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M.Sc. Thesis

Rainwater harvesting system: Quality and impacts on public health

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This thesis was successfully defended and approved on ***February, 2016***

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الخلاصة

نظام جمع مياه الامطار فى بلدة يطا: نوعية المياه والتأثير على الصحة العامة

هدف هذه الدراسة هو تقييم نوعية المياه في آبار جمع مياه الأمطار في بلدة يطا؛ في الجزء الجنوبي من الضفة الغربية، فلسطين. فقد تم جمع 50 عينة مختلفة من آبار جمع مياه الأمطار في يطا وعملت عليها فحوصات مختلفة فيزيائية (درجة الحموضة، درجة الحرارة، التوصيل الكهربائي، الكلور المتبقي، إجمالي الذائبة الصلبة ، القلوية ، نسبة الملح الذائبة، غاز الأمونيا ، الكلوريد ، ونسبة العكورة) وكيميائية جرثومية (القولونيات الكلية والبرازية). تم بحث علاقة المياة بالصحة من خلال اعداد استبيان مصمم تصميما جيدا الذي استهدف عينة ممثلة إحصائيا من الأسر.

نتائج الاختبارات الفيزيائيّة كانت ضمن الحدود المسموح بها من قبل منظمة الصحة العالمية والمؤسسة الفلسطينية ،باستثناء نسبتي العكورة والملوحة التي تجاوزت هذه الحدود بما نسبته 5% لكلا الاختبارين. معظم عينات المياه المفحوصة ملوّثه من الناحية الميكروبيولوجية والكيميائية إجمالي القولونيات البرازية والقولونيات(96%)، (70%) على التوالي. ويبدو أن البيئة المحيطة من الصهاريج مثل أسطح جمع غير لائقة، ووجود خزانات الصرف الصحي في جميع أنحاء الصهاريج وعدم وجود الكلور الحر متاح في مياه الأمطار التي تحصد بالإضافة إلى عدد من العوامل الأخرى لتكون مسؤولة عن انخفاض جودة الميكروبية . ومن المتوقع أن الأمراض المتعلقة بالمياه مثل الإسهال والإسهال والقيء، وأمراض العيون كانت بنسب عالية نتيجة لسوء نوعية المياه.

Abstract

Rainwater harvesting systems in Yatta Town: Water quality and impacts on public health

The aim of this study is to assess the quality of the water harvested in the cisterns of Yatta town; in the southern part of the West Bank, Palestine. It has assembled 50 different cistern samples from Yatta and tested for different physiochemical (pH, Conductivity, Salinity, Total Dissolved Solids, Turbidity, Alkalinity, Chloride, Ammonia, Residual Chlorine) and microbiological (Total *Coliforms* and Fecal *Coliforms*) characteristics. The water-health relationship has been investigated through a well-designed questionnaire that targeted a statistically representative sample of household in Yatta town.

Physicochemical test results were within allowable limits by the World Health Organization (WHO), and the Palestinian Standards Institute (PSI), except for the proportions of turbidity and salinity which exceeded these limits with percentages of 5% for both tests. Most of the tested water samples were microbiologically contaminated with Total *Coliforms* (TC) and Fecal *Coliforms* (FC) with percentages of 96% and 70% respectively. The surrounding environment of the cisterns such as the inappropriate collection surfaces, and the presence of cesspits around the cisterns and the absence of available free chlorine in the RWH in addition to a number of other factors appear to be responsible for the reduced microbial quality. Water related diseases such as diarrhea, diarrhea and vomiting, and eyes diseases with high percentages are anticipated to be a main consequence of the poor water quality.

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

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Table of contents

List of Figures

List of Tables

Abbreviations

Acronyms	Term
°C	Celsius
CDC	The Centers for Disease Control
EPC	Environmental Protection Agency
FC	Fecal Coliforms
GIS	Geographical Information System
HIAs	Health Impact Assessments
MCL	Maximum Contaminant Level
MoH	Ministry of Health
PAHO	Pan American Health Organization
PSI	Palestinian Standards Institution
RWH	Rainwater Harvesting
SPSS	Statistical Package for the Social Sciences
TC	Total Coliforms
TDS	Total Dissolved Solids
WASH	Water, Sanitation and Hygiene

Chapter One
Introduction

1.1 Introductory Remarks

Water is an indispensable commodity necessary for life (Ahmed, 2010; Al-Khatib et al., 2005). It was reported that our existence is *"intimately connected with the quality of water available to us" (*Ahmed, 2010). Water is considered as the most sensitive and important issue that attention to it is increasingly dependent on scarcity, increasing water deficiency, degradation of water and deterioration of available water (Al-salaymeh,2008; AL-Khatib et al., 2003). It is a free source that can be obtained naturally (Rahman et al., 2014) but this resource must be managed sustainably with low impact development (LID) to be easily accessible and adequate in quantity, which can be achieved by low investment cost and low environmental impacts (Lim et al., 2013; AI-Khatib et al., 2005). Rainwater Harvesting (RWH) is one of LID solutions which could enhance green living through low cost, accessibility and ease maintenance in houses (Lim et al., 2013 ; Rahman et al., 2014).

RWH is the most traditional and sustainable method that has been used since ancient time in many regions in world in order to provide human needs for water where the basic water sources has not been able to provide. RWH may serve as an alternative water source (Rahman et al., 2014, Sarikonda, 2010). RWH could be easily used for potable and non-potable purposes both in residential and commercial buildings (Rahman et al., 2014).

RWH is widely used all over the world, not only for poor arid countries but also in developed countries such as Germany, Japan and Australia (Lim et al., 2013). For example, Australia used RWH for potable and non-potable purposes (Lim et al., 2013). *"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"* (Sarikonda, 2010).

Access to clean and safe drinking water is a right for all humans especially children who can be severely affected by water contaminated with human and animal feces (Lucas, 2011). This contaminated water is leading to lose children below five years (Clasen et al., 2003). Due to scarcity of safe water recourses, the access to clean water is a challenge (Ahimah and Ofosu, 2012).

From total water in the world only 1% of it is potable (MPhil, 2013).RWH is suitable for areas that have high rainfall. It is a primary renewable source of water (MPhil, 2013).

The Palestinian Legislative Council has approved the Water Law No. 3 of 2002, which aims to develop and properly manage water sources, build the capacity in the water sector, improve water quality, conservation, and protection from pollution and depletion (Al-Khatib et al., 2009).

1.1.1 Objectives

To examine physiochemical and microbiological characteristics of RWH in the cisterns in Yatta town, in order to assess the quality of it. And, to investigate the water-health relationship and to assess the impacts of RWH on public health.

1.2 Natural and Physical Characteristics of the Study Area

1.2.1 Study Area

The study area is Yatta town which is situated in Hebron Governorate, Palestine nearly 8 km southward of the city of Hebron in the West Bank, Figure 1. It had a population of 52920 in 2015, according to the Palestinian Central Bureau of Statistics (PCBS).

Yatta is bordered by Zif and Khallet Al-Maiyya to the east, Ar-Rihiya, Al-Fawwar Camp and Wadi As-Sada to the north, Beit 'Amra to the west, and As-Samu' to the south. The total estimated area of Yatta (i.e. study area) is 24.6 km^2, of which 9.1 km^2 are classified as a 'built up' area; however 8 km^2 are agricultural areas. The remaining areas are livestock, non-implanted or public lands (Abu Sa'deh, 2012). Hebron district suffers from water scarcity and basically relies on collection and storage of harvested rainwater (Malassa et al., 2014).

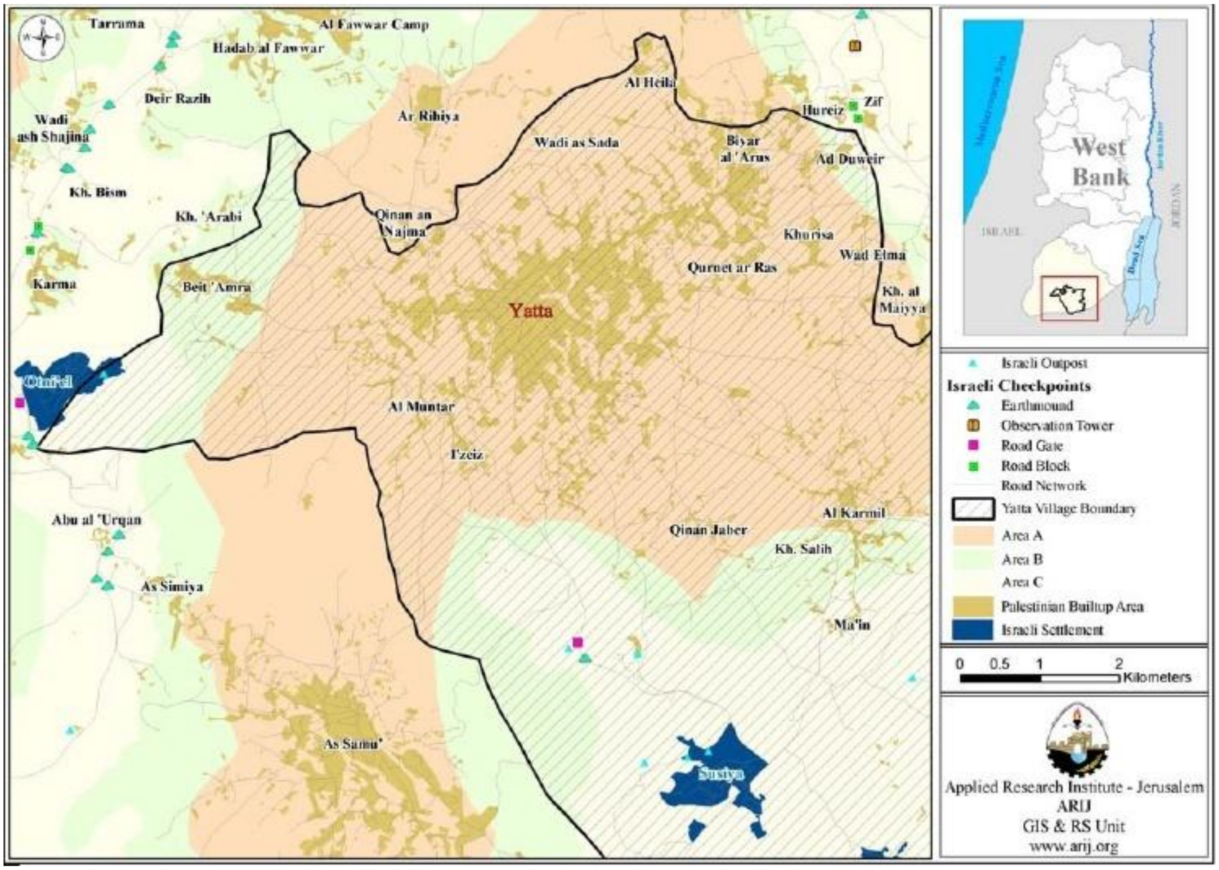

Figure 1 : Yatta Town location and borders (The Applied Research Institute, 2009).

1.2.2 Climate

The climate in Yatta Town as a Mediterranean situation is described as semi-arid and dry sub-humid (Abu Sa'deh, 2012). It can be described as temperate zone and the precipitation varies with direction, warm to hot dry in summer, cool to mild rainy winters (PCBS, 2013).

1.3.2 Precipitation and Humidity

Three categories of seasons; a long dry season, a short wet season and two short transitional (winter and spring). Precipitation in transitional season is characterized as short rainfall duration and higher rainfall intensity (Abu Sa'deh, 2012) with mean rainfall 303 (mm) (The Applied Research Institute, 2009).The amount of annual rainfall in Palestine in 2013 is 661 (mm) .The number of rain days in Palestine in 2013 is 42 days according to the Palestinian Central Bureau of Statistics (PCBs,2013).

Humidity reaches the top in winter; the average humidity is 73%. In summer months, the humidity falls to 55% and the weather is dry. On Khamaseen days, because of wind, air moisture contains sink below 30% (Abu Sa'deh, 2012). The average annual humidity is 61% (The Applied Research Institute, 2009).

1.3.3 Evaporation

As a result of intensive sunshine and low humidity, evaporation is especially strong in summer. The evaporation average rates in summer months are 230 mm/month from June to August whereas evaporation rate is comparatively low during the winter months as a result of low sunshine. The mean monthly evaporation rates from December to February are 83 mm/month. The amount of evaporation in Hebron in 2013 is 1974 mm (PCBs, 2013).

1.3.5. Temperature

The hottest days of the year occur during the summer month of August. The average monthly maximum temperature within the boundary of Yatta is within the range of 23.7°C while mean monthly minimum is 10.6°C (data obtained from Hebron Station during the period 2000-2008, PMD database) (Abu Sa'deh, 2012).

1.3.6. Sunshine Radiation

Yatta as an area of the West Bank has a sunny climate. The amount of radiation is variable according to geological location. For Yatta, the average annual solar radiation is 17.9 $MJ/m^2/day$. In the summer period the solar radiation is strengthened, where the sky is clear with an average sunshine of 11.9 hour/day while in the winter the solar radiation is ineffective on water due to the overcast weather. The average sunshine from December to February is 5.4 hours/day (Abu Sa'deh, 2012).

1.3.7. Wind Speed

Generally, West Bank region is influenced by winds which move from southwest to northwest. In the summer, there are differences on pressure which created wind movement from cooler air in the west to the east. In Yatta town the mean monthly wind speed is 2.5 m/s in the period between June and August. In winter, due to the depression of temperature, there are easterly winds. The mean monthly wind speeds are 3.3 m/s in the period between December and February. Between April and June, Khamaseen winds occur; which bring sand from the dessert. The mean monthly wind speed is 2.8 m/s (Abu Sa'deh, 2012).Wind speed rate is 2.8m/s * (1km/1000m)*(60*60s/ 1h).

1.4. Physical Characteristics

1.4.1. Topography

Yatta is located within the Hebron Mountain (Abu Sa'deh, 2012; The Applied Research Institute – Jerusalem, 2009). It is situated between 680 and 860m above sea level as shown in Figure 2 (Abu Sa'deh, 2012). At an altitude of 793 meters above sea level (The Applied Research Institute – Jerusalem, 2009).

