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Monitoring and Evaluation Water Quality of Cisterns in the Southern Area of Hebron District

By

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Dedication

I dedicate my thesis work to my family, special feeling of gratitude to my loving parents, Issa and Reema whom words of encouragement and push for tenacity ring in my ears. My sisters and brothers, who have never left my side and are very special, I also dedicate this thesis to my many friends who have supported me throughout the process. I will always appreciate all they have done, especially Dr. Mohammad Al-Salimia, Mohammad Al-Amleh and Eyas Abu Rabada for their endless help and support and Waleed Hijazi for the many hours of proofreading and khulod Abo Sharkh for her helping in preparing the questionnaire. I dedicate this work and give special thanks to my best friend and wife Nadeen and my wonderful daughters Lama and Jana for being there for me throughout the entire master program. All of you have been my best cheerleaders.

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List of Abbreviations

C°	**Degrees Celsius**
EC	**Electrical Conductivity**
EPA	**Environmental Protection Agency.**
FC	***Faecal Coliform*.**
TC	**Total *Coliform***
GIS	**Geographical Information System.**
HPCs	**Heterotrophic Plate Counts.**
L/c.d	**Liter/ capita. day**
mg/L	**Milligram/Liter**
MLC	**Maximum Contaminant Level.**
PSI	**Palestinian Standards Institution**
TDS	**Total Dissolved solids**
WHO	**World Health Organization.**
Psi	**pound force per square inch.**
MF	**Membrane Filter Technique**
PMD	**Palestinian Metrological Department**
APHA	**American Public Health Association**
NTU	**Nephlometric Turbidity Unit**
CFU	**Colony Forming Unit**
SPSS	**Statistical Package for the Social Sciences**

Abstract

Two localities namely Masafer Yatta and Road 317 (29 communities: 10 in Masafer Yatta, 19 in Road 317 with a total area of 37500 dunoms) were targeted from Southern part of Hebron district to study the rainwater quality in cisterns.

In this study, water quality of 73 cisterns was analyzed in Southern area of Hebron District. Water samples were directly collected from cisterns in sterile glass bottles and tested for different parameters including: physical (total dissolved solids, pH, and turbidity); chemical (nitrate); and microbiological parameters ((Total *Coliform* (TC) and Faecal *Coliform* (FC)).

In addition to that, pollution sources were studied via distributing, collecting, and analyzing special questionnaires for that purposes. The results showed high level of contamination in tested samples with Total *Coliform* percentage of 92.2% and Faecal Coliform percentage 97.4%. Sources of contamination varied but animal and bird feces were the main source. The solution to this problem is by properly cleaning the catchment area and using chlorination method when storing water.

Introduction

Water is regarded as a focal and crucial issue in the Middle East in general, including Palestine in particular, where augmenting water insufficiency and deterioration are existing. In fact, water resources are tightly limited and do not meet people need (Al-Khatib et al., 2003).

World Health Organization (WHO) states that all people, whatever their stage of development and their social and economic conditions have the right to have access to an adequate supply of safe drinking water (WHO, 1997). In this context, safe water supply refers to the water quality that does not represent a significant health risk, meet sufficiently all domestic needs, available continuously, available to all population and is affordable.

It is well documented that, the most common and widespread danger associated with drinking water is contamination either directly or indirectly via different sources such as sewage or any other wastes or animal excrement. If such contamination is recent, and if among the contributors there are carriers of communicable enteric diseases, some of the living causal agents may be present. Indeed, contaminated drinking water and its uses in the preparation of certain foods may result in further cases of infection (WHO, 1984).

Palestine is characterized by arid to semi-arid climatic conditions and have very limited water resources. The majority of fresh water supplies are coming from scarce ground-water resources. Future population growth in Palestine and its associated water demands is expected to place severe pressure on the limited ground-water reserves (Nasserdin et al., 2009). Therefore, rainfall harvesting is considered of great importance in the socio-economic development of such areas where water sources are scarce or where ground-water and surface water are limited or polluted (Prinz, 1999; Texas Water Development Board, 2005; Sazakli et al., 2007).

Besides water scarcity problem, water contamination also exists at different levels including biological and chemical contaminations. Thus, this study sheds light on the status of water contamination and its causes among twenty-nine communities living in two different localities namely Masafer Yatta and Road 317 located at the southern region of Hebron district.

Study objectives

The main objectives of this study are as the following:

1. To assess the physical, chemical and microbiological quality of water cisterns in the southern area of Hebron district.
2. To assess the sources of water contamination.
3. To explore the perception of people towards water quality and water resources protection.

Chapter One: Literature Review

1.1. Rainwater Characteristics

Generally, natural rainwater (uncontaminated) is free from disinfection by-products as well as has low concentrations of dissolved salts and other natural and man-made contaminants. Users with potable systems prefer the superior taste and cleansing properties of rainwater (Texas Water Development Board, 2005).

Rainwater can be contaminated when it comes in contact with a roof or any other harvesting surface which could wash many types of contaminants agent into the cistern (Zhu et al., 2004 and Sazakli et al., 2007). Therefore, collection processes should always divert the very dirty runoff from the first few millimeters of rainfalls away from the cisterns to avoid contamination and ensuring that the catchment area has been washed off (Zhu et al., 2004). Furthermore, people are advised to boil rainwater before drinking and to use the suitable dosage of sodium hypochlorite for disinfecting.

Roof-yard, land, road, and greenhouse are catchment areas that can be used in water harvest. Compared to roof-yard catchments, a land catchment system provides more flexibility for collecting water from a large surface area; however, the water quality is not as good as roof-yard systems which ensure harvesting of good quality rainwater. Rainwater collected through land and road surfaces should only be used for irrigation instead of drinking, whereas rainwater collected from the greenhouse could be used for both purposes (Zhu and Liu, 1998, Zhu et al., 2004).

The quality of the harvested and stored rainwater depends mainly on the characteristics of the individual area, such as topography, weather conditions, pollution sources (Evans et al., 2006), the type of the catchment area (Zhu et al., 2004), the type of water tank (Evison and Sunna, 2001) and the handling as well as management of the water (Evison and Sunna, 2001, Sazakli et al., 2007).

1.2. Cisterns Design and Characteristics

Designing rainwater harvesting systems in any area depends mainly on economic, social and cultural aspects. A special emphasis should be given on using and employing genuine people and authentic construction material (Appan, 1999).The size of any cistern is dictated by several variables including the rainwater supply (local precipitation), the demand, the projected length of dry spells without rain, the catchment surface area, aesthetics, personal preference, and budget (Texas Water Development Board,2005). Furthermore, cistern should meet the following basic requirements: ability to inhibit algae growth (opaque or painted dark), must never have been used to store toxic materials especially for portable systems, must be covered and vents screened to discourage mosquito breeding and accessible for cleaning.
A recommended structure for cistern should be deep, taking into account the ongoing elements sedimentation to decrease the volume of cisterns. One of the concrete cistern' advantage is ability to reduce rainwater corrosiveness through letting calcium carbonate to decay from the walls.

Bottom of cisterns are preferred to be laid down with red clay in place of concrete for the sake of reducing leakage and providing an adequate environment for rainwater refinement via absorption and biodegrading (Zhu et al., 2004).

1.3. Microbiological Infections

Microorganisms are present everywhere in our environment invisible to naked eye. Vast numbers of these microbes can be found in soil, air, food and water (EPA, 1991). There are organisms whose presence in water are nuisance but which are of no significance for public health, however they produce problems of turbidity, taste, and odor or appear as visible animal life in water, as well as being aesthetically objectionable.

Some organisms naturally present in the environment and not normally regarded as pathogens may cause disease opportunistically (WHO, 2004). In fact, the persistence of a pathogen in water is a measure of how quickly it dies after leaving the body. In practice, the numbers of a pathogen introduced on a given occasion will tend to decline exponentially with time, reacting in significant and undetectable levels after a certain period. A pathogen that persists outside the body only for a short time must rapidly find a new susceptible host (Pepper et al., 1991). Many factors affected most pathogens persistence in water including precisely sunlight and temperature in which lifetimes are shorter at warmer temperatures and longer at cold temperatures (Pepper et al., 1991).

The pathogens that may be transmitted through contaminated drinking-water are diverse (WHO, 2004). A number of studies reviewed by Gould (1999) and Lye (2002) have identified various pathogens in samples taken from rainwater tanks focusing on Total *Coliform* and Fecal *Coliform* as one main criterion for water contamination.

1.3.1. Indicator Microorganisms

Contaminated water generally contains a mixture of pathogenic and non-pathogenic microorganisms. These microorganisms may be derived from sewage effluents, livestock (cattle, sheep, etc.), industrial processes, farming activities, domestic animals (such as dogs and cats) and wildlife. These sources of pollutions including Total *Coliform* and Fecal *Coliform* include pathogenic organisms that cause infections.

The concept of using indicator organisms as a signal of fecal pollution is a well-established practice in the assessment of drinking-water quality. According to the WHO (2004), the criteria determined for such indicators were that they should not be pathogens themselves and should be universally present in feces of humans and animals in large numbers; not multiply in natural waters; persist in water in a similar manner to faecal pathogens; be present in higher numbers than faecal pathogens; respond to treatment processes in a similar fashion to faecal pathogens; and be readily detected by simple, inexpensive methods.

Generally, the three widely used bacterial indicators are Total *Coliform*, Escherichia coli and Enterococci. These bacteria, which can be found in soils and other natural sources, originate in the feces of humans and warm blooded animals (Sazakli et al., 2007).

1.3.1.1. Total *Coliform* Bacteria

Total *Coliform* bacteria includes a wide range of aerobic and facultative anaerobic, Gram-negative, non-spore-forming bacilli capable of growing in the presence of relatively high concentrations of bile salts with the fermentation of lactose and production of acid or aldehyde within 24 h at 35–37 °C. The total *Coliform* group includes both faecal and environmental species. They can be used as an indicator of treatment effectiveness and to assess the cleanliness and integrity of distribution systems and the potential presence of bio-films (WHO, 2004).

Actually, Total *Coliform* should be absent immediately after disinfection, and the presence of these organisms indicates inadequate treatment. The presence of total *Coliform* in distribution systems and stored water supplies can reveal re-growth and possible bio-film formation or contamination through ingress of foreign material, including soil or plants (WHO, 2004).

1.3.1.2. Faecal Coliform Bacteria

Faecal Coliform (also known as thermo tolerant *Coliform*) are able to ferment lactose at 44–45 °C. Escherichia coli (E. coli) can be differentiated from the other production of the enzyme B-glucuronidase. Escherichia coli is present in very high numbers in human and animal (both mammals and birds) feces and is rarely found in the absence of faecal pollution, although there is some evidence for growth in tropical soils (Rivera et al. 1988, Hunter, 2003). If there is *Faecal Coliform* in the water, it is considered as the most suitable index of contamination. Therefore, other harmful pathogenic could presence and other detection should lead to consideration of further action, which could include further sampling and investigation of potential sources such as inadequate treatment or breaches in distribution system integrity.

1.3.2. Seasonal Variation of Microbiological Contamination

Bacteria multiplication in water is affected to summer's warm temperature, taking into account the availability of growth factors. Some bacteria like E. coli and the enterococci can hardly multiply in warm water that has no available nutrients. On the contrary, water in this case helps the decay of intestinal organisms (Rosenberg et al., 1968).Laundering and bathing during warm weather is believed to bring more pollution to wells from infected tanks (Rosenberg et al., 1968).

