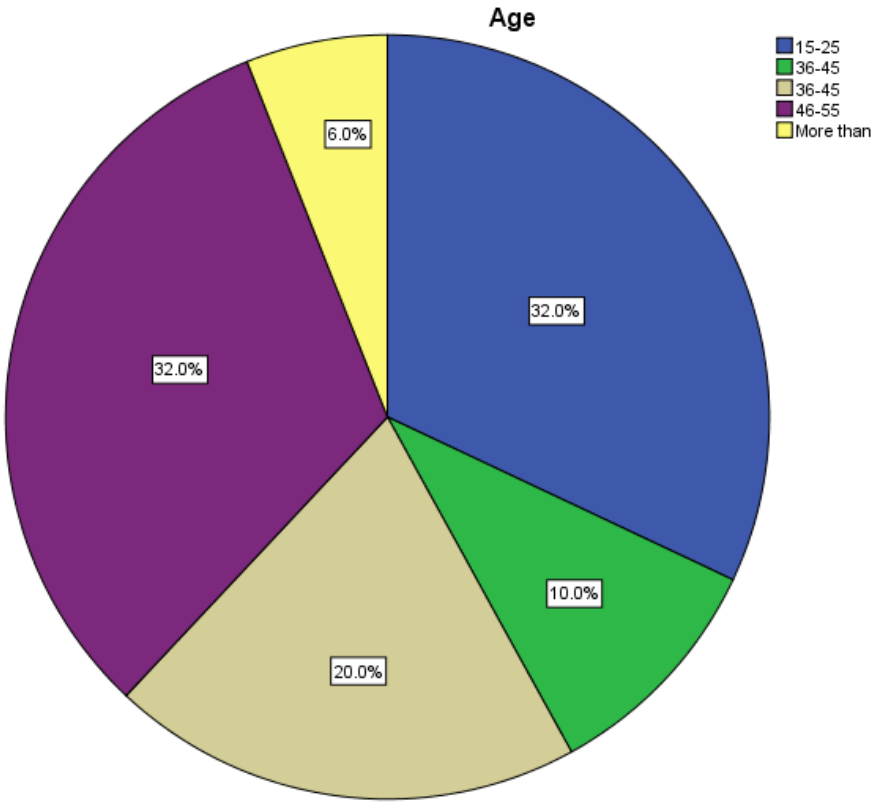

Fig .12: Percentage distribution of age samples in the study area

2% of the questioned people ended their higher education, according to the school students' categories as shown in the Figure 13. Below, 22% of them ended their primary educations, while 44% ended their secondary one, for academic people who graduate or still study in universities formed 30% of the study sample.

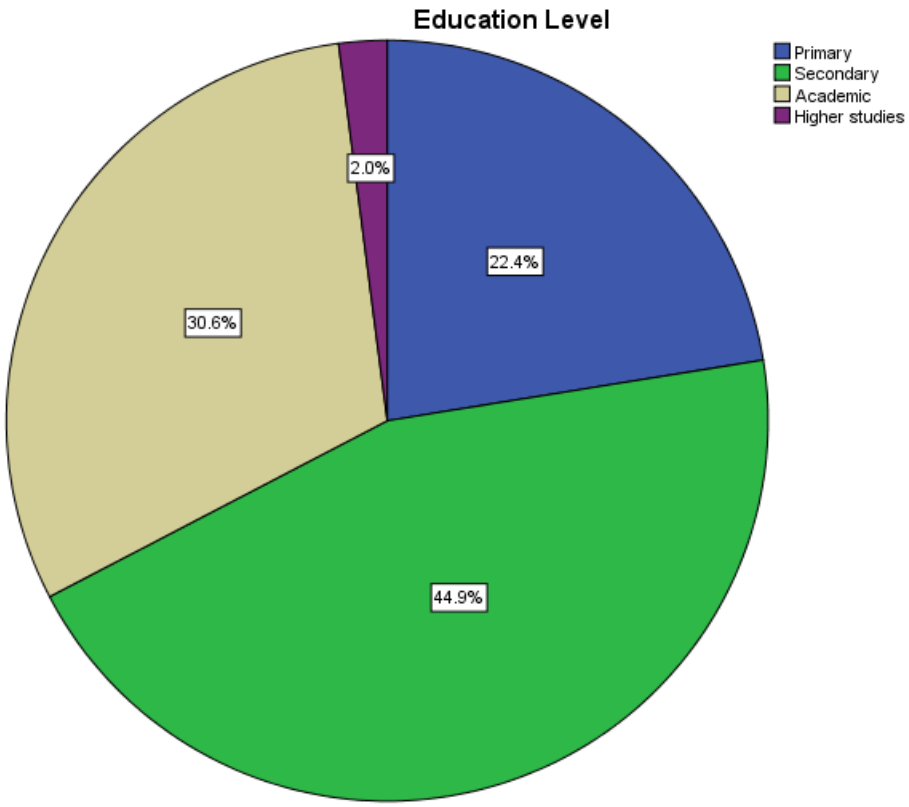

Fig.13: Percentage distribution of educational levels for the tested samples in Natuf area

The variety of education levels for the questioned people reflected the nature of their careers. The study shows that 76% works in vocational careers, while 14% are committed in governmental institutions and 10% works in private sector as in Figure14.

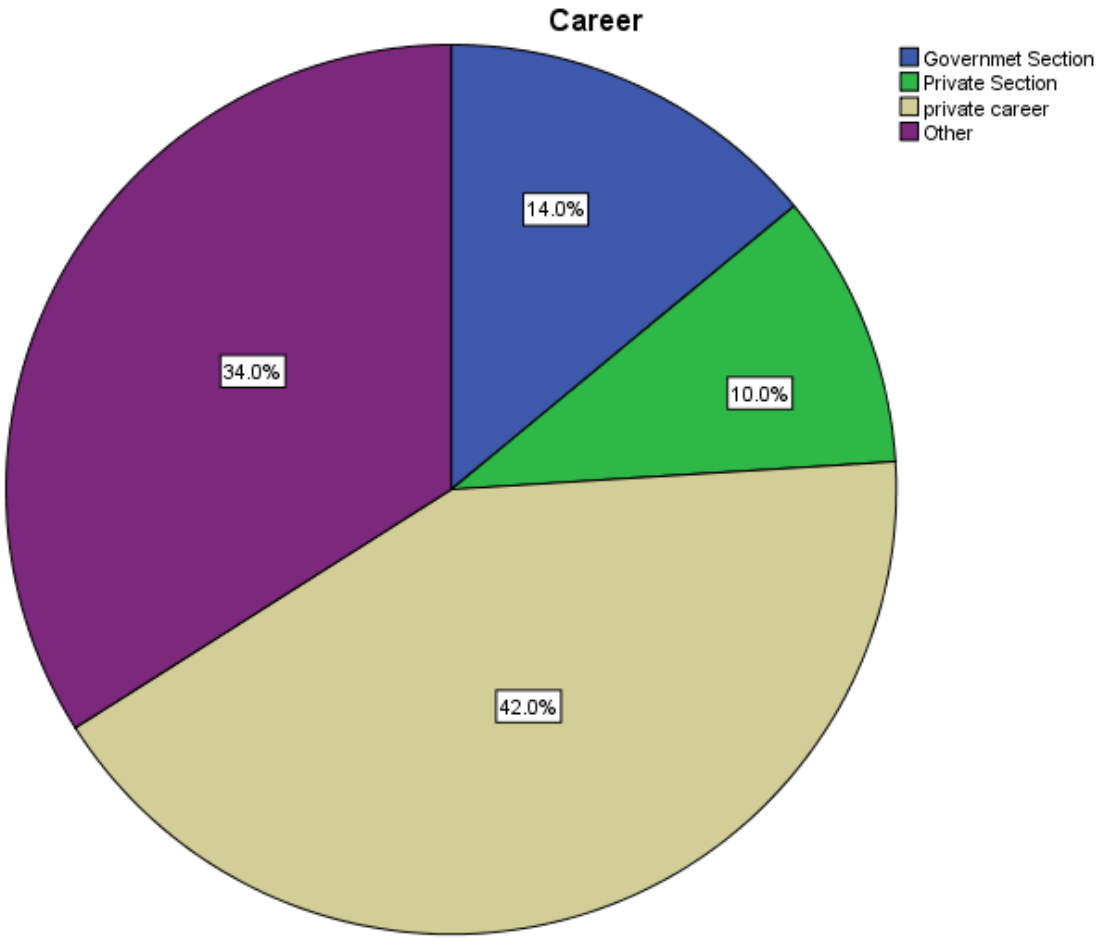

Fig. 14: Percentage distribution of careers types for the tested samples in the study area

4.2.3 Springs utilizations

Springs are one of the most important water resources in the occupied territories, especially in the Natuf catchment which contains 78 springs in Beitillu village only. The study shows that springs water in the study area used in farming and drinking purposes, analysis results of questionnaire show that 89% from the questioned people use it for farming, where as 9% of them use it for drinking and 2% of them use it for other targets such as constructions as shown in Figure 15.