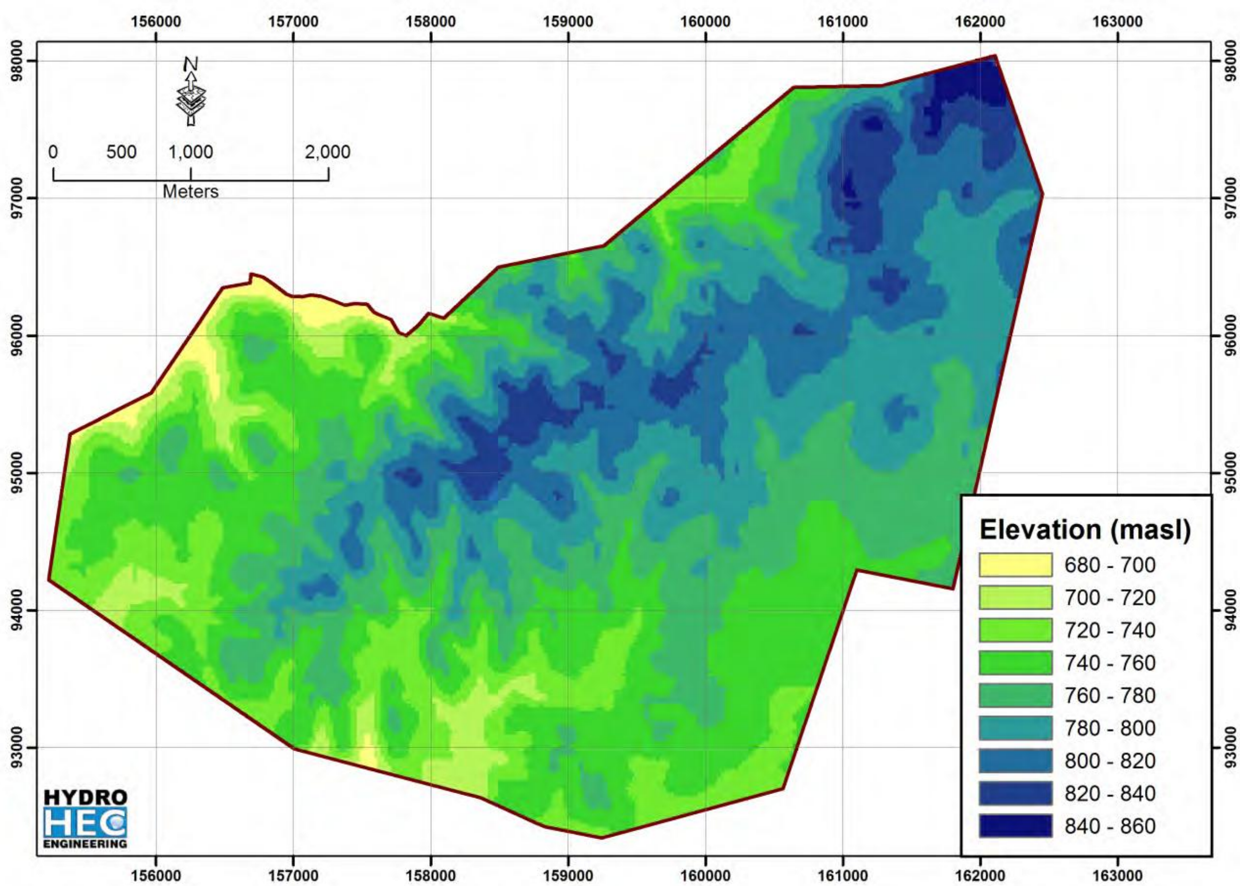

Figure 2 : Topographic map of Yatta Town (Source: Abu Sa'deh, 2012).

1.4.2. Soil Type

The dominant soil type is brown rendizna and pale rendizna, in the southern west, there are a bit terra rossas, brown soils and pale rendizna. The dark brown soils are found in the east. Figure 3, shows the soil map of Yatta (Abu Sa'deh, 2012).

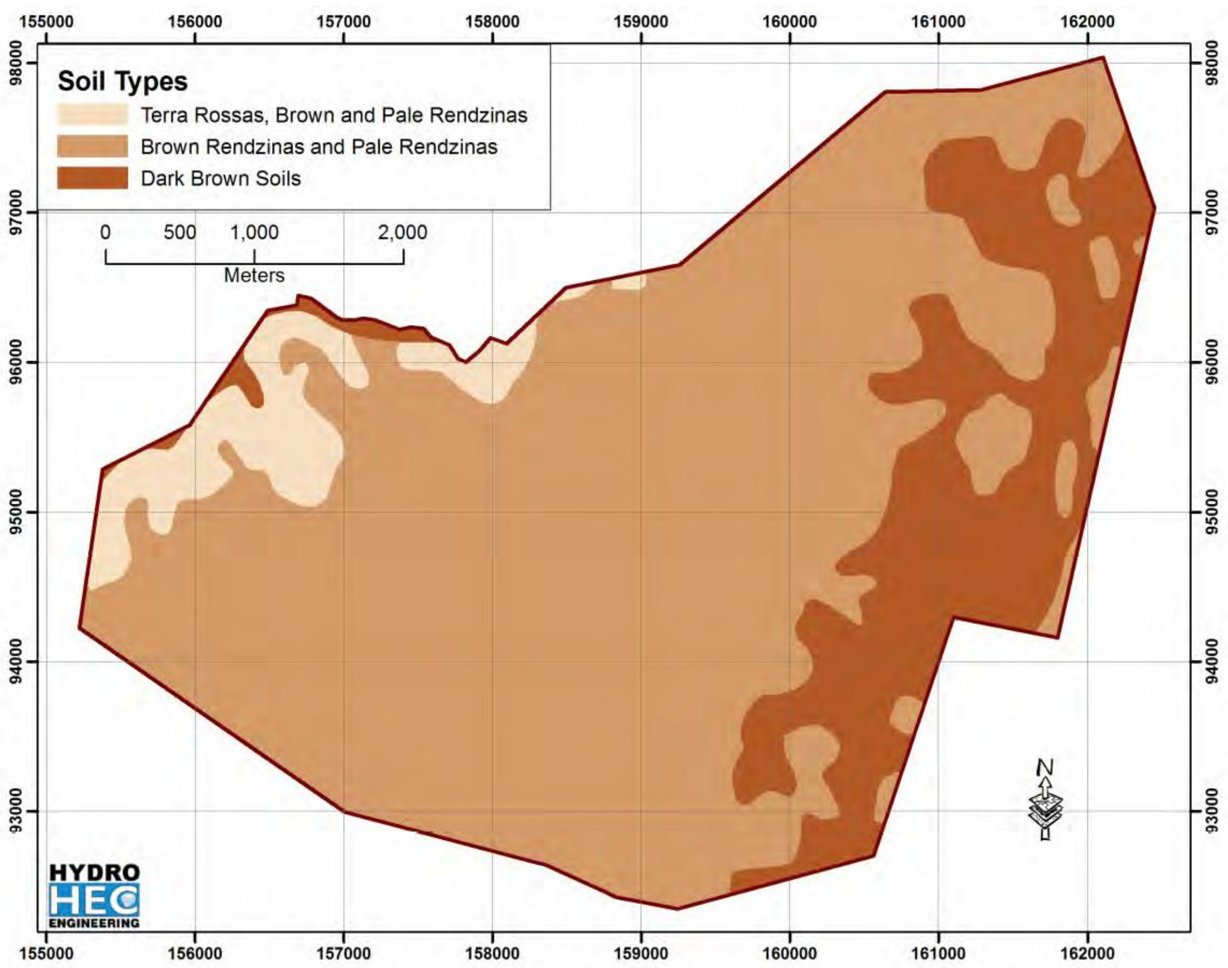

Figure 3 : Soil map of Yatta Town (Source: Abu Sa'deh, 2012).

1.5 Literature Review (RWH)

1.5.1. Rainwater harvesting (RWH)

1.5.1.1 RWH in general

RWH has a low impact development practice (LID) that can serve as a primary or supplementary water source. RWH practice involves capture, diversion and storage of rainwater (RW) for future use (Lay, 2010; Charles, 2007; Barens, 2009).

RWH is listed as a source of domestic water supply called domestic rainwater harvesting (DRWH), practiced both in rural and urban areas from ancient times. This is still apply formally and none formally. Formally means permanent storage systems while none formally means not to establish a storage, but only to put pots under roof edges (Cowden, 2008).

RWH can help alleviate demands on public water supply systems and promote better practices in the public (Lay, 2010).

The RWH adoption varies from one place to another due to the public awareness such as legislative, technical and financial support toward this kind of practice (Lim and Jaint, 2013).

The World Health Organization (WHO) proposed the use of RWH as safe potable water after appropriate treatment techniques (MPhil, 2013).

1.5.1.2 Advantages of RWH

RWH is described as a LID that saves money and time, because there are no monetary costs or travel to the dweller. It is described as flexible because of its fewer complexes than other centralized conventional treatment process. It is also empower slum household in even there was no enhancing of the availability and willing of government (Cowden, 2008). The treatment processes such as solar disinfection are suitable and low cost (MPhil, 2013).

1.5.1.3 Disadvantages of RWH

There are many waterborne diseases that depend on water for several reasons such as the lack of water quality, lack of public hygiene, lack of awareness of people about water-health relationship. Water related diseases are divided into four sections: water borne diseases such as cholera and typhoid, diseases resulting from lack of water or hygiene, water based disease such as schistosomiasis disease, disease associated to transmission avail of the disease such as malaria (Al-Khatib and Abu-Hejleh, 2011).

It was observed that the spread of many diseases within people who depend on the RWH cistern and don’t have water networks in their house especially among children when they check on the health centers (Al-Khatib and Abu-Hejleh, 2011).

1.5.2. Local RWH practices

1.5.2.1. Gaza RWH practice

Most of the Palestinian territories (89%) rely on the public water network for drinking water in West Bank, The percentage in the Gaza Strip is higher than that percentages in the West Bank. Due to the availability of groundwater as the only source of drinking water, where the Gaza Strip is characterized by rareness of surface water, lack of the valleys, and the shallower waters; because of climatic conditions, and the lack of difference in terrain. Usually, surface water exposed to pollution, so it need to treating to become usable (Al-Khatib et al., 2009).

In Gaza, Yassin et al., (2006) collected water samples from cisterns and networks then they calculated the bacterial contamination percentage by total and fecal *Coliforms* (FC) in Gaza Governorate. They find that unaccepted levels of total *Coliforms* (TC) contamination in cisterns, which caused giardiasis, hepatitis and diarrheal diseases (Yassin et al., 2006).

The major problems in Gaza strip are uncontrolled sewage system, cesspool infiltration, poor waste water treatment facilities and inverse pumping of sewage because of disruption of water supply; thus promoting bacterial growth (Yassin et al., 2006).

In Gaza,(98%) of households uses water from networks for nondrinking purposes,(73%) of them did not clean their water cistern,(73%)of them buys water from private vendors for drinking purpose,(39%) of them notices unaccepted colors (76%) of them uses household water filters,(50%) of them has awareness towards hygiene and the relation between diarrhea and water quality and is conscious that the diarrhea can be prevented which the rate of disease case with diarrhea reach to (20%), (21%) of them has their sewage flowed. The largest percentage of repeated diarrhea is among children under 5 was in Khan Younis (54%)(Alpha International for Research, Polling and Informatics, 2013).

1.5.2.2 Jenin RWH practice

Most of Jenin population constructed their cisterns to collect rainwater from the roofs of their houses to use it during winter season. Residents of Jenin district rely on cesspits and cesspools as major method of wastewater disposal. Only 13% of households is connected to sewage network. The problem manifested in existence of sewage pipeline in align with water sewer networks which leads to leakage of sewage to drinking water pipes and thus causing pollution for water (Al-Khatib et al., 2005).

The result from Jenin RWH concludes that there is a relationship between the in which samples were taken and the level of contamination with FC and the free chlorine residual concentration which increases in the winter season compared to the summer. There is a strong correlation between water disinfection and its bacteriological quality (Al-Khatib et al., 2005).

1.5.2.3 Turmus'ayya, Al-Mughaier and Singel RWH practice

123 were collected from the rainfed cisterns of three villages in the Ramallah and Al-Bireh district during the summer months and were tested for TC and FC. The results were as

follows: (84%) in Singel, (83.3%) in Turmus'ayya, and (10%) in Al-Mughaier were contaminated by FC (Al-Khatib and Orabi, 2004).

1.5.3 International RWH practices

1.5.3.1 RWH practices in India

There are 45 different traditional practices of RWH for irrigation and domestic use and their counter for science and environment in New Delhi provides detailed materials on traditional RWH practices in India. There are more technical discussion of system design and components (Barens, 2009).

1.5.2.2 RWH practice in United State (US):

The perspectives toward uses of RWH is varying due to lack of government guidelines that may explain the safe way of RWH usage and advice the public to the right ways to use this safe sustainable technique and lack of scientific studies that may support the practice (Lim et al., 2013).

There are different views of the public divided into two trends: prohibiting and encouraging but in restriction aspects usage (Lim et al., 2013).

Such as US like Atlanta, Portland and Cincinnati are changed their local codes to be more flexible on RW usage but, these changes did not accepted from their governments which running them if RWH system will adopt in wide range may lead to loss of revenues (Lim et al., 2013).

1.5.2.3 RWH practice in United Kingdom:

The receptivity of use RWH is variable. Positive toward used RWH in wide regions in another hand, it is less positive toward used HRW on a personal level. In general, the positive perceptive toward uses RWH is high in a region which suffers from limited water recourses (Lim et al., 2013).

1.5.2.4 RWH practice in Ghana:

Theoretically made up five component there are catchment area, conveyance mechanism, first flush diversion, storage area and delivery mechanism (Barens, 2009).

There are three primary RWH catchment methods include ground, rock and rooftop catchments. Ground catchment is impervious surfaces, impermeable soil and sustainable for region with low rainfall. Rock catchment is low cost but need suitable site, constructing walls to be blockade depressions and to be suitable rainwater catchment. Roof top catchment is water stored above less susceptible to contamination (Barens, 2009).

1.5.2.5 RWH practice in other countries around the world:

Caribbean and the Middle East practice RWH system over 300 years ago. In large rural areas such as Honduras; RWH is a source for domestic water supply. In Thailand, there is evidence of RW collection. In Australia, RWH used before tenth century, which collected on roofs as primary sources for drinking purpose. RWH system is popular in rural Australia, part of India, Africa and parts of US (JeanCharles, 2007).

In Brazil, RWH is effectiveness practice that nearly two million people living in rural semi-arid region get benefit from RWH cement cisterns. However, there are few health risk assessment which linking between consumption of water from different sources and its risks (Fonseca et al., 2014).

1.5.4. Contamination in RWH

1.5.4.1 Water Quality indicators for RWH

In Palestine, available water is affected by its source. Groundwater has high quality; it doesn't need complex process for reuse. The most reason that affected water quality is Israeli behavior because of their control for pump water wells and monopoly it for settlers (Al-Khatib et al., 2009).

Pollution of RWH occurs because of Israeli settler; put their waste in Wadi Gaza that cause high salinity in ground water and make it not suitable for drink or irrigation. The other reason for pollution is leakage of cesspits which may reach groundwater and pollute of water, soil because of nature of sandy ground (Al-Khatib et al., 2009).

Drinking water which contaminated with E. coli harm stomach and intestinal and causes illness such as diarrhea and nausea, and even lead to mortality (Gwimbi, 2011).

The contaminated water contains pathogens like viral, bacterial and parasitic protozoan that cause acute illness, chronic disease, and sometimes leads to death (Schoen et al., 2014).