Possible explanations for the lower values of microbes in the winter are the lower temperature and the dilution due to the large amount of stored water, which do not favor the growth of microorganisms. Moreover, as sedimentation occurs into the water tank, most of the present bacteria co-migrate with the settle able particles (Sazakli, 2007).Once the rain season begins, rain comes in contact with the catchment surfaces, from where it can wash many types of bacteria, algae, dust, leaves, bird droppings and other contaminants into the water tank, even though the first heavy rainfall is discarded, a practice followed globally (Spinks et al., 2003; Villarreal and Dixon, 2005and Sazakli, 2007).

1.3.3. Effect of Water Contamination on Health

Water is not an agent of disease, but a medium through which disease may be spread. When assessing the health risks of drinking rainwater, a series of actions must be considered starting from the path taken by the raindrop through a watershed into a reservoir, through public drinking water treatment and distribution systems to the end user (Texas Water Development Board, 2005). Under guidelines established by WHO, water intended for human consumption should contain no microbiological agents that are pathogenic to humans, with no more 3 CFU/100ml for total *Coliform* and zero CFU/100ml for *Faecal Coliform* (WHO 1993). Microbial water quality may vary rapidly and widely. Short-term peaks in pathogen concentration may increase disease risks considerably and may also trigger outbreaks of waterborne disease (WHO, 2004). A waterborne disease outbreak is defined as an outbreak in which epidemiologic evidence points to a drinking water source from which 2 or more persons become ill at similar times (Curriero et al.,2001).

Three factors primarily influenced the attack rate for infection including the level of contamination; the level of cyst; viability and inactivation through chlorination; and the length of exposure to the population (Haas and Regli, 1991).

The most common waterborne pathogens and parasites are those that have high infectivity and either can proliferate in water or possess high resistance to decay outside the body. Viruses and the resting stages of parasites (cysts, ocysts, and ova) are unable to multiply in water.

Contaminated drinking water, along with inadequate supplies of water for personal hygiene and poor sanitation are the main contributors to an estimated 4 billion cases of diarrhea each year causing 2.2 million deaths, mostly among children under the age of five (WHO, 2000).Waterborne pathogens and their significance in water supplies are illustrated in the following table (Table 1.1).

Table1.1. Water borne pathogens and their significance in water supplies.

Pathogen	Health Significance	Persistence In water Supplies(a)	Resistance To Chlorine(b)	Relative Infectivity (c)	Important animal source
Bacteria					
Burkholderiapseudomallei	High	May multiply	Low	Low	No
Campylobacter jejuni, C. coli	High	Moderate	Low	High	Yes
Escherichia coli - Pathogenic	High	Moderate	Low	High	Yes
E. coli–pathogenic	High	Moderate	Low	Low	Yes
E. coli - Enterohaemorrhagic	High	Moderate	Low	High	Yes
Francisellatularensis	Low	*long*	Moderate	High	Yes
Legionella spp.	High	May multiply	Low	Moderate	No
Mycobacteria (nontuberculous)	low	May multiply	High	Low	Yes
Salmonella typhi	High	Moderate	Low	Low	No
Other salmonellae	High	May multiply	Low	Low	Yes
Shigellaspp.	High	Short	Low	High	No
Vibrio cholera	High	Short to long	Low	Low	No

(Source: WHO: Guidelines for Drinking Water Quality, FOURTH EDITION, 2004).

Many consumers will link the presence of offensive tastes or odors with the possibility of a health risk (Jardine et al., 1999), though an unpleasant taste in water does not necessarily indicate that the water is unsafe to drink (Lou et al., 2007).

1.4. Chemical Aspects

The health concerns associated with chemical constituents of drinking-water differ from those associated with microbial contamination and arise primarily from the ability of chemical constituents to cause adverse health effects after prolonged periods of exposure. Table 1.2 illustrates water quality standard (Palestine and WHO) for human consumption.00000

Table 1.2. WHO Water quality standard for human consumption.

Character	WHO guidelines (2004)
Total *Coliform*-colony forming unit (CFU)/100ml	0
Faeacl *Coliform* CFU/100ml	0
Total dissolve solids TDS mg/l	Up to 500
Nitrates mg NO3-N/L	Up to 10 as NO3-N
Turbidity (NTU)	Up to 5.0
pH	6.5–8.5

There are few chemicals that are mad of water that can cause health issues caused by a single exposure. This is likely to happen through entire pollution in a drinking water supply. Generally, water becomes un-drinkable because of improper taste, smell and form (WHO, 2004). If exposure is classified as a short-term one where health issues will not arise, it is better to get rid of pollution source instead of setting up expensive water treatment devices. This should be done to make sure that rare resources are not unnecessarily meant to those of little or no health concern (WHO, 2004).

Case by case basis is the method by which the probability of significant concentrations of particular chemical occurrence in particular settings must be assessed. In particular countries, chemicals' presence might be already known (Bangladesh and west Bengal case of arsenic in groundwater). Notably, other chemicals are hard to be assessed that way. The widespread of chemical, which presence is unknown, posing high health might cause the significant problems or even crises. When chemical presence is known, this is because chronic exposure as opposed to acute exposure causes their long-term health effect (WHO, 2004).

Chemicals are divided into six major source groups, as shown in table 1.3. Categories may not always be clear-cut. The group of naturally occurring contaminants, for example, includes many inorganic chemicals that are found in drinking-water as a consequence of release from rocks and soils by rainfall, some of which may become problematical where there is environmental disturbance, such as in mining areas (WHO, 2004).
The parameters could influence drinking water flavor (pH, TDS, TH, alkalinity, free available chlorine, sulfate and ammonia-N), while the turbidity and *Coliform* group were measured respectively due to esthetic and health concerns (Lou et al., 2007).

Table1.3. Categorization of source of chemical constituents.

Source of chemical constituents	**Examples of sources**
Naturally occurring	Rocks, soils and the effects of the geological setting and climate.
Industrial sources and human dwellings	Mining (extractive industries) and manufacturing and processing industries, sewage, solid wastes, urban runoff, and fuel leakages.
Agricultural activities	Manures, fertilizers, intensive animal practices and pesticides.
Water treatment or materials in contact with	Coagulants, DBPs, piping materials drinking-water.
Pesticides used in water for public health	Larvicides used in the control of insect vectors of Disease.
Cyanobacteria	Eutrophic lakes.

(Source: WHO Guidelines for Drinking Water Quality, 2004)

1.4.1. Chemical Water Contamination

Samples taken from rainfall chemical composition showed various concentrations of chemical according to rainfall direction, the amount of rainfall, and the time between each rainfall occurrence. The chemical composition of rainwater is mostly affected by dust and soil carried with winds (Granat, 1972 and Me´ndez et al., 2004).

Some factors like the sea environment influence and human practices (especially those that contain nitrites, ammonium and phosphates) affect the chemical composition of rainfall samples (Zunckel et al., 2003 and Sazakli et al., 2007).

The quality variation for the surface runoff appear to mirror differences in toping materials, age and management, the existing environment, season, duration and intensity of storms, regional quality of air conditions (Chang et al., 2004).

Numerous studies of the chemical composition of urban rainwater and roof run-off have demonstrated relationships between concentrations of chemical contaminants and proximity to contaminant sources (emissions), weather patterns, and atmospheric transport and deposition (Evans et al., 2006).

Al-Khashman (2005) investigated the chemical composition of wet atmospheric precipitation samples in the Eshidiya area in south Jordan, concluded that the rainwater chemistry is strongly influenced by natural sources rather than anthropogenic and marine sources.

1.4.2. Nitrate

Public water supplies are routinely monitored for nitrate levels, and whenever these supplies exceed the nitrate standard, public notification via broadcast and print media is required. The current drinking water standard and health advisory level of 10 mg/L NO3− N (equivalent to 10 parts per million NO3-N or 45 parts per million NO3−), is based only on the non-cancer health effects related to infantile methemoglobinemia (Kross et al., 1993). Concentrations over 3 mg/L nitrate nitrogen are usually considered indicative of anthropogenic pollution (Madison&Brunett, 1985, Kross et al., 1993).

The presence of Nitrogen as nitrates proves previous cases of contamination, which is not considered an imminent threat (Karavoltsosa et al., 2008). The combination of $SO4^{2-}$ and $NO3^{-}$ reflect the core ionic products of industrial and traffic exhausts (Evans et al., 2006).

Much of adults' nitrate intake may come from their diet, particularly green vegetables. With children, water intake is proportionately much more important, and often the dominant input (Kross et al., 1993).

Nitrate standard level in drinking water was set primarily to prevent infant cyanosis, or methemoglobinemia (blue baby syndrome), a short-term blood disorder that decrease the functionality of infant's bloodstream to move oxygen through the body. This might leave long-term developmental or neurological effects (Kross et al., 1993).

Some evidence exists from epidemiological studies that high nitrate ingestion is involved in the etiology of human cancer. High nitrate levels in groundwater have been associated with increased rates of non-Hodglin's lymphoma in a Nebraska study. Boiling of water contaminated with nitrate is not effective and, in fact, actually increases the concentration of nitrate because of evaporation (Kross et al., 1993).

1.4.3. pH

pH is the negative log. of the activity of the hydrogen ion in an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline, whereas pure water has a pH of 7.

In many cases, the rain is acid with reported pH values starting at 4.17 (Mantovan et al., 1995, Chang et al., 2004).At this pH range, metals seepage from the collection surfaces is promoted and worsens the quality of harvested rainwater (Sazakli et al., 2007).

The acidity in precipitation depends on the concentration of acid-forming ions, as well as contractions of alkaline species which neutralize the acidity and the amount of rainfall (Al-Khashman, 2005). Such neutralization is frequently reported and attributed to NH3 and/or carbonate materials. In Mediterranean area, carbonate particles were the most dominant neutralizing agents (Al-Momani et al., 1995 andTuncer et al., 2001).

The neutralization by carbonate materials was usually reported in the region where composition of precipitation was strongly affected by high calcite content of Saharan dust (Loye-Pilot et al., 1986; Al-Momani et al., 1995, Al-Khashman, 2005).The ammonium compounds applied to soil can escape into atmosphere by means of gaseous NH3 or as NH_4NO_3 and $(NH_4)_2SO_4$ particles. When ammonium was incorporated in rain, it can neutralize the acidity of rainwater (Al-Momani et al., 1995, Al-Khashman, 2005).

Extra H^+ ions, which reduce the pH values in wood gravel runoff, might be due to the weather effects on wood (cedar, red wood, or cypress in most cases) and the decomposition of growing plants, wood-destroying fungi, debris, lichens, insects and mosses. On the contrary, the pH of runoff can get higher than the pH of rainwater due to galvanized iron roofs, painted aluminum and composition shingles (Chang et al., 2004).

1.4.4. Total Dissolved Solids (TDS)

TDS and conductivity are two separate measures of the same thing. They measure the presence of all anions and cations in drinking water. TDS does not specifically point to any health issues. Since some anions and cations are toxic (lead, arsenic, cadmium, nitrate, and others), a high measure of conductivity/TDS warrants getting a clear understanding of its cause (WHO, 2004).

1.5. Sources of Pollution

Roof runoff is considered a potential source of non-point pollution for two primary reasons including substances contained in the roofing materials and the high temperatures of the roofs. Compounds contained in roofing materials, airborne pollutants and organic substances (such as leaves, dead insects, and bird's wastes), are added to roofs by interception and deposition might frequently leached into runoff. In addition, roof temperatures are generally much higher than temperatures of other surfaces, due to lower albedo, greater surface inclination to direct solar radiation, and less shading effects from surrounding trees (Chang and Crowley, 1993).