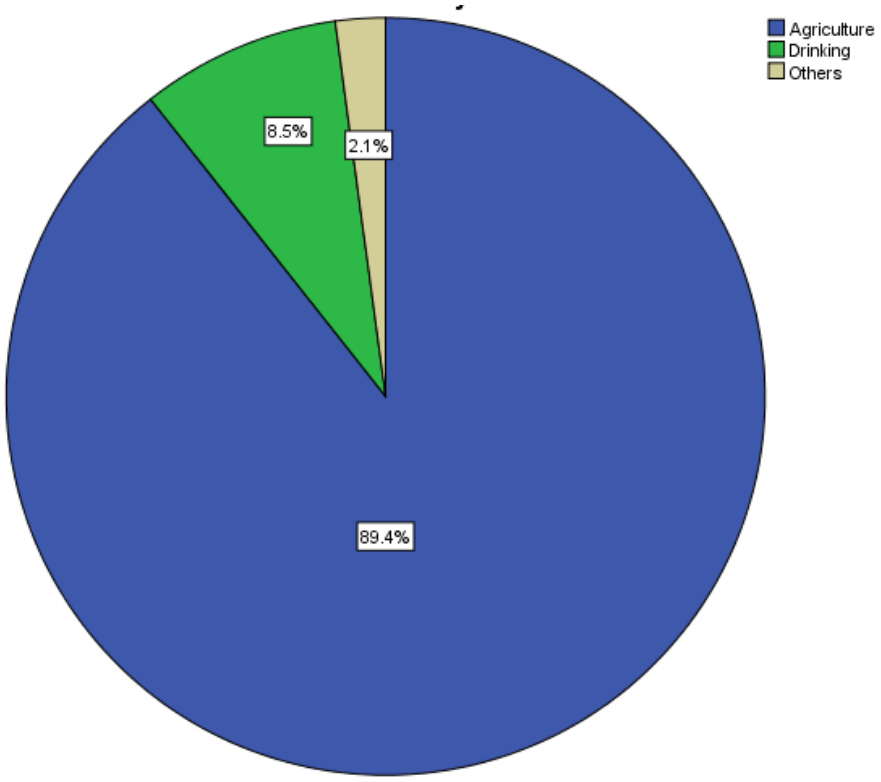

Fig.15: The purposes of using springs in their different activities

The lack of depends on springs as a source of drinking can be attributed to the existence of internal water network in the study area which decreases the people efforts to get the water from the springs. Figure 16 illustrate people's opinions toward the presence of internal water network on spring utilization in the study area.

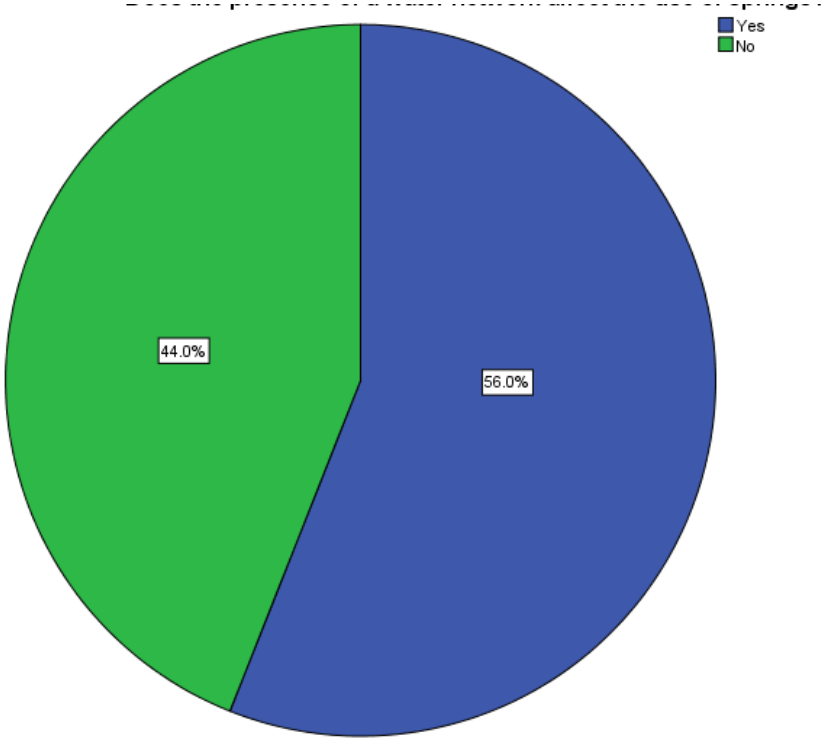

Fig .16: People's opinions toward if the presence of internal water network affects on the use of springs water in the study area.

Supposedly, the concerned authorities such as PWA, authority of quality environment and ministry of archeology and tourism must show interest in the quality and the maintenance of the springs water as they a part of national security. However, in the study area, it's found that by analysis the data received from the questioned people that 79.8% of them see that the authorities don't care about springs, while 20.8% of them see that these authorities take care of springs from time to time as shown in Figure 17.

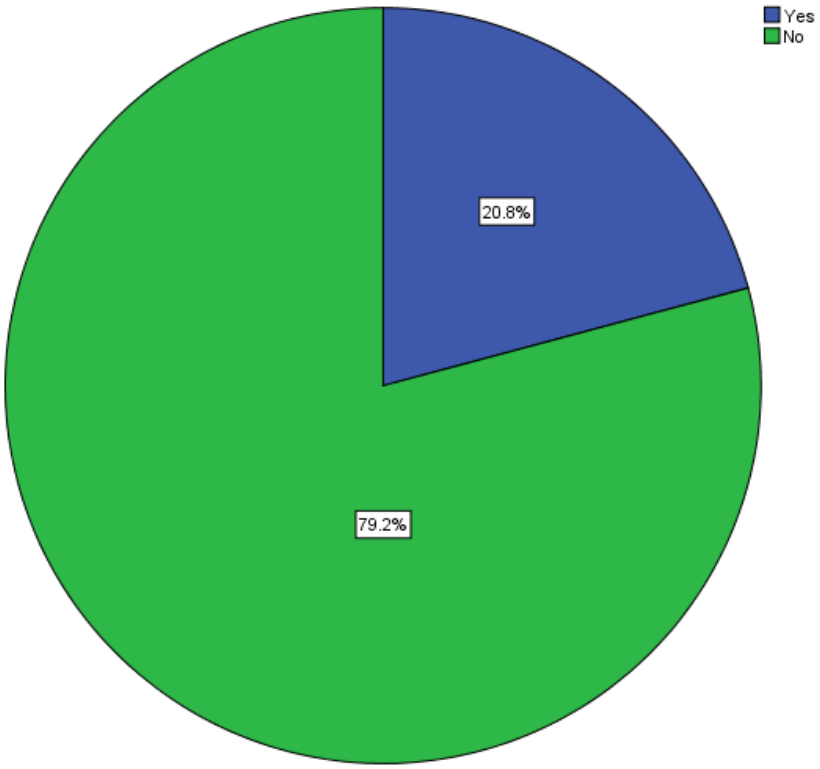

Fig.17: People's opinions toward the concerned authorities if they care about the springs in the study area.