1.5.4.2 RWH and Health

Lack of access to a safe water supply, hygiene and poor sanitation services are the main adversely affect to human health and the most significant risk factors for poor health which may lead to death. Unsafe water supply and poor sanitation are responsible for death of 1.6 million people a year around the world (Haller et al., 2007).

For waterborne diseases, the significant driving forces are extreme weather events, climate change, deforestation, population growth, and agriculture. The spread of it is inversely proportional with clearing it, for example, the spread of cholera and other diarrheal diseases is linked to water quality, censorship on drinking water quality is the most important factors that help to raise the level of public health(Al-Khatib et al., 2009; Gentry-Shields, 2014). The most health risks are related to water pollution, poor sanitation, mis-management of environment and health impact assessments (HIAs) which effect on biological, chemical and physical water properties. Where contaminated water is considered as the reason of many of transferred diseases such as diarrhea and in many cases caused mortality (Mosler, 2011; Al-Khatib et al., 2009; Gentry-Shields et al., 2014; Evans et al., 2014).

Diseases transmitted to persons through drinking, food preparation, clean dishes, showers and irrigating crops (Al-Khatib et al., 2009)

This problem can be limited by (6%) of about (9%) of global diseases around world if followed improvement for environmental management which included drinking water resources, sanitation and hygiene (Evans et al., 2014)

There is a design called “Safe Water System” which Centers for Disease Control and Prevention (CDC) and the Pan American Health Association (PAHO) proposed it which interested on onsite treatment and improvement of water storage and usage behavior (Evans et al., 2014).

Many previous studies emphasized that there is a close link between suitable water facilities and human health, a large proportion between them. Lack of hygiene practices, insufficient hygiene, unsafe drinking water, inadequate sanitation and low level of education cause infectious diseases such as diarrhea, worm infestations, dehydrations, helminthes and protozoa which younger people are most categories susceptible to infection (Evans et al., 2014; Joshi e al., 2013; Dora et al., 2015).

Many bacteria are found in water because of low sanitary behavior. Some of them are harmless and others are pathogenic causing many diseases such as dysentery, cholera, typhoid fever and paratyphoid. Presence of bacteria is an indicator of water pollution (Mahmoud, 2010).

The most effective and efficient intervention for the diseases evaluated was sanitation which the high results from WASH related with high socioeconomic levels (Gentry-Shields, 2014; Joshi e al., 2013).

Diarrheal diseases are prevalent in developing countries among children younger than 5 years which effect on their growth by about 8cm, reduce their IQ point and also lead to death causes These diseases cause mortality before the fifth birthday of the child by about 1.5 million children each year worldwide. Another study said that 9% of 6.5 million children are estimated to die annually and diarrhea is the main reason (Evans et al., 2014; Mosler, 2012; Dora et al., 2015).

Acute respiratory infections and diarrhea lead to absences between children who affected negatively their academic and social development, learning performance and pass rates to deal with this problem in means to reduce absenteeism, should sanitize by alcohol sanitizers (Evans et al., 2014).

In developing countries, the main reasons of health risks augmentation are lack of adequate urban WASH facilities and rapid urban development. The major causes of increased risks on human health are unplanned environments, increasing crowding, inadequate operation and maintenance, dysfunctional facilities and consequently open defecation (Johannessen et al., 2014).

Waterborne diseases caused by viable microbial pathogens such as a virus, bacterium, prion, fungus, viroid or parasite are closely related to environmental processes transported across surface and ground water.

Animal and human sources contaminated air and soil then their pathogenic organisms transfer to the water (Bridge et al., 2010).

Chapter Two
Methodology

2.1. Rainwater Harvesting Sampling

Yatta town was chosen as a study area. Figure 4 shows rainwater harvesting cisterns in Yatta town and water sampling from the cisterns.

Figure 4 : Rainwater harvesting cisterns in Yatta town and sampling (January2015)

2.2. Data collection and Questionnaire

A household questionnaire study has been conducted. A questionnaire has been designed to investigate the water-health relationship. A well-designed questionnaire has been targeted a statistically representative sample of households in Yatta town.

The questionnaire included questions related to the general information about the person, building, RWH cisterns, sewage cesspit, surrounding environment and the presence of disease. The full questionnaire is in Appendix 1.

The sample of households was estimated by utilizing Herbert Larkin equation:

$$n = \frac{p(1-p)}{(SE \div t) + [p(1-p) \div N]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

$\boldsymbol{n}$**:** Sample Size.

N: The population size.

$\boldsymbol{t}$**:** Z-score corresponds to the level of significance of 0.95 and equals to 1.96.

SE: percentage errors=0.05

p: The proportion of property= 0.50

After applying the equation:

$$n = \frac{0.50(1 - 0.50)}{(0.05 \div 1.96) + [0.50(1 - 0.50) \div 67000]}$$

$$n = 381.96$$

$$n \approx 382$$

Depending on direction and density of the population, the study area was divided to nine regions which are north, east-north, west-north, east, middle, west, south, south-east, south-west of Yatta town. The SPSS software was utilized for data analysis. SPSS has been used to know the percentages for each question in a questionnaire, and to conclude the relationship between related variables in a questionnaire.

2.3. Laboratory analysis

It has assembled 50 different cistern samples from Yatta and tested for different physiochemical (pH, Conductivity, Salinity, Total Dissolved Solids, Turbidity, Alkalinity, Chloride, Ammonia, and Residual Chlorine) and microbiological (TC and FC) characteristics. Sampling of rainwater was performed during January 30, 2015. Rainwater Harvesting samples were drawn from rain-fed cisterns using sterilized sampling devices (Ruttner sampler) (Fresenius et al., 1987). The sampling depth was in the middle of the existing water column. The samples were placed in polyethylene bottles for chemical analysis and glass sterilized bottles for microbiological analysis, put into ice-bag containers and transported to the Institute of Environmental and Water Studies Laboratory at Birzeit University (Birzeit-Palestine), within 24 hours. During sampling period 50 samples were collected. All of them were drawn from rainfed cisterns that receive only rainwater. At each sampling site, pH, electrical conductivity, salinity, total dissolved solids, and turbidity of cistern water were measured, following applicable standard procedures (Al-Salaymeh et al. 2011; Tortora et al. 2003; APHA1998). A CO150 conductivity meter, an EC-10 pH-meter, and a Hach 2100P Turbidimeter, a Hach CO150 TDS and a Hach CO150 salinity meter (Hach Company, Loveland, Columbia—USA) were used for those measurements. In addition to the field measurements mentioned above, collected samples were sent for biological analysis. This was done in accordance with the standard methods for the examination of water (APHA 1998). At the Water Lab, water was analyzed for indicator organism concentrations (FC and TC) and other chemical water quality parameters (Chloride, Alkalinity, and Ammonia) using the applicable standard procedures (APHA 1998; Tortora et al. 2003). The indicators (pH, TDS, alkalinity, free residual chlorine, and ammonia-N) could influence drinking water flavor, while the turbidity and Coliform were measured due to esthetic and health concerns, respectively (Lou et al. 2007). At the following, Figure 5 shows RWH samples and Figure 6 shows RWH analysis at water lab.

Figure 5 : RWH samples (Water Studies Laboratory at Birzeit University /Palestine- February2015)

Figure 6 : RWH analysis at water laboratory (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.3.1. Physicochemical Parameters

2.3.1.1 pH

pH is the most important parameter used to determine whether a solution acid or base or neutral. pH value will controlled within the range suitable to particular organisms involved, small pH means that the solution is acidize, high value of pH means that the solution is alkaline (Mahmoud, 2010).

The suitable pH for the existence of the most biological life is between 6 and 9 (Mahmoud, 2010). This experiment done in Birzeit University laboratories for environmental and water tests using the pH device shown in Figure 7 and the pH results are between (6.9 – 7.6). The results were good; because they were within allowable limits by the World Health Organization (WHO) and the Palestinian standards institution (PSI). See Table 30.

Figure 7 : pH device (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.3.1.2 Alkalinity (mg/L CaCO3)

It can be defined as their ability to neutralize the acid (Mahmoud, 2010). In this experiment, conical flask was brought filled with 50 ml sample (RWH) which measured in flat bottomed then, two drops of bromo cresol (green indicator) which has ph= 4.5. After that, the sulfuric acid (H_2SO_4), which has 0.02 concentrations, is titrated from the acid burette until the color changed from blue to yellow. The sterol magnetic is used to be the mixing easy. The yellow color indicates that the test is done and the alkalinity is measured from the amount of H_2SO_4 used. The results are between 62 and 338 mg/L CaCO3. Figure 8 shows the titration tool which was used. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

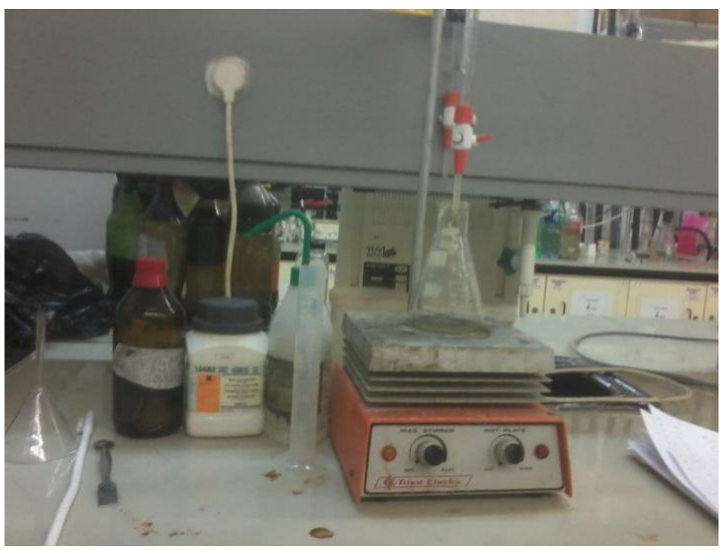

Figure 8 : Titration tool (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.3.1.3 Conductivity EC (µScm−1)

The Electrical conductivity measurement is a practical estimate of the variation in dissolved mineral content of a specific water supply. It can be expressed as microsiemens per centimeter (µS/cm) (Mahmoud, 2010).

In the field testing, using the EC device (Figure 9), the results were between (135 – 633) µS/cm. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

Figure 9 : EC, TDS and Turbidity device (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.3.1.4 Salinity (%)

Salinity is an important parameter in the analysis of drinking water, irrigation water, industrial water and sea water (Bilby and Naiman, 1970),Salinity of water can be determined by measuring its conductivity of electricity by measuring its capability to carry electric current, which varies according to the number and type of ions in the solution (Mahmoud, 2010). In this experiment, the salinity results are between (0.3% - 1.2%). (5%) of the samples are above the allowable limits by the WHO and PSI. See Table 30.

2.3.1.5 Total Dissolved Solids-TDS (mg/L)

High levels of total dissolved solid (TDS) made water unfit for drinking purposes. Chlorine has a low taste threshold. Sodium sulfate and Magnesium sulfate may cause a laxative effect for people if the levels are above 250 mg/L in drinking water. Excessive concentration of sodium affects people sensitive to sodium and pregnant women which causing the poisoning of embryos (NCSU Water Quality Group ,1988)

The limit of TDS in drinking water is less than 500 mg/l (Mahmoud, 2010). This experiment was done in Birzeit University laboratories for environmental and water tests. 50 RWH samples were tested, using the EC, TDS and Turbidity device shown in Figure 9. The results were between (67.30 - 317.00) µS/cm. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

2.3.1.6 Turbidity (NTU)

Turbidity is an optical property that indicates the clarity of water leads to light scattering and absorption when the passage of light in a straight line through a sample of water, in another meaning, turbidity is a measure of light transmitting through water that it caused because of suspensions (Mahmoud, 2010).

This experiment done in Birzeit University laboratories for environmental and water tests using EC,TDS and Turbidity device shown in figure 9,the results are between (0.24-7.00)NTU. (5%) of the samples are above the allowable limits by the WHO and PSI. See Table 30.

2.3.1.7 Chloride (Mg/L)

Existence of chloride in drinking water made the water salty. Some waters are noticeable of salt tasty when contains only 250 mg Cl-/L in spite of some water consist 1000 mg Cl-/L and did not feel of salty because of the cation presence. Presence of sodium cation made the water salty on the other hand, presence of magnesium or calcium cations did not effects on salty of water (Mahmoud, 2010).

In this experiment, conical flask was brought filled with 50 ml water sample (RWH) which measured in flat bottomed then, small amount of potassium dichromate KCr2O7 (orange indicator). After that, the silver nitrate (AgNO3) is titrated from the burette until the color changed from yellow to brown. The sterol magnetic is used to be the mixing easy. The brown color indicates that the test is done and the chloride is measured from the amount of AgNO3 used. In this experiment, the chloride results were between (14 – 77) mg/L. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

2.3.1.8 Ammonia (ppm)

Ammonia is a substance that exists in nature as colorless gas and in water as ammonium salts form when its reacted with acids (SEPA, 2007)

If the ammonia presence in concentration more than 2 mg/L this will cause taste, odor problems and reduce disinfection efficiency in drinking water. Fecal *coliform* is an indication of presence of ammonia in higher concentration than geogenic level. When ammonia react with sodium hydrocarbonate, it release chloramines also when it react with chlorine release a product which the two product released are affected the disinfection process. Water pipes are coated by using cement mortar which may release amounts of ammonia that react with chlorine and reduce its disinfection effect on drinking water (WHO, 1996).

In this experiment, conical flask was brought filled with 50 ml a (RWH) sample which was measured in flat bottomed then, two drops of Rochelle salt were mixed. After that, 2.0 mL Nessler reagent were added and mixed. Then, the absorbance was measured at 425 nm in a 1 cm cell after 15 minutes against H_2O. In the field testing, using the Ammonia device shown in figure 10, the results were between (0.004- 0.143) ppm. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

Figure 10 : Ammonia device (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.3.1.9 Residual Chlorine (mg/L)

The presence of residual chlorine indicates that the cistern had been sterilized with chlorine recently. This residual chlorine disables the bacteria and some viruses that cause diarrheal disease; and thus it is a measure of the extent of the validity of water to drink. It is also protect the water from contamination during storage in cisterns. The presence of free residual chlorine in drinking water is related with the absence of live pathogenic organisms which caused the disease (Mahmoud, 2010). In the field testing of the residual chlorine device, the results were between (0.00 - 0.73) mg/L. The results were good; because they were within allowable limits by the WHO and PSI. See Table 30.

2.3.2. Microbial Parameters

2.3.2.1 Total Coliform*s* (TC) (CFU/100ml)

TC bacteria are numerous and include wide range of aerobic and facultative anaerobic and always are detected in animal feces and human sewage. Some scientist described coliform bacteria as microbial indicator; it is not detect to any illness but their presence in water is a predictor to bacteria, protozoan or viruses. Therefore, TC is utilized as an indicator of pollution to soils or plants with sewage (Mahmoud, 2010; Al-Salymeh, 2008).