Results of roof runoff studies have been variable. The variation reflects differences in roofing materials, industrial treatments, care and maintenance, age, climatic conditions, orientation and slope of roofs, and air quality of the region (Chang et al., 2004).

Awadallah (2004) summarizes the factors affecting collected rainwater quality as the following:

- Any waste existing in the catchment area.
- Penetration of sewage water from adjacent cesspit into the cistern.
- Sediments accumulated and not regularly removed year after year in the cistern.
- Unreliable water quality, expected in case rainwater is finished and tanker-water is brought into the cistern (depending on the original source of tankered water, contaminated water is frequently supplied to consumers)
- Insects breeding and waste entered in the cistern from the surface gate or the piping system left opened.

1.5.1. Septic (Infected) Systems

The true pollution sources are the activities that happen on the land on-lot septic systems, nitrogen fertilizer use, and road salt application to name a few. Septic systems have been noted as one of the largest sources of pollution in the suburbs (along with construction erosion) through failing systems and subsurface movement of pollutants (Novotny, 1991). Septic systems have been cited as a major source of nitrogen to the groundwater as approximately only 10% of the nitrogen that processes through the septic tank is removed. Nitrate leaching can occur when home lawns are over watered after nitrate forms of nitrogen fertilizers are applied (Gold et al., 1990).

1.5.2. Environmental Factors

Because of failing systems and subsurface movement of pollutants, septic systems (mainly construction erosion) have become one of the largest sources of pollution in suburban areas. Factors such as site characteristics, interval duration, and UV intensity would all impact on the survival of micro-organisms on the catchment surface and their viability in the run-off (Evans et al., 2006).

It should be stated that inert release and airborne transport of micro-organisms from environmental sources/surfaces is dependent upon a number of variables, including bonding forces, wind shear forces and mechanical disturbances (Jones and Harrison, 2004).

A large proportion of organic contaminants found in the harvested rainwater are associated with various sources of contamination. Organic compounds are introduced into the atmosphere as a result of evaporation from land surfaces, combustion of fossil fuels and emissions from industrial plants. These substances may be transported in the atmosphere for long distances and may pollute the rainfall in areas remote from the pollution sources. If using roads, fields and/or plastic film as the collection surfaces, rainwater can dissolve and wash any spilled petrol, pesticides and other chemicals from these surfaces, and show an increase in organic pollutants and phthalate esters (Zhu et al., 2004).

Chapter Two: Materials and Methods

2.1. Study Area

This study was conducted in two localities namely Masafer Yatta and Road 317 with 29communities (10 in Masafer Yatta, 19 in Road 317) located in the southern part of Hebron district (Figure 2.1). The total area of these localities is about 37,500 dunom (ARIJ. GIS Database, 2006-2009).

The study area has a semi-arid climate that is characterized by a low annual rainfall from November to April and very dries weather for the rest of the year, with hot, dry, uniform summers. Generally, winter is cool and most of the precipitation occurs during this season. The average maximum and minimum temperature in summer are 26.6, 16.4°C respectively, and in winter is about 12.1 and 5.2°C respectively. The average annual rainfall is about 149 mm and the average relative humidity is about 61%, (Palestinian Metrological Department, 2007).

The area has a serious water scarcity problem coupled with no network for water supply.

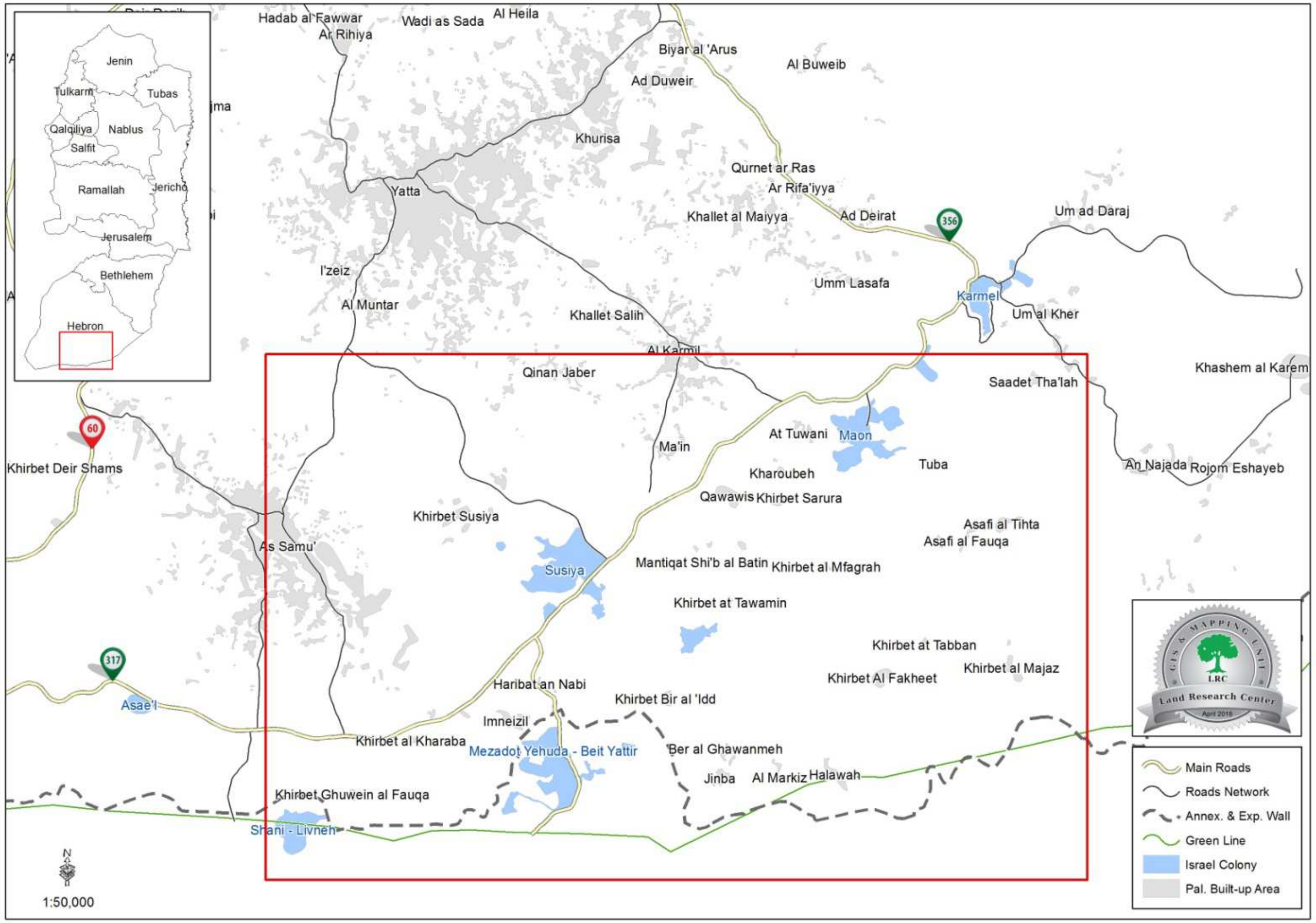

Figure2.1 Study areas of the two targeted localities located at the southern part of Hebron district – Map prepared by GIS and Mapping Unit – Land Research Center – LRC - 2016.

2.2. Study Preparation

After several visits to the localities and the communities as well, the intended target area and cisterns were determined. Different materials needed, devices and any logistics were done.

2.3. Preparing the Questionnaire

A questionnaire consisted of five topics was prepared, modified, validated, and finally formulated (Appendix1). The topics include:

- Household personal profile, such as age, and level of education and water uses.
- Cistern characteristics and sources of cistern water, various aspects of domestic water supply for the people who live in the study area, such as source of drinking water, age of cistern and its capacity.
- Cisterns sanitation and assessing water quality.
- Knowledge of the study population on drinking water contamination and their motivation towards water quality.
- Environment surrounding the cisterns having livestock around the cistern.

The questionnaire consists of two types of questions: those related to yes and no answers (usually offers a dichotomous choice), and multiple choice once (offers several fixed alternatives).

The questionnaires were then distributed among the sampled households (communities); verbally answered by the owners and filled thereby by the researchers during the water samples collection. Obtained data were tabulated, and prepared for further analysis.

2.4. Water Sampling

A schedule for sample collection throughout a year (March 2010 to March 2011), was set-up in collaboration with the relevant stakeholders (households and technicians of Hebron University labs).

All samples were collected from the targeted cisterns at about half meter below water level using 500 ml individual marked sterile glass-bottles. To avoid contaminations, bottles were carefully cleaned and rinsed, given a final rinse with distilled water, and sterilized at 121^0C, 15 psi for 20 minutes in autoclave.

Samples were labeled by giving numbers correspond to the numbers given to the questionnaires.

Water samples were collected from each cistern by shaking the surface water inside the cistern. Then, water was transferred to the pre-prepared bottles until it completely filled. Accordingly, all bottles were transported to the laboratories of Hebron University in ice boxes at 4^0C in. (Abo-Shehada et al., 2004). Furthermore, containers used were in accordance to the 18^{Th}edition of standard methods for examination of water and wastewater (Greenberg et al., 1992).

2.5. Laboratory Works

2.5.1. Biological Test

2.5.1.1. Media Preparation

Two selective media's of m-Endo Agar LES and m-*Faecal Coliform* Agar were used for TC as well as FC tests respectively.

First: m-Endo Agar LES media was prepared by suspended 51g of wet-able powder in 1 liter of purified water that contains 20 ml of 95% ethanol. The obtained media was mixed thoroughly. To complete the wet-able powder dissolving, the obtained media were heated frequently and boiled for 1 minute. Accordingly, the media were cooled to 50 ^{0}C and transferred into petri dishes. Final pH of 7.2 was calibrated (APHA, 2003).

Second: m-*Faecal Coliform* Agar (selective medium that generally used for isolation and enumeration official *Coliform* organisms) was prepared according to MF technique method. 50 g of wet-able powered was suspended in 1 liter of cold distilled water. Then, 10 ml of Rosalic acid (1% solution in NaOH 0.2 N) was added, and accordingly well mixed and heated until boiling. Finally, the media was cooled and transferred in petri dishes (APHA, 2003).

2.5.1.2. Membrane Filter Technique

One hundred milliliter water samples were filtered through 0.45um pore size cellulose nitrate membrane using vacuum for each total *Coliform* and *Faecal Coliform* tests. Then the membrane placed into the petri dishes for the two culture media's (m-Endo and m-FC media respectively). Petri dishes were then incubated at 37^0Cand 44^0Crespectively for 24 hours (Greenberg et al., 1992 and WHO, 2004). To avoid any mistakes, all samples and media's were carefully labeled.

2.5.1.3. Colony Count

After the incubation period, only colonies inside the membrane (gridded filter) were counted for each petri dish. Dark blue colonies were considered as FC and red with metallic sheen colonies were deliberated as the TC. However; red, pink, blue, white, gray, color's lacking sheen and colorless colonies were discarded.

2.5.1.4. Quality Control

Glass control: All used glass-bottles (1 liter size) were highly sterilized using some drops of sodium thiosulfate for each bottle in order to sediment the free chloride.

Culture control: two new membranes were cultured directly into two plates contains only media's (m-Endo & m-FC media). Actually, this check was done to avoid any un-expected contamination that might related to the filter, water, membrane, media surrounding environment, human mistakes, etc.

