Faculty of Graduate Studies

Master Thesis in Water and Environmental Engineering

Assessment of Drinking Water Quality at public schools at Jenin Directorate of Education, Palestine

تقييم نوعية مياه الشرب في مدارس مديرية التربية والتعليم جنين, فلسطين

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BIRZEIT UNIVERSITY

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Examining committee signature

Dr. Nidal Mahmoud ……………
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I would like to thank my supervisor Dr. Nidal Mahmoud for his cooperation and support during the research, and to the members of the committee, Dr. Maher Abu-Madi and Dr. Rashed Al-Sa'ed, who were an important part in the success of the work. Special thanks to my husband for his support and encouragement.

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DEDICATION

To the soul of my mother

To my dear father

To my dear husband

To my life "Judy" & "Ahmad"

Abstract

The aim of this study was to assess drinking water quality at public schools in Jenin directorate of education. A structured questionnaire was conducted and submitted to schools according to geographical area (east Jenin villages, west Jenin villages, and Jenin city), drinking water sources, location of school (rural & urban), and different grade levels of schools. 59 samples of drinking water were collected from schools faucets and tested for different physiochemical (pH, Free Residual Chlorine, Turbidity, EC, Total Hardness,) and microbiological (Total *Coliforms* and Fecal *Coliforms*) characteristics. The research results indicated that the drinking water sources of the schools of different grade levels include: municipal water only, purchased water tanks (unknown source of water), agricultural wells, direct from Mekorot Company, and rain water harvesting.

With respect to physical and chemical analysis, all items conform to PSI and WHO Guidelines except the total hardness, 20% of schools exceeded the standards, and free residual chlorine were 70% of schools had value less than the minimum standard.
Schools purchasing water tanks or use agricultural wells, rain water harvesting all have total coliform bacteria and fecal coliform bacteria in their water.

Schools in rural area had higher percent of contamination than schools in urban area. And schools in villages in east Jenin had the highest rate of microbe detection (TC: 52.9%), (FC: 41.2%).

Results showed a significant relationship between the long interruption in municipal water supply and water contamination, while there was no relation between the absence of free residual chlorine in drinking water and the presence of contamination.
In all schools tanks for drinking water are separated from water tanks for other purposes, all the tanks at the roof of the school and made from plastic only. All schools make sure periodically that water tanks are closed. All school principals had no idea about how close the cesspits were from school water network or well (if there is).

الخلاصة

تقييم نوعية مياه الشرب في مدارس مديرية التربية والتعليم جنين, فلسطين

هدف هذه الدراسة هو تقييم نوعية مياه الشرب في مدارس مديرية التربية والتعليم منطقة جنين. تم إجراء استبيان منظم وتقديمه للمدارس حسب المنطقة الجغرافية (قرى شرق جنين وقرى غرب جنين ومدينة جنين) ومصادر مياه الشرب وموقع المدرسة (الريفية والحضرية) ومستويات مختلفة من المدارس.
تم جمع 59 عينة من مياه الشرب من حنفيات المدارس وعملت عليها فحوصات مختلفة فيزيائية و كيميائية مختلفة (درجة الحموضة ، الكلور المتبقي الحر، نسبة العكورة ، التوصيل الكهربائي، عسر الماء) والصفات الميكروبيولوجية (القولونيات الكلية والبرازية) (مجموع القولونيات والعصيات البرازية). أشارت نتائج البحث إلى أن مصادر مياه الشرب للمدارس من مستويات مختلفة تشمل: المياه البلدية فقط ، و صهاريج المياه المشتراة (المصدر غير المعروف للمياه) ، الآبار الزراعية ، مباشرة من شركة Mekorot ، وحصاد مياه الأمطار.

نتائج الاختبارات الفيزيائيّة والكيميائية كانت ضمن الحدود المسموح بها من قبل منظمة الصحة العالمية والمؤسسة الفلسطينية باستثناء عسر الماء، حيث تجاوزت 20 ٪ من المدارس المعايير ، 70 ٪ من المدارس كانت قيمة الكلور المتبقي الحر لها أقل من الحد الأدنى المعياري.
المدارس التي تشتري صهاريج المياه أو تستخدم الآبار الزراعية ، وحصاد مياه الأمطار جميعها تحتوي على بكتيريا القولون الكلية وبكتيريا القولون البرازية في مياهها.
نسبة التلوث في المدارس في المناطق الريفية أعلى من في المدارس في المناطق الحضرية. كما سجلت المدارس في قرى شرق جنين أعلى معدل للكشف عن الميكروبات ٪41.2 (٪52.9 :FC:TC).

وأظهرت نتائج الاستبيان وجود علاقة ذات دلالة إحصائية بين الانقطاع الطويل في إمدادات المياه البلدية وتلوث المياه ، في حين لا توجد علاقة بين عدم وجود الكلور الحر المتبقي في مياه الشرب ووجود تلوث. كما أظهرت نتائج الاستبيان في جميع المدارس يتم فصل خزانات مياه الشرب عن خزانات المياه المخصصة لأغراض أخرى ، جميع الخزانات على سطح المدرسة ومصنوعة من البلاستيك فقط. جميع المدارس تتأكد دورياً من أن خزانات المياه مغلقة.
لم يكن لدى جميع مديري المدارس أي فكرة عن مدى قرب الحفر الامتصاصية من شبكة المياه المدرسية أوالابار الموجودة في المدرسة (إن وجدت).

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Abbreviations

Acronyms	**Term**
°C	Celsius
FC	Fecal Coliforms
MoEHE	Ministry of Education and Higher Education
MoH	Ministry of Health
PSI	Palestinian Standards Institution
RWH	Rain Water Harvesting
SPSS	Statistical Package for the Social Sciences
TC	Total Coliforms
WASH	Water, Sanitation and Hygiene

Chapter One - Introduction

1.1 Introduction

Access to safe, clean and secure drinking water is an essential prerequisite for communities to prosper. Sadly, this is far from reality for many of the poorest communities in the world who don't have access to clean drinking water supplies (Brookers, 2017).

The statistics around the world are shocking and highlight the need for improved access to clean water: According to WHO, currently 1.2 billion people do not have access to safe drinking water, and 80% of diseases and 30% of deaths around the world are caused by contaminated water (Hênio, 2011). A study conducted by the UN showed that at least 1.8 billion children under five years old have died till now as a result of poor water quality (Giraldi, 2010).

The Palestinian communities in the West Bank suffer from a severe shortage in basic services. Many societies are not connected to electricity, water or sewage networks.
The Palestinian children are also living insecure conditions. Lack of adequate and clean drinking water in school in West Bank prevents children from enjoying their educational process as children are more susceptible to diseases (MoEHE, 2016).

Having safe water maintains healthy populations capable of investing its time in productive pursuits such as attendance at school for children. Healthy school environment which provides access to clean drinking water is an important issue that encourages children to attend school. Contamination of drinking water at schools is a dangerous issue that represents a significant health risk and exposes children to water born related diseases such as diarrhea and other infectious diseases (MoEHE, 2016).

Drinking water quality affects the children's health and it is an indicator whether the supervision on drinking water is appropriate or not (Chung, 2008). Schools offer daily drinking water to their students, which is either stored in concrete tanks in the ground then pumped to the tanks on the roof of the school or directly from the roof tanks or they are connected directly to the water network. If the sources of drinking water are contaminated or not treated with appropriate methods, the quality of drinking water in the schools will be a big problem (Chung, 2008). Schools are considered as a high-risk environment due to complex water system and the high sensitivity of their occupants. So access to clean and safe drinking water at school is an important issue since children spend most of their day there (Chung, 2008).

Education is an influential factor in the development of individuals and societies. It's not only a way to build a strong human being who is aware of his rights and duties to build the nation it is also help him to be connected with the world. And from this perspective the United Nations Millennium Development Goal 2.A was set to "ensure that, by 2015, children everywhere, boys and girls alike, will be able to complete a full course of primary schooling" (UN, 2011).

This goal has broadened the view of the quality of the school environment and the factors that encourage the child to attend school and stay in it a long enough period of time.

Healthy school environment which provide a sufficient amount of clean drinking water that satisfies their daily needs of water is a major issue for the achievement of this goal. However, monthly, quarterly and annual reports showed that there is a severe shortage of fresh water or the contamination of water resources in governmental schools in the West Bank (MoEHE, 2016).

Many schools face water shortages as a result of limited water resources, poor financial resources for the schools and rural communities. Many schools are not connected to water network especially in rural areas and they depend on purchasing water tanks which include water of unknown source or even tested water, and the poor quality of pipe distribution networks which will lead to the increase in infectious diseases between school students (MoEHE, 2016).

According to a survey done by UNICEF in 2012, 87% of schools in the West Bank are connected to the public water network as the main source of drinking water, and around 10% of schools mainly exist in rural areas have unsafe drinking water sources such as water tankers and using rainwater harvesting wells (UNICEF, 2012).

It is usually considered that municipal water network is a safe and clean source of water. However, the quality of water for consumers may not be suitable for drinking (UNICEF, 2012).

Jenin Governorate lies over the North-Eastern aquifer. However, it suffers from severe shortage in water resources. Of the 80 localities in Jenin, only 69 of them have water distribution network. So not all governmental schools in Jenin governorate are connected to the public water network. And many schools got their drinking water from different non-safe resources such as the private vendors.

The minimum daily amount of water that should be available for human consumption is 100 L a day according to the World Health Organization (WHO, 2003). However, because of the water scarcity and the political situation in Palestine that prevents Palestinian from their water rights; average consumption in the West Bank is 66 L per capita, which is two-thirds the minimum amount according to WHO. Even in Jenin city and the surrounding villages have a water network, people there suffer from interruption in water supply over the year. In 32 localities in Jenin water is provided only several hours a day. In remote areas, water supply is cut off for days or weeks (Abusafa *et al*., 2012). Added to that, 33 localities have old water networks where the probability of water leakage is high (PCBS, 2016).

Additionally, according to a survey done by UNICEF in 2012 around 73.6% of schools in the West Bank their water was tested for chemical, physical and biological parameters. However, those tests were done by the Ministry of Health randomly without taking into account the multiplicity of water resources at the region and so at schools. For example, in Jenin area west villages have water resources different from the water resources in east villages and even in Jenin city. Added to that many villages in east Jenin are still not connected to water network which forces the community their to search for other water resources such as agricultural wells, rain water harvesting and purchasing unknown sources water tanks. Schools that depend on purchasing water tanks of unknown origin should have special attention. Add to that private vendors from which many schools got their drinking water are unsafe sources of water since they are not monitoring the quality of water they provide through water tank trucks and that may lead to the probability of water pollution in school (UNICEF, 2012).

1.1.1 Problem Statement

In Jenin governorate not all governmental schools are connected to the public water network, some schools receive their water by purchasing water-tank trucks and some of them use their own wells (rainwater harvesting), added to that poor financial resources for the schools specially in rural communities. Since the water comes from various sources in schools there should be regular water quality testing and monitoring in schools to identify the source of contamination (if there is) and to see if it meets the WHO standards on water quality.

According to the Palestine Standards Institution, PSI, drinking water should be tested continuously to ensure that it is free from pathogens and the concentration of specific compounds such as free residual chlorine is within the allowable limits by the guidelines (Al-Khatib, 2003). However, only 73.6% of schools in West Bank their water were tested for chemical, physical and biological parameters. Those tests were done by the Ministry of Health. Add to that private vendors from which many schools got their drinking water from are not safe since the quality of water may not be monitored and that may lead to the probability of water pollution in school (UNICEF, 2012).

1.1.2 Main Objective

The main objective is to assess the chemical, physical and microbial quality of drinking water from the various sources in schools that is consumed by the students in Jenin directorate of education.

1.1.3 Specific Objectives

- Evaluate the chemical, physical and microbial quality of water consumed by students at school.
- To investigation and analyze the results based on several factors such as the water source, grade levels at school, if school in rural urban area, and geographical area affiliated with the school (east villages, west villages, and Jenin city).

- To understand more the current drinking water conditions in schools of different grade levels in Jenin governorate.
- To evaluate school conditions and the surrounding environment that may affect the quality of water for end users.

1.1.4 Thesis Outline

This thesis consists of five chapters: Chapter one presents an introduction to the research, its questions and objectives, and describes the study area, chapter two reviews available literature on drinking water quality at educational institutions, chapter three shows the methodology, chapter four presents the results and discussions, and chapter five summarizes the conclusions and gives recommendations.

1.2 Study Area Description

1.2.1 Geographical Location

Jenin is one of the three Palestinian cities (Nablus, Tulkarm) that figure the "triangle" of the north-central region Palestine as shown in Figure 1. It is overlooking the Jordan valley from the east and Marj Ibn Amer from the north. It's bordered by Nablus from the south and by Tulkarm from the south west, it's location between 90-750m above sea level (ARIJ, 2010).

Jenin's Governorate is about 10.25% of the West Bank area. And the largest agricultural land in Palestine is in Jenin, around 19.4% of the planted land in Palestine (PCBS, 2011). It also has many large plains which rely on planting such as Marj bin Amer and Sanur Plain (ARIJ, 2010). Jenin governorate has a population of 325,271, about 43.4% of them are under the age of 15 (PCBS, 2017). A map of Jenin Governorate in Figure 2.

Figure 1: Jenin District in the West Bank (source: In Wikipedia. Retrieved October, 28, 2018, from: https://en.wikipedia.org/wiki/Jenin)

Figure 2: Governorate of Jenin (source: In Wikipedia. Retrieved October, 28, 2018, from: https://en.wikipedia.org/wiki/Jenin)

1.2.2 Climate

Jenin district lies within the Mediterranean climatic zone. The summer season is very dry and hot and the winter season is moderately cold (ARIJ, 2010).

1.2.3 Precipitation and Humidity

The rainfall in Jenin area begins in the mid of October and extends to May, Where rain falls frequently between November and March. The snowfall is uncommon in Jenin. The annual amount of rainfall in Jenin district is 438.8mm according to records of PCBS in 2016. The number of rainy days in Jenin district is 52 days according the Palestinian Central Bureau of Statistics (PCBS, 2016). The relative humidity affects people especially in very dry weather where the humidity is very low. The humidity in Jenin district reaches 64% according to the Palestinian Central Bureau of Statistics (PCBS, 2016).

1.2.4 Evaporation

As a result of high temperature in the summer the evaporation is also high and reaches 2,119.9 mm in Jenin district according to the Palestinian Central Bureau of Statistics (PCBS, 2016). While low evaporation rate in winter as a result of less solar radiation and especially in December.

1.2.5 Temperature

The temperature in Jenin district is relatively high in the summer (during June to August), the general average temperature in Jenin district is 21.5 ºC according to the Palestinian Central Bureau of Statistics (PCBS, 2016).