4.2.4 Springs and pollution

Wastewater is considered as one of the pollution sources that threats the groundwater quality if it disposed as a raw or not fully treated to receiving environment. The major urban areas in the study area extend over the high parts of Ramallah geographic, these high parts are the main recharge area to the Natuf basin. The inadequate disposal of wastewater, especially over the highly permeable areas of the karstic, limestone W.B aquifers, will definitely endanger the quality of groundwater.

In the study area, the majority of villages are missing to sewer systems and people get rid of their wastewater through cesspits or in open areas. Therefore, people were asked about whether there are cesspits close to the

springs. The answer is 36.7% of springs are located close to cesspits, while 63.3% of springs are not close to them as shown in Figure18.

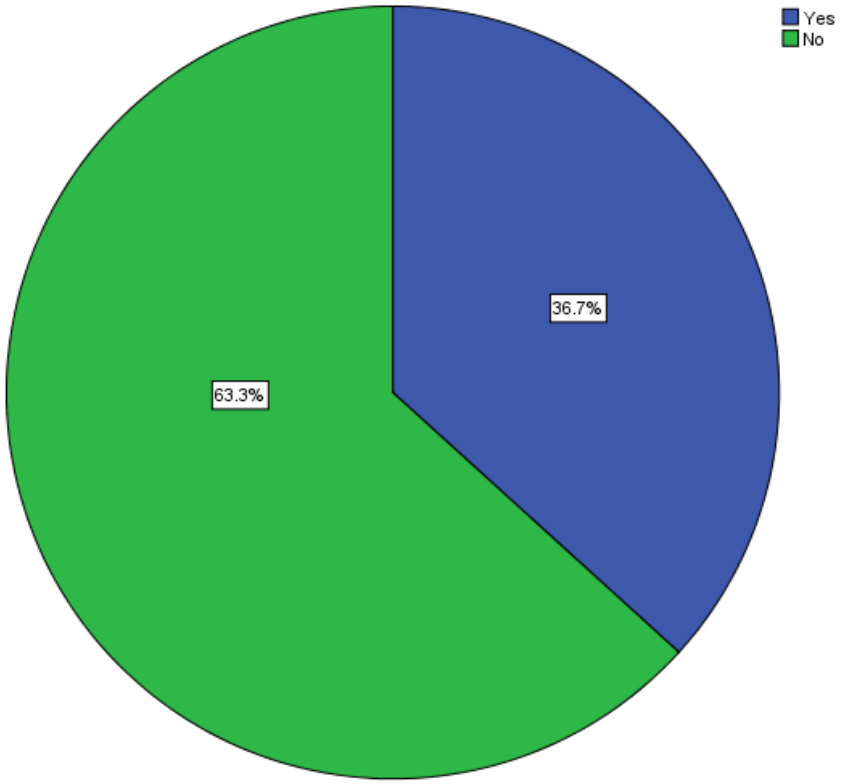

Fig.18: Site location of springs for pollution sources (cesspits) in the study area

Even though the vast majority of springs are located far away from the cesspits, the population in the study area get rid of the cesspit's waters by withdrawing it by tanks and then throwing them in the neighboring Wadis which are close to the springs like what happens in Ein Qinia and Abud villages which contribute to contaminate ground water there. Figure19 illustrates the percentage distribution of disposing the tank contents and where.

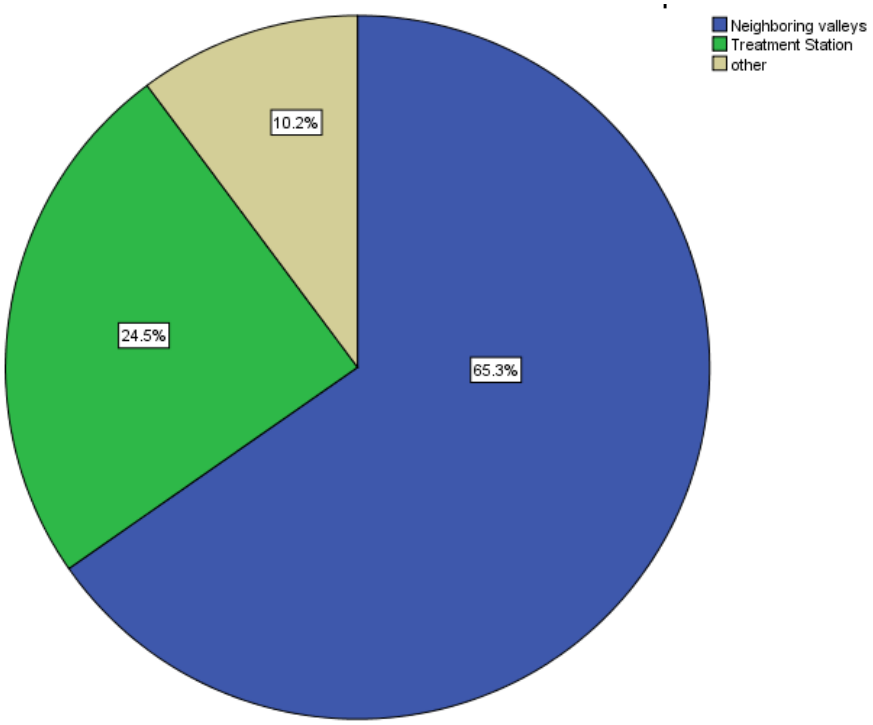

Fig.19: The places where people dispose cesspits contents in the study area

Dumpsites are another source of groundwater pollution. In the study area there is no sanitary landfills and people tend to dispose from their solid wastes randomly near roads, farming lands or close to water resources, so people were asked about whether there are dumpsites located close to the springs, the answer is 84% of springs are not close to them, while 16% of which are located to them as shown in Figure 20 and play role in polluting the springs of the study area.

4.2.5Farming in the study area

The Natuf area was named after the ancient Natuf Culture (8000 P.C) which is between Shibteen and Shuqba Villages north-west of Ramallah City. That era was a phasal between hunting societies and agricultural societies who farmed their lands using simple tools.

Nowadays, the agriculture in Natufe area retreated sharply for many reasons related to over population, urban expansion, occupation policy and measures led to decreasing the important of agriculture productions and farming lands. In the study area 77.1% of the questioned people cultivate their lands, while 22.9% are not according to the Figure 21 below.

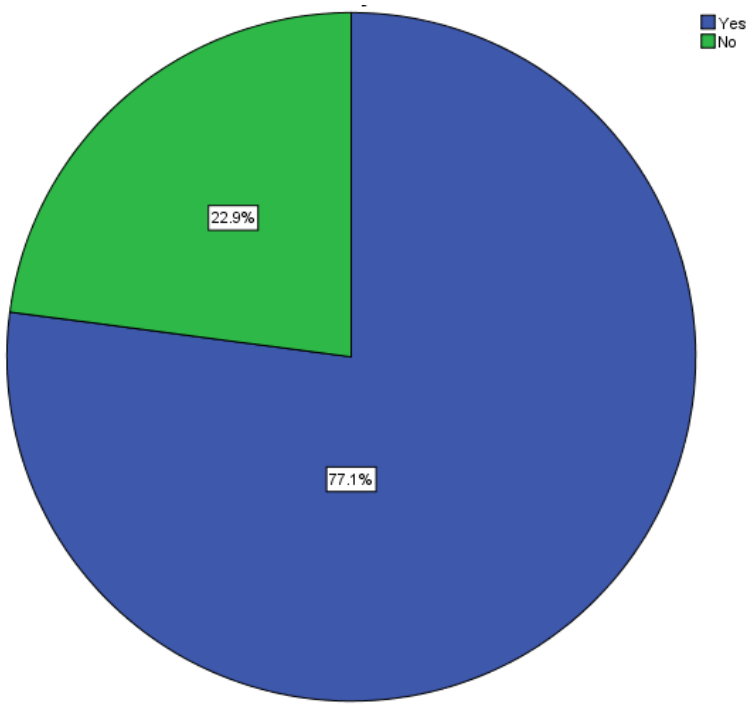

Fig.20: The percentage of people who practice farming in the study area

According to the crops types in the study area, it's obvious that there is diversity in crops. The results of the analysis to the questionnaires show that 40% of lands planted with vegetables such as lettuce, parsley,

cauliflower, aborigine while 28.6% of which planted with field crops, where as 31.4% of them planted with olives and fruit trees. Figure (22) illustrates the percentage distribution of crops types in the study area.