2.5.2. Chemical and Physical Tests

At the same day of sample collections, samples were directly transported to the laboratories of Hebron University. Chemical tests including electrical conductivity, total dissolved substances, nitrate, and pH as well as physical tests mainly turbidity were conducted (table 2.1 and table

2.2),in accordance with the standard procedures for examination of water and wastewater (EWW, 1992 and Greenberg et al., 1992).

Table 2.1. Chemical and physical (microbiological) tests.

Test	Used Method	Method Principle
Total *Coliform* (TC)	Membrane filters technique.	Membrane Filtration
Fecal *Coliform* (FC)	Membrane filters technique.	Membrane Filtration
Nitrate (NO_3)	Ultraviolet Technique	UV Spectrophotometric screening

Table 2.2.Equipment's used for chemical and physical tests.

Tests	Equipments	Company, Country
pH	pH Meter 3305.	JENWAY, UK
Temperature (Temp.)	pH Meter 3305.	JENWAY, UK
Electrical Conductivity(EC)	Conductivity Meter 4320.	JENWAY, UK
Total Dissolved Substances(TDS)	Equation TDS= EC*640.	Milton Roy Spectronic, Canada
Turbidity	Turbidity Meter.	Hanna , USA

2.6. Data Entry & Analysis

All gathered data were transformed to the computer using excel sheets. Data were manipulated and arranged for analysis using Statistical Package for Social Sciences (SPSS), version 19.

Chapter Three: Results

Tables (3.1) and (3.2) showed the minimum, maximum and the mean values for each measured parameter in wet and dry seasons.

3.1. Chemical Analysis

3.1.1. pH and TDS

Water samples of 73 cisterns were subjected to chemical, physical and biological parameter. The results showed a great diversity in the chemical and physical characteristics.

3.1.1.1. pH and TDS / Masafer Yatta cluster

pH value for the first sampling(wet season, March2010) ranged between 7.21(MF2) and 9.93 (MJ2); for the second sampling (February, 2011), pH values of three cisterns (MF2, MJ1, and MF1) were exceeding the WHO standard with a pH values of 9.93, 9.81 and 9.63 respectively (Appendix IV, presents the cods of tested cisterns). Whereas, in the dry season, pH values in the two sampling (April 2010 and October 2010) exhibited an acceptable values related to WHO standard for the pH value (Table 3.1).

In addition, TDS (mg/L) values in both seasons varied for all the examined cisterns. TDS values for the first sampling (wet season) ranged between 104 mg/L in MF3 cistern to 1040 mg/L in MI2 cistern (Table 3.1, Figure 3.1). However, all of the remaining cisterns exhibited intermediate values of TDS (Appendix II).

In the dry season, TDS values ranges between 118 mg/L (MF3) and 454 mg/L (MF1).

3.1.1.2. pH and TDS / Road 317 cluster

pH value for the first sampling (wet season, March 2010) ranged between 6.87 (RE1)to 10.10(RI2);whereas in the second sampling (February 2011), RI2 and RQ2 cisterns were exceeding the WHO standard with a pH values of 10.10 and 9.63 respectively (Table 3.2).

Concerning the pH values in the dry season, it ranges between 7.20 (RR1) to 11.26 (RQ2) in the first sampling, however in the second sampling pH values ranged between 7.22 (RJ1) to10.53 (RQ2) cisterns. Indeed, RQ2 exceed the WHO standard for the pH value in both seasons.

TDS values in R317 cluster (first sample, wet season) presented a values of 71 (RM1) to 647 (RO5). However, in the second sampling (dry season), TDS values range between 70 mg/L (RK1) to 544 mg/L (RD3) (Table 3.2, Figure 3.2). In fact, these values are within WHO standards (Appendix II).

Table 3.1. Mean, maximum, and minimum values of total coliform, fecal coliform, pH, total dissolved solids and turbidity in Masafer-Yatta cluster.

	Parameter	TC – CFU/100 ml	FC – CFU/100 ml	pH	TDS – mg/L	Turbidity - NTU
MY in dry season	**Mean**	245	97	7.56	242	7.58
	N	52	52	52	52	37.00
	Std. Deviation	345	195	0.30	80	5.64
	Maximum	1373	970	8.32	454	26.65
	Minimum	0	0	7.06	118	.87
MY in wet season	**Mean**	259	111	7.95	317	4.71
	N	84	84	84	84	59.00
	Std. Deviation	512	263	0.47	145	2.65
	Maximum	3040	1820	9.93	1040	23.00
	Minimum	0	0	7.21	104	3.35
MY around the year	**Mean**	254	106	7.80	288	5.82
	N	136	136	136	136	96.00
	Std. Deviation	454	239	0.45	129	4.28
	Maximum	3040	1820	9.93	1040	26.65
	Minimum	0	0	7.06	104	0.87

Table 3.2. Mean, maximum, and minimum values of total coliform, fecal coliform, pH, total dissolved solids and turbidity in R317 cluster.

	Parameter	TC – CFU/100 ml	FC – CFU/100 ml	pH	TDS – mg/L	Turbidity - NTU
R317 in Dry season	**Mean**	389	141	8.09	263	5.79
	N	135	135	135	135	77.00
	Std. Deviation	653	450	0.65	121	4.36
	Maximum	3800	3200	11.26	544	29.56
	Minimum	0	0	7.20	70	0.24
R317 in Wet season	**Mean**	351	93	8.21	300	5.79
	N	202	202	202	202	146
	Std. Deviation	660	253	0.45	147	3.56
	Maximum	4520	2020	10.09	647	25.33
	Minimum	0	0	6.87	71	3.32
R317 around the year	**Mean**	366	112	8.16	285	5.79
	N	337	337	337	337	223
	Std. Deviation	656	346	0.54	139	3.85
	Maximum	4520	3200	11.26	647	29.56
	Minimum	0	0	6.87	70	0.24

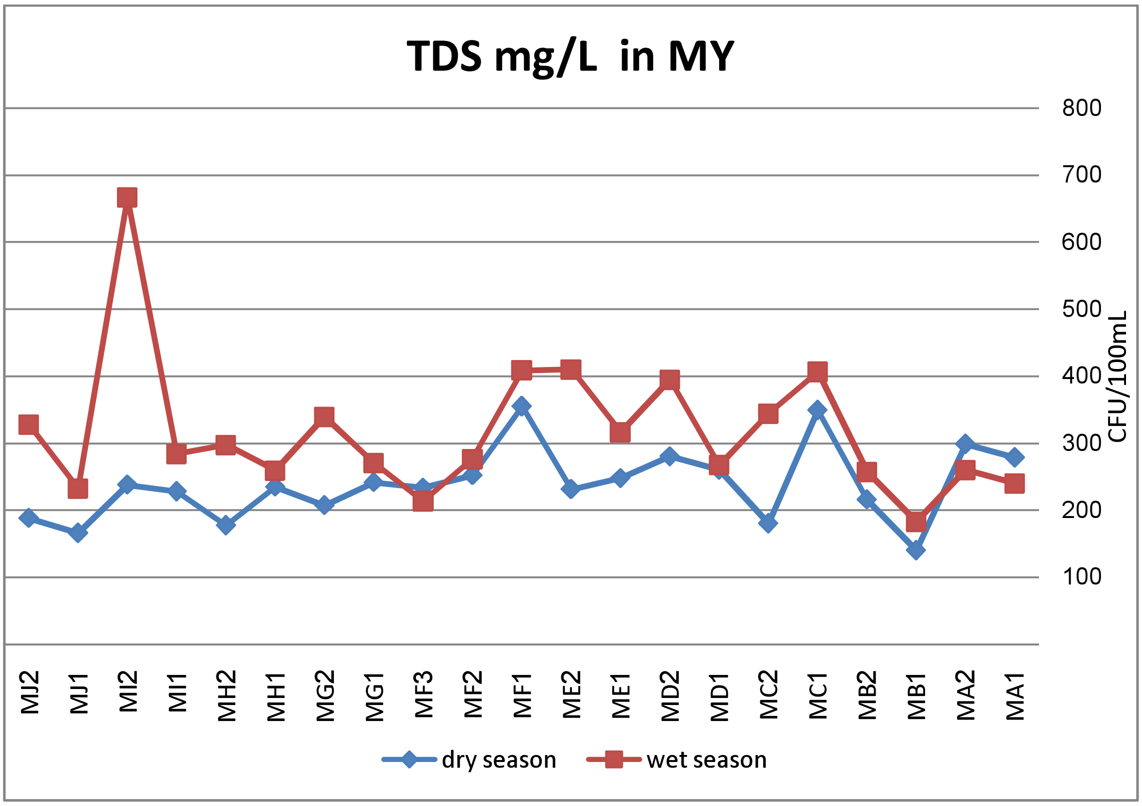

Figure 3.1 TDS values in Masafer Yatta in wet and dry seasons.

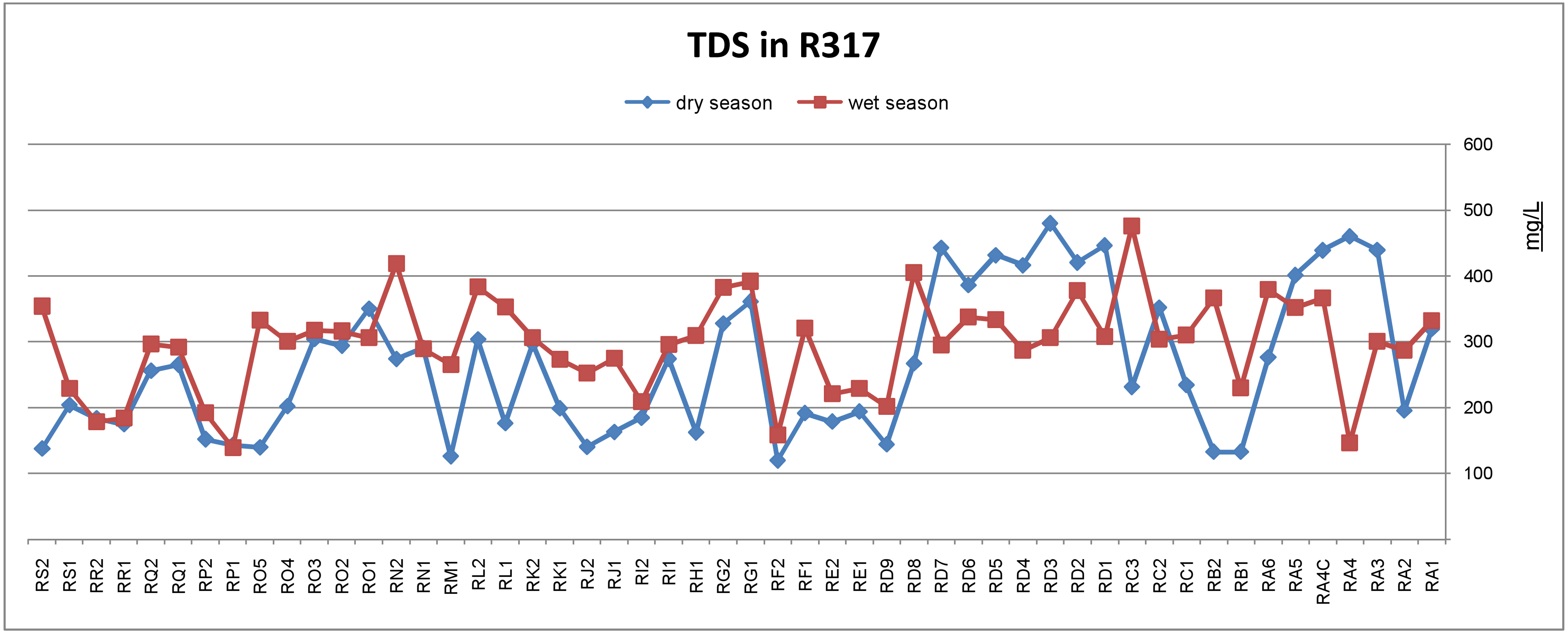

Figure 3.2 TDS values in R317 in wet and dry seasons.