1.2.6 Sunshine Duration

Jenin district has a sunny climate; the solar radiation varies from place to place depending on geological location. In June and July the longest hours of sunshine is noticed and during December to February the shortest hours of sunshine. In the summer, solar radiation is very strong due to totally clear skies. In the winter, less solar radiation because of clouds that cover the sky. The rate of solar radiation hours in Jenin district is 8.7 hours in the day according to the Palestinian Central Bureau of Statistics (PCBS, 2016).

1.3 General Information about Jenin Directorate of Education

Jenin Directorate of Education covers 149 public schools which have 40,673 students distributed between the 1st grade and 12th grade. These schools are distributed in Jenin city and in surrounding eastern and south eastern villages of Jenin Governorate (PCBS, 2017).

This study covered Jenin city and the western and eastern area surrounding the city in which the schools are run by Jenin education directorate as shown in Figure 3. Table 1 shows general information about schools at Jenin Directorate of Education.

The schools in the research are distributed and classified as follows:

- level of school (primary & secondary)
- community type (urban & rural)
- geographical classification (Eastern villages of Jenin, western villages of Jenin, & Jenin city)

Table 1: General information about Schools at Jenin Directorate of Education (PCBS, 2016)

Authorities	Government			Private			UNRWA			All Authorities		
	Basic	Sec.	Total	Basic	Sec.	Total	Basic	Sec.	Total	Basic	Sec.	Total
Number of Schools	84	65	149	12	2	14	6	-	6	102	67	169
Number of Students	40673			2276			2566			45515		

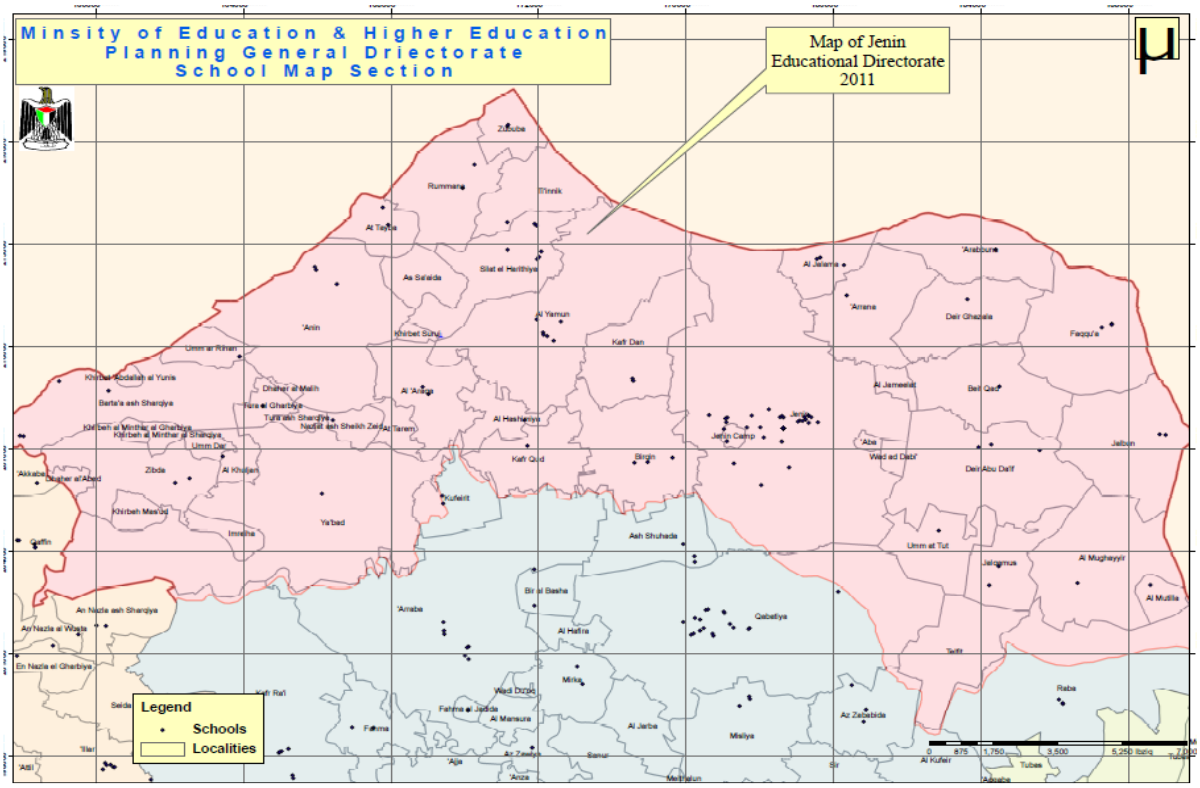

Figure 3: Jenin directorate of education (Source: MoEHE, Palestine, 2016)

2.1 Water Status in Palestine

Water scarcity in Palestine is big problem that will continue as result of Israeli occupation that refuses to give the Palestinians their rights in water and limit their access to water resources. And with population growth, agricultural, industrial and commercial growth the demand on clean water will continuously increase. Several physical, political and socio-economic issues deny the Palestinians from having clean and safe water supply. These include varying and unpredictable rainfall, the continuous reduction in water table and the high levels of salinity, the pollution as a result of chemical, solid waste and waste water run off and filtration into ground water (ARIJ, 2009).

The general environmental situation in Palestine is bad; where the apparent deficiencies in the sewage system especially in the rural areas where they depend on cesspits for drainage of household waste. Additionally, solid waste disposal usually on the ground near residential areas, where they are usually exposed to air, humidity, heat and other weather factors, which have the most suitable conditions for organic degradation, which will infiltrate with water through the soil leading to ground water contamination (ARIJ, 2009).

2.1.1 Water Resources in Palestine

Ground water is the main source of water for the Palestinians which is in the form of ground wells and springs besides the Jordan River and rain water harvesting in winter season. However, due to political situation in Palestine, Palestinians are not allowed to benefit from their own water resources such as the Jordan River which is considered one of their own water rights. Added to that, currently less than 20% of the Palestinian water output from the West Bank's aquifer systems is available for them. This has limited the amount of water available for the Palestinians in the West Bank and prevent them to get access to their own water resources.

The minimum daily amount of water required for daily use according to the world health organization WHO is 100L/capita/day. However, because of the severe shortage in water in Palestine the average consumption of water in Palestine is 66L/capita/day (Abusafa *et al*., 2012). Palestinian communities suffer from a severe shortage in water and that will continue in the future as a result of population growth, urbanization, industrial and commercial development. Figure 4 shows the average water supply per capita in the West Bank

There are three main aquifers in the West Bank through which ground water flow as showed below in Figure 5.

1.The western aquifer

It is the largest basin and the most important one among the West Bank Aquifer basins. It has a sustainable yield estimated at 362-400 MCM per year. However, this basin is heavily exploited by the Israelis compared to the Palestinians through wells.. The main aquifer system in this basin is the upper and lower Cenomanian aquifers.

2.The north-eastern aquifer

Most of the recharge areas of this basin are located within the West Bank boundaries and it has an annual sustainable yield of 100-145 MCM. The aquifer system in this basin includes the shallow Eocene Aquifer, Upper and Lower Cenomanian Aquifers.

3.The eastern aquifer

The basin is divided into three main sub-aquifers, namely the Mountainous Heights, North-eastern Tip and Jordan Valley. The annual sustainable yield of this basin is estimated at 145-185 MCM.

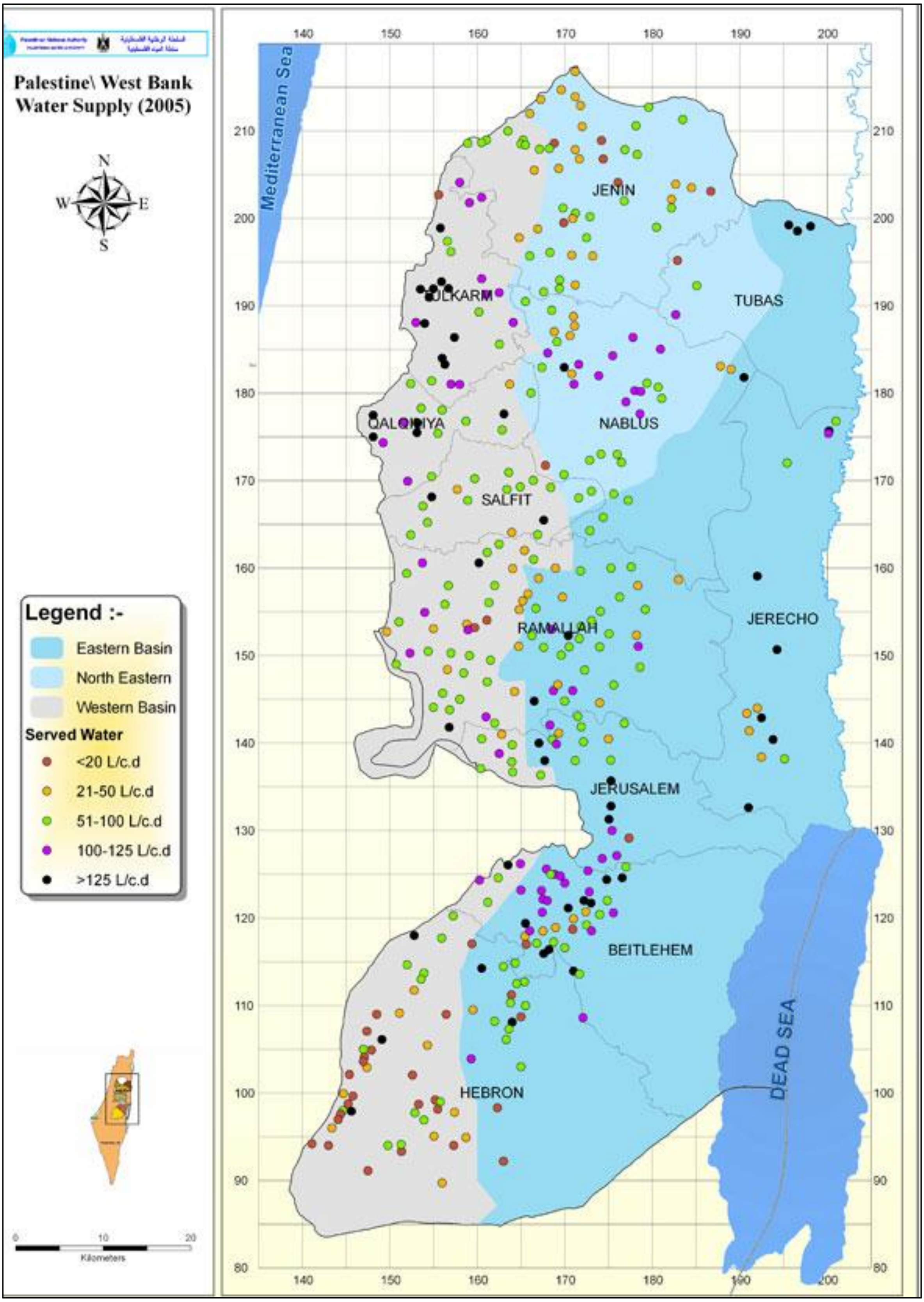

Figure 4: Average water supply per capita in the West Bank (source: PWA, 2005)

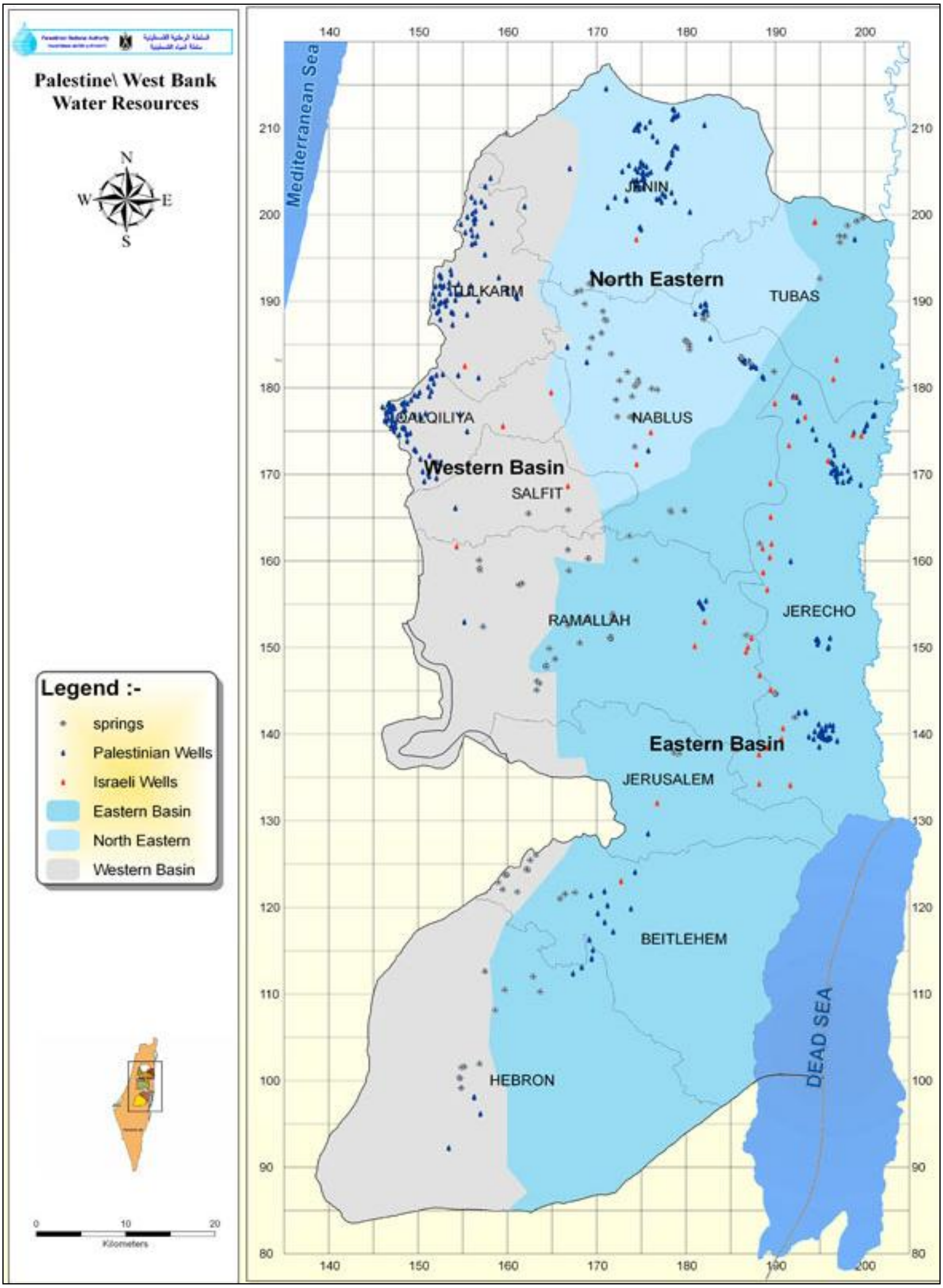

Figure 5: Main aquifer system in the West Bank (source: PWA, 2005)

2.1.1.1 Water Resources in Jenin

Although Jenin area lies over the North-Eastern aquifer it suffers from severe shortage in water resources. Jenin has different water resources (shown in Figure 6):

- **Ground Water Wells**

In Jenin there are 63 wells used for drinking, domestic purposes and irrigation; 58 wells of them are use for irrigation purposes and owned by the private sector. The five remaining wells are owned by either local municipality such as (Jenin, Yabad), or by Mekorot Water Company (Arrabe, Qabatye and Sanur wells) and used for household purposes (ARIJ, 2010). Figure 7 and 8 show ground water wells location and uses in Jenin Governorate.