In this experiment, first thing M Coliforms were prepared. Then, 4.8 g were suspended in 100 mL distilled water containing 2 mL of ethanol. After that, they were heated to boiling point then, wait until cool to room temperature. Finally, they were dispensed onto sterile absorbent pads. To measure TC; membrane filter (0.45 μm) were putted. The samples (100 mL) were filtered onto the top of the saturated absorbent pad. Then, cover of Petri dish was placed on tightly. Finally, blue points on dish were counted.

Source of TC bacteria is fecal materials which are exist in the intestinal tract of animals, soil and grain (Mahmoud, 2010). The results were between (16 – 189000) CFU/100mL; which means that all the fifty RWH samples were above allowable limits of the WHO and the PSI.

2.3.2.2 Fecal Coliform*s* (FC) (CFU/100ml)

To prepare M FC broth Base, first, 3.7 g were suspend in 100 mL distilled water. Then, 1 mL was added and 1% Bacto Rosolic Acid were suspended in 0.2 N NaOH solution and were heated to boiling point. Finally, they were cooled to room temperature and 2 mL of broth were added to each sterile absorbent pad placed in a Petri dish.

FC test done by following steps, membrane filter which 0.45 µm were placed through which the sample (100 mL) was filtered onto the top of the saturated absorbent pad. Then, cover of Petri dish was placed on tightly, and were incubated at 44.5 ºC for 22 – 24 hours. Finally, red points were counted . The results were between (0 – 6700) CFU/100ml; which means almost of fifty RWH samples were above allowable limits of the WHO and the PSI.

Figure 11 : Evaporation Tool (Water Studies Laboratory at Birzeit University /Palestine - February2015)

2.4. Data Analysis techniques:

2.4.1 Tools identification:

Statistical Package for the Social Sciences (SPSS) is a software package used for statistical analysis. It was used to enter and analyze data in order to test the differences between the various different groups (Banda et al., 2007). Excel was used for statistical purposes.

In this study, questionnaire's data were filled in columns. They were analyzed in descriptive statics. Frequencies statics explain order of the data, summation and percentages. Descriptive statics were used to detect correlations between related variables.

Chapter Three
Results and Discussion

3.1. Personal Data of the Respondents

In general the average age of the respondent interviewed is 55 years (Minimum 18 and maximum 92), most of them ages from 36-50 (89%). Most of the respondent interviewed have a bachelor degree (41.36%) followed by a secondary education level (16.75%). Most of the respondents are married (55.0%) followed by a single marital status (41.1%). 343 responds out of 382 are lived in detached house (89.8%) respectively (Table 1).

Table 1 : Personal data of the respondents

<table>
<tr><td>Independent Group</td><td colspan="9">Number of respondents</td><td>Total %</td></tr>
<tr><td rowspan="2">Level of education</td><td>Illiterate</td><td>Can read</td><td>Primary stage</td><td>Preparatory</td><td>Secondary</td><td>Average Diploma</td><td>Bachelor</td><td>Master</td><td>Doctorate</td><td rowspan="2">283 (100%)</td></tr>
<tr><td>32 (8.4)</td><td>6 (1.6)</td><td>45 (11.8)</td><td>30 (7.9)</td><td>64 (16.8)</td><td>36 (9.4</td><td>158 (41.4)</td><td>6 (1.6)</td><td>5 (1.3)</td></tr>
<tr><td rowspan="2">Age</td><td colspan="2">18-25</td><td colspan="3">26-35</td><td colspan="2">36-50</td><td colspan="2">51+</td><td rowspan="2">382 (100%)</td></tr>
<tr><td colspan="2">168 (44)</td><td colspan="3">93 (24.3)</td><td colspan="2">80 (20.9)</td><td colspan="2">41 (10.7)</td></tr>
<tr><td rowspan="2">Marital status</td><td colspan="2">Single</td><td colspan="3">Married</td><td colspan="2">Widower</td><td colspan="2">Divorced</td><td rowspan="2">382 (100%)</td></tr>
<tr><td colspan="2">160 (42)</td><td colspan="3">210 (55)</td><td colspan="2">10 (2.6)</td><td colspan="2">2 (0.5)</td></tr>
<tr><td rowspan="2">Nature of house</td><td colspan="2">Villa</td><td colspan="3">Apartment in Building</td><td colspan="2">Detached house</td><td colspan="2">Bracks</td><td rowspan="2">382 (100%)</td></tr>
<tr><td colspan="2">17 (4)</td><td colspan="3">20 (5)</td><td colspan="2">343 (89.8)</td><td colspan="2">2 (0.5)</td></tr>
</table>

In order to determine the extent of respondents' awareness, a cross-tabulation was made between personal data and three questions in the questionnaire which are:" Q1:Do you think there is a connection between health and water?, Q2: Do you think cistern water is of good quality? And Q3: Do you concern to have water of good quality?''

In SPSS analyses, if the value of the P equals or less than 0.05, it means that there is a significant relationship between the related variables.

Here the results showed that there is a significant relationship between level of education and the thought of respondents the relationship between health and water (Chi-square = 33.565, df = 16, P-value = 0.006) (Table 2).

Table 2 : The results of personal data of respondents when cross tabulated with three questions in questionnaire.

Cross-tabulation	Level of education		Age of respondents		Profession		Marital status		Nature of house	
	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value	Chi-square	P-value
Q1	33.565	0.006	8.816	0.358	28.081	0.031	38.862	0.000	13.115	0.041
Q2	11.481	0.176	3.653	0.455	25.896	0.056	4.238	0.834	1.558	0.956
Q3	12.001	0.744	10.58	0.227	6.475	0.594	20.313	0.000	11.315	0.010

There is a significant relationship between profession of respondents and the thoughts of the respondents about if there is a relationship between health and water where the person's chi-square Asymp. Sig. (2-sided) = 0.031 (Chi-square = 38.862, df = 16, P-value = 0.031) (Table 2).

There is a significant relationship between thoughts of respondents that there is a relationship between health and water, have concerned to have water of good quality and marital status. (person's chi-square Asymp. Sig. (2-sided) of 0.000, 0.000), respectively (Table 2).

Opposite, there is no significant relationship between marital status and people's thought about water is of good quality here the person's chi-square Asymp. Sig. (2-sided) = 0.834 (Table 2).

There is a relationship between nature of house and Q1: “Do you think there is a connection between health and water?” and Q3 : “Do you concern to have water of good quality?”. (person’s chi-square Asymp. Sig. (2-sided) of 0.041, 0.010), respectively (Table 2).

All the cross-tabulations above clarify that whenever there is a low education level there are lack of concerns in quality of water and lack in awareness toward the connection between health and water. Also, nature of living reflected that the awareness toward environmental issue and the concern toward quality of water dropped in people who have low standard of living.

There is a significant relationship between treating cistern water, checking the cistern and cleaning the cistern with age of the respondents (Tables 3 - 5).

Three tables (Table 3, 4, and 5) explain the relationship between the age of the respondents and three practices which are related to awareness practices toward hygiene of cisterns.

Most of the respondents who are treating cistern, checking the cistern and cleaning the cistern (46%, 90%, 93%) respectively their ages were between 18 and 25, this means that; the younger have the full awareness toward cistern water attention, respectively (Table 3, Table 4, Table 5).

Table 3 : Cross-tabulation between the age of the respondents with treating cistern water

Age of the respondents	**Treating water cistern (%)**		Total
	Yes	No	
18 - 25	77 (46)	91 (54)	168 (100)

26 – 35	38 (41)	55 (59)	93 (100)
36 – 50	17 (21)	63 (79)	80 (100)
51 +	13 (32)	28 (68)	41 (100)
Total	145 (30)	237 (62)	382 (100)

(Chi-square = 14.920, df = 3, P-value = 0.002)

Table 4 : Cross-tabulation between age of the respondents and checking water cistern

Age of the respondents	**Checking the cistern (%)**		Total
	Yes	No	
18 - 25	152 (90.5%)	16 (9.5%)	168 (100.0%)
26 – 35	75 (80.6%)	18 (19.4%)	93 (100.0%)
36 – 50	68 (85.0%)	12 (15.0%)	80 (100.0%)
51 +	36 (87.8%)	5 (12.2%)	41 (100.0%)
Total	331 (86.6%)	51 (13.4%)	382 (100.0%)

(Chi-square = 19.425, df = 3, P-value = 0.000)

Table 5 : Cross-tabulation between age of the respondents and cleaning water cistern

Age of the respondents	**Cleaning the cistern**		Total
	Yes	No	
18 - 25	154 (93.3%)	11 (6.7%)	165 (100.0%)
26 – 35	75 (84.3%)	14 (15.7%)	89 (100.0%)
36 – 50	62 (79.5%)	16 (20.5%)	78 (100.0%)
51 +	37 (90.2%)	4 (9.8%)	41 (100.0%)

Total	328 (87.9%)	45 (12.1%)	373 (100.0%)

(Chi-square = 13.877, df = 6, P-value = 0.031)

3.2. Sources of RWH Collection and the Specific Actions before RWH

In Yatta town, cisterns have different capacity depending on the physical condition of the home owner. The municipality water of cisterns' water is only 7.9% while rainwater is 92% which collected from different sources concluded roof of the house, yard in the front of the house and Main Street as shown in Table 6. Figure 13 illustrated specific actions which people was doing it before RWH.

Table 6: Type of water collection surface

Type of water collection surface	Valid Percent	%
Roof of the house	64.1%	69.6%
Yard in front of the house	8.1%	8.8%
Main street	6.8%	7.4%
Roof of the house +Yard in front of the house	11.3%	12.2%
Roof of the house +Yard in front of the house +Main street	1.0%	1.1%
Municipality	7.9%	……..
Roof of the house + Main street	0.8%	0.9%

Table 6 shows that the highest percentages (69%) of RWH sources in cisterns were roof of the house, (61.5%) of people clean the roof of the house before first storm, (12%) dispose the first storm water and (23%) cleans the roof of the house and dispose the first storm water in the same time as shown in (Figure 13).

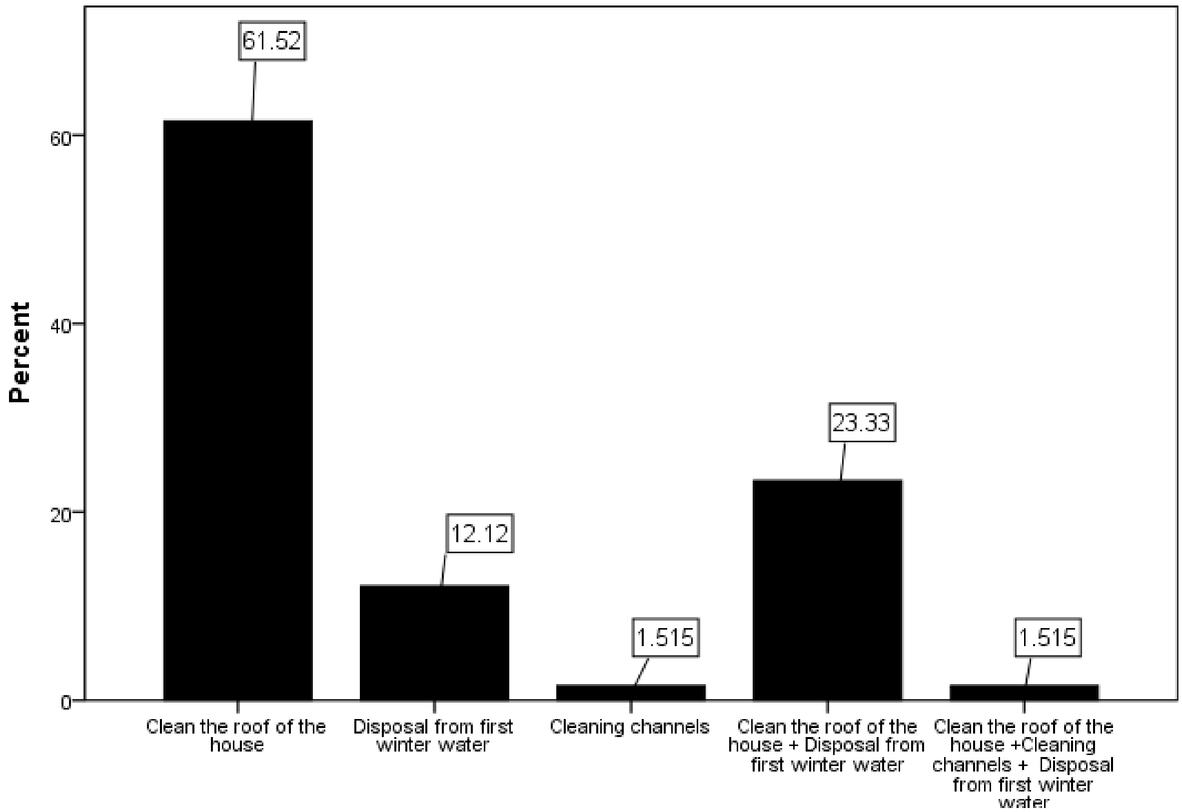

Figure 12 : Specific action before RWH collection

3.3. Cistern's Properties

There are different factors effects on the quality of RWH; the roof type, the age, the location, the local climate, atmospheric pollution, drought period and presence of plants surrounding (Lay, 2010).

The age of cisterns for more than (61%) in Yatta town is less than 15 years which means that rainwater harvesting is still practiced and is growing (Table 7). Some cisterns have an age of more than 50 years (2.4%).

Table 7 : Characteristics of Rainwater Harvesting Cisterns in Yatta town

<table>
<tr><th colspan="13">Response distribution</th></tr>
<tr><td>Cistern Age</td><td colspan="4">1-15
(61.3%)</td><td colspan="4">16-50
(36.4%)</td><td colspan="4">51+
(2.4%)</td></tr>
<tr><td>Cistern Capacity (m^3)</td><td colspan="3">11-49
(18.6%)</td><td colspan="3">50-79
(30.7%)</td><td colspan="3">80-119
(26.7%)</td><td colspan="3">120-300
(24.0%)</td></tr>
<tr><td>Cistern Type</td><td colspan="3">Steel Reinforced Concrete
(57.9%)</td><td colspan="3">Rocky
(23.0%)</td><td colspan="3">Rocky + Concrete
(18.8%)</td><td colspan="3">Poplar
(0.3%)</td></tr>
<tr><td>Type of cistern door</td><td colspan="3">Opened
(8.2%)</td><td colspan="3">Closed
(87.8%)</td><td colspan="3">Kink
(3.7%)</td><td colspan="3">Something else
(0.3%)</td></tr>
<tr><td>Surface RWH collection type</td><td colspan="2">Roof of the house(1)
(69.6%)</td><td colspan="2">Yard in front of the house(2)
(8.8%)</td><td colspan="2">Main street (3)
(7.4%)</td><td colspan="2">(1) +(2)
(12.2%)</td><td colspan="2">(1)+(2)+(3)
(1.1%)</td><td colspan="2">(1)+(3)
(0.9%)</td></tr>
<tr><td>Building material of the roof of the house</td><td colspan="3">Reinforcement concrete
(97.1%)</td><td colspan="3">Zenko Sheets
(1.8%)</td><td colspan="6">Asbestos sheets
(1.0%)</td></tr>
</table>

Table 10 shows that capacity of cisterns, cisterns with a capacity less than $50m^3$ (18.6%), cisterns with a capacity between 50 and 79 (30.7%), cisterns with a capacity between 80 and 119 (26.7%), cisterns with a capacity between 120 and 300 (24.0%). Almost of cisterns are built from steel reinforced concrete (57.9%) which insures that RWH is a modern practice.