3.2. Biological Analysis

For all of the examined cisterns in both clusters, microbiological contamination were very high related to the international WHO standers, in which total *Coliform* (TC) presented an average contamination of 92.2%, whereas Faecal *Coliform* (FC) exhibited an average contamination of 97.4%. In fact, the average total *Coliform* contamination for both clusters was255 CFU/100ml (Table 3.1, Table 3.2, and Figure 3.3).

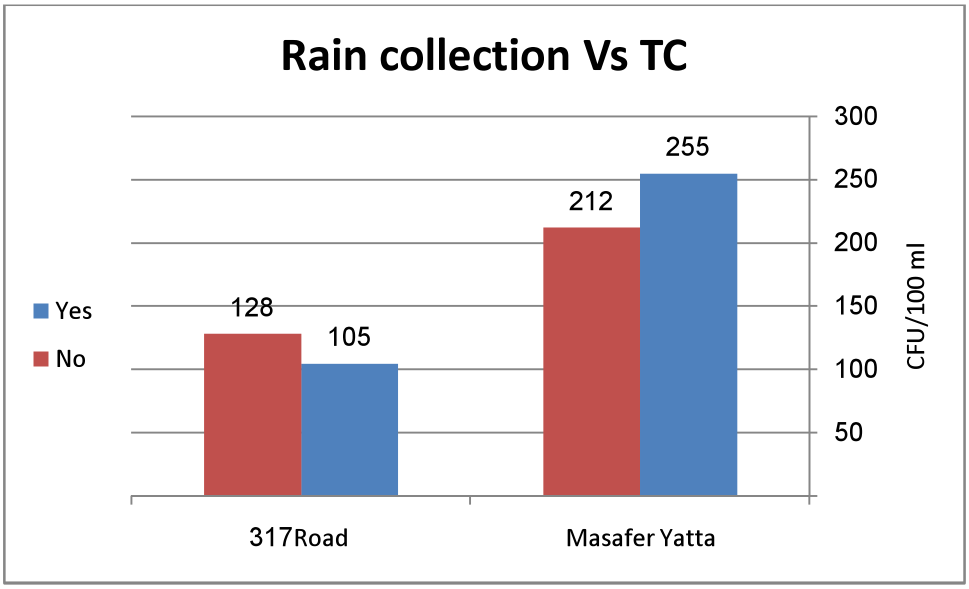

Figure 3.3. The relationship between rain water collection and total *Coliform* in both clusters

3.3. Physical Analysis / Turbidity

In general, significant differences presented in turbidity parameter among the two examined clusters as well as wet and dry seasons. Indeed, dry season exhibited high turbidity comparing to the wet season in Masafer Yatta over Road317 cluster (Figure 3.4). To show the significances, tests of normality (Table 3.4) and mann-whitney test were used (Table 3.5)

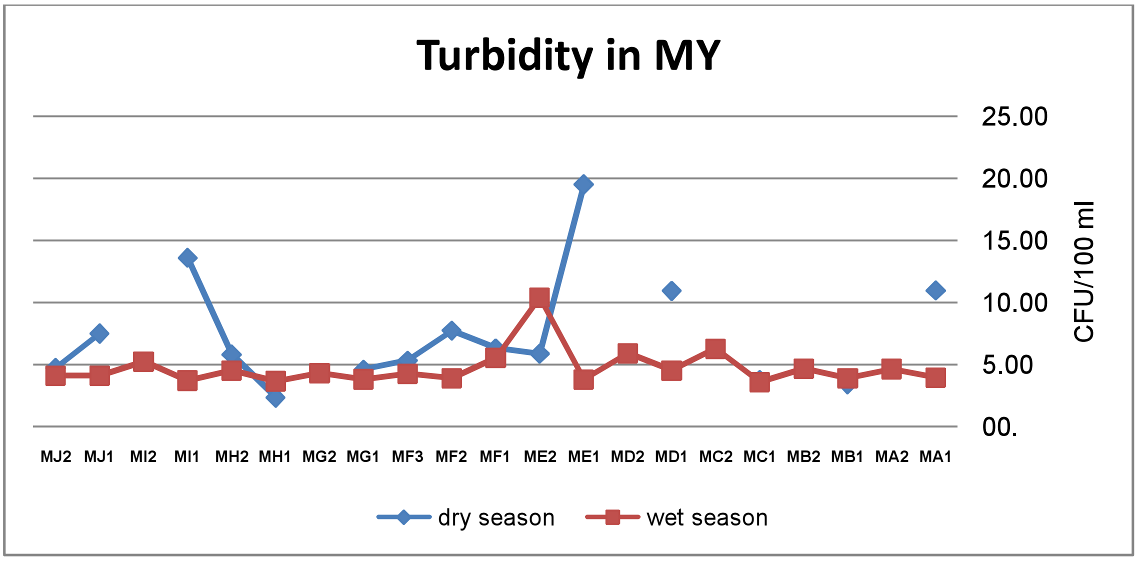

Figure 3.4 Turbidity variations among the wet and dry seasons in Masafer Yatta.

Table 3.4. Test of normality for turbidity parameter.

Season class		Kolmogorov-Smirnova			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Turbidity	dry season	0.229	114	0.00	0.692	114	0.0
	wet season	0.260	205	0.00	0.628	205	0.0

Table 3.5.Mann-Whitney test for turbidity parameter.

Season class		N	Mean Rank	Sum of Ranks
Turbidity	dry season	114	***183.43***	20911.00
	wet season	205	146.97	30129.00
Total		319		

3.4. Questionnaire Analysis

3.4.1. Rain water collection and cleaning

The results showed that, out of 73 cisterns; 71 cistern-owners were harvesting rain water compromising an average of 97.2% (Table 3.3). From these cistern-owners, only 15% (usually having small cisterns) were annually cleaning their cisterns. In contrary, those having large sizes didn't clean their cisterns for almost five years (Table 3.4).

Table 3.3. Rain water collection percentages in the two clusters.

Cluster			**Rain water collection**		Total
			Yes	No	
Masafer Yatta and R317	Total	Count	71	2	73
		% within Community Name	97.2%	2.8%	100.0%

Table 3.4. Cleaning the cistern percentage in the two clusters.

Cluster			Did you clean the cistern		Total
			Yes	No	
Masafer Yatta and R317	Total	Count	10	63	73
		% within Community Name	15%	85%	100.0%

3.4.2. Refinery Type

Results showed that 50% of the farmers were using plants as a refinery material, whereas 30% didn't used any refinery. In addition 13% and 7% of the farmers were using combining (metal and plants) and metal alone, respectively.

3.4.3. Source of Water

As shown in table 3.5., five main water sources including rain, filling point, filling point and other cistern, other cisterns, and spring were found to be used in the two targeted clusters, in which they presents an averages of 69.8%, 21.9, 1.36%, 5.5%, and 1.36% respectively.

Table 3.5. The percentages of water sources in the cisterns.

Cluster		Source of water						Total
		Rain	Filling points	Filling point+ Rain	Filling point+ Other cistern	Other cistern	Spring	
Two clusters	Count	51	16	0	1	4	1	73
	% within Community Name	69.80%	21.90%	0	1.36%	5.50%	1.36%	100 %

3.4.4. Return of the bucket to the cistern

Almost 68.5% of the respondent found to return the bucket inside the cistern after they used (Table 3.6).

Table 3.6. The percentages of returns the bucket to the cistern after used.

Cluster		Return bucket inside Cistern		Total
		Yes	No	
Two clusters	Count	50	23	73
	% within Community Name	68.5%	31.5%	100%

3.4.5. Distance of the septic tank to the cistern

Out of 73 respondents, 93.1% having septic tank with more than 20 meter away from the cistern, whereas the remaining 6.9% were with less than 20 meter.

Chapter Four: Discussion

4.1. Chemical Analysis

As it was shown in tables (3.1 and3.2) and figures (3.1 and 3.2), pH values of some cisterns in both clusters have exceeding the WHO standard. Indeed, the higher pH values might related to the runoff collecting that occurs during rainwater harvesting from the ground catchment area surrounding the cisterns. Similar results was recorded by Chang et al. (2004), who stated that, the pH of runoff can get higher than the pH of rainwater due to galvanized iron roofs, painted aluminum and composition shingles.

In addition to that, alkaline materials like the carbonate that using in the plastering material especially with the new constructed cisterns might also increase the pH value (Al-Momani et al. 1995 and Tuncer et al. 2001). The same authors also stated that, In Mediterranean area, carbonate particles were the most dominant neutralizing agents.

Al-Khashman (2005), also found that the ammonium compounds applied to soil can escape into atmosphere by means of gaseous NH3 or as NH4NO3 and (NH4)2SO4 particles, and when ammonium was incorporated in rain, it can neutralize the acidity of rainwater (rain-water is acid thus mixing ammonium increase the alkaline.

Regarding the TDS value for both clusters in both seasons were within the range of WHO standard implying its acceptability except with some cisterns that exceeds the range.

Indeed, this acceptable range might related to the discharge of the first flush out of the cisterns and the regularly removal of the accumulated sedimentation which is a common good practice that help in harvesting a good water quality. Our result is also supported by Awadalla (2004), who stated that sedimentation accumulated and not regularly removed year after year in the cisterns affecting the quality of collected rainwater.

In contrary, some cisterns showed high TDS value which might related to one or combinations of many factors that occur during runoff dilution including compounds that might contained in roofing materials, airborne pollutants and organic substances (such as leaves, dead insects, and bird's wastes), that added to roofs by interception and deposition which frequently leached into runoff Chang and Crowley(1993).In fact, the dilution contains the salts and cations and other organic wastes surrounding the cistern catchment area which resulted in high TDS value.

4.2. Biological Analysis (Total Coliform and Faecal Coliform)

The microbiological contamination was very high related to the international WHO standards. In which Total *Coliform* (TC) presence an average contamination92.2%, were Faecal *Coliforms* (FC) exhibited an average contamination of 97.4%. This high contamination may be attributed to the way of rainwater harvesting from the ground area surrounding of the cisterns; where the herders watering their animals and birds on. As the results of the questioner show that 97.2% of the cistern-owner harvesting the rainwater from the surrounding area. A total Coliform result is similar with what was shown in the study of Al Salaymeh A. and Al-Khatib. (2008) whom found in their study in Hebron city that 95% of the rainwater samples contaminated with Total *Coliform* (TC), while for Faecal *coliforms* (FC) only 57% of their sample were contaminated; this result is lower than what our results showed.

Also our results related to the Total *coliforms* were higher than the results obtained by Al-Khatib and Orabi. (2004) in their study "Causes of drinking-water contamination in rain-fed cisterns in three villages in Ramallah and Al-Bireh District" that found 87% form tested sample contaminated with Total *Coliform*, and lower in regarding to *Faecal Coliform* that was contaminated by 100% of tested sample.