Additionally, the people in Jenin dug illegal wells without any license since Israel refuse to give them the permission for drilling wells and that leads to hard to count the exact number of wells in Jenin.

- **Mekorot Water Company**

According to the Palestinian Central Bureau of Statistics (2015) around 23 localities in Jenin Governorate got their water from Mekorot Water Company through the western aquifer of the West Bank. Mekorot Company commits to provide Palestinian in Jenin with 1.4 MCM/Yr for drinking and daily uses, they started to drill a new deep well to meet the above amount of water that should be provided to people in Jenin. The well was 4km north west Jenin city and the depth of the well was 933m and the level of water raised to 150-200m under the ground surface. However, Israel claimed that this well would not provide enough amount of water to cover the expenses. There was confirmed information that the well produces 18CM/hr and this could help to solve water shortage in Jenin.

Negotiations are still ongoing to explain the reasons behind the project failure and if there are any possible improvements on the well or searching for other alternatives to supply the people in Jenin with further amounts of water that cover there needs.

- **Springs**

42 springs exist in Jenin, but most of them are unuseful as a result of infiltration, and they are seasonal and affected by drought. They are mostly used for domestic purposes and little bit for irrigation. According to the Palestinian Central Bureau of Statistics the annual flow of water from springs in Jenin governorate is around 0.5M m3 of water, and around 50 localities in Jenin governorate use spring water (PCBS, 2016, PCBs, 2015).

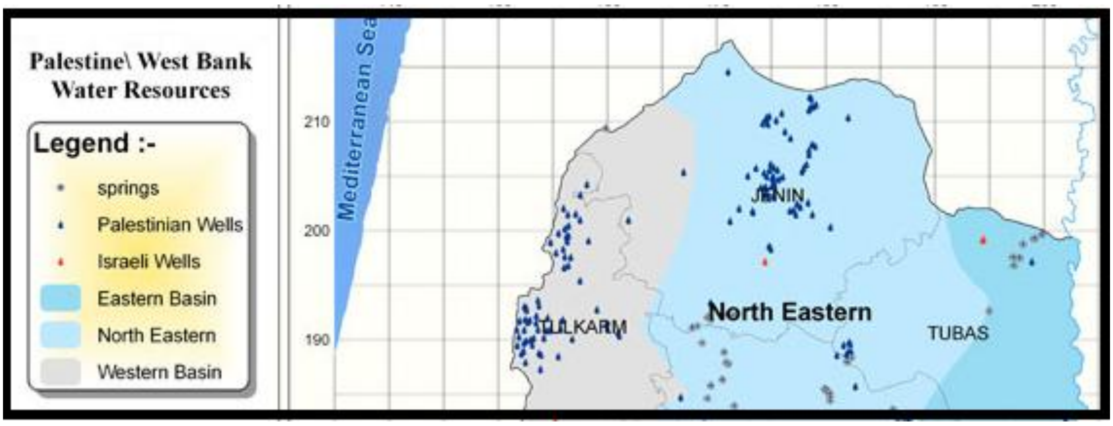

Figure 6: Water resources in Jenin governorate (source: PWA, 2005)

- **Rain Water Harvesting**

People in Jenin also depends on extra source of water which is rain water harvesting. Most People in Jenin dig their own wells so that in rainy seasons they can collect the water from their roofs and use it for different purposes (ARIJ, 2010). According to Palestinian Central Bureau of Statistics there are 50 localities in Jenin governorate depends on rain water harvesting to cover their needs of water (PCBS, 2015).

Rainy season in Jenin begins usually in mid-October and lasts until April. Around 3.2% of the rainfall falls in October annually, while approximately 80% of the annual rainfall falls in November to February. The rain fall usually starts to decline in March to 12% of the annual rain while it's almost rare in June to September (ARIJ, 2010).

- **Purchasing Water Tanks**

In Jenin Governorate 46 localities need to purchase water tanks of unknown origin of water according to Palestinian Central Bureau of Statistics (PCBS, 2015). Purchased water is widespread in various regions around the world for many reasons such as severe water shortages, poor financial resources that limits infrastructure projects development. The quality of purchased water can vary significantly, and purchased water has been related to the occurrence of diarrhea diseases (Hutin *et al.*, 2003). Purchased water is usually transferred and delivered through tanker trucks. There should be addition of chlorine to the water when large volume are transported so that free residual chlorine concentration at point of delivery not less than 0.5mg/l. added to that the tankers must be used only for water and if that is not possible there should cleaning process before water transport (WHO, 2004).

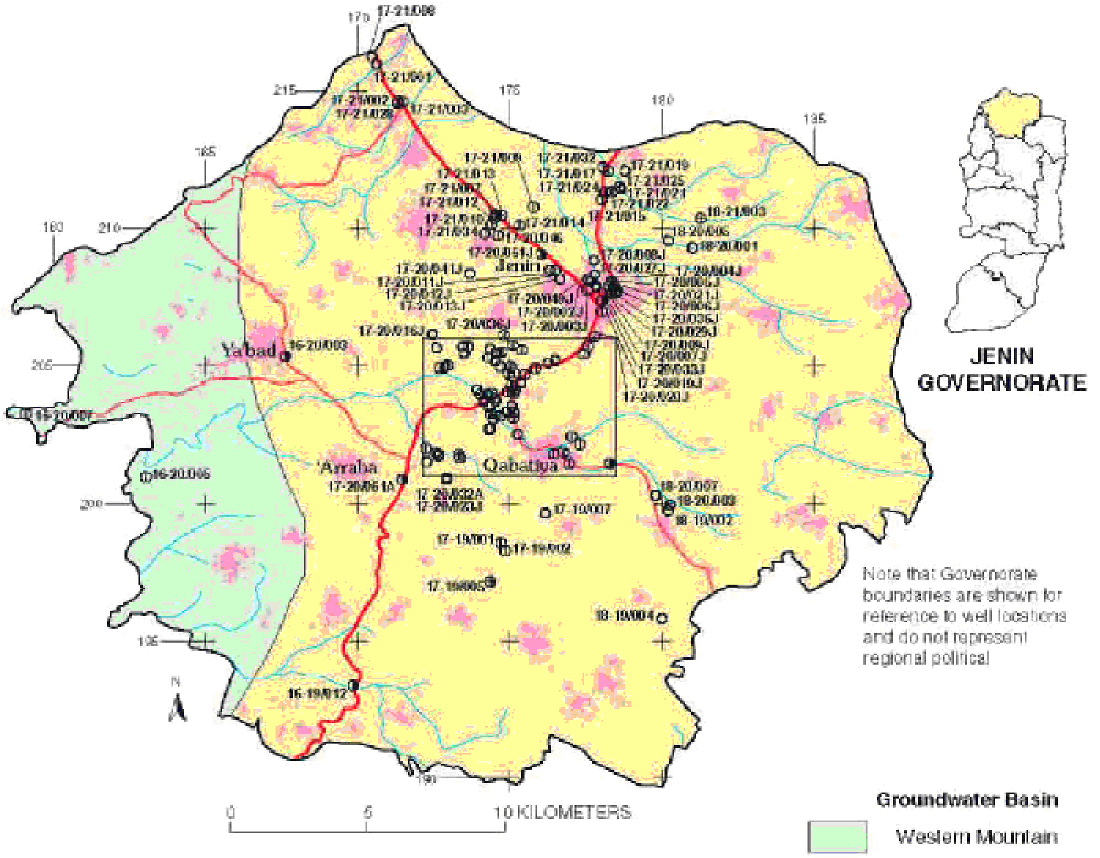

Figure 7: Ground water wells in Jenin governorate (source: PWA, 2005)

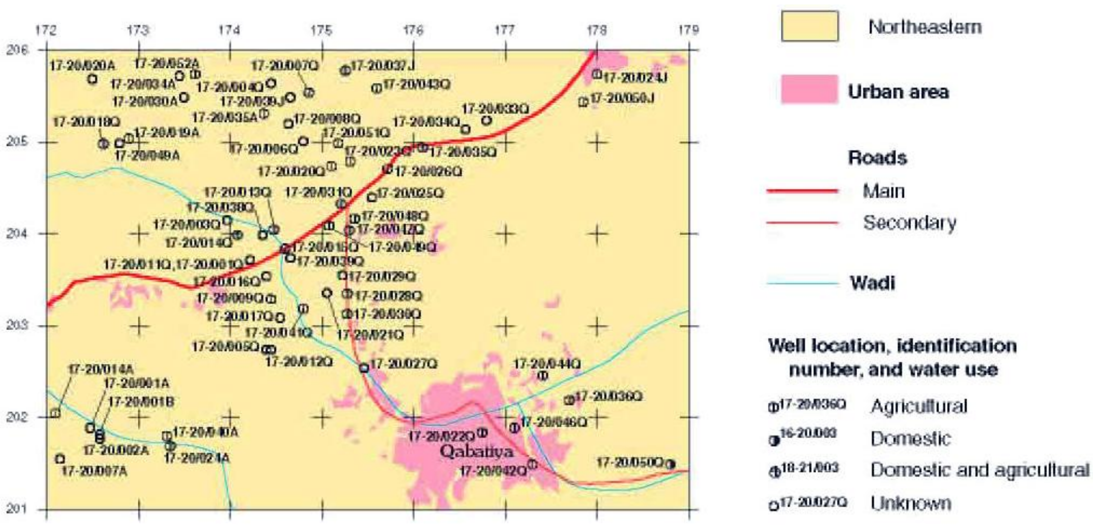

Figure 8: Ground water wells location and water uses (source: PWA, 2005)

2.1.2 Water Supply and Demand

Palestinians are familiarized to occasional droughts, water shortage, and water Obstruction; as reaching the needed amount of drinking water is a huge challenge under the on-going circumstances. A total amount of 139.6 MCM of water was supplied to the Palestinian in 2011; 88.3MCM for domestic uses and 51.3MCM for agricultural use. Figure 9 shows quantity of water supplied, consumed per capita in the west bank.

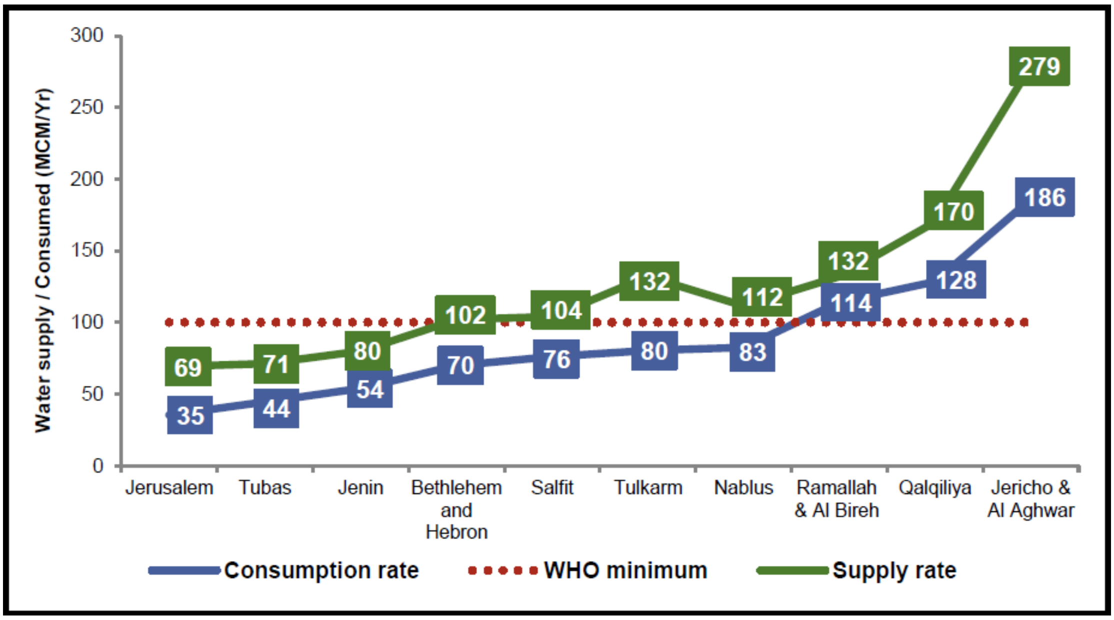

Figure 9: Quantity of water supplied, consumed per capita in the west bank (ARIJ, 2013)

For Jenin governorate a total volume of 6.8 million cubic meters (MCM) of water was supplied. 5.7 MCM was for domestic use. However, the total amount of water consumed was 3.9 MCM which means that there was 1.8 MCM as total losses which is about 31% (PCBS, 2016).

Water consumption is the amount of water delivered to people from distribution network and metered which is not representing the actual amount of water supplied. According to WHO standard the needed quantity of water to provide per capita per day is 150 L/c/d (WHO, 2004).

In Jenin area the needed quantities of water is 15.4MCM (based on the WHO standard supply rate), but the actual amount of water supplied is 5.7MCM. Moreover, and paying attention to the actual consumption (after deducting the losses in the water supplied) which is 3.9MCM which means that the gap between supply and demand is 11.5MCM (PCBS, 2016). Figure 10 shows quantities of water Supply at Jenin governorate.

Water resources management in Jenin lies on different bodies:

1- Jenin and Ya'abad municipalities.
2- West Bank Water Department and Mekorot Water Company; managing water supply from Mekorot wells.
3- Private irrigation wells managed by their owners.