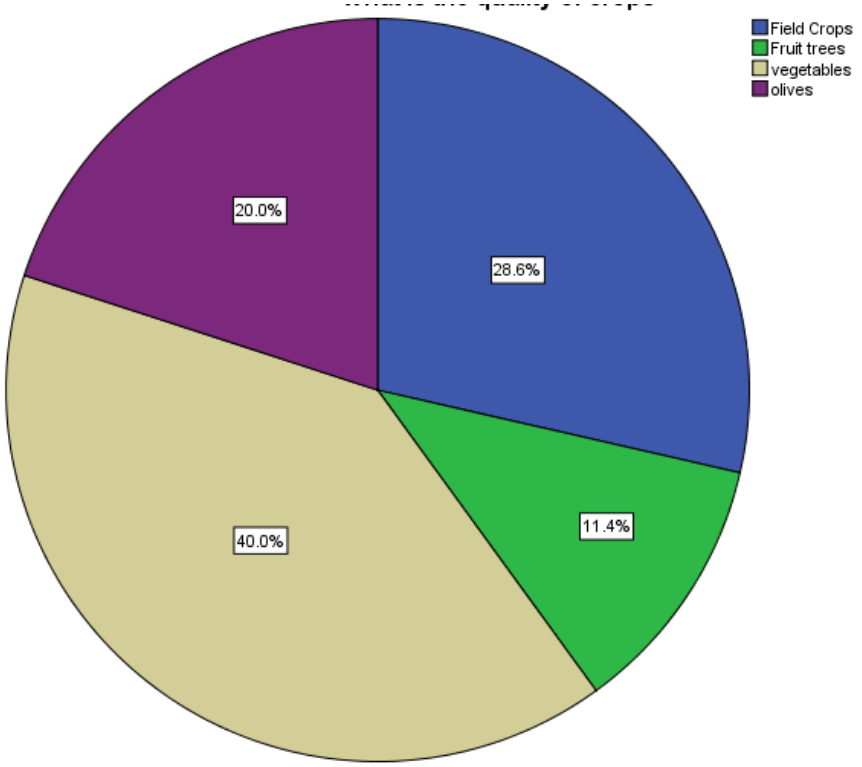

Fig.21: Types of crops that people farm in their lands in the study area

An irrigation method varies in the study area as the farmers use three available methods. The study shows that 50% of farmers use plastic pipes, while 31% of them directly irrigate their crops as they close to the springs, whereas the least used methods is by channels especially in Ein Qinia because the farm lands are plain and the abundant of water in the area Figure (23) shows how water distributed to the crops in Natuf area.

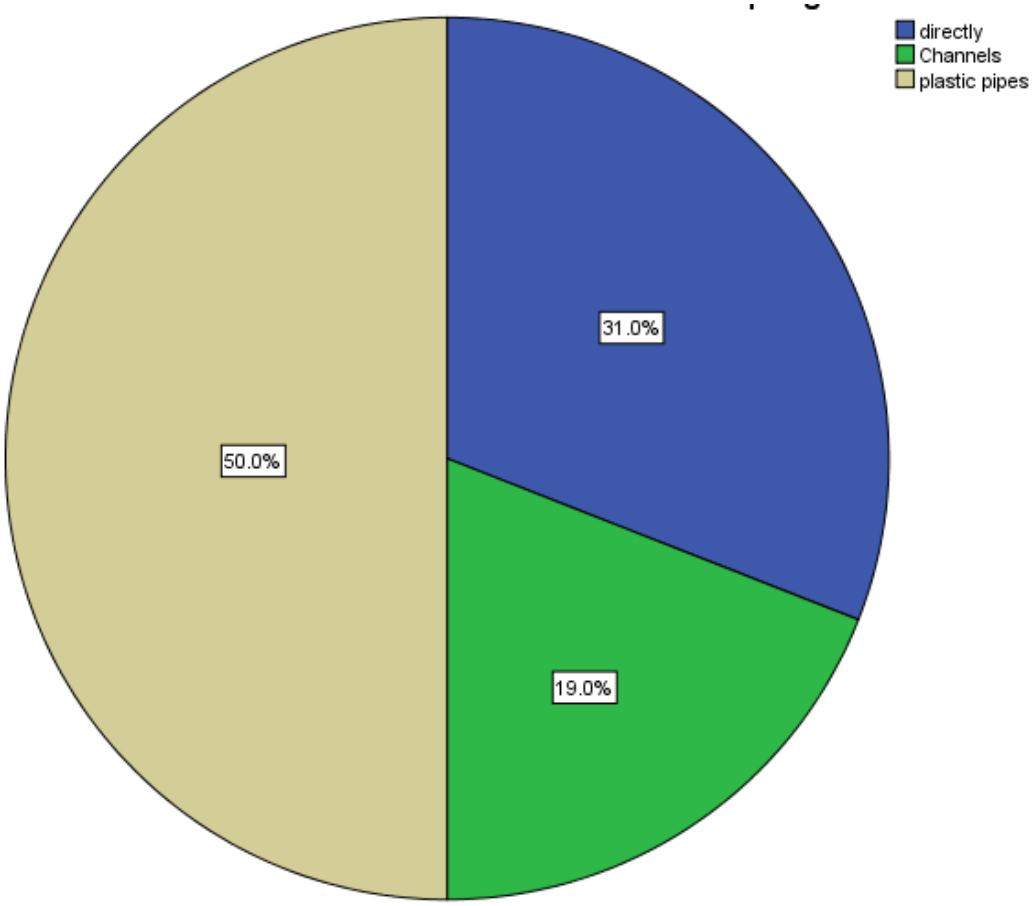

Fig.22: Different irrigation methods that are used in the study area

According to artificial chemical fertilizers and pesticides, farmers in the study area use the least rates of them, where the study shows that 55.6% of farms use an amount ranges between 1-5 kg, while 33.3% of them use an amount ranges from 5-10 kg, 3.7% of them use an amount within the range 10-20 kg the percentage of farmers who use more than this is 7.4%

This revels the awareness of farmers toward uses these chemical fertilizers and pesticides and how danger these pesticides affect the environment and water resources in the area. These fertilizers and pesticides may play a role in contaminating soil and groundwater if they use in large amounts or they use arbitrary. Figure 24 shows the amounts

of pesticides and fertilizers are used in the area and where the farmers get them from.