Crabtree et al., 1996 in their study about microbiological quality of cisterns in Virgin Islands of USA reported that 57% of the samples were positive for Total *Coliform* and 36% were positive for fecal *Coliform* which is lower than the results of this study.

In other study conducted by Al-Khatib et al, (2003) about drinking water quality in Tulkarm District- Palestine, they found that only 34% of samples were contaminated with Total *Coliform* and 9.2% contaminated with *Faecal Coliform*.

In addition, The percentages of water samples contamination of this study are higher than results obtained by Abo-Shehada et al. (2004) of cisterns in Bani-Kenanah District–Northern Jordan, that founded the contamination with total *Coliform* was 49% of the tested samples were *Faecal Coliform* 17% of tested sample.

Uncontrolled rainwater harvesting systems especially in rural or remotes area that the animals and birds can reach easily(un well protected or close cisterns and catchment areas) like the study area can easily contaminated with waterborne diseases; this mach with any private water supply like Canadian; Canadian private water supplies may pose a risk to public health; numerous studies report such water supplies in excess of the minimal acceptable standards for microbial and chemical contamination, and an estimated 45% of all waterborne disease epidemics in Canada involve non-municipal systems, largely in rural or remote areas (Yassin et al., 2006).

4.3. Physical Analysis/ Turbidity

Results show significance differences in turbidity parameter among the tow clusters in wet and dry seasons. Indeed, dry season exhibited high turbidity comparing to the wet season in Masafer Yatta over Road 317 cluster. The possible causes of these high results are, some of the samples are collected while it is raining and water is entering the cistern so the whole water is mixed. Collecting the house wastes in the house yard, presence of green spots at the sides of the cistern, presence of floating things at the surface of the cistern's water, increases the turbidity of the cistern's water.

4.4. Questionnaire Analysis

4.4.1. Rain water collection and cleaning

Results showed that a high percentage of cistern-owners in both clusters used rainwater harvesting technique. Indeed, the area is not connected with public network and there is no other source for water. Al-Khatib et al. (2003) stated that water is regarded as a focal and crucial issue in the Middle East in general, including Palestine in particular, where augmenting water insufficiency and deterioration are existing, in fact, water resources are tightly limited and do not meet people need. On the other hand, Abu Dayyeh (2005) stated that the measures imposed by the Israeli Occupation forces that are often implemented as collective punishment or simply as means of further humiliation and destabilization play a major role in hindering the establishment of water infrastructure. As a result of these harsh policies, numerous communities in Hebron district have been left without food, work and/or water and other necessities for days, weeks or even months. So rainwater harvesting is the main source of water supply in such areas. It means that rainwater harvesting is a priority and highly needy in Hebron especially in the southern area.

Cistern-owners who use rainwater harvesting methods and clean their cisterns often own small ones. In contrary, those having large-sized ones didn’t clean their cisterns for almost five years. This could be due to the large size and time insufficiency to empty and clean the cisterns. Also, it's noted that cistern-owners lack awareness about cistern hygiene and water safety. Taraba et al. (1990) stated that practices like cisterns cleaning that include cleaning gutters, roof washer, water pump and distribution pipe are helpful to guarantee safer water.

Given that people are herders who usually water their flocks directly on cisterns, where animals and birds faces usually exist and that the owners of rainwater harvesting cisterns collect the runoff that already contains pollutants and dust, the high values of contamination in cisterns are explained as such.

4.4.2. Refinery Type

Results showed that 50% of the cisterns-owners were using plants as a refinery material, whereas 30% didn’t used any refinery. In addition 13% and 7% of the cisterns-owners were using combining (metal and plants) and metal alone, respectively. This kind of refinery were useless especially the plant one which is source of contamination. Using save filter and chlorine treatment is helping to guarantee safer water (Taraba et al., 1990).

4.4.3. Source of Water

Using the five main water sources for filling citterns didn't affect the percentage of contamination in them. Contamination was relatively similar in target cisterns. Most of the cisterns that are filled by different source of water are contaminated. And thus, the study found out that the source of water doesn't affect water quality. The contamination might be explained due to water tanks used for moving water to the area.

4.4.4. Return of the bucket to the cistern

High percentage of the respondents was found to return the bucket inside the cistern after they used it. This means that the buckets could be an agent of contamination and bring contaminations from outside the cisterns to the water inside the cisterns.

4.4.5. Distance of the septic tank to the cistern

A percentage of 93.1% of the 73 respondents was found to have septic tanks with a distance of more than 20 meters away from cisterns, whereas the remaining 6.9% of the study sample had their cisterns located in a distance less than 20 meters from septic tanks. Contamination in both cases was closely similar. Thus, the distance between septic tanks and cisterns didn't affect the level of cisterns contamination in the study area.

Conclusions

- There is highly contaminated cistern in both cluster with Total *Coliform* 92.2% and *Faecal Coliform* 97.4%or both from different sources but mainly from the animal and bird faces.
- Most of the people in both cluster work in livelihood sector and irrigate their animal and birds directly on the cistern that lead to contaminate the catchment and the surrounding area, also highly percentage of them use the bucket to get the water from the cistern and put it on the contaminated surrounding area then put it back inside the cistern.
- The source of *Faecal Coliform* in both clusters might come from the animal and birds faces in wet season and from the transporter tanks during the dry season.
- Some of the new establishing cisterns show high number of pH (11.26); this is due to the plastering cements and materials that used.
- Low TDS values in some rain fed cistern might come from mixing with spring water during dry season.
- Large cistern (more than 100 m^3) in this study show high contamination and hard to control (cleaning, disinfection, filling) than small one.

- For disinfection, there is highly percentage of the tested cistern that did not use any kind of disinfections.
- Even there is cistern which clean and discarded the first flush it's highly contaminated because no or bad refinery used.

Recommendations

1. Since the study area classified as arid and semi aired area, were water scarcity is the main challenge and contamination is highly existed, therefore it is necessary connecting to the municipal water network or constructing a new cisterns is needed to avoid water contamination that lead to water born diseases.
2. Deliver the water from the cistern by using fixed method (pump or by gravity using tube) to avoid opening the cistern which make it easy to environmental contamination.
3. Washing the new construction or plastering cistern very well before use it for domestic purposes.
4. Discard the first heavy rainfall outside the cistern.
5. Make sure that all the entrance of the cistern is closed very well after recharge it to avoid any contamination.
6. Use suitable and good quality filter when collecting the water.
7. The cistern volume should be large enough (not more 100 m^3) to store the large quantity and to be easy to manage (cleaning and disinfection).
8. Animal and bird should not reach to the cistern surrounding area.

9. The cisterns should be cleaned every two or three year if it possible before the rain season to remove any possible contaminations resource.
10. Cleanses of water and chlorine should be used regularly to avoid contamination.
11. Using other surface as catchment area and avoiding the ground around the cisterns well reduce the contamination possibility.
12. Several program and educational material should target these communities to highlight the water contamination sources, effects and protection methods.

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Appendix (I): Questioner

استمارة تقييم جودة المياه /جنوب الخليل

.1	القسم الأول:البيانات الشخصية
	رقم الإستبانة المتسلسل في العينة المطابق لرقم البئر: التجمع:
	عنوان الأسرة : رقم الهاتف:
	تاريخ تعبئة الاستمارة: يوم: شهر: سنه:
	اسم الباحث/ة:
.2	القسم الثاني:خصائص المبحوث:
	الجنس: 1-ذكر 2-أنثى
	العمر بالسنوات الكاملة:
	المستوى التعليمي : 1-اقل من ثانوي 2-ثانوي فأكثر
	الوظيفة الرئيسية : 1-مزارع 2-موظف 3-عامل 4- تاجر 5- راعي
.3	القسم الثالث: خصائص الأسرة الديموغرافية :
	عدد أفرادالأسرة: 1-الذكور: 2-الإناث:
.4	القسم الرابع: السكن والخدمات المتوافرة :
	نوع السكن الذي تقيم فيه الأسرة : 1-طوب/باطون 2-حجر 3-خيمة 4- غير ذلك

	مساحة البيت م2:							
	عمر البيت : أقل من 5 15-5 15 فأكثر							
	هل يتم استخدام مياه البئر لغير أغراض الاستخدام المنزلي: نعم لا							
	الاستخدامات ونسبة الاستهلاك :							
		البيت %		الزراعة %		الثروةالحيوانية %		أخرى %
	ما هي المسافة بين البيت واقرب نقطة مياه؟ متر							
	كم من الوقت يلزم للحصول على المياه من خلال اقرب مصدر مياه؟							
		1- اقل من نصف ساعة		2- ساعة/ساعتين		3- أكثر		
	ما هي الوسيلة التي تقوم بإيصال المياه من خلالها إلى البئر؟							
		1- تركتور	2- تنك	3- حيوانات	4- أخرى			
5.	القسم الخامس : معلومات مصدر المياه/البئر							
	مانوع البئر؟	بركة إسمنتية مغلقه		انجاصة				
	سعته:	اقل من 50كوب		من 50-100		أكثر من 100		
	أين موقع البئر ؟ 1- داخل المنزل 2-خارج المنزل							
	عمر البئر : أقل من 5 من 5-15 15 فأكثر							
	مصدر المياه:	1- أمطار جمع		2- نبع		3- تنكات		
		4- شبكات عامه						
	مصدر جمع المياه:		1- سطح المنزل	2- سطح البئر	3- محيط البئر	4- أكثر من طريقه		
	هل يتم تنظيف سطح الجمع قبل عملية الجمع ؟ 1- نعم 2- لا							
	هل يتم تنظيف الخزانات ؟ 1-نعم 2- لا							
	هل الكميه المجموعة تكفي طوال العام؟			1- نعم		2- لا		

	كم كوب يتم شرائه خلال الموسم؟				
	تكلفة الكوب الواحد؟				
	وسيلة ضح المياه من البئر:	1- ماتور	2- دلو	3- أخرى/حدد	
	إذا وجد دلو أين يوضع عادة؟	1- في البئر		2- خارجه	
	هل يوجد أي مشاكل في ماسورة جمع المياه؟	1- نعم		2- لا	
	هل البئر مغلق بالكامل؟	1- نعم		2- لا	
	هل يوجد تسريب في جدران البئر؟	1- نعم		2- لا	
	هل يوجد فتحات أخرى غير الباب؟	1- نعم		2- لا	3- حدد/
	ما هو نوع الصخور والتربة في منطقة البئر؟ حدد/				
	وجود نظام تصفيه لمياه الجمع	1- نعم		2- لا	
	إذا وجد كيف تتم العملية	1- جهاز	2- نبات	3- أخرى/حدد	
	هل منطقة البئر معزولة عن النشاطات الزراعية والحيوانية 1- نعم 2- لا				
	هل يوجد لديك أرض مزروعة 1- نعم 2- لا				
	مساحة الأرض المزروعة متر				
	ما هو بعد الأرض المزروعة عن البئر ؟ متر				
	هل تستخدم الأسمدة والمبيدات 1- نعم 2- لا				
6.	القسم السادس :جودة مياه الجمع				
	ماهو تقييمك لنظافة مياه البئر ؟	1- جيده	2- مقبولة	3- سيئة	4- لا ينطبق
	هل تستخدم المعقمات في البئر؟ 1- نعم 2- لا 3- حدد/				