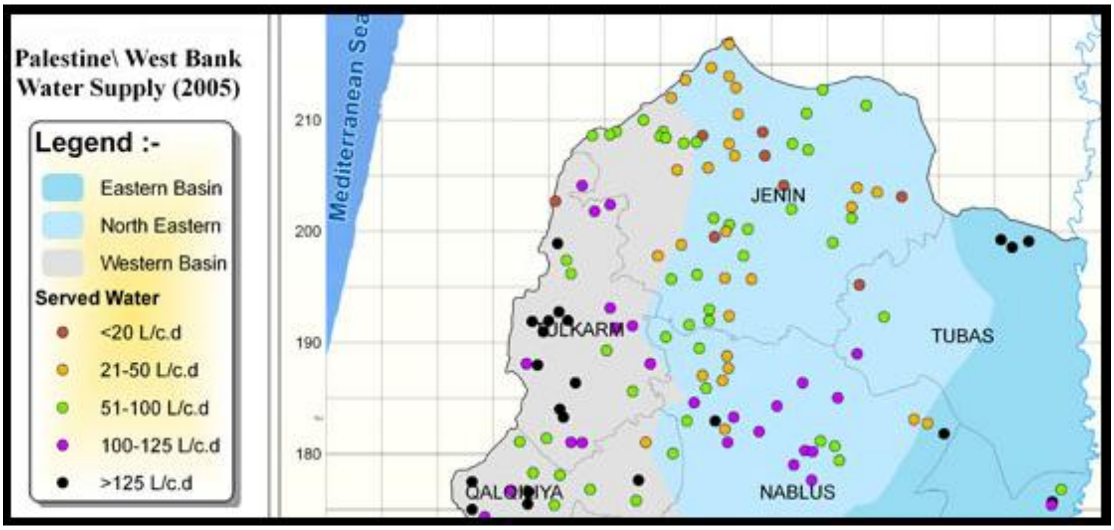

Figure 10: Water Supply at Jenin governorate (source: PWA, 2005)

2.1.3 Water Distribution Networks

Of the 80 localities in Jenin only 69 of them have water distribution network. So not all governmental schools in Jenin governorate are connected to the public water network. And many schools got their drinking water from different non-safe resources such as the private vendors. Even in Jenin city and the surrounding villages that have a water network, people their suffer from interruption in water supply over the year. 32 localities in Jenin the water is provided only several hours a day. In remote areas, water supply is cut off for days or weeks (Abusafa *et al*., 2012). Added to that, 33 localities have old water networks where the probability of water leakage is high (PCBS, 2016). Figure 11 shows connectivity to water network in the West Bank.

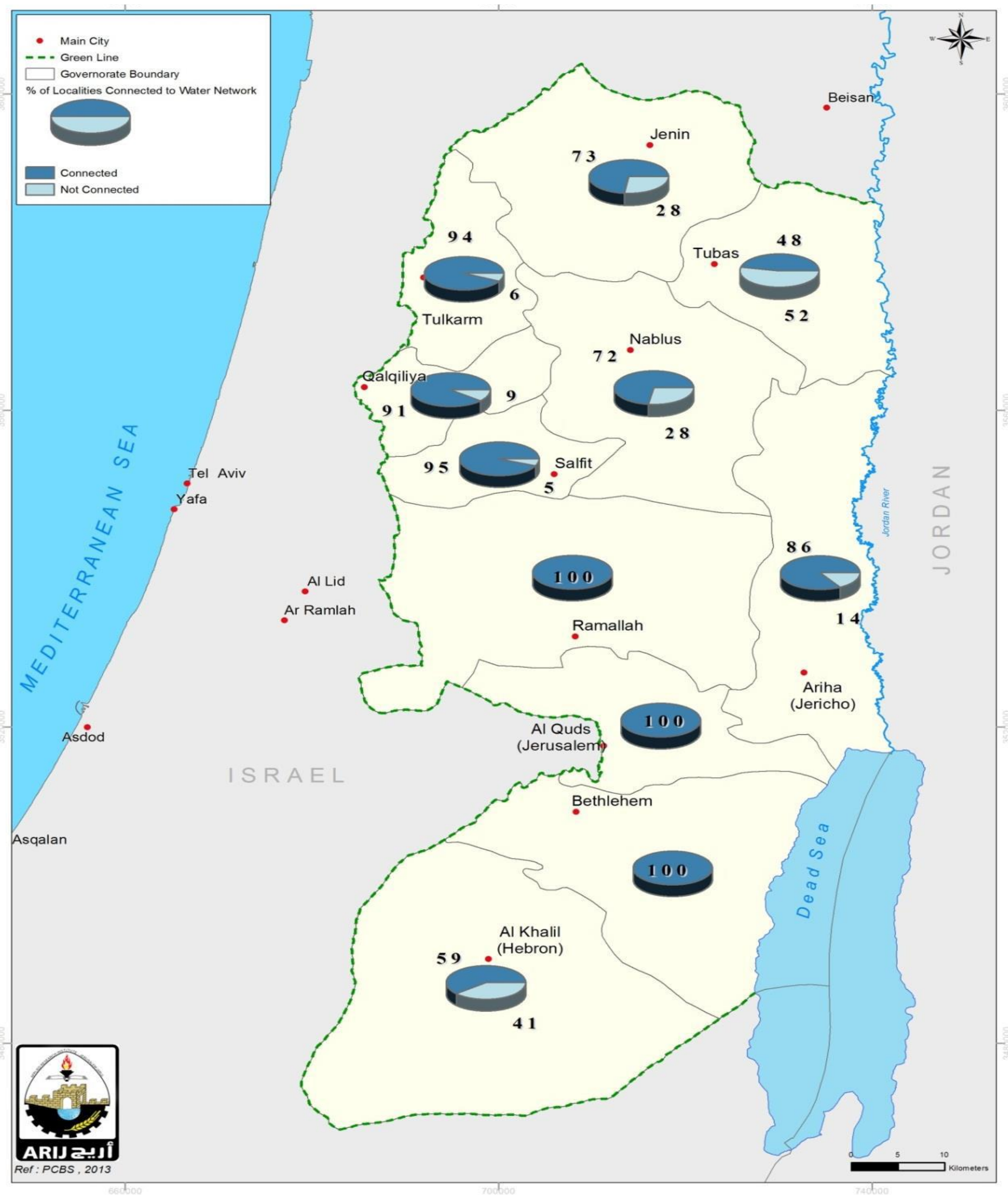

Figure 11: Connectivity to water network in West Bank (ARIJ, 2013)

It should be mentioned that any further development in infrastructure projects (in water and waste water) and even regular maintenance of the networks in Jenin area require the approval from the Joint Water Committee (JWC), a joint body established to manage water development. And this leads to limit infrastructure improvement, and lack of proper maintenance of water networks (ARIJ, 2013).

2.1.3.1 Main Water Problems in Jenin Governorate

With respect to Jenin governorate there are 69 communities with a population of 262,145 having a served water network and the remaining 11 communities with a population of 19,013 are still un-served with a water network. The water network in Jenin was built before 50 years. Water leakage accounts for around 40% of the water from the network. Additional amounts are lost by illegal connections or incorrect measures of water meters, and the quantities of water lost can reach 60% of the pumped water to the network (PCBS, 2015).

Even in Jenin city and the surrounding villages that have a water network, people there suffer from interruption in water supply over the year. 32 localities in Jenin the water is provided only several hours a day. In remote areas, water supply is cut off for days or weeks (Abusafa *et al*., 2012). Added to that, 33 localities have old water networks where the probability of water leakage is high (PCBS, 2016). Figure 12 shows percent distribution of households in West Bank by continuity of water supply service.

Another important issue in Jenin is that water pipelines are positioned nearby sewage lines which is dangerous as wastewater may infiltrate to drinking water lines in many cases (Al-Khatib *et al*., 2005).

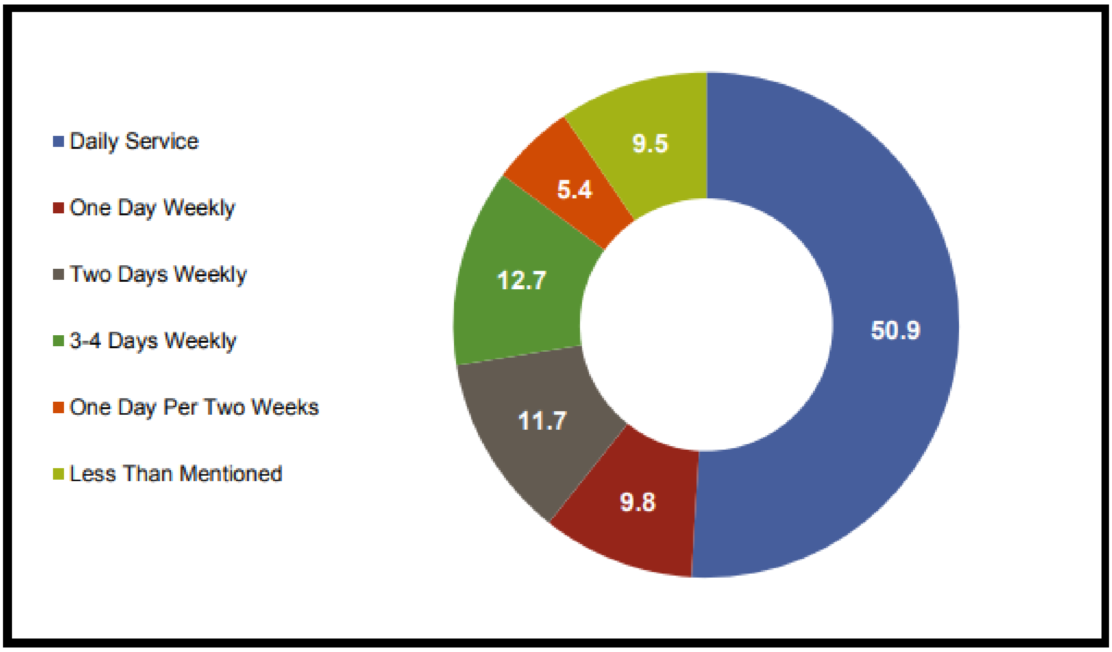

Figure 12: Percent distribution of households in West Bank by continuity of water supply service (ARIJ, 2015)

2.1.4 Waste Water Disposal in Jenin Governorate

Only 4 localities in Jenin governorate are connected to wastewater network, while 76 localities use cesspits for wastewater disposal. Only 23 localities of them use tight cesspits, and one locality dispose wastewater in exposed wastewater network, another one more locality dispose wastewater in exposed wastewater channel without a network (PCBS, 2015).

2.1.4.1 Waste Water Disposal at Educational institutions in Jenin Governorate

More than half of the schools in Palestine are not connected to sewage networks. Around 45.3% of schools are connected to sewage networks, 40.1% of them use cesspits for waste water disposal, while 14.4% of them use closed pits (PCBS, 2014).

Only 6.3% of educational institutions in Jenin governorate dispose wastewater into wastewater networks, while 57.3% use cesspits for wastewater disposal and 36.4% use tight cesspits for wastewater disposal (PCBS, 2016).

2.2 Water Quality

The quality of drinking water affects human health and also reflects whether the management for drinking water is effective or not (Chung, 2008). It is a human right to have clean and safe water as stated by General Assembly of United Nations (UNNC, 2010). However, many developing countries suffer from chronic drinking water shortage and the pollution of accessible water resources. According to the World Health Organization – WHO, around 1.2 billion People do not have safe drinking water, and 80% of the diseases and 30% of death around the world are a result of contaminated drinking water (Hênio, 2011). A study by the UN shows that around 1.8 billion children under 5 years old have died as a result of contaminated drinking water (Giraldi, 2010).

So, testing the source of water is very important, particularly when the water is not treated. The essential parameters that should be examined to make sure that water is safe and free from pathogens in order to reduce the probability of diseases which are recommended by WHO are: (1) Escherichia coli and thermo-tolerant coliforms accepted as suitable substitutes, (2) chlorine residual (if chlorination is practiced), (3) pH and (4) turbidity (WHO, 2003).

2.2.1 Water Pollution

Safe drinking water means that it doesn't represent any significant health risk during long period of time of consumption. Any change on physical, chemical or biological quality of water that may have a negative side effect on living organism is considered pollution. Pollutants can be biodegradable or non-biodegradable or slowly degradable compounds. Sewage, chemicals and heavy metals are examples of pollutants discharges into water streams.

2.2.2 Tap Water Quality

Most of tap water in Palestine is assured by the water supplier (municipalities) that is clean and safe for consumption. However, in some cases tap water consumption may contribute to health hazardous due to contamination that results from unsafe plumbing systems or contaminated water source. The source water is often inconformity with standards. However, the concentration of free residual chlorine at the distribution networks declined, and that means there is as there is a slight protection against any microbiological contamination that may occurs in pipelines and the probability of pollution of water at taps is high and therefore gastrointestinal morbidity might appear, so there should other dose of chlorine to be added (Al-Khatib *et al*., 2005).

It is important to test regularly drinking water so that any problem can be addressed if it exists. In those cases schools should report this problem to the concerned authorities and should look for alternative clean water sources or can install a filtration system that may remove contaminants.

2.2.3 Purchased Water Quality

Purchased water is widespread in various regions around the world for many reasons such as severe water shortages, poor financial resources that limits infrastructure projects development. The quality of purchased water can vary significantly, and purchased water has been related to the occurrence of diarrhea diseases (Hutin *et al*., 2003).

Purchased water is usually transferred and delivered through tanker trucks. There should be addition of chlorine to the water when large volume are transported so that free residual chlorine concentration at point of delivery not less than 0.5mg/l. added to that the tankers should be used only for water and if that is not possible there should cleaning process before water transport (WHO, 2004).

2.3 Healthy School Environment

2.3.1 Impact of Healthy School Environment on Children Health and Academic Performance

Children are still in the growth stage and they are more sensitive to environmental risks than adults. They spend most of their time indoor and most of that time is at school. Unhealthy school environment have an impact on children health, attendance and performance at school. Edmonds and Burford (2009) found that drinking water affects cognitive performance when he made the different tests on children between 7-9 years old. Children who drank extra amounts of water there performance were better on different cognitive tests compared to children who did not drink extra amounts of water and their performance was better on a test of visual attention (letter cancellation) and two tests of visual memory (spot the difference tasks). So drinking water has a strong positive effect on cognitive performance. Table 2 shows international standards of children needs for water.

Table 2: Children needs of water according to international standards (DNR, 2012)

<table>
<tr><td>Child. Age</td><td colspan="2">USA & Canada
(IoM, 2004)</td><td colspan="2">Europe
(EFSA, 2010)</td><td colspan="2">World
(WHO 2003, 2005)</td></tr>
<tr><td>1-2 yrs</td><td colspan="2" rowspan="2">1.3 L/d</td><td colspan="2">1.1 – 1.2 L/d</td><td colspan="2" rowspan="2">1 L/d</td></tr>
<tr><td>2-3 yrs</td><td colspan="2">1.3 L/d</td></tr>
<tr><td>4-8 yrs</td><td colspan="2">1.7 L/d</td><td colspan="2">1.6 L/d</td><td rowspan="4">Females
2.2 L/d</td><td rowspan="4">Males
2.9 L/d</td></tr>
<tr><td>9-13 yrs</td><td>Girls
2.1 L/d</td><td>Boys
2.4 L/d</td><td>Girls
1.9 L/d</td><td>Boys
2.1 L/d</td></tr>
<tr><td>14-18 yrs</td><td>Girls
2.3 L/d</td><td>Boys
3.3 L/d</td><td rowspan="2">Females
2 L/d</td><td rowspan="2">Males
2.5 L/d</td></tr>
<tr><td>Adults
(>18 yrs)</td><td>Females
2.7 L/d</td><td>Males
3.7 L/d</td></tr>
</table>

The average quantities of water consumed monthly in each educational institution is around $60m^3$/month according to the Palestinian Central Bureau of Statistics (2016).