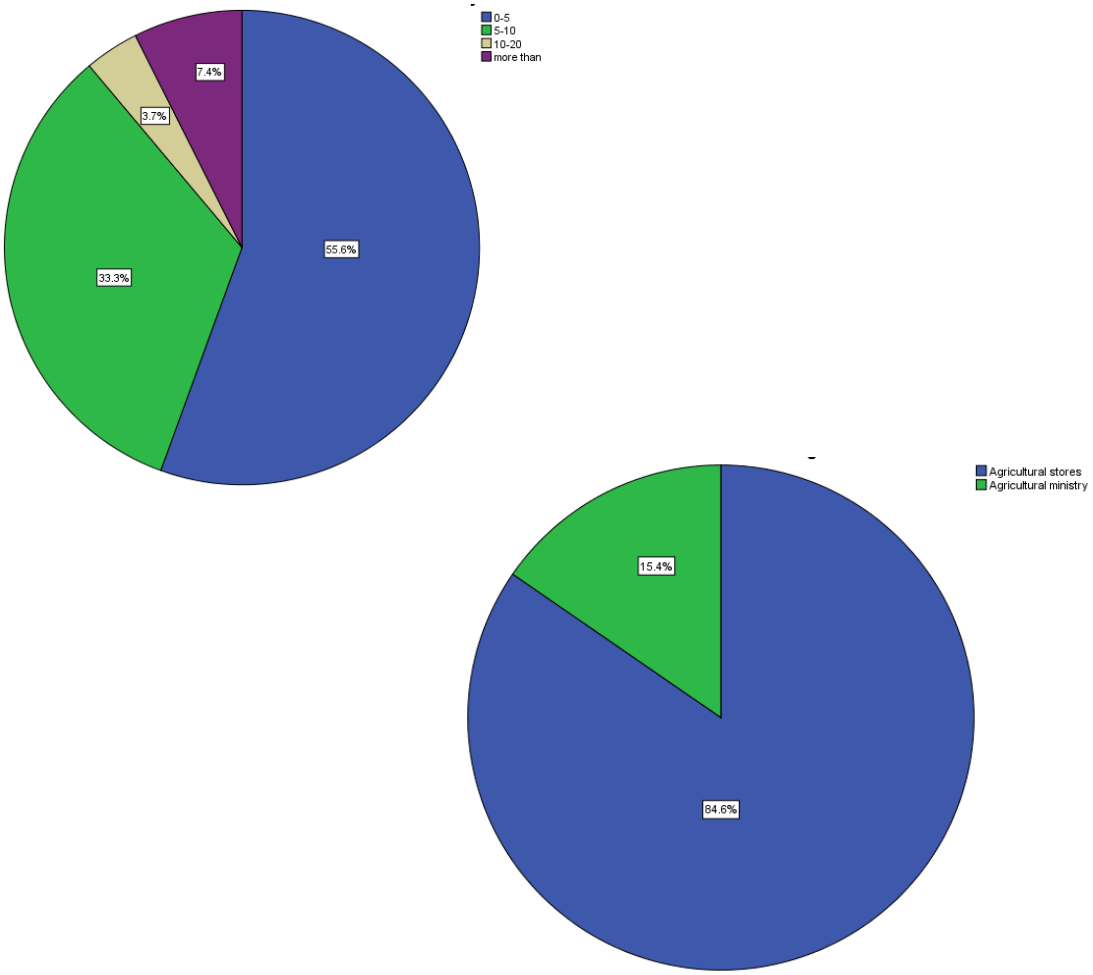

Fig.23: The ratios of fertilizers that are used by farmers in farming in the study area

Although, the majority of the questioned people in the study area practice farming, never the less farming doesn't consider as a main career for them, which indicates that farming is not a primary source of income for the families in the area. Figure 25 shows that 75.5% of the questioned people see farming as not a primary source of income, while 24.5% of them consider it as a primary one.

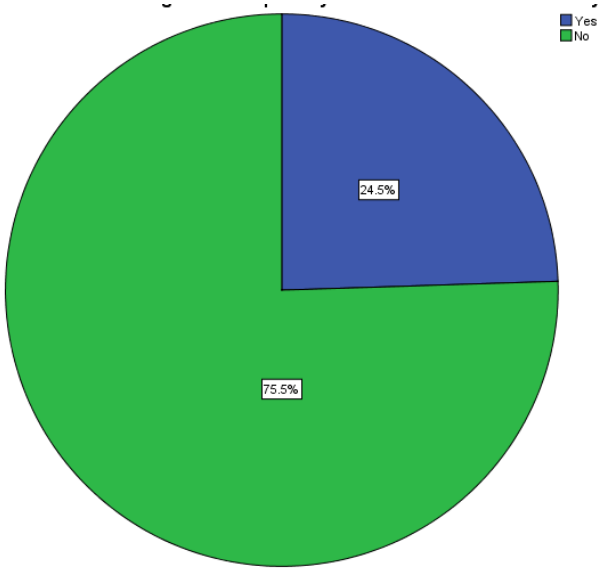

Fig.24: People's opinions toward if agriculture contributes in improving their income in the study area

65.3% of questioned people confirm that the aim of farming in the study area are related to home use and consumption, while 34.7% of them related to selling and market as shown in Figure 26

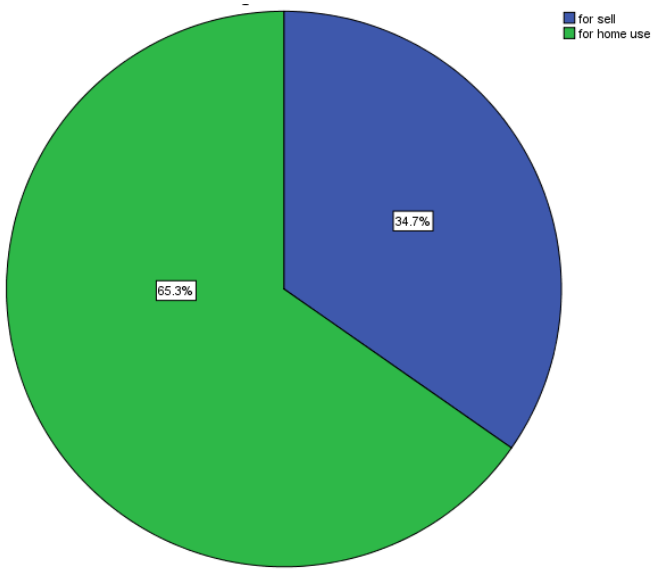

Fig.25: The purpose of farming in the study area

4.2.6 Political Part

The Israeli occupation negatively influence the water resources and the agricultural activities in the W.B by denying Palestinians access to the water resources, over pumping of groundwater without accountability and responsibility, and annex the agricultural lands and water resources so that they can build settlements units. For example, in the study area there are 12 settlements threating the water resources and the farming lands. Moreover, these settlements play a significant role in polluting springs water as they get rid of waste water in the adjacent valleys. There are no studies done to show the quality and the quantity of the waste water resulted from Israeli settlements, which demonstrated by the questionnaire results that 59.2% of the questioned people see that these settlements prevent them from accessing their farming lands and using their available water resources, while 40.8% of them (Figure26) see that these settlements don't affect them giving the fact that there is no Israeli settlement built there like the situation in Ein Arik.

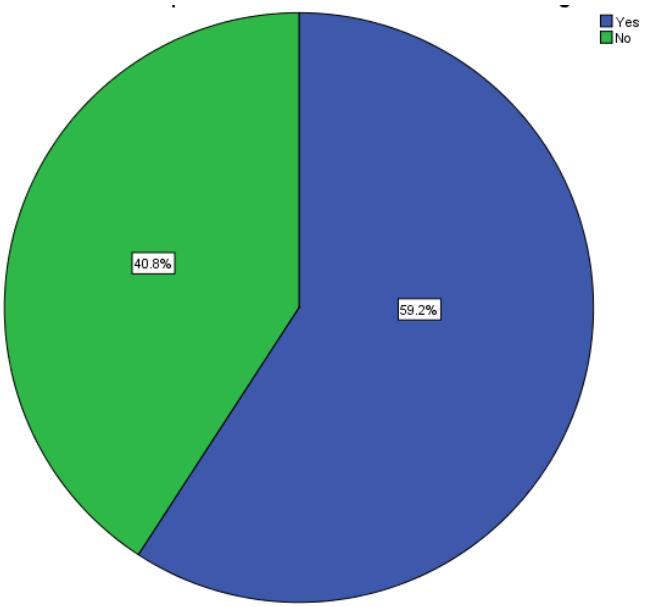

Fig.26: People's opinions toward the impact of Israeli settlements on water resources and farming lands in Natuf catchment area

4.2.7 Rainfall harvesting in the study area

The Palestinian population growth in the West Bank has limited their water resources which pushed them to look for alternative water resources. (Abu-Madi et.al, 2008). One of these alternatives is rainfall water harvesting technique.