	هل قمت بفحص المياه سابقاً ؟			1- نعم		2- لا		
	أين تقوم بعملية الفحص؟							
	ما هي الإجراءات التي تقوم بها في حالة تلوث المياه 1- كلورة 2- إضافة شيد 3 – تغير مياه البئر 4 – غير ذالك							
7.	القسم السابع : تأثير مياه الصرف الصحي على مياه البئر							
	كيف يتم التخلص من نفايات المنزل والمزرعة؟							
		1-حاوية النفايات			2- حرقها			
			3- خارجا علىالأرض		4- أخرى/حدد			
	كم تبعد حفرة الامتصاص عن البئر؟							
	أين يوجد المرحاض؟			1-داخل البيت		2-خارج البيت		
	هل محيط البئر ملائم صحياً ؟ 1- نعم 2- لا							
	ما هوة ارتفاع حفرة البئر مقارنة بحفرة الامتصاص متر							
8.	القسم الثامن : الصحة							
	هل عانى أفرادالأسرة من أمراض خلال الفترة السابقة(6 أشهر)؟							
		إسهال						
		أمراض جلديه						
		التهاب الكبد الوبائي						
		التهابات في الكلى						
		وفيات أطفال						
		أخرى	حدد/					
	هل ذهب المريض إلى عيادة/دكتور؟			1- نعم		2- لا		
	ما هي المسافة بين المنزل واقرب مركز صحي؟ متر							

	معدل تكرار إصابةالأفراد بالمرض نفسه 1- أسبوعي 2- شهري 3- سنوي							
	هل توجد حالات فشل كلوي في الأسرة 1- نعم 2- لا							
	هل تقوم باستخدام المياه الرمادية(المغسلة ،المجلى) في ري المزروعات					1- نعم	2- لا	
9.	القسم التاسع : الثروة الحيوانية							
	هل يوجد لدى الأسرةحيازة حيوانيه 1-أغنام 2- أبقار 3- دواجن حدد/							
	هل يوجد نظام تصريف بعد عملية السقاية ؟ 1- نعم 2- لا							
	بعد الحظيرة عن البئر متر							
10.	القسم العاشر: إجراءات المزارعين							
	ما هي الآلية التي تستخدمها للقضاء على الديدان ؟ حدد/							
	ما هو انطباع أفرادالأسرة تجاه المياه المكلورة؟ 1- آمنة للاستخدام 2- مضرة 3- غير ذلك 4- حدد							
	ما هي الإجراءات التي يتبعها أفرادالأسرة لتجنب تلوث المياه ؟ حدد/							
	ما هي وسائل المعالجة التي تستخدمها الأسرة في حال حدوث تلوث للمياه؟ حدد/							

Appendix (II): TDS values and the other parameters for the first (wet season) and the second (dry season) sampling to 73 cisterns in the study.

Cluster	season class	Cistern Code	Total *Coliform* Group CFU100ml	*Faecal Coliform* Group CFU100ml	pH	TDS mg/L	NO3	Turbidity
Masafer Yatta	dry season	MA1	137	30	7.36	279		11.00
		MA2	268	1	7.37	299		
		MB1	28	7	7.62	140		3.45
		MB2	374	339	7.38	216		
		MC1	267	171	8.18	350		3.80
		MC2	12	0	7.64	180		
		MD1	73	55	7.48	261		10.96
		MD2	497	0	7.72	281		
		ME1	203	195	7.47	248		19.53
		ME2	273	140	7.31	232		5.90
		MF1	16	1	7.52	356	4.91	6.33
		MF2	162	12	7.36	253		7.77
		MF3	81	0	7.33	234		5.35
		MG1	452	75	7.72	242		4.62
		MG2	568	485	7.42	208		
		MH1	241	37	7.77	235		2.37
		MH2	353	234	7.81	178		5.83
		MI1	259	184	7.53	228		13.62
		MI2	797	96	7.29	238		
		MJ1	196	98	7.84	166	1.23	7.52
		MJ2	168	33	7.53	188		4.75
		Total	245	97	7.56	242	3.07	7.58

Masafer Yatta	wet season	MA1	341	28	7.85	240		3.96
		MA2	445	223	8.07	260		4.66
		MB1	115	71	7.91	183		3.91
		MB2	220	50	8.09	258		4.70
		MC1	64	26	8.05	407		3.60
		MC2	1087	651	8.02	344		6.30
		MD1	112	69	7.91	268		4.54
		MD2	199	59	7.92	395		5.94
		ME1	80	54	7.94	317		3.82
		ME2	513	383	7.79	410		10.41
		MF1	138	26	8.16	409		5.56
		MF2	107	46	8.18	276		3.89
		MF3	302	156	7.96	214		4.28
		MG1	97	59	8.21	271		3.83
		MG2	271	136	7.61	339		4.31
		MH1	76	45	8.12	259		3.68
		MH2	125	55	7.91	298		4.52
		MI1	131	88	7.92	284		3.73
		MI2	948	81	7.70	667		5.24
		MJ1	183	113	8.37	232		4.12
		MJ2	67	24	7.46	328		4.10
		Total	259	111	7.95	317		4.71
Road 317	dry season	RA1	569	42	8.03	320		3.43
		RA2	380	67	7.88	196	1.70	5.10

		RA3	194	5	8.06	439		5.45
		RA4	152	8	7.63	460		
		RA4C	0	0	8.08	439		5.10
		RA5	271	92	8.10	401		5.10
		RA6	1643	671	8.02	276		
		RB1	173	0	8.60	133	1.62	5.23
		RB2	1963	1600	7.87	133		
		RC1	171	0	8.28	234		5.11
		RC2	0	0	8.36	352		.24
		RC3	245	48	7.82	231		
		RD1	570	13	8.07	447		6.10
		RD2	491	283	8.16	420	1.56	4.99
		RD3	276	83	8.31	480		5.88
		RD4	242	13	8.26	416		5.57
		RD5	107	0	8.16	432		4.25
		RD6	865	150	7.89	386		7.90
		RD7	2400	520	8.25	443		
		RD8	289	164	7.63	267		
		RD9	62	22	7.72	144		
		RE1	343	35	7.49	194		5.63
		RE2	100	94	8.29	179		
		RF1	173	50	7.69	192		1.70
		RF2	573	325	8.32	120		
		RG1	533	95	7.80	361		3.82

		RG2	26	0	8.28	328		
		RH1	262	4	7.70	162		7.22
		RI1	57	0	7.88	274		4.93
		RI2	152	12	9.67	185		
		RJ1	212	25	7.58	163		5.69
		RJ2	1009	108	8.10	140		
		RK1	290	20	8.06	199		6.14
		RK2	846	120	8.27	297		
		RL1	72	54	7.89	176		6.60
		RL2	488	6	8.30	304		
		RM1	607	470	7.99	126		5.72
		RN1	329	183	7.74	291		2.90
		RN2	996	639	7.80	274		
		RO1	23	1	8.36	350		7.92
		RO2	33	33	7.62	294	3.15	6.60
		RO3	396	110	8.13	304		4.94
		RO4	166	7	7.77	202		
		RO5	83	0	7.72	140		
		RP1	67	19	7.96	144		3.01
		RP2	640	104	7.93	152		
		RQ1	628	267	8.17	265		23.51
		RQ2	0	0	10.97	256	1.97	5.30
		RR1	87	22	7.43	175		3.89
		RR2	729	534	7.77	184		

		RS1	304	0	8.19	204		7.46
		RS2	1994	1600	8.12	138		
		Total	389	141	8.09	263	2.00	5.79
Road 317	wet season	RA1	685	89	7.91	332	2.17	4.03
		RA2	338	141	7.86	287	2.07	5.01
		RA3	420	57	8.05	301		5.41
		RA4	77	54	7.79	147		
		RA4C	58	2	7.86	366		7.53
		RA5	468	11	8.19	352		7.04
		RA6	903	250	8.36	379		6.09
		RB1	155	82	8.38	230	2.01	5.67
		RB2	858	380	8.46	367		6.86
		RC1	269	16	8.17	310	4.03	10.97
		RC2	107	4	8.09	304		5.04
		RC3	1349	700	8.49	476		4.02
		RD1	614	100	8.01	308	1.95	6.81
		RD2	319	146	8.23	378	2.04	3.94
		RD3	285	57	8.11	307	1.97	5.23
		RD4	186	13	8.03	287	2.08	3.60
		RD5	241	14	8.19	334	1.88	7.58
		RD6	661	451	8.18	337		4.72
		RD7	172	17	8.27	295		5.47
		RD8	489	265	8.41	405		5.60
		RD9	1193	52	8.27	202		5.88

		RE1	659	264	7.83	229	2.29	5.06
		RE2	57	3	8.10	221		9.12
		RF1	229	67	8.11	321	1.97	5.31
		RF2	102	15	8.45	158		7.58
		RG1	57	15	8.08	392		4.22
		RG2	11	1	8.39	383		3.48
		RH1	39	12	8.19	310		5.45
		RI1	268	50	7.95	296	2.01	7.15
		RI2	25	4	9.52	209		5.75
		RJ1	339	130	7.85	275	2.35	5.08
		RJ2	335	66	8.33	252		6.22
		RK1	73	62	7.86	273		4.61
		RK2	319	32	8.42	306		5.78
		RL1	83	46	8.05	353	1.56	8.43
		RL2	1357	301	8.47	384		8.89
		RM1	407	310	7.79	265	3.02	3.60
		RN1	622	34	8.06	289		5.17
		RN2	166	3	8.05	419		4.89
		RO1	35	0	8.00	307	1.47	4.04
		RO2	79	0	8.04	316	2.07	7.94
		RO3	742	57	8.19	318	2.21	3.79
		RO4	22	0	7.98	301		5.85
		RO5	862	253	8.28	333		5.91
		RP1	307	9	8.07	139	1.28	6.39

		RP2	128	26	8.35	192		5.38
		RQ1	290	173	8.15	292	1.24	4.98
		RQ2	92	57	8.81	297		4.74
		RR1	68	52	8.59	184		5.47
		RR2	277	31	8.38	178	2.46	4.39
		RS1	275	58	7.93	229	1.67	6.32
		RS2	143	14	8.48	354		5.09
		Total	351	93	8.21	300	2.08	5.79

Appendix (III): means of the community of the two clusters for each parameter.