Considering the number of students (40673) and employees (1356) and number of schools in Jenin directorate of education (149) it can be calculated that the specific water consumption is around 7 L/capita/day.

2.3.2 School Water Quality

Children drinking poor water quality are more susceptible to water related diseases.
Healthy school environment which provides access to clean drinking water is an important issue that encourages students to attend to school as they spend along period of time there. Healthy school environment which provide a sufficient amount of clean drinking water that satisfies their daily needs of water is a major issue. However, many reports showed that there is a severe shortage of clean water and pollution of water resources in governmental schools in West Bank (MoEHE, 2016).
Contamination of drinking water at schools is a dangerous issue that represents a significant health risk and exposes students to water born related diseases such as diarrhea and other infectious diseases (WHO, 2004).

2.3.3 Importance of adequate Clean Water at Schools

Addressing the water quality at schools is important to ensure that students have healthy learning environment. And this is of high importance for the children. Since their bodies are still growing, they are more likely to be affected by poor water quality Schools should be provided with the safest drinking water that complies with WHO Standards and Palestinian standards (MoEHE, 2016).

At schools where the water is not tested it is more complicated to make sure that water is safe for consumption even if the water at the area of school is safe, since the quality of water differs according to the source of water the fixtures and pipes through which water flows and the conditions at the school and how the school maintain clean water (CDPH, 2014).

Factors associated with water quality at schools include the following:

- School water source: if the school water comes from known source like the municipality, chances that water meet all standards and guidelines.

- If the school has its own source of water such as a ground water well or rain water harvesting or purchasing water tanks there should be regular testing of water.
- Water quality at the school area: some regions have poorer water quality than other due to different reasons such as agricultural regions where they use chemicals (such as pesticides and herbicides) or near industrial areas.
- The state of pipes and fixtures in school: even if the water source at school is clean the water may contaminate due to problems in pipes, fixtures, pollutants may infiltrate to the water due to disruption of water network.
- The availability of sewage networks: regions where there are no sewage networks people depend on cesspits for waste disposal. Schools near cesspits opposed the school to water pollution (CDPH, 2014).

2.3.4 Health Hazardous Associated with Contaminated Drinking Water

Lack of pure drinking water, poor hygiene and sanitation are the main factors that affect human health negatively and may lead to death. Unclean water supply and poor sanitation are the main reason for death of 1.6 million people a year around the world (Haller *et al*., 2007).

Drinking water contaminated by pathogenic bacteria, viruses and parasites results in Infectious diseases which are the most common and widespread health risk. The severity and incidence of the illness associated with pathogens, and the prevalence of the disease are all indicators on the intensity on public health. People who live in poor conditions and in remote areas, the disease outcome may be more severe on their health (WHO, 2011).

Diseases associated with contaminated drinking water may pose a threat to human health. For example, water borne diseases such as cholera and typhoid may lead to epidemic if it spread in societies (Bakir *et al*, 2015). Sometimes water passing through old water networks may contain harmful metals like lead, or water may come from well or reservoir that is already contaminated as a result of near cesspits or from the infiltration of chemicals. Many schools face a problem with their own drinking water because it doesn't come from the community network but from other different sources.

Several previous studies showed that there is a close relation between improved water facilities and human health, as Lack of hygiene practices, unsafe drinking water, poor sanitation and low level of education cause infectious diseases such as diarrhea, worm infestations, dehydrations, helminthes and protozoa to spread between people especially younger people who are more susceptible to infection (Joshi e al., 2013; Evans *et al*., 2014; Dora *et al*., 2015).

Several kinds of bacteria can be found in water as a result of poor water quality and sanitation. Some of them are risk-free and others may cause serious health problems and diseases such as dysentery, cholera, typhoid fever and paratyphoid. Presence of bacteria is an indicator of water pollution.

Diarrhea disease is widespread in developing countries especially among children under 5 years which may have an effect on their growth, reduce IQ and may lead to death. Each year about 1.5 million children under 5 years around the world die as a result of diarrhea disease. A study said that 9% of 6.5 million children are expected to die annually and diarrhea is the main reason (Mosler, 2012; Evans *et al*., 2014; Dora *et al*., 2015). Figure 13 shows the percentages of Diarrhea between children under five years in Gaza and in the West Bank.

Diarrhea diseases also affects adversely the academic and social development of children , affects their learning process at school and their performance as the rate of absence from school increase (Evans *et al*., 2014). Lack of WASH facilities in developing countries lead to health risks. Add to that the rapid urban growth without previous planning and the population overcrowding, inadequate operation and maintenance as a result of fund deficit all of that lead to major health risks at the level of large community and the small school environment. (Johannessen *et al*., 2014).

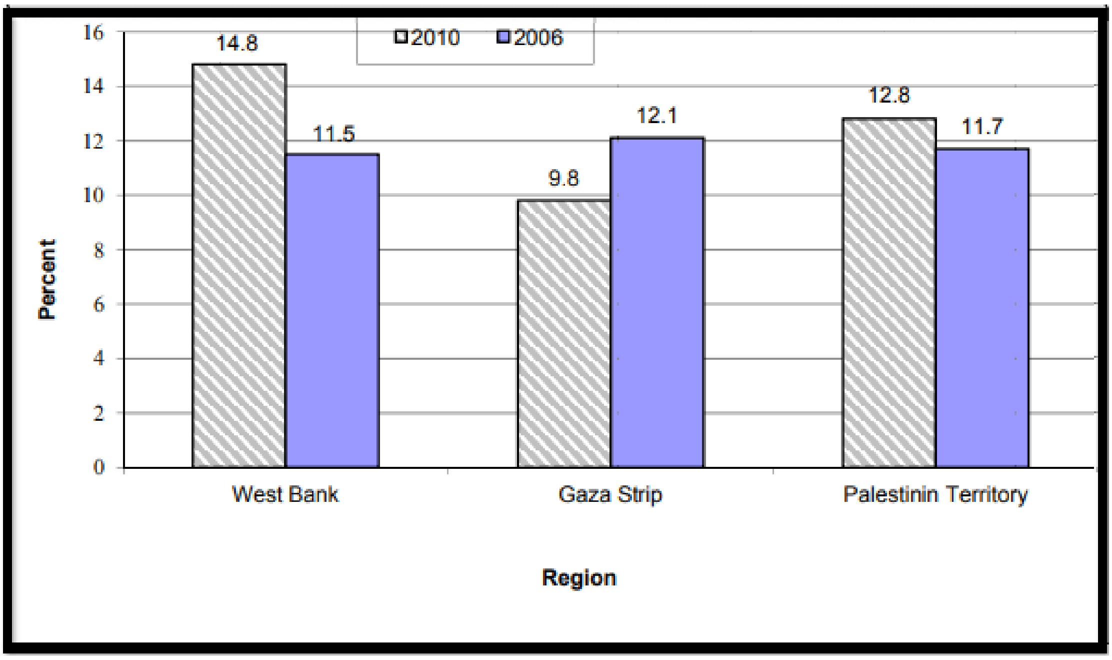

Figure 12: Percentages of Diarrhea between children under five years in 2006 and in 2010 (Source: PCBS, 2011. Palestinian Family Survey 2010, Main Report. Ramallah, Palestine)

2.4 Water Status at Schools in Palestine

The average consumption of water at schools in Palestine is 58.9m3 monthly. 93.4% of schools in Palestine are connected to the general water network and 19.9% of schools got their water by purchasing water tanks. 1,520 water samples from schools were tested for biological properties; around 299 water samples of them were polluted. Around 19.7% of schools water tanks are polluted. Additionally around 71 samples of water from the networks connecting to schools were tested to check the quality of water before entering the school water tanks and found that 64 samples were clean while 7 samples were polluted (Annual Health Report, 2016).

2.4.1 Attitudes towards drinking water at school

Below results from a survey done by UNICEF (2012) showed the student's attitudes toward drinking water at school in West Bank:

- 75% of students drink water from school faucets
- 19.6% of students bring water from home
- 6.6% of students purchase bottled water
- 2.5% of students never get drinking water at school

2.5 Studies on Drinking Water Quality in Schools and Educational Institutions

A global report by WHO & UNICEF (2016) reported the importance of drinking water quality to human health. However, comparatively few countries check the quality of drinking water in schools regularly. It was reported that students in many schools in different countries bring drinking water from home. This is common when schools do not have their own water sources, or when the amounts of water is not enough or it is not suitable for drinking purposes. Around 570 million children suffer from a lack of basic drinking water service at their schools.

The report showed that globally, 69% of schools had basic water supplies with water available at the time of the survey, while 12% of schools had basic water supplies but not available at the time of the survey, 19% of schools did not have drinking water service (WHO & UNICEF, 2016). However, in many countries the percentage of schools in which drinking water is monitored stills low. For example, in Palestine water quality has been tested in three out of four schools while in Bangladesh one in four schools, in other countries such as Liberia and Georgia water quality monitoring is more common in schools in urban area more than schools in rural area (WHO & UNICEF, 2016).

In Jordan most of the schools depend on water tankers, the deliveries are around 5 times per month. According to a study conducted at public schools in Jordan, 86% of the schools had water testing conducted during 2015 and most of them successfully passed the test. The percentage of schools where water testing was not conducted is highest in rural areas at 21%. There is a possibility that some schools might be neglected due to difficulties associated with access and other reasons (JMoE, JEN, & UNICEF, 2016).

In Lebanon measurement of E. coli in school supplies showed that conformity with national standards varies widely (UNICEF & WHO, 2018). Figure 14 shows proportion of public schools by level of E-coli detected by governorate in Lebanon.

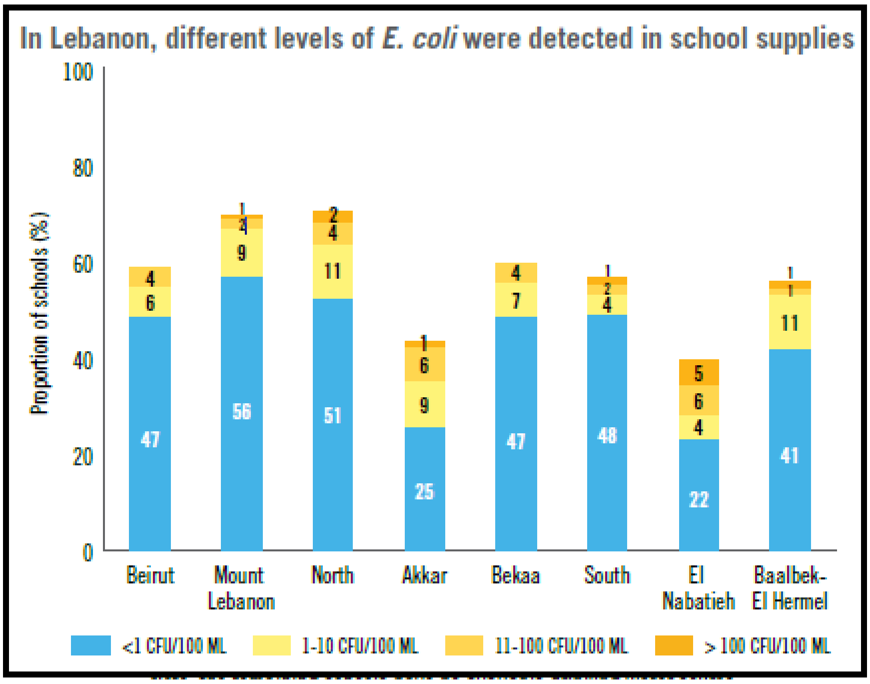

Figure 13: Proportion of public schools by level of E-coli detected by governorate, Lebanon (2016) (source: WASH: global baseline report 2018. New York: (UNICEF) and WHO, 2018. License: CC BY-NC-SA 3.0 IGO).

In one of the cities in Taiwan bacillary dysentery diffused between students and the reason for that is that tap water at school is from the ground water and the ground water was contaminated by near septic tank (Chung, 2008). And that episode led Chung (2008) to conduct a study in Pingtung County in Taiwan to assess school drinking water. The researcher choose 42 schools, a questionnaire survey was performed in accordance to school water sources, treatment facilities, location of school and different grades levels. The researcher has created a number of statistical ratios of schools. 45% of all schools depend on tap water as the main source of drinking water. Biological tests showed that 26.2% of drinking water samples were contaminated. All physical and chemical parameters met the domestic standards.

Bakir (2015) studied drinking water quality in primary schools of a metropolitan area in Ankara. Samples of water from 31 primary schools were collected for testing water quality. The results showed that 93.5% of the primary schools used public water system; the physical and chemical parameters met the standards.

While in Babylon governorate, Nahaba (2014) conducted a study on drinking water quality of 30 schools. The study was carried in accordance to location and different grade levels. The study showed that all schools in the city depend on tap water while schools in rural areas used transported water by special cars.

A study conducted in academic institutions of Abbottabad (Pakistan) to evaluate drinking water quality and its effects on health. Ahmed (2015) assessed 63 samples from 60 institutions and analyzed them for physiochemical properties and bacteriological analysis. All results were acceptable. However, 66.6% of water samples revealed the presence of total coliform bacteria. 54% of secondary institutions used government supply of water, 53% of higher secondary institutions used bore wells and 44% of post secondary institution used tube wells. The most widely used source of water was Bore well.

Sanches (2015) studied the chemical and microbiological quality of water consumed at schools in the city of Uberaba. Samples of water were collected from the fountains and kitchen faucets of eight public schools, results of fecal coliforms and total coliforms tests were higher than the values accepted by legislation in more than 50% of the samples, the concentration of free residual chlorine was below the minimum allowable limit required by law in around half the samples.

In a study conducted in Nepal by Shrestha (2017) the researchers assessed drinking water quality, sanitation, and hygiene (WASH) conditions in schools and households, with respect to schools, a cross-sectional surveys were conducted in 16 schools. 75% of school drinking water samples were contaminated with E-Coli. The values of pH, free and total residual chlorine were within allowable limits.

A studied conducted at elementary schools in Calgary, Alberta (2002) to evaluate the quality of water in personal bottles of the students. The samples were collected from bottles directly and tested for fecal coliforms and total coliforms and heterotrophic bacteria. The results for total coliform exceeded the Canadian drinking water quality guidelines in 13.3% of the 75 samples. Fecal coliform and heterotrophic bacteria exceeded in 8.9% and 64.4% respectively.