Rainfall water harvesting means the capture, diversion and storage of rainfall water for multi-purposes including landscape irrigation, drinking and domestic uses. In the Natuf catchment, it's clear that the questioned people show no inters of rainwater harvesting, where 44.9% of them collected rainwater in winter season as an additional water resource to Mekarot and springs in the area, while 55.1% of them don't care of this and feel enough of the water resources available. Figure (27) shows the percentage distribution of people who collect rainwater and what method used to collect these waters.

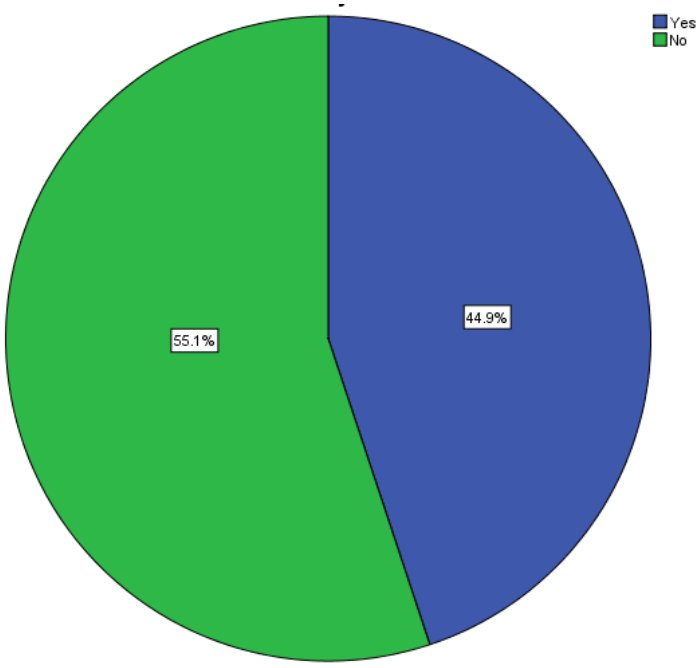

Fig.27: The percentage of people who collect rainwater during winter semester in Natuf catchment area

Rainfall water is affected by different factors including climatic condition, surrounding environment, storage time of water and mostly with roof catchment materials. In the study area, the questioned people show an awareness of the health risks that may cause by rainwater if they collect or consume without cleaning the roofs surfaces in the area. The study showed that 64.7% of questioned people clean clearly the roof surface before rainwater harvesting, where as 35.3% of them don't care of that. Figure 28 represents the percentage distribution of cleaning roof surface before rainwater harvesting.

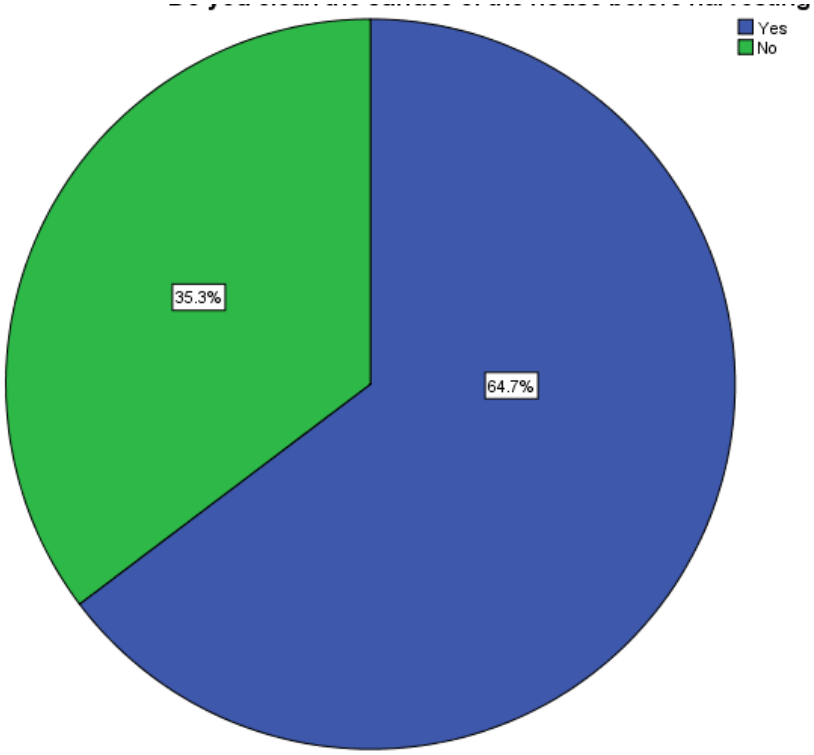

Fig.28: The percentage of people who clean roofs surfaces before rainwater harvesting process in the study area.

4.3Socio-economic and water quality relation for springs in the study area

Although 63.3% of the questioned people in the study area asserted that the majority of springs are located far away from cesspits, still examinations of lab showed that seven water samples out of twelve were contaminated of fecal coliform bacteria which revels the impact of human activities on quality of springs.

There was a great match between questionnaire analysis and lab tests analysis of being water samples free of industrial pollutants, especially that 84% of studied spring are located far away from randomly dump sites and industrial activities (Figure 29).

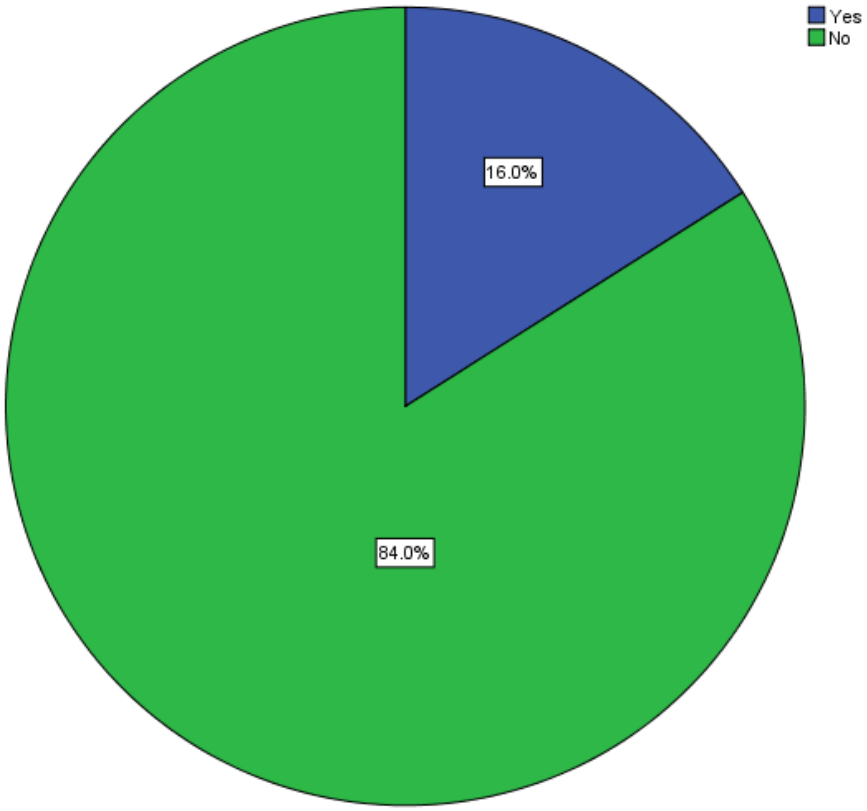

Figure 29: Locations of springs related to dump sites in the study area

Despite the fact that the majority of farmers are using different amounts of chemical fertilizers range between 5-20 kg. However, there is no effect of these fertilizers on the quality of springs water, especially as the chemical analysis of water samples showed that the measurements of TDS, EC, cations and anions were within the WHO guidelines and Palestinian standards for drinking water.