Clusters Means	season class	Community Name	Total *Coliform* Group CFU100ml	*Faecal Coliform* Group CFU100ml	pH	TDS mg/L	NO3	Turbidity
Masafer Yatta	dry season	Asfi al Tahta	166	140	7.52	171		3.45
		Asfi al Foga	190	18	7.36	287		11.00
		Al Taban	474	149	7.43	232		13.62
		Al Halawa	286	116	7.79	212		3.24
		Al Tuba	498	239	7.60	228		4.62
		Al Fakheit	238	168	7.39	240		14.99
		Al Majaz	203	128	8.05	308		3.80
		Al Marqiz	184	72	7.72	175	1.23	6.83
		Junba	86	4	7.40	281	4.91	6.62
		Maghayir al 'Abeed	243	33	7.58	269		10.96
		Total	245	97	7.56	242	3.07	7.58
	wet season	Asfi al Tahta	167	60	8.00	220		4.36
		Asfi al Foga	398	136	7.97	251		4.36
		Al Taban	539	85	7.81	475		4.48
		Al Halawa	97	49	8.03	276		4.01
		Al Tuba	184	97	7.91	305		4.21
		Al Fakheit	297	218	7.86	364		7.12
		Al Majaz	502	293	8.04	380		4.68
		Al Marqiz	118	63	7.86	286		4.11
		Junba	182	76	8.10	300		4.62
		Maghayir al 'Abeed	155	64	7.92	331		5.10
		Total	259	111	7.95	317		4.71
	Total	Asfi al Tahta	167	91	7.82	201		4.09
		Asfi al Foga	324	94	7.75	264		6.35
		Al Taban	514	109	7.66	382		7.53
		Al Halawa	176	77	7.93	249		3.67
		Al Tuba	304	152	7.79	276		4.37
		Al Fakheit	277	201	7.70	322		9.74
		Al Majaz	394	233	8.04	354		4.35
		Al Marqiz	142	66	7.81	246	1.23	5.32
		Junba	141	45	7.80	292	4.91	5.62
		Maghayir al 'Abeed	189	52	7.79	307		7.30
		Total	254	106	7.80	288	3.07	5.82
Road 317	dry season	Irfaiya	494	125	7.99	341	1.70	4.74
		Al Juwaia	306	142	7.90	168		1.70
		Al Khraba	980	640	8.16	178		7.46

		Ad Deirat	449	108	8.07	392	1.56	5.70
		Al Razeem	596	366	7.76	284		2.90
		Al Teeran	301	193	7.54	178		3.89
		Immfagarh	889	640	8.31	133	1.62	5.23
		Imneizil	145	32	7.94	267	3.15	6.27
		Tuwani	125	12	8.19	278		2.19
		Zanuta	364	63	7.96	350		3.82
		SadetTha'la	246	59	7.81	188		5.63
		Susya	95	5	8.60	238		4.93
		Shi'b al Butm	238	35	8.05	227		6.60
		Gwin	512	60	8.14	238		6.14
		Quwawes	531	58	7.79	154		5.69
		Hrebit al nabi	296	53	7.94	147		3.01
		Wadijheash	607	470	7.99	126		5.72
		Wadi Al Amayer	269	114	9.77	260	1.97	16.22
		widadi	262	4	7.70	162		7.22
		Total	389	141	8.09	263	2.00	5.79
		Irfaiya	479	94	8.06	330	2.12	5.42
		Al Juwaia	156	37	8.30	228	1.97	6.44
		Al Khraba	218	39	8.17	283	1.67	5.82
		Ad Deirat	462	124	8.19	317	1.98	5.45
		Al Razeem	394	18	8.05	354		4.98
		Al Teeran	187	40	8.47	181	2.46	5.04
		Immfagarh	507	231	8.42	298	2.01	6.27
		Imneizil	317	62	8.15	322	1.92	5.60
		Tuwani	464	182	8.25	349	4.03	7.79
		Zanuta	31	7	8.25	387		3.79
	wet season	SadetTha'la	358	133	7.97	225	2.29	7.09
		Susya	147	27	8.73	252	2.01	6.45
		Shi'b al Butm	720	174	8.26	368	1.56	8.66
		Gwin	196	47	8.14	290		5.20
		Quwawes	337	98	8.09	264	2.35	5.65
		Hrebit al nabi	217	17	8.21	166	1.28	5.89
		Wadijheash	407	310	7.79	265	3.02	3.60
		Wadi Al Amayer	191	115	8.48	294	1.24	4.89
		widadi	39	12	8.19	310		5.45
		Total	351	93	8.21	300	2.08	5.79
		Irfaiya	485	106	8.03	334	1.98	5.14
		Al Juwaia	225	85	8.12	200	1.97	5.26
	Total	Al Khraba	536	289	8.16	239	1.67	6.44
		Ad Deirat	457	118	8.14	345	1.91	5.54
		Al Razeem	472	152	7.94	327		4.46

		Al Teeran	240	110	8.04	179	2.46	4.71
		Immfagarh	654	388	8.37	235	1.82	6.01
		Imneizil	254	51	8.07	302	2.23	5.81
		Tuwani	328	114	8.23	321	4.03	5.63
		Zanuta	185	33	8.12	370		3.80
		SadetTha'la	315	105	7.90	211	2.29	6.61
		Susya	127	19	8.68	247	2.01	6.07
		Shi'b al Butm	535	120	8.18	314	1.56	7.97
		Gwin	318	52	8.14	270		5.51
		Quwawes	411	83	7.97	222	2.35	5.66
		Hrebit al nabi	248	31	8.11	158	1.28	4.93
		Wadijheash	527	406	7.91	182	3.02	5.01
		Wadi Al Amayer	227	115	9.08	278	1.61	10.56
		Widadi	134	8	7.98	247		6.04
		Total	366	112	8.16	285	2.07	5.79

Appendix (IV): Cods of tested cisterns.

Cluster	Community	Name	Code
Masafer Yatta	Asfi al Foga	بدر أحمد عوض	MA2
	Asfi al Foga	محمد خليل دبابسه	MA1
	Junba	يوسف محمد يوسف	MF1
	Junba	خالد حسين الجبارين	MF2
	Junba	عيسى جبري الربعي	MF3
	Al Tuba	ابراهيم علي عوض	MG1
	Maghayir al 'Abeed	شحادة مخامرة	MD1
	Al Fakheit	محمد ايوب الشعابين	ME1
	Al Marqiz	محمد راغب جبريل	MJ2
	Al Marqiz	عمر الصريع حوشية	MJ1
	Asfi al Tahta	حسن حريزات	MB1
	Al Halawa	خليل يونس ابوعرام	MH1
	Al Majaz	محمود موسى ابوعرام	MC1
	Al Taban	عيسى محمود حماد	MI1
	Asfi al Tahta	محمد احمد ابوعلي	MB2
	Al Halawa	احمد اسماعيل ابوعرام	MH2
	Al Tuba	ابراهيم محمد ابوجندية	MG2
	Maghayir al 'Abeed	موسى جبريل النجار	MD2
	Al Majaz	محمود احمد ابوعرام	MC2
	Al Fakheit	عيسى اسماعيل حماد	ME2
	Al Taban	خالد حسن العمور	MI2
Road 317	Irfaiya	خالد حسين العمور	RA1
	Irfaiya	محمد جبريل العمور	RA2
	Irfaiya	عيد جبرائيل العمور	RA3
	Irfaiya	ابراهيم احمد العمور	RA4
	Irfaiya	رسمية حماد عواد	RA5
	Irfaiya	محمود محمد ربعي	RA6
	Immfagarh	نعيم شحادة الحمامدة	RB1
	Immfagarh	محمد حسن جبر حمامدة	RB2
	Tuwani	فضل احمد جبريل ربعي	RC1
	Tuwani	نعيم سالم عيسى العدرة	RC2
	Tuwani	كمال موسى ربعي	RC3
	Ad Deirat	خليل محمد الحمامدة	RD1
	Ad Deirat	عيسى خليل حمامدة	RD2
	Ad Deirat	جبريل اسماعيل العدرة	RD3
	Ad Deirat	عايد عيسى مسعف	RD4
	Ad Deirat	بدر عيسى الحمامدة	RD5

	Ad Deirat	عبد اسماعيل العدرة	RD6
	Ad Deirat	محمد علي حسن العدرة	RD7
	Ad Deirat	جبريل جبر العدرة	RD8
	Ad Deirat	محمود خليل حمامدة	RD9
	SadetTha'la	ابراهيم حماد المخامرة	RE1
	SadetTha'la	عيسى حماد مخامرة	RE2
	Al Juwaia	حسين احمد النواجعة	RF1
	Al Juwaia	محمد محمود النواجعة	RF2
	Zanuta	خليل عيسى السمامرة	RG1
	Zanuta	عبدالحليم علي البطاط	RG2
	Widadi	شحدة محمد عواد	RH1
	Susya	محمد احمد النواجعة	RI1
	Quwawes	خالد موسى النجار	RJ1
	Quwawes	خالد موسى ابوعرام	RJ2
	Gwin	مريم سليم الحوامدة	RK1
	Gwin	خضر اسماعيل الحوامدة	RK2
	Shi'b al Butm	عبد محمد النجار	RL1
	Shi'b al Butm	اسماعيل عبدالفتاح النجار	RL2
	Wadijheash	ابراهيم اسماعيل النواجعة	RM1
	Al Razeem	عيسى احمد ابوالكباش	RN1
	Al Razeem	صافي عيسى ابوالكباش	RN2
	Imneizil	حسن محمد الصغير حريزات	RO1
	Imneizil	يوسف ابراهيم ابوصبحة	RO2
	Imneizil	عادل علي رشيد	RO3
	Imneizil	عبدالله محمد حريزات	RO4
	Imneizil	سليمان محمد الكبير حريزات	RO5
	Imneizil	محمد الكبير سالم حريزات	RO6
	Hrebit al nabi	عبد المحسن محمد رشايدة	RP1
	Hrebit al nabi	علي محمد ابوعلي	RP2
	Wadi Al Amayer	يوسف عارف الدغامين	RQ1
	Wadi Al Amayer	اسماعيل عارف الدغامين	RQ2
	Al Teeran	ادعيس عيسى ابوشرخ	RR1
	Al Teeran	بسام سليمان الزعارير	RR2
	Al Khraba	منور عبدالرحمن الدغامين	RS1
	Al Khraba	علي محمد حسن الدغامين	RS2

ملخص

تهدف هذه الدراسة إلى تقييم جودة مياه آبار الجمع الموجودة في منطقة جنوب محافظة الخليل. لتحقيق ذلك تم استهداف ما مجموعه تسعه وعشرون تجمع سكاني من منطقتي مسافر يطا وطريق 317 من جنوب محافظة الخليل بواقع عشر تجمعات من المنطقة الأولى و تسعة عشر أخرى من الثانية وما مساحته 37.500 دونما لدراسة جودة مياه آبار الجمع الموجودة في المنطقة.

تتميز المنطقة المستهدفة بمناخ جاف وشبه الجاف والذي يتميز بمعدل أمطار منخفض شتاءا وحرارة وجفاف صيفا. تتراوح درجات الحرارة في المنطقة ما بين 14-26 درجة مئوية صيفا و5.2-12.1 درجة مئوية شتاءا. ويتراوح معدل الأمطار السنوية ما بين 149-303 ملم بينما تتراوح الرطوبة النسبية بين 60-61%.

وخلال هذه الدراسة، تم فحص وتحليل جودة المياه في ثلاثة وسبعون بئر جمع مياه في المنطقة المستهدفة حيث تم جمع العينات في عبوات زجاجية معقمة ليتم فحصها لاحقا حسب معايير "عوامل التجربة المتغيرة" والتي تتضمن من ناحية فيزيائية كمية الأملاح المذابة ورقم الحموضة وعكورة المياه. ومن ناحية كيميائية، تم فحص نسبة النيترات في العينات. وكان الفحص والتحليل قد شمل أيضا ناحية "معيار وجود الأحياء الدقيقة" والذي تضمن فحص للبكتيريا القولونية والبرازية على حد سواء.

بالإضافة لما سبق، تمت دراسة مصادر التلوث عن طريق توزيع وتحليل استبيان متخصص حيث أظهرت النتائج وجود نسبه عالية من التلوث بالبكتيريا القولونية والبرازية في العينات المجموعة من مناطق الدراسة بما نسبته 92.2% للأولى و 97.4 للثانية. هذا وقد بين التحليل تنوع مصادر التلوث والتي كان أكثرها شيوعا براز الحيوانات والطيور.

بناءً على ذلك ، فان الحل لتلك المشكلة يكمن في تطبيق عدة إجراءات تتعلق بنظافة منطقة الجمع بالآبار مثل تنظيف منطقة الجمع وطرح مياه أول مطرية قوية و وضع مصفاة لتنقية المياه المجموعة بالإضافة إلى تطبيق تقنيات التعقيم والمتمثلة بالكلورة.