2.6 Studies on Drinking Water Quality at Schools in Palestine:

A survey carried out by the Palestinian ministry of education and UNICEF in 2011. The survey dealt with water issue at schools, in addition to sanitation and hygiene knowledge, attitudes, and practices (WASH). The survey was carried out at government schools included primary and secondary schools located at urban and rural areas. With respect to school drinking water the survey showed that 87% of schools in the West Bank use the community water network as the main source of drinking water, schools which are not connected to the water network suffer from water shortages and poor water quality. 10% of surveyed schools and most of them in rural areas do not have access to safe sources of drinking water. In these schools, they collected rainwater and used for different purposes.

Although water at school is provided from safe sources, the quality of the water at taps may not be suitable for drinking for different reasons. School principals' perception is that schools water quality might not be in accordance to WHO standards, since water quality reports are not always available to school. So their opinion is that there should be regular drinking water quality monitoring at schools and the school should have a copy of the results of the water tests.

Not all of the schools in Palestine have their water tested, when searching for previous water testing almost 73.6% of schools have their water tested for all chemical, physical, and biological parameters. The ministry of health conducted those tests and those tests were carried out by sampling water from the faucet. In 65% of schools in West Bank schools, water is tested only one time during the year.

In Gaza strip a research conducted by Haneya (2012) to check if there is microbial contamination at desalinated water at Gaza city schools and to determine the source of contamination if any. The results revealed the presence of contamination in the desalination plant inlet and in school water tanks. At school year 2010-2011, about 23.8% of monitored schools at East directorate were contaminated before follow-up process. Nearly 20.8% of monitored schools at West were contaminated. But 56.5% of monitored schools at UNRWA were contaminated.

2.6.1 Studies on Drinking Water Quality in Cisterns (Purchased water tanks)

A study conducted by Al-Salaymeh (2008) in Hebron city to assess the water quality in100 cisterns. Water samples were tested for physiochemical and microbiological parameters, all physical parameters were within the allowable limits except for turbidity. For chemical parameters only calcium and magnesium exceeded the allowable limits. The results revealed the presence of total coliform and fecal coliform in 95%, 57% respectively of the samples. High values of hardness found in cisterns contained municipal water.

While Al-Khatib & Orabi (2004) conducted a study on rainwater cisterns in three villages in Ramallah and Al-Bireh district and they found that 87% of the tested samples were highly polluted with total coliform bacteria. The reason behind that was the presence of cesspits, solid waste dumping sites, and wastewater near the cisterns were the main reason behind the pollution.

Abusafa (2012) conducted a study on drinking water from rain water harvesting cisterns in northern West Bank region (Jenin, Nablus, Tulkarm district). 106 samples of water were collected and 176 cistern owners were surveyed. The results showed that most of the cisterns were found to contain fecal coliform more than 8000 CFU/100ml in several cases.

Al-Tamimi (2016) studied the water quality of rain water harvesting in cisterns in Yatta town and its impact on public health. 50 samples were collected and tested for physical, chemical and microbiological properties. The results were within the allowable limits (PSI standard) except for turbidity and salinity and most of the tested samples were contaminated with fecal coliforms and total coliforms 70%, 96% respectively.

2.7 Studies on the Relation between Drinking Water Quality and Human Health

- **Local Studies in Palestine**

A study done by Abu Hijle (2011) in Tubas Directorate about the relation between water quality and human health showed that diarrhea is the most widespread health issue followed by eye illnesses and skin diseases especially between students. Of the most affected areas with water related diseases was Tamun village where the infection rate reached 43.9% followed by Tubas and Aqqaba.

Other study dealt with the water- health relationships was done by Al-Khatib (2003) in Tulkarm district. From the records of the public health department in the ministry of health of Tulkarm district data obtained for 500 drinking water samples. The samples were examined for free chlorine residual concentration, fecal coliforms and total coliforms. It was found that 60.6% of the samples have a concentration of free chlorine less than that recommended by WHO which is 0.2 ppm. 34% and 9.2% of the samples were contaminated by total coliforms and fecal coliforms respectively. The study also showed that the diffusion of water related diseases is high in areas of contaminated or non-chlorinated drinking water.

Menawee (2004) studied the microbial water quality in Nablus district. The data obtained from the environmental health department at the ministry of health in Nablus district were reviewed and analyzed. The outputs from the study showed higher percentages of contamination of drinking water with total coliforms and fecal coliforms than the recommended as safe drinking water by WHO standards.

- **International Studies**

In Lebanon UNICEF, in cooperation with WHO (2016), conducted a water quality survey. The survey showed that 53 per cent of the population in Lebanon did not drink safe water and the water was contaminated by E-Coli.

Mohsin (2013) studied the quality of ground water and its related water diseases and compared the results with WHO standards in Bahawalpur City. The results showed that groundwater quality in Bahawalpur is deteriorating. Analysis of water quality parameters also showed significant contamination in ground water pH, TDS, EC, and hardness, were considerably high when compared with WHO standards. Such poor quality of water is the main reason behind the occurrence of waterborne diseases like diarrhea, cholera.

2.8 Water Quality Parameters

Three main characteristics are used to assess the quality of drinking water according to WHO:

1) Physical – temperature, color, smell, taste and turbidity
2) Chemical – minerals, metals and chemicals
3) Microbiological – bacteria, viruses, protozoa, and worms

Safe drinking water should have the following microbiological, chemical and physical characteristics: (WHO, 2004).

- no pathogens
- concentrations of toxic chemicals should be according to guidelines set by WHO or EPA
- free from impurities
- colorless and tasteless (for aesthetic purposes)

The main parameter that must be considered when examining the quality of water is pathogenic contamination as it is responsible for health risks (WHO, 2004).

2.8.1 Physical Parameters

It is of high importance that drinking water to be accepted in appearance, taste, and odor. People do not have any means of judging drinking water quality, but their attitudes toward their drinking water will be affected by what they are able to see and feel with their own senses.

The physical parameters of water can be determined through some measurements such as turbidity and total suspended solids by detecting color caused by floating impurity (Cretu *et al*., 2015).

2.8.1.1 Temperature

High water temperature enhances microorganism's growth and can contribute to a change in taste, odor, and color of water and may result in some problems such as corrosion. The temperature of water in streams and rivers throughout all over the world varies from 0 to 35 °C (WHO, 2004).

2.8.1.2 Color

It is of high importance that drinking water to be accepted in appearance. Colored water seems unsuitable for dinking, even if it is safe to consume. Color presence in water is an indication for organic substances such as algae or humic compounds. More recently, color has been used as an indicator for the presence of potentially hazardous toxic organic compounds in water.

2.8.1.3 Taste and Odor

Taste and odor are good signs for the quality of drinking water. Taste and odor in drinking-water is an indicator of some form of pollution or of a malfunction during water treatment or distribution. It may therefore be an indication for the presence of potentially harmful substances (WHO, 2004).

2.8.1.4 Turbidity

Turbidity occurs as a result of suspended colloidal particulate matter in drinking water sources; for example turbidity in ground water is a consequence of inert clay and the precipitation of insoluble oxides. Turbidity in distribution system comes from the presence of biofilm and sediment. High levels of turbidity have an influence on the effectiveness of disinfection process and results in significant chlorine dosage demand, stimulate the growth of bacteria. So turbidity is acting as an indicator of possible sources of microbial contamination (WHO, 2011).

In order to achieve safe and clean drinking water particulate matter removal by coagulation, sedimentation, and filtration is important. Turbidity should be less than 1 NTU to ensure effectiveness of disinfection. However, in cases of limited water resources and in cases where there is no treatment such low levels of turbidity can not be achieved, so a turbidity of less than 5 NTU in water is usually acceptable. There is an increasing risk of Gastro-intestinal infections that connected with high levels of turbidity in distribution (WHO, 2011).

2.8.2 Chemical Parameters

The chemical composition of drinking water affects its quality; long periods of exposure to some chemical constituents of water may result in serious health problems (WHO, 2004).

2.8.2.1 pH

It is an important water quality parameter. It is necessary to control pH at all stages of water treatment to ensure complete disinfection. It is important to know the pH since alkaline water demands a longer contact time or a higher chlorine dose. At the end of contact time to have suitable disinfection (0.4-0.5 mg/liter at pH 6-8, rising to 0.6mg/liter at pH 8-9: chlorination may be not effective at pH above 9). The optimum pH usually varies between 6.5-8.5 (WHO, 2011).

2.8.2.2. Total Hardness

One of the factors that express the quality of drinking water is hardness. Hardness expresses the concentration of calcium and magnesium ion in water. Hardness is usually reported as parts per million (ppm) of calcium carbonate since most analyses do not distinguish between Ca^{+2} and Mg^{+2}. According to WHO water with hardness above approximately 200 mg/l of $CaCO_3$ may results in scale deposition in the distribution system and pipe work and in tanks within buildings. It will also result in high soap consumption. Soft water, with a hardness of less than 100 mg/l of $CaCO_3$ may be more corrosive to water pipes and for sure depending on other factors such as Ph and alkalinity (WHO, 2011).

2.8.2.3 Total Dissolved Solids (TDS)

It is a parameter that measures the total amount of inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides and sulfates) and small amount of organic matter that dissolved in water. Measurements of TDS in water samples vary considerably depending on geographical regions that responsible for variation in minerals solubility. The presence of high levels of TDS in water may lead to excessive scaling in water pipes, so it is important to measure the TDS values of drinking water samples. According to WHO drinking water samples with TDS levels of less than 600mg/l are considered to be good; TDS levels greater than about 1000 mg/l the drinking water becomes unpleasant in taste

2.8.3 Microbiological aspects

Microbial contamination of drinking water poses a threat to human health. Consumption of water that is contaminated with feces from human or animals (even birds) is considered the greatest microbial risk. Feces can be a source of pathogenic bacteria, viruses, protozoa and helminths. Failure to ensure drinking water safety may expose the whole community to the risk of occurrence of intestinal and other infectious diseases between many people at the same time. To verify that drinking water is microbiological polluted, analysis of fecal indicator microorganisms has to be done. The presence of Escherichia coli in analysis provides conclusive evidence of recent fecal pollution and should not be present in drinking water.

The best way to recognize microbiological contamination in drinking water is the use of simple measurements of what is called "indicator organisms" to show that pathogenic contamination may be present in water. The coliform group of bacteria is the indicator used for this purpose in order to test drinking water. They are found in water, soil and on vegetation, and they are found in large numbers in the feces of worm blooded animals.

2.8.3.1 Total Coliform Bacteria

Total coliform bacteria include a wide range of aerobic and facultative anaerobic, Gram-negative, non-spore-forming bacilli have the ability to grow in the presence of high concentrations of bile salts and to ferment lactose and produce acid or aldehyde during 24 hours at 35–37 °C. Total coliform bacteria occur in sewage and natural waters. Some of these bacteria are excreted in the feces of humans and animals, but many coliforms are heterotrophic and have the ability to grow in water and soil environments. Total coliforms can also stay alive and grow in water distribution systems, particularly in the presence of biofilms. After disinfection process Total coliforms should be absent immediately, their presence indicates inadequate treatment. The presence of total coliforms in distribution systems and in water supply tanks can result in biofilm formation (WHO, 2011).

2.8.3.2 Fecal Coliform

Bacteria have the ability to ferment lactose at 44–45 °C are known as Thermo tolerant coliforms. One of the thermo tolerant coliforms is Escherichia coli which is presented in large numbers in human and animal feces and is rarely found in the absence of fecal pollution, although there is some evidence for growth in tropical soils. Escherichia coli is the best choice in monitoring programmes for the examination of drinking-water quality, as it is considered the most suitable indicator of fecal contamination, as populations of thermo tolerant coliforms are composed basically from E-coli.

3.1 Data Collection and Questionnaire Survey

Several visits were conducted to different Palestinian authorities such as the Ministry of Health, the Ministry of Education, the Directorate of Education of Jenin, the Joint Services Councils, and department of environmental health in the directorate of health in Jenin in order to understand the water status in Jenin governorate. The Palestinian Ministry of Health laboratory conducts TC & FC tests for schools in cooperation with the Palestinian Ministry of Education. Permission was asked from the ministry of health to use available data. Also permission was asked from the Palestinian Ministry of Education to visit the schools in the study area and to take samples of water from there and to distribute the questionnaire.

In this research 59 public schools in Jenin directorate of education were selected to assess drinking water quality and evaluate the current water situation at schools. The selected sample of schools covers the geographical area that the directorate of education of Jenin is responsible for them. Also the choice of schools was based on the population, number of schools in each part of the study area. A structured questionnaire was addressed to the school principal or to the teacher of environmental health. The questionnaire included general information about the school; the location of school, grade levels, drinking water sources in school, and several questions related to how they handle drinking water at school and the surrounding environment.
The number of schools was estimated using below equation:

$$n = \frac{Nt^2 * p\,(1-p)}{e^2(N-1) + t^2\,p\,(1-p)}$$

Where:

n: Sample Size

N: The Population Size = 149

t: a constant equal 1.96 correspond to the level of confidence of 0.95

e: Percentage of Errors = 0.05

p: The proportion of property

The SPSS software version 19 was utilized for data analysis. SPSS has been used to find the percentages for each question in a questionnaire, and to conclude the relationship between related variables in a questionnaire

3.2 Field Visits and Drinking Water Sample Collection

Visits to the selected schools were done during the period of January 28, 2018 until March 10, 2018 to collect drinking water samples and to distribute the questionnaire. Also drinking water samples were collected from each school.

3.3 Laboratory Analysis

Drinking water samples were collected from 59 schools. The samples were collected from the faucet after putting alcohol on the outside of the faucet and waiting few minutes before taking the sample. The samples were tested for different physiochemical (pH, Conductivity, Hardness, Turbidity, free residual chlorine) and microbiological (TC, FC) characteristics. Sampling was performed during the period of January 28, 2018 until March 10, 2018. The samples were collected in sterilized bottles, put into ice box containers and transported to laboratory at Birzeit University within 24 hours.

Physical, chemical, and biological properties were tested in the laboratory following the applicable standard procedures (Al-Salayme *et al*., 2011, Tortoraet *et al*., 2003; APHA, 1998).

The indicators (pH, Conductivity, Free residual chlorine, Hardness) could influence drinking water flavor, while turbidity and coliform indicators were measured for health reasons (Lou *et al*., 2007). In Table 3 the water quality parameters and their methods.

Table 3: School drinking water quality analysis tests and methods

Property	Test	Method
Physical and Chemical	pH	pH Meter
	Electrical Conductivity	EC Device
	Turbidity	Turbid Meter
	Free Residual Chlorine	Spectrophotometer
	Hardness	EDTA Titration
Microbiological	Total Coliform	Membrane Filtration
	Fecal Coliform	Membrane Filtration

3.3.1 Membrane Filtration Technique

First of all the m-Endo and m-FC media were prepared as will be mentioned below in sections (3.3.1.1 & 3.3.1.2), after that 100ml of water sample was filtered through 0.45µm pore size membrane filter for each Total Coliform and Fecal Coliform test. Then the membrane filter was placed on the corresponding culture media Petri dish containing either m- Endo or m-FC media respectively, the Petri dish was incubated at the required temperature in incubators at 37˚C or at 44˚C.