The questionnaire analysis showed that the higher percentage of springs in the study area are used for agricultural targets and not for drinking, this can be attributed to the fact that the presence of internal water network which lead to easy access to water.

It's no doubt that Israelis settlements affect on water resources and farming lands in the study area, but in indirect way since there are no accurate studies describe types and amounts of pollutants (wastewater and solid wastes) produced by these settlements. 59.2% of the questioned people confirm that these colonies prevent them from accessing their farming lands and using their available water resources as in happen in Deir Nidham village.

There is a relation between lack of interest of concerned authorities toward springs and deterioration of the quality of springs water but it is not statistically significant at $\alpha \leq 0.05$

The questionnaire analysis showed that 64.7% of the questioned people who collect rainwater clean clearly their roof surfaces which indicate the level of awareness to water quality matter in the study area.

Based on hypothesis testing on SPSS, it is showing that there is a relationship between farming and source of income and it is statistically significant at $\alpha \leq 0.05$ as shown in test below

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.757[a]	1	.029		
Continuity Correction[b]	3.184	1	.074		
Likelihood Ratio	7.358	1	.007		
Fisher's Exact Test				.044	.027
Linear-by-Linear Association	4.658	1	.031		
N of Valid Cases	48				

a. 1 cells (25.0%) have expected count less than 5. The minimum expected count is 2.75.

b. Computed only for a 2x2 table

Chapter Five

Conclusion

&

Recommendations

5.1 Conclusion

- Natuf drainage basin is sited in the western part of Ramallah city, with an area estimated at 204 km^2, and contains more than 130 springs, the majority of them are located in middle part of the study area near Beitillu village.
- According to TDS, EC and HCO_3^-, water can be generally classified as fresh water which is suitable for all purposes (household and farming).
- Microbial analysis of water samples showed that seven water samples are contaminated with fecal coliform which indicates that there is human impact on water quality and water should be boiled before consumption as drinking water.
- Ca^{2+} concentration rate in this study is less than Ca^{2+} concentration rate in the former studies for the same springs of (Ein Ayoub, Arik Al-tehta and Al-fuqa, Al-balad and Al-qus), and this can be attributed to the short contact time and lack weathering process with minerals and bed rocks of springs.
- The concentration of Na^+ for all water samples was close, except in Abu Danfora spring which recorded the highest value with 76mg/L and this is due to the mixing process of treated effluent that comes from Alterih wastewater treatment plant, in addition to the farming activities and use of fertilizers near the spring.
- The concentrations of NO_3^- in all water samples showed much more less values than WHO standard limit of 50mg/L.

- The presence of (TOC) was recorded only in the springs of (Ein Arik Al-tehta and Al-zarka Bietillu, while the rest of samples were free of it and the reason could be attributed to wastewater, because these two springs are contaminated with fecal coliform.
- The concentration of trace elements [Ni, Zn, Fe, Ag, Cu, Co, Cr, Mn, Pb, Al, B, Ba, Li, Ti and Cd] was in the allowed WHO guidelines and Palestinian standers limits for drinking water with exception of Zn which recorded the highest concentrations in springs of (Abu Danfora , Al-qus and Al-zarka Beitillu).
- According to chemistry diagram, most of samples have a water type of Mg- Ca- HCO^-.
- The questionnaire analysis showed that 90% of the respondents use springs water mainly for farming purposes and for drinking as they get their drinking water by internal water network.

- Chemical analysis of water samples in labs show that the source of pollution in the study area is caused by wastewater from local communities despite that 63.3% of springs are located away from cesspits.
- Most of tested samples were free of hazard industrial pollutants and this refers to the fact that 84% of them are located away from dumpsites and populated areas.

- The availability of water network in addition to the pollution matter to some springs decrease the people's dependency on the springs water as drinking source. 79.2% of the questioned people complained the lack of concerned authorities monitoring and inspections toward springs in Natuf area.

- Although 77.1% of questioned people cultivate their lands, they assert that agriculture is not considered as a basic source of income for them and practice it as second craft
- 44.9% of the questioned people collect rain water into wells and use them as additional source of water in case of discontinuous supply of water from water network.
- People who collect rainwater during winter showed awareness toward water quality as they clean their roof surfaces before collecting process.

5.2 Recommendations

- ✓ The concerned authorities such as PWA must perform complete and regular tests for springs to ensure that they are safe for domestic and agricultural uses, especially for springs which located near populated areas.

- ✓ Randomly disposal of wastewater by tankers into seasonal Wadis, land farming should be controlled or stopped.

- ✓ People's awareness of the importance of springs and introducing them how to keep on them to insure a sustainable use of fpring water for the future generation.

- ✓ Consult the concerned authorities such as (Ministry of Agriculture and Environment Quality Authority) in the use of pesticides and chemical fertilizers and use a quantity with reasonable.

- ✓ Keeping animals away from the roofs surfaces and cleaning up bird droppings before rainwater harvesting process.

- ✓ Utilization of treated wastewater for (Al-rihan and Al-tirah) treatment plants in agriculture sector and stop disposing of it in neighboring Ein Qinia Wadis to preserve springs from possible pollution.

- ✓ Preparing comprehensive environmental and development plans including construction of sewer systems in the area, continuous monitoring of springs water quality and build cesspits with reinforced concrete to prevent wastewater infiltrating into groundwater and contaminate it.

- ✓ advanced research on other tested chemicals such as pesticides, hazard organic matters which is beneficial for any advance studies in the Natuf basin.

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Appendix

	pH	CL^- mg/l	$NO3^-$ mg/l	So_4^- mg/l	Hco_3^- mg/l	F.C CFU/100mL	T.C CFU/100mL
وادي ريا	6.95	33.8	7.1	23	177	15	75
عين الزرقاء ـ بيت الو	6.89	33.1	6.5	23.8	182	7	58
عين عريك التحتا	6.92	35.2	6.1	16.8	201	42	187
عين ايوب	6.99	36.2	7.8	18.5	166	0	29
عين بوبين	7.01	40.2	8.2	29.8	178	19	82
عين البلد	6.81	45.2	8.5	20.8	188	14	77
عين وادي اللمون	**6.77**	**49.8**	**7.9**	**21.2**	**192**	**0**	**13**
عين أبو دغفورة	6.79	39.4	6.7	23.9	205	0	27
عين القوس	6.93	36.7	8.1	18.7	168	0	17
عين عريك الفوقا	7.05	34.5	8.7	23.7	183	16	81
عين ام الرمان	6.84	33.2	6.6	27.3	209	0	14
عين الزرقاء ـ عابود	7.08	38.3	6.9	26.5	193	12	86

عين بوبين	H1	0.75	6.90	46.11	1.92	230.68	0.94	686.20	1.49	99.33	1.04	14.66	1.39	<0.000	N/A
عين عريك التحتا	H2	1.39	3.70	69.02	2.12	229.33	4.50	850.05	1.62	120.35	1.06	25.62	0.52	<0.000	N/A
عين عريك الفوقا	H3	0.50	2.81	33.07	3.91	225.43	3.74	401.67	1.29	90.94	0.26	12.76	1.22	<0.000	N/A
عين البلد	H4	0.56	6.60	38.18	0.97	247.34	8.03	868.14	2.31	72.57	0.53	16.23	1.81	<0.000	N/A
عابود عين الزرقاء	H5	0.80	5.91	34.35	3.13	227.34	2.83	413.72	2.88	122.82	0.67	21.17	0.74	<0.000	N/A
عين ايوب	H6	0.99	4.13	44.22	3.59	202.24	6.64	681.81	2.08	122.24	0.55	22.34	0.35	<0.000	N/A
عين واد الليمون	H7	0.48	9.84	26.28	5.45	187.15	3.12	792.46	6.63	124.43	1.25	16.88	3.03	<0.000	N/A
عين ام الرمان	H8	0.39	8.31	24.19	4.74	197.05	1.36	695.87	2.43	79.68	0.33	12.80	4.19	<0.000	N/A
عين واد ريا	H9	0.39	8.90	29.37	0.93	229.20	1.24	560.30	2.91	83.18	0.19	14.96	2.63	<0.000	N/A
عين الزرقاء بيتلو	H10	1.32	3.97	31.10	1.08	202.65	8.69	891.79	1.95	105.03	0.98	27.80	3.55	0.13	65.44
عين القوس	H11	2.05	2.39	28.38	3.61	263.75	4.06	443.39	1.38	61.61	0.59	11.21	2.85	1.38	6.25
دنفورة	H12	3.27	1.23	86.19	1.55	226.84	6.64	1413.91	0.79	283.01	0.19	35.50	2.48	0.43	38.60