Almost of cisterns have closed door (86.6%) which they have specific key for protective as we noticed during field work, this is good in order to avoid seepage of contamination to the cistern.

The most common RWH surface type used to collect rainwater is a roof of the house (69.6%) which (97.1%) of them was built from Reinforcement concrete.

There is a significant relationship between cistern type and incidence of diarrhea, P-value = 0.001) (Table8).

Table 8 : Cross-tabulation between cistern type and incidence of diarrhea

Cistern type	**Incidence of diarrhea**		Total
	Yes	No	
Steel Reinforced Concrete	63 (28.5%)	158 (71.5%)	221 (100.0%)
Rocky	41 (46.6%)	47 (53.4%)	88 (100.0%)
Rocky + Concrete	17 (23.6%)	55 (76.4%)	72 (100.0%)
Poplar	1 (100.0%)	0 (0.0%)	1 (100.0%)
Total	122 (31.9%)	260 (68.1%)	382 (100.0%)

(Chi-square = 14.317, df = 3, P-value = 0.003)

3.4. Sanitary and Hygiene Practices for Water Cisterns

There are many good sanitary practices which have to be done with the cistern to achieve good water quality such as cleaning the cistern, cistern water treatment, checking the cistern water, adding chlorine during the period of rainwater collection and other practices as shown in Table 9.

Table 9 : Cistern's sanitation practices in Yatta , 2015.

#	Questions	Answers	Percentage of respondents
1-	Do you clean the cistern?	Yes	85.3%
		No	12.3%
		No Answer	2.4%
2-	If the answer is yes (cleaning the cistern), when did you clean the cistern last time?	before half a year	47.5%
		before a year	26.0%
		before more than a year	26.6%
3-	Do you treat cistern water in general?	Yes	38%
		No	62%
4-	If yes (cistern water treatment), how do you treat?	Chlorine tablets	77.1%
		Filters	10.0%
		Chlorine tablets + Filters	1.4%
		Chlorine tablets + whitewash	10.0%
		Chlorine tablets + Solar	1.4%
5-	Did you add chlorine during the period of rainwater collection?	No Answer	1.0%
		Yes	31.4%
		No	67.5%
6-	Do you check the cistern water?	Yes	37.7%
		No	62.3%
7-	If the answer is yes (checking the cistern water), when did you check the cistern last time?	Before one year or less	76.8%
		Before more than one year	23.2%
8-	Do you take specific action before rainwater harvesting?	Yes	86.6%
		No	13.4%
9-	If yes (take specific action before rainwater harvesting), what are these actions?	Clean the roof of the house	61.1%
		Disposal from first storm water	12.1%
		Cleaning channels	1.5%
		Clean the roof of the house + Disposal from first storm water	23.3%
		Clean the roof of the house +Cleaning channels + Disposal from first storm water	1.5%

The results show that the respondents have awareness in terms of attention toward cleanliness,(85.3%) clean their cistern; (47.5%) of them clean before half a year. (61.1%) of respondents clean the roof of the house, (1.5%) clean channels as specific action before rainwater harvesting, approximately (62.6%) of respondents are interested in hygiene.

Only (38%) of respondents treat their cistern, (77.1%) add chlorine tablet, (10.0%) put filters on the water source entrance, (1.4%) do both of treatment practices, these sanitary practices indicate that the municipality of Yatta region is cooperative and helpful for peoples with respective of cistern water sanitary practices.

Although the percent of respondents who checked their cistern is (37.7%), (76.8%) of them checked their cistern recently before around year that indicate that there is high awareness of people. See Table 9.

Following good sanitary practices is very important to obtain potable water, where the cross-tabulation between water sanitary practices and occurrence of variable diseases showed that there is a significant relationship. There is a statistically significant relationship between cleaning the cistern and suffering from eyes disease (P-Value = 5.734,df = 1, Chi-square = 0.017). See Table 10.

Table 10 : Cross-tabulation between" Do you clean the cistern? " and "Do any of family members suffer from eye disease during the last two months?"

Do you clean the cistern?	Do any of family members suffer from eye disease during the last two months?		Total
	Yes	No	
Yes	38 (11.6%)	290 (88.4%)	328 (100.0%)
No	11 (24.4%)	34 (75.6%)	45 (100.0%)

Total	49 (13.1%)	324 (86.9%)	373 (100.0%)

(Chi-square = 5.734, df = 1, P-value = 0.017)

3.5. Perspective of Cisterns' owners about Cisterns' Quality

The highest percentage of respondents (85.9%) thought that the water is of good quality. Almost of the respondents (83.5%) have concerned to have water with good quality, (16.5%) is not concerned.

Only (23.3%) of people felt a change in water taste when cistern's water is mixed with rainwater, (41.9%) of them felt the taste is bad, (47.0%) said it is bitter taste and (11.1%) said that the taste is salty.

Turbidity in water and floating impurities on the surface were noticed by 25.7% and 39.5% of respondents respectively, and 18.1% noticed something green in color on the sides of the cistern (Table 20). Other concerns are summarized in Table 11

.

Table 11 : Cisterns water quality

#	Questions	Answers	Percentage of respondents
1-	Do you think that the water is of good quality?	Yes	85.9%
		No	10.7%
		I don't Know	3.4%
2-	Do you concern to have water of good quality?	Yes	83.5%
		No	16.5%
3-	Do you feel a change in water taste when it is mixed with rainwater?	Yes	23.3%
		No	72.5%
		I don't Know	4.2%

4-	If the answer is yes (feels a change in water taste), what is the taste?	Bad	12.8%
		Bitter	14.4%
		Salty	3.4%
5-	Do you notice turbidity in water?	Yes	25.7%
		No	74.3%
6-	Do you notice floating impurities on the surface of the cistern water?	Yes	39.5%
		No	60.5%
7-	Do you notice something green in color on the sides of the cistern?	Yes	18.1%
		No	81.9%

3.6. Environmental Conditions Surrounding the Cisterns

Table 12 summarizes the environment conditions surrounding the surveyed cisterns in Yatta town.

Table 12 : Cistern's Surrounding Environment in Yatta town,2015.

#	Questions	Answers	Percentage of respondents
1-	Do you breed pets at home?	Yes	40.9%
		No	59.1%
2-	Are there trees close to cistern?	Yes	48.7%
		No	51.3%
3-	Do you collect the waste in the yard of the house?	Yes	21.5%
		No	78.5%

As shown in Table 12 there are (40.9%) of respondents breed pets at home which may be one of the reasons to microbial contamination of the harvested water.

More than a half of the respondents are following the proper behaviors relating to the conservation of the environment surrounding the cistern such as not implant trees beside cistern and not collect the garbage in the house yard in order to save the water of the cistern clean. (51.3%) of respondents do not plant trees near cistern. And (78.5%) of respondents do not collect waste in house yard. (Table 12).

There is a significant relationship between collecting of garbage in house yard and existence of diarrheal disease between the respondents (Chi-square = 9.966, df = 1, P-value = 0.001). (Table 13).That's mean existence of garbage in the RWH collection area may be a reason to pollute the cisterns water.

Table 13 : Cross-tabulation between "Do you collect the waste in the yard of the house?" and "Do any of family members get sick with diarrhea during the last two months?"

Do you collect the waste in the yard of the house?	Des any of family members get sick with diarrhea during the last two months?		Total
	Yes	No	
Yes	38 (46.3%)	44 (53.7%)	82 (100.0%)
No	84 (28.0%)	216 (72.0%)	300 (100.0%)
Total	122 (31.9%)	260 (68.1%)	382 (100.0%)

(Chi-square = 9.966, df = 1, P-value = 0.001)

There is a significant relationship between collecting of garbage in house yard and existence of vomiting and diarrheal disease together between the respondents (Chi-square = 4.133,df = 1, P-value = 0.042) (Table 14) That's mean existence of garbage in the RWH collection area may be a reason to pollute the cisterns water and cause diarrhea disease between respondents.

Table 14 : Cross-tabulation between "Do you collect the waste in the yard of the house? "and "Do any of family members get sick with diarrhea and vomiting together during the last two months?"

Do you collect the waste in the yard of the house?	Do any of family members get sick with vomiting and diarrhea during the last two months?		Total
	Yes	No	
Yes	31 (37.8%)	51 (62.2%)	82 (100.0%)
No	79 (26.3%)	221 (73.7%)	300 (100.0%)
Total	110 (28.8%)	272 (71.2%)	382 (100.0%)

(Chi-square = 4.133, df = 1, P-value = 0.042)

3.7. The Sewage System in the House

More than the half (53.4%) of the people in Yatta town have cesspit do not leak wastewater, while (34.5%) have cesspit seeps wastewater. Only (3.4%) have municipal sewerage system, (8.6%) of respondents dispose their sewage in street, in open channel, in random lines and in another choice.

With regard to two choices of using cesspits, (46.7%) of respondents have cesspits in a distance less than 20 meters away from the cistern, (32.6%) of them have cesspits existing on distance more than 20 and less than 50 meters. (20.7%) of respondents have cesspits far away from the cistern (50+ meters). Mostly of cesspits exist in a level lower than the cisterns (70.4%), while (14.0%) of cesspits are higher than cisterns and (15.6%) of cesspits are in the same level with respect to cisterns. (2.4%) of respondents was pumped their cesspits every two weeks, (15.0%) monthly, (2.6%) every 4 months, (8.1 %) every 6 months, (10.0%) yearly, (0.8%) every 4 years, the highest percentage of respondents who do not pump their cesspits ever (58.4%). (83.8%) of cesspits do not overflow during the past 12 months, (16.2%) overflowed. Apparently, their cesspits have large capacity.

With respect to using municipal sewerage system; just 14 respondents, (15.9%) of respondents said that the sewer flood occur from sewer network in the vicinity of the cistern. (77.6%) less than two times per year flood occur, (22.4%) more than two times per year the flood occur (Table 15).

Table 15 : Sewerage system in Yatta town

Variables	**Frequencies**	**Percentages %**
Sewerage system		
1. Cesspit seeps wastewater	131	34.5
2. Cesspit doesn't seep wastewater	204	53.4
3. Municipal Sewerage system	14	3.7
4. In street	9	2.4
5. Open Channels	2	0.5
6. Random lines	2	0.5
7. Other	20	5.2
In the case of using the cesspit as a disposal of wastewater, distance between Cesspit and cistern		
Distance <20	165	46.7
50 >Distance >20	115	32.6
100 > Distance >50	38	10.8
Distance>100	35	9.9
Level of cesspit in relation to cistern		
1. Upper	52	14.0
2. Rappel	261	70.4
3. The Same Level	58	15.6
How many times the cesspit pumped?		
Every two weeks	9	2.4
Monthly	58	15.2
Every 4 months	10	2.6

Every 6 months	31	8.1
Yearly	39	10.2
Every 4 years	3	0.8
There is no perfusion	223	58.4
Did the cesspit overflow during the past 12 months?		
Yes	60	16.2
No	311	83.8
If use public sewers, does sewer flood occur from sewer network in the vicinity of the cistern?		
	52	15.9
Yes	276	84.1
No		
If the answer is yes, When does the sewer flood occur?		
	20	21.1
In summer	43	45.3
In winter	32	33.7
Something else		
What is the number of times per year flood occur?		
Less than two times	59	77.6
More than two times	17	22.4

There is no a significant relationship between cistern level with respect to cesspit, cesspit overflow, cesspit pumping periodically, sewer flood occurrence, distance between cesspit and cistern and existence of diarrheal disease between the respondents.

3.8. Usage of Cistern's Water

Water used for drinking, agriculture, household requirements and livestock watering. Most of the respondents use cistern water for drinking, household requirements and irrigation purpose Figure 13.

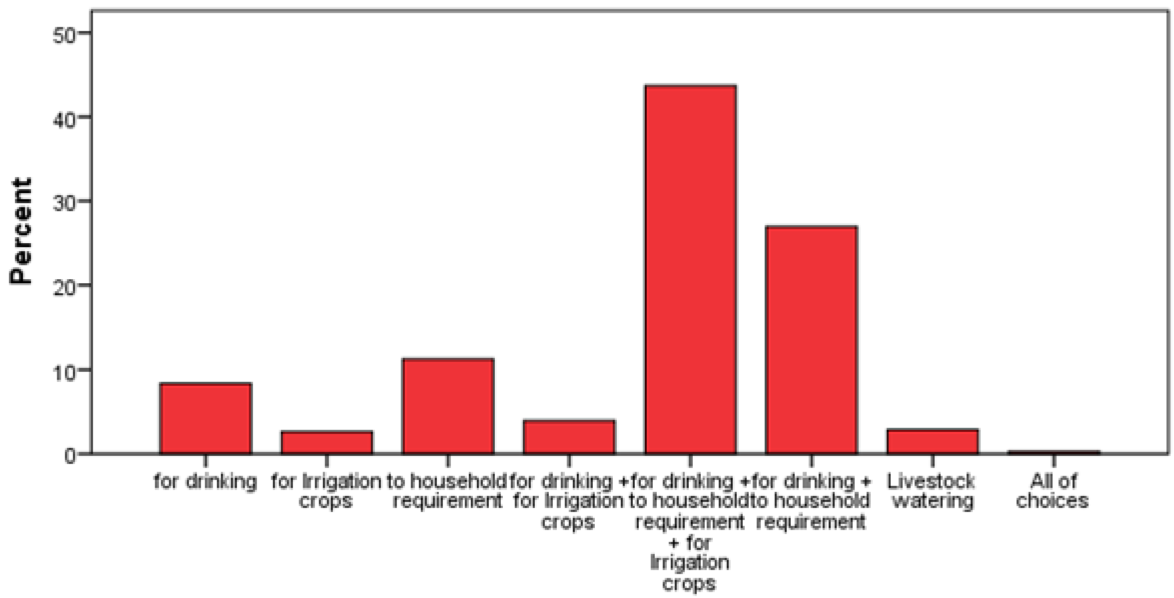

Figure 13 : Cistern's water usage

3.9. Microbiological Contamination of Cisterns' Water

Most of cisterns in Yatta town (96%) were contaminated with TC which indicates to intermediate risk (51-50000 CFU/100 ml) and only (4%) indicates to low risk TC contaminated (Table 16). 30% of cisterns' water samples are safe and there is no risk respective to FC (0 CFU/100ml). (22%) of RWH samples was contaminated with FC low risk (maximum 10 CFU/100ml), (48%) of RWH samples was contaminated with FC from high risk (1000 CFU/100ml). In resultant (70%) of RWH samples are FC contaminated. See Table 17. These results are approximately the same results obtained in Hebron-Palestine district by Al-Salymeh (2008) (95%) for TC, but higher regarding FC (57%).