After 24 hours of incubation at 37˚C on an Endo-type medium containing lactose red colonies with metallic sheen will appear on the surface indicating the presence of total coliforms. Fecal coliforms will give blue colonies on m-FC medium after 24 hours of incubation at 44˚C. In this technique any colony doesn't have metallic sheen are considered non colifoms (Greenberg *et al*., 1992).

To make sure that the contamination in the sample is corresponding to the sample not to any other reason such as the media, the media should be tested, so other two Petri dishes containing the media (m-Endo & m-Fc media) and the membrane filter with E-coli bacteria added over the membrane filter and then incubated as the samples to give positive results of growth of bacteria

3.3.1.1 Total Coliform Test

In this experiment, first M-endo media were prepared by adding 4.5 g in 100ml of distilled water containing 1.2 ml of a solution consist ethanol (50% conc.) and 0.01g of basic fuschin. After that, they were heated to boiling point, then wait until the media cooled down, and then they were putted on Petri dish. The drinking water samples (100ml) were filtered into the top of absorbent pad and finally the membrane filters (0.45µm) were putted over the m-Endo media, and the cover of Petri dish was placed tightly. The Petri dish was incubated at 37C for 24 hours. Coliforms ferment lactose and the resulting acetaldehyde reacts with Sodium Sulphite and basic fuchsin to form red colonies. Total coliform media give red color with metallic sheen on it (as in Figure 14) in the presence of total coliform bacteria after 24 hours of incubation at 37˚C on an Endo-type medium containing lactose.

Figure 14: Total coliform bacteria on M-endo media plate

3.3.1.2 Fecal Coliform Test

M-FC Agar with 1% Rosolic Acid is recommended for the detection of fecal coliforms in water samples by membrane filtration and elevated temperature. To prepare M-FC media, first 5.21g of M-FC Agar base was added to 100ml of distilled water, then 1ml of 0.01g Rosolic acid suspended in 0.2 N NaOH solution was added. Then the solution was heated until boiling and then waits until cool down. FC test done by following steps, membrane filter (0.45 µm pore size) were placed through which the drinking water sample (100 ml) was filtered onto the top of the saturated absorbent pad. Then cover of Petri dish was placed on tightly, and was incubated at 44.5 ºC for 24 hours. Fecal coliform will give blue color of the m-FC media with metallic sheen on it in the presence of fecal coliform bacteria after 24 hours of incubation at 44˚C (as in Figure 15).

M-FC Agar with 1% Rosolic Acid contains peptones as a source of carbon, nitrogen, vitamins and minerals. Lactose is a carbohydrate that can be fermented by fecal coliforms at elevated temperatures. Bile salts inhibit the growth of undesirable microorganisms. Agar is added as the solidifying agent. Finally, rosolic acid is utilized to differentiate fecal from non-fecal coliforms.

Figure 15: Fecal coliform bacteria on M-FC media

3.3.2 Titration Principle

The principle of titration requires gradual addition of titrable reagent to the sample which includes the analyte of choice, when all the analyte react with the reagent then the reagent will react with the indicator and the color will change to indicate the end point. This principle was used to measure the hardness of drinking water samples, a solution of 50ml of sample water with 2ml of ammonia buffer (pH=10) and some Erichrome T powder (to give pink color) was prepared. Then gradual addition of EDTA (0.01M).

3.4 Data Analysis Techniques

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). In this study SPSS version 19 was used. Questionnaire's data were entered on the data view window, the entered data was checked and reviewed, frequency tables were produced for all questions and observations. The data was analyzed in descriptive statistics to detect correlations between related variables. Frequencies statistics explain order of the data, averages, summation and percentages.

4.1 General Information about the Examined Schools

In this research a questionnaire survey and water sample analysis were carried out to evaluate the quality of drinking water in the public schools of Jenin directorate of education. The study covers primary and secondary schools of the directorate. Fifty nine questionnaires were given to 59 schools. The schools cover all the geographical region of the directorate. The invested schools include 34 schools of primary level and 25 schools of secondary level. According to location of schools, there are 29 schools in urban and 30 schools in rural area.

4.2 School's Drinking Water Source at Jenin Directorate of Education

The analysis carried out on the drinking water source of 59 public schools in Jenin Directorate of Education shows that 69% of schools use municipal water as water source, while 7% of schools purchase water tanks to cover their needs of drinking water, 3% of schools get their water directly from Mekorot Company, 2% of schools use agricultural wells as water source, 10% of schools use both municipal water and purchase water tanks as drinking water source, other schools use both municipal water and rain water harvesting wells make up 5%. 2% of schools use both municipal water and agricultural wells as water source, and finally 2% of schools use rain water harvesting and purchase water tanks. Figure 16 illustrates drinking water sources at the schools at Jenin Directorate of Education.

In a similar study conducted in Jordan for the assessment of public schools drinking water showed that 91% of the surveyed schools consume water from the public water network, while 2% purchase water tankers to cover their need for water as they are not connected to the water network, 6% depend on public water network in addition to purchasing water tankers (JMoE, 2016).

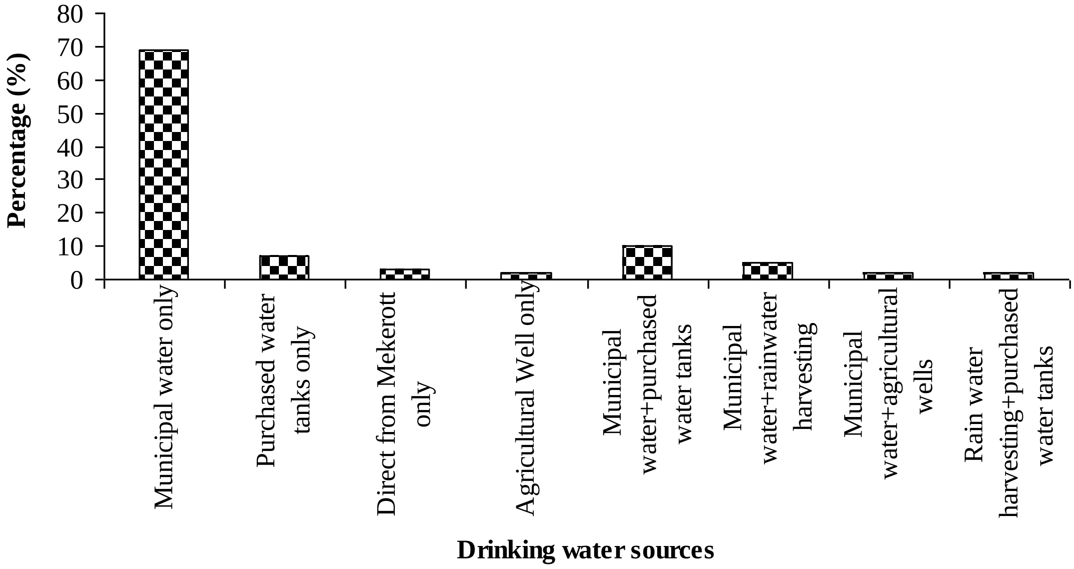

Figure 16: Drinking water sources at public schools at Jenin Directorate of Education

Among the 34 primary schools, those using municipal water as drinking water source were 67.6%. Primary schools that get water directly from Mekorot company (school's water network had a direct connection with Mekorot water Company) were 5.9%. 14.7% of primary schools use municipal water and purchase water tanks. Those primary schools that purchase water tanks and those who use agricultural wells or those use municipal water and rain water harvesting or those who purchase water tanks with rain water harvesting wells all account for 2.9% respectively as shown in Figure 17.

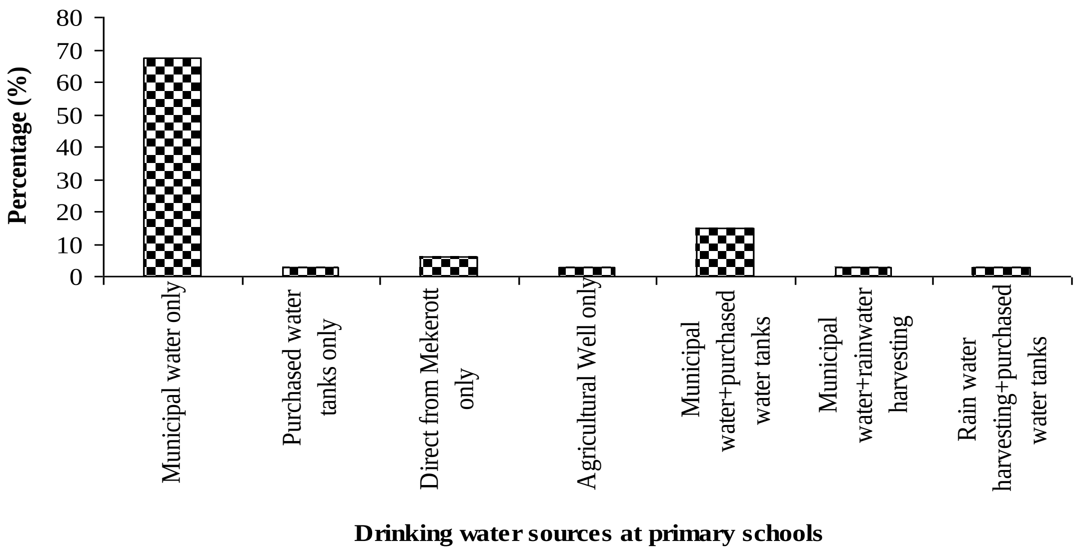

Figure 17: Drinking water sources at primary schools at Jenin Directorate of Education

With respect to the 25 secondary schools, 72% of them use municipal water only as drinking water source, 12% of them purchase water tanks, while 4% of them use municipal water plus purchasing water tanks, 8% of secondary schools use both municipal water and rain water harvesting for drinking water purposes, 4% of them use both municipal water and agricultural wells as shown in Figure 18.

secondary schools had higher coverage of drinking water services than primary schools (municipal water), similarly found by UNICEF and WHO (2018) as one of six secondary schools compared to one of four primary schools did not have drinking water service globally. Same results found by Chung (2008) in Taiwan that 57% schools above senior level use tap water while 34% of schools under junior level use tap water.

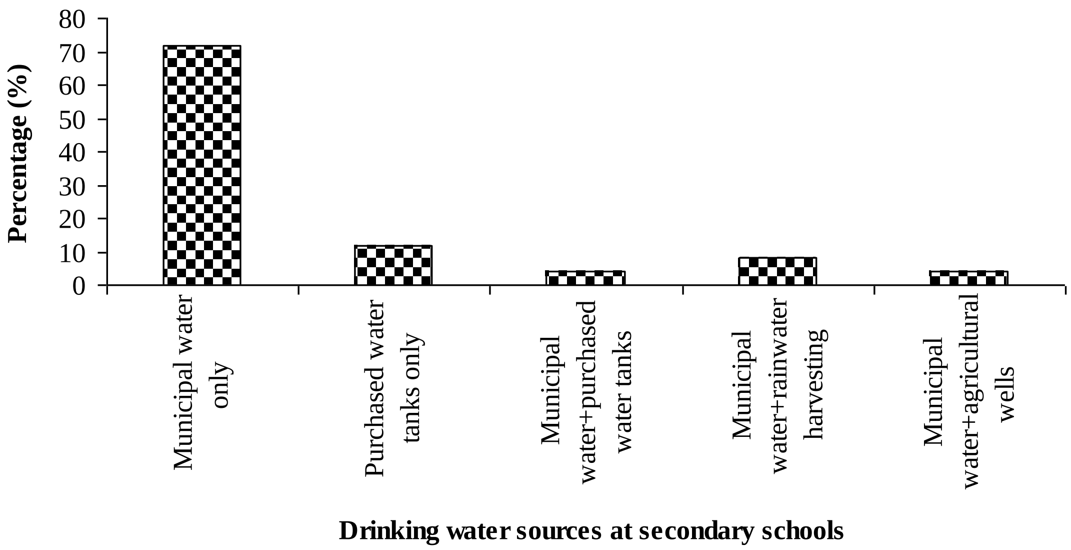

Figure 18: Drinking water sources at secondary schools at Jenin Directorate of Education

Among the 29 schools in urban area 79.3% of them use municipal water as drinking water source, 13.8% of them use municipal water and also purchase water tanks, and 6.9% of them use municipal water and rain water harvesting wells as drinking water source. Among the 30 schools in rural area, 60% of them use municipal water as drinking water source, 13.3% of them purchase water tanks, 6.7% of them get drinking water directly from Mekorot Company (school's water network directly connected to Mekorot Company) , 3.3% of them use agricultural wells water as drinking water source, 6.7% of them use municipal water and purchase water tanks, those who consume municipal water and rain harvesting wells or agricultural wells account for 3.3% respectively, also 3.3% of the rural schools use both rain water harvesting wells and purchase water tanks. Schools in urban area had higher coverage of drinking water services (93.1%) than schools in rural area (66.7%) which is the same found globally (UNICEF & WHO, 2018).

Additionally, Figures 19 and 20 below show the multiplicity of drinking water sources in schools in rural area compared to urban areas due to the absence of a water network in the region which force schools to seek for other unsafe sources of drinking water. Table 4 illustrates all the results regarding schools drinking water sources according to different grade levels and school location.