			23 Na [1]		24 Mg [1]		43 Ca [1]		39 K [2]	
التحليل الاول										
Sample	عين بوبين	H1	12.04	0.57	16.26	1.43	9.55	1.28	0.95	3.02
Sample	عين عريك التحتا	H2	31.73	0.95	16.78	0.48	11.88	0.71	5.10	0.79
Sample	عين عريك الفوقا	H3	12.55	1.33	15.19	1.00	5.35	0.38	1.21	0.93
Sample	عين البلد	H4	23.14	1.31	25.79	1.12	11.61	0.83	0.77	2.47
Sample	عابود عين الزرقاء	H5	14.13	0.23	12.39	0.56	5.61	0.51	0.63	2.35
Sample	عين ايوب	H6	26.10	1.52	19.69	0.36	9.20	0.72	1.40	1.75
Sample	عين واد الليمون	H7	12.48	1.23	11.24	1.22	10.67	1.15	0.48	4.30
Sample	عين ام الرمان	H8	10.00	2.73	17.02	2.24	9.33	1.56	1.17	1.26
Sample	عين واد ريا	H9	14.51	0.81	21.19	0.99	7.43	1.48	0.56	1.34
Sample	عين الزرقاء بيتلو	H10	19.30	0.94	24.08	1.57	11.90	1.27	1.51	0.98
Sample	عين القوس	H11	11.61	0.58	17.62	0.43	5.28	1.05	0.64	2.38
Sample	عين ابو زنفورة	H12	76.39	1.20	15.31	1.50	18.95	1.63	2.74	2.23
التحليل الثاني اعادة لنفس العينات على نفس البلازما ونفس الظروف لجهاز ICP-Ms										
Sample	عين بوبين	H1	12.14	1.06	16.54	0.51	9.57	0.48	0.97	0.48
Sample	عين عريك التحتا	H2	31.80	0.86	16.96	0.72	11.76	1.00	5.17	0.85
Sample	عين عريك الفوقا	H3	12.78	1.07	15.21	1.15	5.37	1.12	1.23	0.29
Sample	عين البلد	H4	23.33	1.06	25.63	1.56	11.67	0.56	0.78	1.15
Sample	عابود عين الزرقاء	H5	14.34	1.85	12.39	1.48	5.34	0.36	0.63	0.93
Sample	عين ايوب	H6	26.10	1.10	19.72	1.27	9.18	1.22	1.42	1.40
Sample	عين واد الليمون	H7	12.47	1.07	11.35	1.05	10.69	2.24	0.49	0.23
Sample	عين ام الرمان	H8	9.99	1.25	17.21	1.63	9.39	0.83	1.16	1.52
Sample	عين واد ريا	H9	14.51	0.80	21.16	1.34	7.47	0.51	0.53	1.23
Sample	عين الزرقاء بيتلو	H10	19.32	0.77	24.18	0.98	11.96	0.72	1.50	2.73
Sample	عين القوس	H11	11.64	1.77	17.64	2.38	5.29	1.75	0.64	0.81
Sample	عين ابو زنفورة	H12	76.40	0.38	15.35	2.23	19.00	1.30	2.72	0.58

Smith Darwaish Institute for Pharmaceutical Industries

Faculty of Pharmacy, Nursing and Health professions

Oxidisable substances Test according to EP 7.0

Sample Name	Result	Limit
عين القدس (بيتالو) 820	PASS	The solution remains faintly pink after 5 minutes boiling.
عين انبك (بيتالو) 1336	PASS	
عين بوبين (دير بزيع) 997	PASS	
عين عريك التحتا (عين عريك) 1264	FAIL	
عين وادليمون (معبود) 1040	PASS (BEST ONE)	
عين أم الدمان (عين قنب) 1017	PASS	
عين عريك الفوقا (عين عريك) 723	PASS	
عين وادريا (دير نظام) 951	PASS	
عين الزرقا (معبود) 748	PASS	
عين ابوب (رأس كركر) 1306	PASS	
عين الزرقاء (بيتالو) 1392	FAIL (Turbid)	

Prepared BY: ..... Date: 12/12/2017

Checked By: ..... Date: 12/12/2017

BIRZEIT UNIVERSITY
Birzeit University Testing Laboratories

Environmental Unit
PS/ISO 17025 Accredited
Phone : 02-2982010/ 02-2982102
Fax : 02-2982166

Analytical Report

Report Date : 11 March 2015
Customer : شركة الخدمات البيئية العالمية

Sample Code	: ES-20153671
Source Sample Code	:
Sample Name	: Inlet
Sample Receiving Date	: 07 February 2015
Category	: Waste Water
Batch No.	:
Sample Size	: 1.5 L
Origin	: Al Treh WWTP
Representative	:
Container Type	: Bottle
Sample Condition	: OK
Sampled By	: BZUTL

Test	Result	Method	Comments	Test Date
BOD	375 mg/L	StMe	Inlet	07 MAR 2015
COD	685 mg/L	StMe	Inlet	07 MAR 2015
Total suspended solids	340 mg/L	StMe	Inlet	07 MAR 2015
Total Nitrogen	177.62 mg/L	StMe		11 MAR 2015
Nitrate-N	Below Detection Limit	StMe	D.L = 50 ppb	11 MAR 2015
Ammonia-N	76.68 mg/L	StMe		11 MAR 2015

* The Center is only responsible for the results of the sample tested.

Signatures:

Belal Amous
Director of BZUTL

1041765

Senior Analyst,
Environmental Unit

Center of Birzeit University Testing Labs
Environmental Analysis Unit

BIRZEIT UNIVERSITY

مركز مختبرات جامعة بيرزيت للفحوص
وحدة التحاليل البيئية

Analytical Report

Report Date : 08 March 2016
Customer : شركة الخدمات البيئية العالمية

Sample Code	ES-20164242
Source Sample Code	
Sample Name	Outlet
Sample Receiving Date	25 February 2016
Sampling dat	25 February 2016
Category	Waste Water
Batch No.	
Sample Size	1.5 L
Origin	Al Tireh WWTP
Representative	
Container Type	Bottle
Sample Condition	OK
Sampled By	بلال - بندى رام الله

Test	Result	Method	Comments	Test Date
BOD	7.8 mg/l	SMe		05 MAR 2016
COD	17.4 mg/l	SMe		08 MAR 2016
Total suspended solids	2 mg/l	SMe		26 Feb 2016
Total Nitrogen	19.99 mg/l	SMe		05 MAR 2016
Nitrate-N	11.49 ppm	SMe		02 MAR 2016
Fecal Coliforms	1 cfu/100ml	SMe		29 FEB 2016

* The Center is only responsible for the results of the samples received.

Signatures:

Jolie Arrous
Director

1046072

Senior Analyst,
Environmental Analysis Unit

P.O.Box: 14 BIRZEIT, PALESTINE . PHONE: 972-2-2982010 . FAX: 972-2-2982188
e-mail: bzutl@birzeit.edu