In another study district by Al-Khatib and Orabi (2004) in three villages in Ramallah, these results are higher than it (87%) for TC, but lower regarding FC (100%).

According to AI-Khatib and their authors (2005) result that (85%) of have zero degree of contamination (no risk), while (7.8%) in the second degrees of contamination (low risk) and (6.8%) of samples are third degree of contamination (intermediate risk level). Of the 247 samples tested samples tested for FC, they were 172 (69.6%) of good quality, and had no risk, while 21 (8.5%) of the samples had low risk, 33 (13.4%) of the samples had an intermediate risk level, 21 (8.5%) of the water samples showed high risk level, and none of these samples showed very high risk level. This classification of risk is recommended by WHO standards.

Table 16 : Cisterns' Contamination Degree with TC in Yatta Town

Range of TC (CFU/100 ml)	Degree of Contamination *	Number of positive samples%	Treatment Procedure
0-3	No Risk	(0)0%	……………..
4-50	Low Risk	(2)4%	Chlorination only
51-50000	Intermediate Risk	(48)96%	Flocculation, Sedimentation then Chlorination

*(Al-Khatib, 2004)

Table 17 : Cisterns' Water Contamination Degree with FC in Yatta town

Range of FC (CFU/100 ml)	Degree of Contamination *	Number of positive samples%
0	No Risk	15(30%)
1-10	Low Risk	24 (48%)
101-1000	High Risk	11 (22%)
>1000	Very high risk	0 (0%)

*(Alkhatib, 2004)

According to MPhil (2013) the National Sample Survey Organization in India reported that microbiological sources such as fecal contamination are the most significant risk to human health related to drinking water quality.

3.10. Water Quality Chemically

The presence of some organisms in water is annoying but there are no significant effects on health such as turbidity, taste, odor and aesthetically distasteful (Alsalymeh, 2008).

The results of physiochemical and microbiological analysis of sampled cisterns water along with relevant PSI guideline and WHO guideline in Yatta town in Table 18.

3.10.1 Physicochemical and microbiological analysis

The results of pH, conductivity EC, salinity, total dissolved solids, turbidity, alkalinity, chloride, ammonia and residual chlorine are below the maximum contaminant levels established by PSI and WHO standards. Table 29 shows that cistern water had low mean values for conductivity (404.1720 µScm−1*)* and Chloride (41.6280 ppm).

Table 18 : Physicochemical and microbiological analysis of the cistern water and its relation to PSI guideline and WHO guideline in Yatta town- Palestine, 2015.

Physicochemical Character	Reading Range	Reading Mean	Samples above MAC[a] (%)	PSI (2004) guidelines	WHO (2004) guidelines
pH	6.96-7.0	7.3060	0	6.5 – 8.5	6.5 – 8.5
Alkalinity (mg/L CaCO3)	62-338	185.1800	0	400	NA [b]
Conductivity EC (µScm−1)	134.9-633	404.1720	0	Up to 2000	Up to 2000
Salinity (%)	0.3-1.2	0.7940	5	Up to 1.0	Up to 1.0
Total Dissolved Solids	67.30-317.00	202.0680	0	Up to 500	Up to 500
Turbidity (NTU)	0.24-7.00	2.7906	5	Up to 5.0	Up to 5.0
Chloride (Mg/L)	14-77	41.6280	0	Up to 250	Up to 250
Ammonia	0.004-0.34	0.0495	-	NA [b]	NA [b]
Residual Chlorine (Mg/L)	0.00-0.73	0.1532	0	0.2- 0.8	NA [b]
Total Coliforms (CFU/100ml)	16-189000	11722.9200	96	0 – 3	0
Faecal Coliforms (CFU/100ml)	0.0-6700	210.6200	70	0	0

[a] *MAC* Maximum Allowable Concentration according to PSI (2004)
[b] *NA* not available

3.10.2. pH

The results of pH ranges from 6.96 to 7.0 with a mean value of 404.17 (Table 18), all of the samples are below PSI and WHO allowable standards. Figure 14 shows the values of pH of the fifty samples examined.

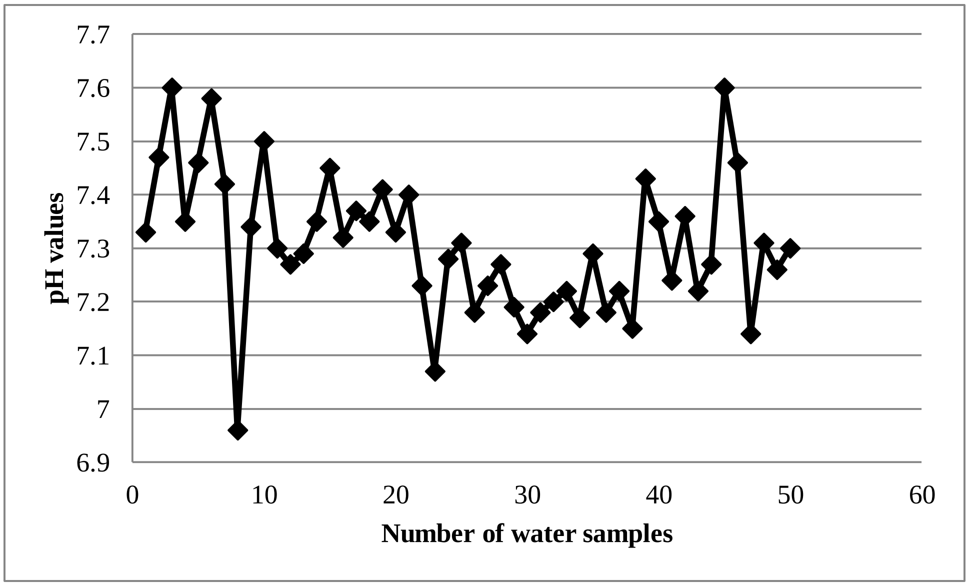

Figure 14 : pH Values of 50 RWH samples

3.10.3 Conductivity EC

The results of conductivity with a mean value of 404.17 (μScm−1) which ranges from 134.9 to 633 (Table 18), all of the samples are below PSI and WHO allowable standards. Figure 15 shows the values of conductivity of the fifty samples examined.

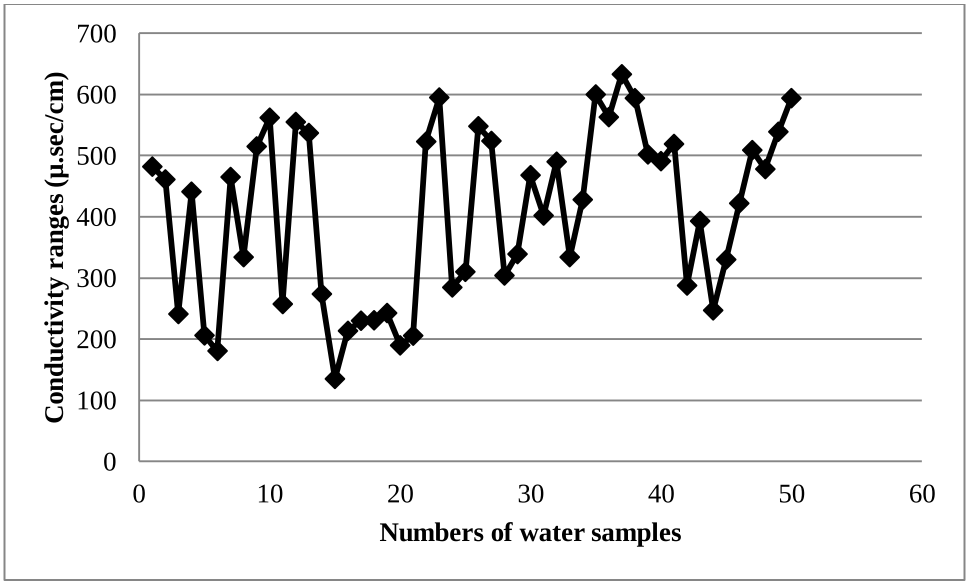

Figure 15 : Conductivity EC Values of 50 RWH samples

3.10.4. Salinity

The mean value of salinity is 0.75% with ranges from 0.3 to 1.2 (%)(Table18), (100%) of the cistern water sample are brackish water (0.05% - 3%) and also all of them above PSI and WHO allowable standards. Figure 16 shows the values of Salinity of the fifty samples examined.

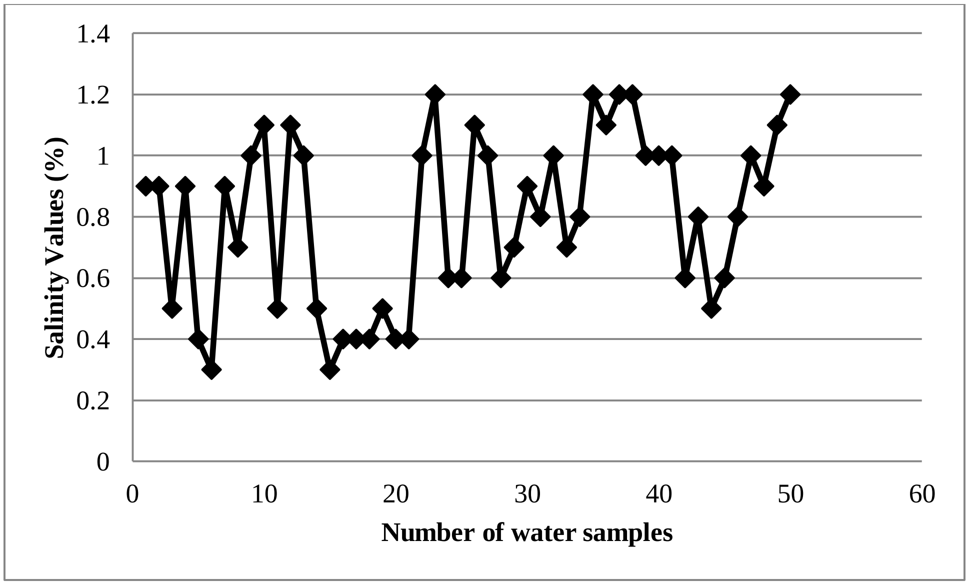

Figure 16 : Salinity Values of 50 samples

3.10.5. Turbidity

The results of turbidity range from 0.24 to 7.00 NTU with a mean value of 2.79 NTU (Table 18). Figure 17 shows the values of turbidity of the fifty samples examined where 5% of them were above PSI and WHO allowable standards.

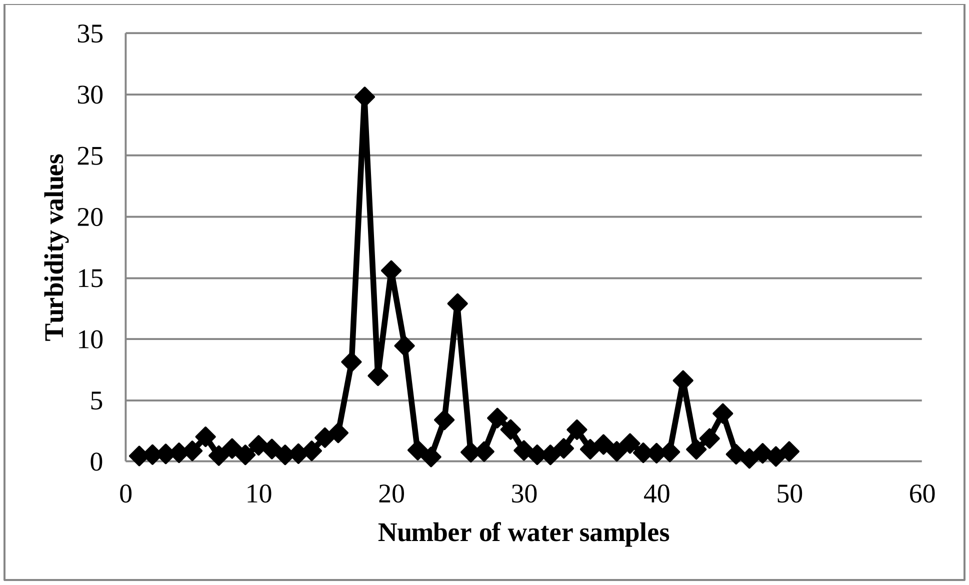

Figure 17 : Turbidity Values of 50 RWH samples

3.10.6. Total Dissolved Solid (TDS)

The results of TDS ranges from 67.30 to 317.00 mg/L, with a mean value of 202.07 (Table 18), all of them above PSI and WHO allowable standards. Figure 18 shows the values of TDS of the fifty samples examined.

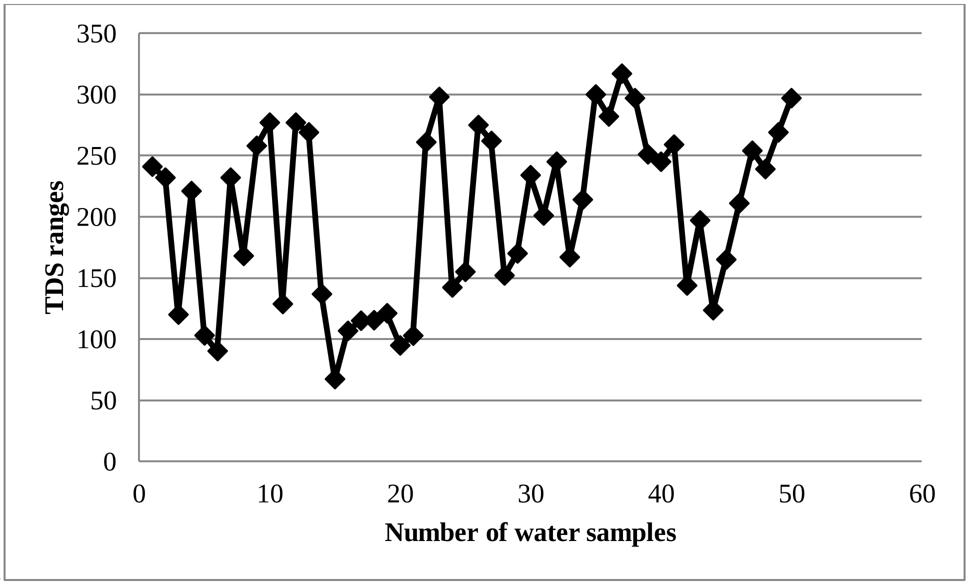

Figure 18 : TDS Values of 50 RWH samples

3.10.7. Alkalinity

The mean value of alkalinity is 185.1800 mg/L $CaCO_3$ results (Table 18). All of the samples are below PSI and WHO allowable standards. Figure 19 shows the values of alkalinity of the fifty samples examined.

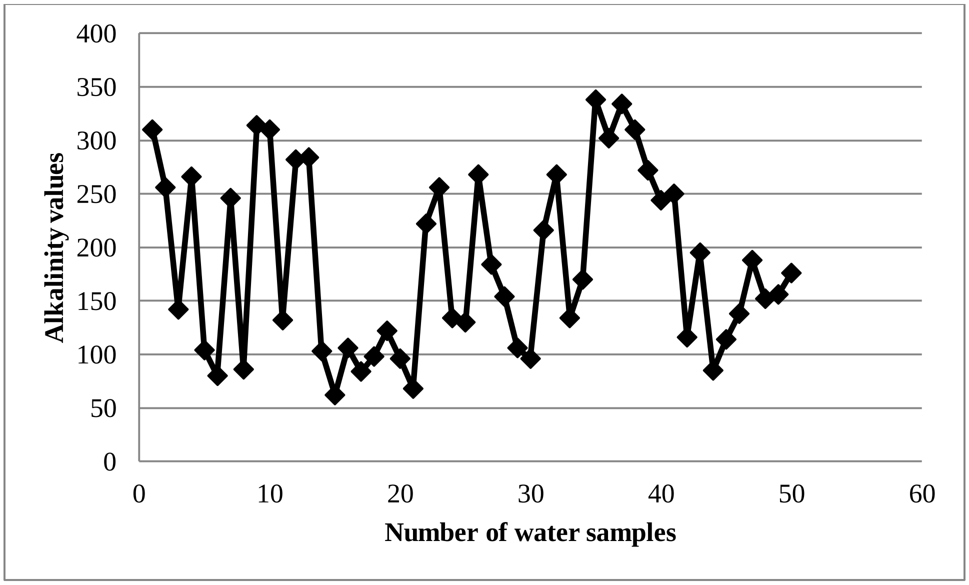

Figure 19 : Alkalinity Values of 50 RWH samples

3.10.8 Chloride

The mean value of chloride is 41.63 mg/L with ranges from 14 to 77 mg/L (Table 18), all of the samples are below PSI and WHO allowable standards. Figure 20 shows the values of chloride of the fifty samples examined.

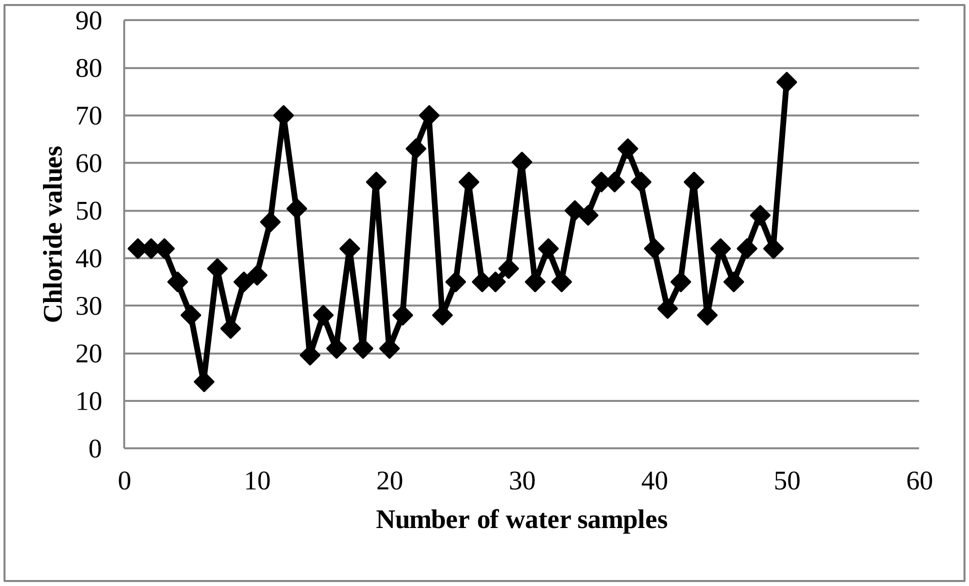

Figure 20 : Chloride Values of 50 RWH samples

3.10.9. Ammonia

The mean value of ammonia is 0.0495 mg/L with values ranging from 0.004 to 0.34 mg/L (Table 18), 96% of Ammonia results are below 2 mg/L. Figure 21 shows the values of ammonia of the fifty samples examined.

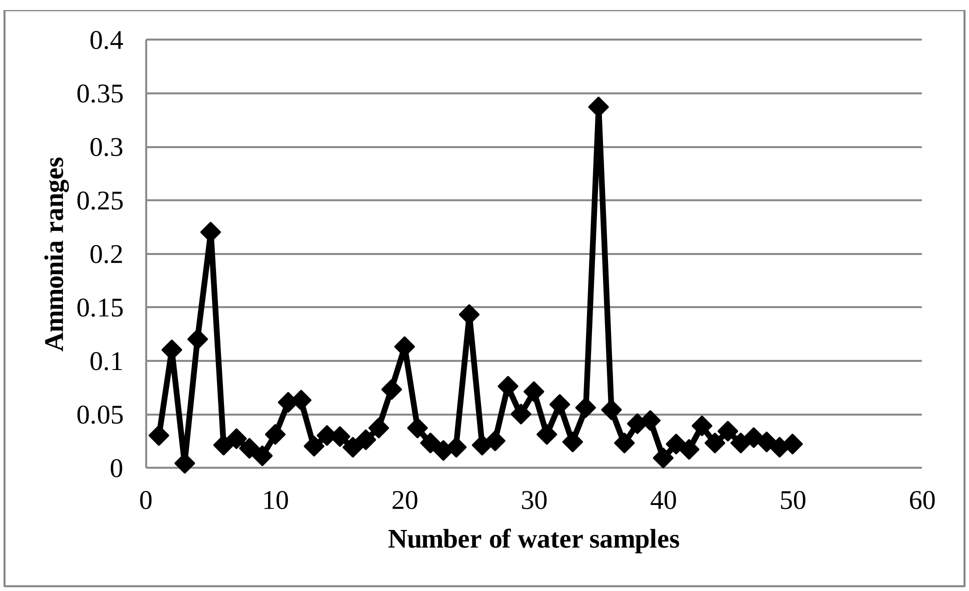

Figure 21 : Ammonia Values of 50 RWH samples

3.10.9 Residual Chlorine (mg/l)

The mean value Residual Chlorine is 0.15 mg/L with ranges from 0.00 to 0.73mg/L (Table 18). Figure 22 shows the values of Residual Chlorine of the fifty samples examined.

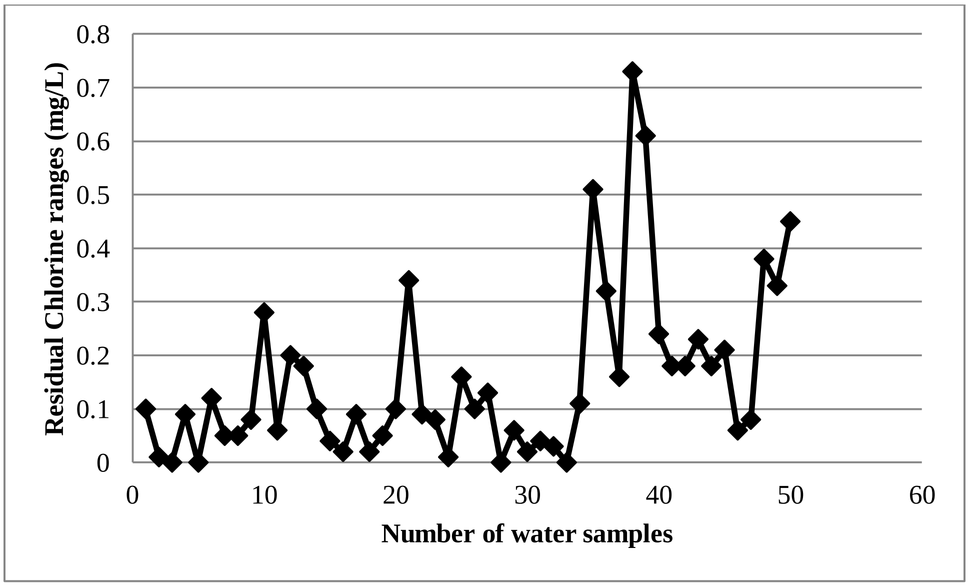

Figure 22 : Residual Chlorine Values

3.11. Water Related Diseases

With respect to diseases and their relation with cistern water quality, 71.2% of respondents are free of diarrhea and vomiting during the last two months from the study. The convergent percentage related to people who are free of diarrhea disease only 68%. See Table 30.

18% of respondents were infected with intestinal worm during two months, 3% of respondents were infected with typhoid during two months, and 13% of respondents during two months were infected with eye disease. See Table 19.

There is 6.5% of family members get sick of jaundice, 6.5% of family members get sick of head lice and 6.0% of family members get sick of scabies (Table 19).

Table 19 : Water related diseases

#	Questions	Answers	Percentage of respondents
1-	Do any of family members get sick with diarrhea and vomiting together during the last two months?	Yes	28.8%
		No	71.2%
2-	Do any of family members get sick with diarrhea during the last two months?	Yes	31.9%
		No	68%
3-	Do any of family members infected with intestinal worm during the last two months?	Yes	18%
		No	81.7%
4-	Do any of family members get sick with jaundice during the last two months?	Yes	6.5%
		No	93.5%
5-	Do any of family members infected with typhoid during the last two months?	Yes	3%
		No	96.9%
6-	Do head lice appear in any of the family members in the last two months?	Yes	6.5%
		No	93.5%
7-	Do any of family members get sick with scabies during the last two months?	Yes	6.0%
		No	94.0%
8-	Do any of family members suffer from eye disease during the last two months?	Yes	13.1%
		No	86.9%

There is a statistically significant relationship between cistern type and incidence of diarrhea disease (Chi-square = 14.317, df = 3, P-value = 0.003) (Table 12).

There is a statistically significant relationship between cleaning the cistern and suffering from eyes disease (P-Value=5.734, df = 1, Chi-square = 0.017) (Table 14).

There is a significant relationship between collecting of garbage in house yard and existence of vomiting and diarrheal disease together between the respondents (Chi-square = 4.133,df = 1, P-value = 0.042) (Table 23)

Table 20 : Cross-tabulation between "Do you add chlorine during rainfall season?" and "Do any of family members suffering from eye disease during the last two months?"

Do you add chlorine during rainfall season?	Do any of family members suffering from eye disease during the last two months?"		Total
	Yes	No	
Yes	23 (19.2%)	97 (80.8%)	120 (100.0%)
No	25 (9.7%)	223 (90.3%)	258 (100.0%)
Total	48 (12.7%)	330 (87.3%)	378 (100.0%)

(Chi-square = 6.635, df = 1, P-value =0.010)

There is a statistically significant relationship between noticing the floating impurities on the surface of the cistern and incidence of diarrhea disease (Chi-square = 6.985, df = 1, Chi-square = 0.008). This means that do not add the chlorine during the last two months before rain season cause diarrhea disease.

Table 212 : Cross-tabulation between "Do you notice floating impurities on the surface of the cistern water?" and "Do any of family members get sick with diarrhea during the last months?"

Do you notice floating impurities on the surface of the cistern water?	Do any of family members get sick with diarrhea during the last months?		Total
	Yes	No	
Yes	60 (39.7%)	91 (60.3%)	151 (100.0%)
No	62 (26.8%)	169 (73.2%)	231 (100.0%)
Total	122 (31.9%)	260 (68.1%)	382 (100.0%)

(Chi-square = 6.985, df = 1, P-value = 0.008)

There is a statistically significant relationship between collecting house waste in the yard and incidence of diarrhea disease (Chi-square = 9.966,df = 1,P-value = 0.002).

Table 22 : Cross-tabulation between "Do you collect waste in the yard of the house?" and "Do any of family members get sick with diarrhea during the last months?"

Do you collect waste in the yard of the house?	Do any of family members get sick with diarrhea during the last months?		Total
	Yes	No	
Yes	38 (46.3%)	44 (53.7%)	82 (100.0%)
No	84 (28.0%)	216 (72.0%)	300 (100%)
Total	122 (31.9%)	260 (68.1%)	382 (100.0%)

(Chi-square = 9.966, df = 1, P-value = 0.002)

There is a statistically significant relationship between notice turbidity in water and incidence of diarrhea disease (Chi-square = 17.613, df = 1, P-value = 0.000). This means, the turbidity of the cistern water cause diarrhea disease.

Table 23 : Cross-tabulation between "Do you notice turbidity in water?" and "Do any of family members get sick with diarrhea during the last months?"

Do you notice turbidity in water?	Do any of family members get sick with diarrhea during the last months?		Total
	Yes	No	
Yes	48 (49.0%)	50 (51.0%)	98 (100.0%)
No	74 26.1%)	210 (73.9%)	284 (100.0%)
Total	122 (31.9%)	260 (68.1%)	382 (100.0%)

(Chi-square = 17.613, df = 1, P-value = 0.000)

There is a statistically significant relationship between breed pets home, notice floating impurities on the surface of the cistern water and incidence of diarrhea disease during the last two months(Chi-square = 6.543, df = 1, P-value = 0.011). This means, breeding animals and birds pets at home abreast to presence of floating impurities cause diarrhea disease.

Table 24 : Cross-tabulation between "Do any of family members get sick with diarrhea during the last months?", breeding pets at home and "Do you notice impurities floating on the surface of cistern water?"

Do any of family members get sick with diarrhea during the last two months?			Do you notice impurities floating on the surface of cistern water?		Total
			Yes	No	
Yes	breeding pets at home	Yes	32 (62.7%)	19 (37.3%)	51 (100%)
		No	27 (39.1%)	42 (60.9%)	69 (100%)
	Total		59 (49.2%)	61 (50.8%)	120 (100%)
No	breeding pets at home	Yes	42 (42.0%)	58 (58.0%)	100 (100%)
		No	42 (28.2%)	107 (71.8%)	149 (100%)
	Total		84 (33.7%)	165 (66.3%)	249 (100%)
Total	breeding pets at home	Yes	74 (49.0%)	77 (51.0%)	151 (100%)
		No	69 (31.7%)	149 (68.3%)	218 (100%)
	Total		143 (38.8%)	226 (61.2%)	369 (100%)

(Chi-square = 6.543, df = 1, P-value = 0.011)

Chapter Four
Conclusions and Recommendations

4.1. Conclusions

The research showed that the main source of the RWH contamination in cisterns is surrounding environment of the cisterns such as the inappropriate collection surfaces, and the absence of available free chlorine in the harvested rainwater in addition to a number of other factors appear to be responsible for the reduced microbial quality.

The research reached that the cistern type is a reason to incidence of diarrhea in Yatta town. Most of cisterns are built from steel reinforced concrete (57.9%); which means that used of reinforced concrete in the cisterns is a reason for diarrhea disease.

The research indicated that the probability to incidence of diarrhea and diarrhea with vomiting was because of collecting the waste in the yard of the house where the RWH was collected.

Unexpectedly, the level of cesspits with respect to cisterns and the short distance between cesspits and cisterns were not sources of contamination for RWH cisterns.

Moreover, it is noticeable there is a statistically significant relationship between cleaning the cistern and incidence with eyes diseases, that's mean that it is possible avoid the incidence with eyes diseases by take care about cistern cleaning it periodically.
With regard to physiochemical quality of RWH in Yatta town is reasonably satisfactory. It is perceptible that there are no exceeding WHO and PSI guidelines values for all the pH, alkalinity, conductivity, TDS, chloride, ammonia, and residual chlorine. Only turbidity and

salinity parameters are being detected above the corresponding maximum allowable concentration for drinking purposes.

On the contrary, microbiological indicators (TC and FC) were detected in the majority of samples, though at low to high risk levels. It is concluded, based on the findings of this work, that the surrounding environment, cistern management practices, and the cistern owners' weak awareness of preventing rainwater contamination are the main factors that contributed to RWH contamination. Based on the existence of the microbiological contamination indicators in the RWH, a number of pollution sources were discussed in this paper, which is strongly suggested to be considered as contamination prevention strategies are developed. As a simple precaution, RWH should be disinfected before usage for drinking purposes.

According to people's education, marital status and profession, there is a significant relationship between these variables and awareness scale. The results showed that whenever there is low education level, there is lack of concern in quality of water and lack in awareness toward the connection between health and water. Also, nature of living reflected the awareness toward environmental issue; the concern toward quality of water was dropped in people who have low standard of living.

In general, the analyzed results for many parameters such as physicochemical and microbiological as well as the questionnaire survey showed a correlation between the hygiene practices, and the cistern owners' awareness of preventing RWH cisterns and the quality of the RWH samples obtained.

4.2 Recommendation

The following recommendations can be drawn:

- Involvement of local communities in awareness campaigns and education about the danger of contaminated water.

- Increased awareness of the need to maintain a rainwater harvesting cisterns, and protect it from contamination.

- The need to build cesspits in accordance with the sanitary standards, environmental and construction suitable to prevent contamination of rainwater collected in cisterns and on the lower level of the rainwater harvesting cisterns.

- Activating the role of the agencies responsible for water quality; monitoring and working on documenting the results.

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Appendices

APPENDIX1: The Questionnaire

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جامعة بيرزيت / كلية الدراسات العليا
معهد الدراسات المائيّة والبيئية

استبيان خاص بآبار جمع مياه الشرب في منطقة يطا

يهدف هذا الاستبيان إلى جمع المعلومات اللازمة لعمل رسالة ماجستير بعنوان (حصاد مياه الأمطار في بلدة يطا وتأثيرها على صحة الناس) والتي أقوم بإعدادها أنا الطالبة لينا التميمي لاستكمال درجة الماجستير في تخصص علوم المياه والبيئة من جامعة بيرزيت وتحت إشراف د.عصام الخطيب. أرجو المساعدة في تعبئة الاستبيان كاملا علما بان المعلومات الواردة فيه سوف تستخدم لأغراض البحث العلمي والأكاديمي فقط.

V 1	المقابلة تمت مع: 1. الأب 2. ألام 3. الابن/الابنة (أكثر من 18 سنة) 4. غير ذلك/حدّد/ي:...............
V 2	مستوى التعليم 1. أمي 2. ملم 3. ابتدائي 4. إعدادي 5. ثانوي 6. دبلوم متوسط 7. بكالوريوس 8. ماجستير 9. دكتوراه
V 3	المهنة: 1. موظف في القطاع العام (الحكومي) 2. موظف في القطاع الخاص 3. موظف في القطاع الأهلي 4. موظف وكالة 5. مزارع 6. عامل 7. طالب 8. لا أعمل 9. ربة بيت
V 4	الحالة الاجتماعية: 1. أعزب 2. متزوج/ة 3.أرمل/ة 4. مطلق/ة
V 5	طبيعة المسكن: 1. فيلا 2. شقة سكنية في عمارة 3. منزل مستقل 4. براكس 5. خيمة 6. غير ذلك حدد/ي:......................
V 6	العمر:...................... (18 سنة فما فوق)
V 7	الجنس: 1. ذكر 2. أنثى
V 8	عدد افراد الاسرة:.................

عدد العائلات المشتركة بالبئر:	V 9
عدد الافراد المستفيدين من البئر:	V 10
حجم البئر م^3	V 11
مساحة السطح م^2	V 12
عمر البئر (سنة)	V 13
من أين يتم جمع مياه الشرب في البئر؟ 1.سطح المنزل 2. ساحة امام المنزل 3. الشارع العام 4 .غير ذلك حدّد/ي	V 14
ما هي مادة بناء سقف المنزل؟ 1. باطون مسلح 2. صفائح زينكو 3. صفائح اسبست 4. غير ذلك حدّد/ي	V 15
نوع البئر : 1. باطون 2. صخري 3. صخر+باطون 4. غير ذلك حّدد/ي	V 16
هل المنزل مربوط بشبكة مياه عامة ؟ 1. نعم 2. لا	V 17
هل يتم الاستغناء عن شبكة المياه خلال موسم الشتاء ؟ 1. نعم 2. لا	V 18
هل تشعر بان البئر يساعدك في حل ازمة المياه ؟ 1. نعم 2. لا	V 19
كم شهر يستطيع البئر ان يغطي احتياجات المنزل ؟ .... شهر	V 20
كم مرة يمتلئ البئر خلال موسم الجمع ؟	21V
ما هي استخداماتك لماء البئر ؟ (يمكن أن يكون الجواب أكثر من خيار) 1. للشرب 2. لري المزروعات 3. لاحتياجات المنزل 4. غير ذلك حدّد/ي	22V
هل تتخذ إجراءات محددة قبل تجميع مياه الأمطار ؟ 1. نعم 2. لا	V 23
إذا كان الجواب نعم ، فما هي هذه الاجراءات ؟ (يمكن أن يكون الجواب أكثر من خيار) 1. تنظيف سطح المنزل 2 .التخلص من مياه اول شتوة 3. غير ذلك حددّ/ي	V 24
هل يتم معالجة مياه البئر؟ 1. نعم 2. لا	V 25

V 26	إذا كان الجواب نعم ، فكيف تتم المعالجة ؟ ………………
V 27	هل تم فحص مياه البئر ؟ 1. نعم 2. لا
V 28	إذا كان الجواب نعم ، فمتى تم الفحص ؟ قبل ……………
V 29	هل تم تنظيف البئر؟ 1. نعم 2. لا
V 30	إذا كان الجواب نعم ، متى تم تنظيف البئر آخر مرة ؟ قبل …………
V 31	هل تقوم بإضافة الكلور خلال الفترة التي يتم فيها جمع مياه الامطار ؟ 1. نعم 2. لا
V 32	هل باب بئر التجميع 1. مفتوح 2. مغلق 3. شبك 4.غير ذلك حدّد/ي ……………
V 33	كيف يتم التخلص من المياه العادمة في منزلك؟ 1. حفرة امتصاصية تسرب المياه العادمة 2 . حفرة صماء لا تسرب المياه العادمة 3. شبكة مجاري عامة 4. في الشارع 5. قنوات مفتوحة 6. خطوط عشوائية 7 . أخرى ، حدّد/ي: ………………
V 34	في حالة استعمال حفرة امتصاصية اذكر بعدها عن البئر بالمتر ……………
V 35	هل مستوى الحفرة الامتصاصية؟ 1. أعلى من مستوى البئر 2. أهبط من مستوى البئر 3. نفس المستوى
V 36	كل كم من الوقت تقومون بنضح الحفرة الامتصاصية؟ 1. كل اسبوعين 2. شهريا 3. كل 6 شهور 4. سنويا 5. لا يتم نضحها 6.أخرى،حدّد/ي ………
V 37	هل فاضت الحفرة الامتصاصية خلال ال 12 شهر الماضية؟ 1. نعم 2. لا
V 38	في حالة استعمال المجاري العامة ، هل يحدث فيضان للمجاري في المنطقة القريبة من منزلك ؟ 1. نعم 2. لا
V 39	إذا كانت الاجابة نعم . متى يحدث الفيضان ؟ 1. في الصيف 2. في الشتاء 3. غير ذلك
V 40	ما هي عدد المرات التي يحدث فيها الفيضان سنويا؟ ……………………
V 41	هل تقوم بتربية حيوانات او طيور اليفة في المنزل ؟ 1. نعم 2. لا
V 42	هل يوجد أشجار قريبة من بئر التجميع ؟ 1. نعم 2. لا
V 43	هل تلاحظ شوائب تطفو على سطح ماء البئر؟ 1. نعم 2. لا

V 44	هل تلاحظ شيء ذو لون أخضر على جوانب البئر ؟ 1. نعم 2. لا
V 45	هل يتم تجميع النفايات في ساحة المنزل ؟ 1. نعم 2. لا
V 46	هل تلحظ عكوره للمياه ؟ 1. نعم 2. لا
V 47	هل تشعر تغيّر في طعم مياه آبار الجمع؟ 1. نعم 2. لا
V 48	اذا كانت الاجابة نعم ، ما هو الطعم؟ 1. سيء 2. مرّ 3. مالح
V 49	هل تعتقد أن المياه التي تستعملها من البئر صالحة للشرب ؟ 1. نعم 2. لا
V 50	هل أنت مهتم للتأكد من جودة المياه التي تستعملها ؟ 1. نعم 2. لا
V 51	هل تعتقد بوجود علاقة بين الصحة والماء ؟ 1. نعم 2. لا 3. لا أعرف
V 52	هل أصيب أحد أفراد الأسرة خلال آخر شهرين بالإسهال والمراجعة معا؟ 1. نعم 2. لا
V 53	هل أصيب أحد أفراد الأسرة خلال آخر شهرين بالإسهال؟ 1. نعم 2. لا
V 54	هل أصيب أحد أفراد الأسرة خلال آخر شهرين بالديدان المعوية؟ 1. نعم 2. لا
V 55	هل أصيب أحد أفراد الأسرة خلال آخر شهرين باليرقان ؟ 1. نعم 2. لا
V 56	هل أصيب أحد أفراد الأسرة خلال آخر شهرين بالتيفوئيد ؟ 1. نعم 2. لا
V 57	هل ظهر القمل في رأس أحد أفراد الأسرة خلال آخر شهرين ؟ 1. نعم 2. لا
V 58	هل أصيب أحد أفراد الأسرة خلال آخر شهرين بالجرب ؟ 1. نعم 2. لا
V 59	هل أصيب احد أفراد الاسرة بمرض في العيون خلال اخر شهرين ؟ 1. نعم 2. لا

APPENDIX 2 : Physiochemical and Biological Parameters

	Residual Chlorine mg/L	Conductivity EC µ.sec/cm	TDS mg/L	pH	Salinity %	Turbidity NTU	Alkalinity	Ammonia	Chloride mg/L	Total Coliform CFU/100 ml	Fecal Coliform CFU/100 ml
1	0.10	482	241	7.33	0.9	0.44	310	0.03	42	1800	88
2	0.01	461	232	7.47	0.9	0.55	256	0.11	42	1200	280
3	0.00	241	120	7.60	0.5	0.61	142	0.004	42	9800	6700
4	0.09	441	221	7.35	0.9	0.70	266	0.12	35	129000	560
5	0.00	206	103	7.46	0.4	0.86	104	0.22	28	112000	270
6	0.12	180.6	90.2	7.58	0.3	2.01	80	0.021	14	980	110
7	0.05	465	232	7.42	0.9	0.47	246	0.027	37.8	2800	56
8	0.05	334	168	6.96	0.7	1.05	86	0.018	25.2	2600	100
9	0.08	515	258	7.34	1.0	0.53	314	0.011	35	3200	340
10	0.28	562	277	7.50	1.1	1.31	310	0.031	36.4	189000	0
11	0.06	257.3	128.7	7.30	0.5	1.01	132	0.061	47.6	89	17
12	0.20	555	277	7.27	1.1	0.53	282	0.063	70	108	23
13	0.18	537	269	7.29	1.0	0.63	284	0.02	50.4	72	0
14	0.10	273.7	136.8	7.35	0.5	0.86	103	0.03	19.6	310	22
15	0.04	134.9	67.3	7.45	0.3	1.94	62	0.029	28	79	15
16	0.02	213.4	106.7	7.32	0.4	2.33	106	0.019	21	3400	18
17	0.09	230	115	7.37	0.4	8.13	84	0.026	42	11200	66
18	0.02	230.7	115.4	7.35	0.4	29.8	98	0.037	21	4300	19
19	0.05	242.6	121.1	7.41	0.5	7.00	122	0.073	56	4800	87
20	0.10	189.7	94.8	7.33	0.4	15.6	96	0.113	21	8900	11
21	0.34	205.6	102.8	7.40	0.4	9.45	68	0.037	28	2440	13
22	0.09	523	261	7.23	1.0	0.92	222	0.023	63	5600	101
23	0.08	595	298	7.07	1.2	0.36	256	0.016	70	2700	0
24	0.01	284.5	142.2	7.28	0.6	3.39	134	0.019	28	13000	40
25	0.16	310	155	7.31	0.6	12.9	130	0.143	35	16	0
26	0.10	548	275	7.18	1.1	0.75	268	0.021	56	4500	10
27	0.13	524	262	7.23	1.0	0.80	184	0.025	35	12800	0
28	0.00	304	152	7.27	0.6	3.54	154	0.076	35	9700	0
29	0.06	339	170	7.19	0.7	2.6	106	0.050	37.8	5690	13
30	0.02	468	234	7.14	0.9	0.89	96	0.071	60.2	8800	215
31	0.04	402	201	7.18	0.8	0.54	216	0.031	35	99	0
32	0.03	490	245	7.20	1.0	0.53	268	0.059	42	87	7
33	0.00	334	167	7.22	0.7	1.06	134	0.024	35	1880	66
34	0.11	428	214	7.17	0.8	2.59	170	0.056	50	1340	16
35	0.51	600	300	7.29	1.2	0.99	338	0.337	49	313	0
36	0.32	563	282	7.18	1.1	1.38	302	0.054	56	7800	317
37	0.16	633	317	7.22	1.2	0.82	334	0.023	56	786	12
38	0.73	594	297	7.15	1.2	1.46	310	0.041	63	940	0
39	0.61	502	251	7.43	1.0	0.70	272	0.044	56	670	0
40	0.24	491	245	7.35	1.0	0.67	244	0.009	42	1460	44
41	0.18	519	259	7.24	1.0	0.77	250	0.022	29.4	590	0

42	0.18	287.6	143.8	7.36	0.6	6.61	116	0.017	35	8900	378
43	0.23	393	197	7.22	0.8	0.98	195	0.039	56	6500	440
44	0.18	247	123.6	7.27	0.5	1.87	85	0.023	28	210	0
45	0.21	330	165	7.60	0.6	3.91	114	0.034	42	89	0
46	0.06	422	211	7.46	0.8	0.58	138	0.023	35	2200	55
47	0.08	509	254	7.14	1.0	0.24	188	0.028	42	88	0
48	0.38	478	239	7.31	0.9	0.66	152	0.024	49	1200	13
49	0.33	539	269	7.26	1.1	0.40	156	0.019	42	22	9
50	0.45	594	297	7.30	1.2	0.81	176	0.022	77	88	0