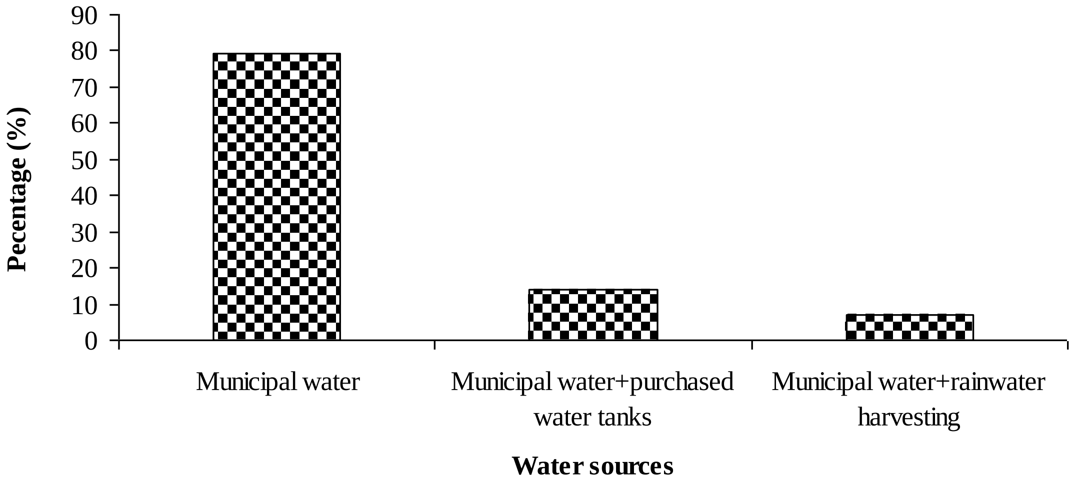

Figure 19: Drinking water sources at schools at urban area in Jenin Directorate of Education

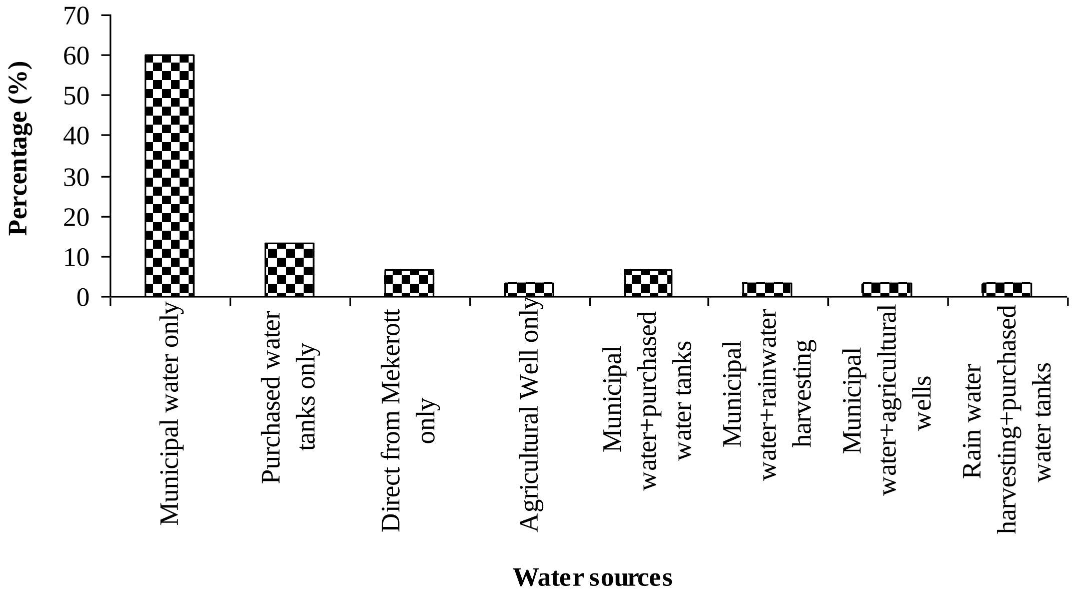

Figure 20: Drinking water sources at schools at rural area in Jenin Directorate of Education

Table 4: Schools drinking water sources in Jenin Directorate of Education according to different grade levels and school location

Drinking Water Source	Total number of schools	School Grade Level		School Location	
		Primary school	Secondary school	Urban	Rural
Municipal water only	41 (69%)	23 (67.6%)	18 (72.0%)	23 (79.3)	18 (60.0%)
Purchase of water tanks only	4 (7%)	1 (2.9%)	3 (12.0%)	0 (0.0%)	4 (13.3%)
Direct from Mekorot only	2 (3%)	2 (5.9%)	0 (0.0%)	0 (0.0%)	2 (6.7%)
Agricultural wells only	1 (2%)	1 (2.9%)	0 (0.0%)	0 (0.0%)	1 (3.3%)
Municipal water + purchase water tanks	6 (10%)	5 (14.7%)	1 (4.0%)	4 (13.8%)	2 (6.7%)
Municipal water + rain water harvesting	3 (5%)	1 (2.9%)	2 (8.0%)	2 (6.9%)	1 (3.3%)
Municipal water + agricultural wells	1 (2%)	0 (0.0%)	1 (4.0%)	0 (0.0%)	1 (3.3%)
Rain water hervesting + purchase water tanks	1 (2%)	1 (2.9%)	0 (0.0%)	0 (0.0%)	1 (3.3%)

4.3 School's Drinking Water Quality Analysis

In this research drinking water samples were taken from the 59 schools, the samples were taken from the faucets from where the students drink water. The tests done for each school include pH, conductivity, turbidity, hardness, free residual chlorine, total coliform and fecal coliform indicator bacteria. Table 5 shows the drinking water physiochemical and microbiological properties and its relation PSI guideline and WHO guideline.

Table 5: Drinking water physiochemical and microbiological properties and its relation PSI guideline and WHO guideline at Schools at Jenin Directorate of Education

Water Test	Minimum	Maximum	Mean	Std. Deviation	PSI (2004) Guidelines	WHO (2004) Guidelines
Turbidity (NTU)	0.23	4.09	0.83	0.71	up to 5	up to 5
Cl_2 (mg/l)	0.00	0.67	0.13	0.17	0.2 – 0.8	0.6 – 1.0
pH	7.50	8.42	8.09	0.20	6.5 - 8.5	6.5 - 8.5
Electrical Conductivity (μS/cm)	168.20	1735.50	593.51	310.56	Up to 2000	Up to 2000
Hardness (ppm)	73.20	467.70	266.06	118.60	400	NA*
Total Coliforms (CFU/100ml)	0.0	Too many to count			0-3	0.0
Fecal Coliforms (CFU/100ml)	0.0	Too many to count			0.0	0.0

NA*: not available

Table 6 and 7 shows the average school drinking water physical and chemical properties with respect to school location and different grade levels respectively.

Table 6: Average school drinking water physical and chemical properties with respect to school location

Drinking Water Source	Test Standard*	pH 6.5-8.5	Turbidity (NTU) >5	Electrical Conductivity (µS/cm) >2000	Hardness (mg/l) 400	Residual Chlorine (mg/l) 0.2-0.8
Municipal Water						
Schools in Urban Area		8.0	0.90	585.1	281.5	0.11
Schools in Rural Area		8.2	0.80	515.5	236.9	0.17
Purchase of Water Tanks						
Schools in Urban Area		.	.	.	.	.
Schools in Rural Area		8.2	0.87	628.9	201.1	0.03
Direct from Mekorot						
Schools in Urban Area		.	.	.	.	.
Schools in Rural Area		7.9	0.33	355.6	162.7	0.46
Agricultural Wells						
Schools in Urban Area		.	.	.	.	.
Schools in Rural Area		8.3	1.1	657.3	219.7	0.03
municipal water + purchase Water Tanks						
Schools in Urban Area		8.1	0.51	682.2	316.2	0.04
Schools in Rural Area		8.2	0.66	660.7	272.5	0.21
municipal water + Rain Water Harvesting						
Schools in Urban Area		8.0	0.96	781.0	396.9	0.03
Schools in Rural Area		7.6	0.68	879.1	467.7	0.21
municipal water + Agricultural Wells						
Schools in Urban Area		.	.	.	.	.
Schools in Rural Area		8.2	1.7	1735.5	463.7	0.15
Rain Water Harvesting + Purchase Water Tanks						
Schools in Urban Area		.	.	.	.	.
Schools in Rural Area		7.9	1.1	169.8	73.2	0.02

*Palestinian standard institution guideline

Table 7: Average school drinking water physical and chemical properties with respect to school grade levels

Drinking Water Source	Test Standard*	pH 6.5-8.5	Turbidity (NTU) >5	Electrical Conductivity (µS /cm) >2000	Hardness (mg/l) 400	Free Residual Chlorine (mg/l) 0.2-0.8
Municipal Water						
Primary Schools		8.1	0.83	570.5	276.1	0.14
Secondary Schools		8.1	0.89	534.1	243.8	0.13
Purchase of Water Tanks						
Primary Schools		8.2	0.56	1208.1	341.7	0.00
Secondary Schools		8.127	.98	435.90	154.24	.03
Direct from Mekorot						
Primary Schools		7.9	0.33	355.6	162.7	0.46
Secondary Schools		.	.	.	.	.
Agricultural Wells						
Primary Schools		8.3	1.1	657.3	219.7	0.03
Secondary Schools		.	.	.	.	.
Municipal Water + Purchase Water Tanks						
Primary Schools		8.1	0.56	745.6	337.6	0.08
Secondary Schools		8.1	0.59	322.4	122.0	0.15
Municipal Water + Rain Water Harvesting						
Primary Schools		7.7	0.52	825.1	387.0	0.02
Secondary Schools		7.9	1.0	808.0	437.2	0.12
Municipal Water + Agricultural Wells						
Primary Schools		.	.	.	.	.
Secondary Schools		8.2	1.7	1735.5	463.7	0.15
Rain Water Harvesting + Purchase Water Tanks						
Primary Schools		7.9	1.1	169.8	73.2	0.02
Secondary Schools		.	.	.	.	.

*Palestinian standard institution guideline

4.3.1 pH Value

In this research the pH value of all tested schools was between 7.5-8.4 which has met the Palestinian standard and within WHO allowable limits.

4.3.2 Turbidity

Turbidity is an optical property that indicates the clearness of water. It is known that turbidity higher than 1 NTU will affect the disinfection process efficiency of. However, turbidity less than 5 NTU is acceptable in regions of limited water resources (WHO, 2011). The values of turbidity in this research were between 0.23-4.0 NTU which is within the Palestinian standard and WHO standards.

Results showed that there is a statistically significant relationship between turbidity and the presence of total coliform (Chi-Square= 455.775, df= 405, P= 0.041) and fecal coliform (Chi-Square= 499.247, df= 450, P= 0.054). Also, results showed that there is a statistically significant relationship between turbidity and drinking water sources (Chi-Square= 364.573, df= 315, P= 0.028). Tamimi (2016) also found that there is a statistically significant relationship between Turbidity in water and incidence of diarrhea disease when they test the quality of water in cisterns for rain water collection and that confirms our results.

4.3.3 Electrical conductivity

The Electrical conductivity is an estimate of total dissolved solids and mineral content of a specific water supply. It can be expressed as micro Siemens per centimeter (μS/cm). In the research the results for EC were between (168 – 1735) μS/cm. The results were good; because they were within allowable limits by the WHO and PSI.

4.3.4 Total hardness

Total hardness expresses the concentration of Calcium and Magnesium ion in water (WHO, 2011). The concentration of each differs depending on geological diversity. Hardness affects water taste.

According to WHO water with hardness above 120 mg/l is considered as hard water and may results in scale deposition in the pipe work and distribution system and in tanks on the roof of buildings. It will also result in high amounts of soap consumption. When heating hard water, calcium carbonates scale precipitate on the surface. Soft water, with a hardness of less than 60 mg/l is corrosive to water pipes considering other factors such as pH and alkalinity (WHO, 2004).

In Palestine, the standard for total hardness is 400mg/l. In this research schools in rural areas using either rain water harvesting or agricultural wells water have the highest total hardness of around 468 mg/l as $CaCO_3$ which is higher than the PSI. Schools in rural areas using rain water harvesting in addition to purchasing water tanks have the lowest value of hardness of 73mg/l as $CaCO_3$. There is a significant relationship between the value of total hardness and the source of drinking water

(Chi-Square= 315.182, df= 249, P= 0.012), and that confirmed by WHO (2004) that natural and treated waters vary widely in levels of minerals content, begins with very low levels in naturally soft and softened water and in rainwater to higher levels in naturally hard waters. Thus, the minerals content in drinking-water will differ widely, depending upon location, water source, and treatment.

4.3.5 Free residual chlorine

The availability of chlorine in drinking water is essential for safety reasons. When the concentration of chlorine in water is around 2-3 mg/l, a nuisance odor can be smelled. The free residual chlorine concentration in drinking water should be between 0.6-1.0 mg/l as recommended by WHO (WHO, 2006). In this research very low levels of free residual chlorine can be detected in all schools except 4.9% of schools that depend on municipal water with a value of 0.56mg/l of Cl^2, and schools in rural areas that have direct access of water from Mekorot Company with a value of 0.63, 0.65mg/l of Cl^2 respectively. Chung (2008) also found that approximately no residual chlorine can be noticed in all tested schools in his research in Pingtung County, Taiwan. Most of the time, the source water meet the guidelines. However, the concentration of free residual chlorine decrease in the distribution network, as the chlorination process doesn't take into account the microbiological contaminants present in water in pipelines. And that leads to the very low free chlorine residual at taps (Al-Khatib *et al*., 2005).

4.3.6 Microbial Detection

The best way to recognize microbiological contamination in drinking water is the use of simple measurements of what is called "indicator organisms" to show that pathogenic contamination may be present in water. The coliform group of bacteria is the indicator used for this purpose in order to test drinking water. Coliforms are common bacteria can survive in the intestines of human beings and mammals, and will be excreted out in the dejection. If we find coliforms in the water, we can say that the water has been contaminated by the excrement of human beings and/or mammals.

Coliform bacteria must be undetectable in drinking water (WHO, 2004). The Palestinian standards call for a maximum of 4 CFU/100ml for total coliform and zero

CFU/100ml for fecal coliform (PSI, 2004). The prediction of total coliform bacteria after disinfection means that water has already been polluted by microbes. In this research, the presence of either total coliform or fecal coliform will mean the contamination of water. For the total coliform bacteria detection among the 59 schools, there are 15 contaminated schools with a percent of 25.4%. For the fecal coliform bacteria detection, among the 59 schools, there are 11 contaminated schools with a percent of 18.6%.

4.3.6.1 Microbial Detection with respect to Drinking Water Source

In light of water source, from the 41 schools using municipal water there are 9 schools have total coliform bacteria with rate of 22% and 6 schools have fecal coliform bacteria with a percent of 14.6%. All schools purchasing water tanks or use agricultural wells or purchasing water tanks plus using rain water harvesting wells are all have total coliform bacteria and fecal coliform bacteria in their water. Table 8 shows detailed school drinking water TC and FC bacteria content with respect to drinking water source.

Table 8: School drinking water TC and FC bacteria content with respect to drinking water source

		Total Coliform Bacteria Detection		Fecal Coliform Bacteria Detection	
Drinking Water Source	Number of Schools	Number of contaminated Schools	Percentage of contamination	Number of contaminated Schools	Percentage of contamination
municipal water	41	9	22%	6	14.6%
purchase of water tanks	4	4	100%	4	100%
Direct from Mekorot	2	0	0%	0	0%
agricultural wells	1	1	100%	0	0%
municipal water + purchase water tanks	6	0	0%	0	0%
municipal water + rain water harvesting	3	0	0.0%	0	0.0%
municipal water + agricultural wells	1	0	0.0%	0	0.0%
rain water hervesting+ purchase water tanks	1	1	100%	1	100%

4.3.6.2 Microbial Detection with respect to School Grade level

In light of school grade level, non-conformance rate of total coliform bacteria detection for the primary schools is 17.6%, while that for secondary schools is 36%. For the non-conformance of fecal coliform bacteria detection for primary schools is 11.8%, while for secondary schools is 28%. The results showed that secondary schools were more contaminated than primary schools as shown in Table 9.

Table 9: School drinking water TC and FC bacteria content with respect to school grade level

		Total Coliform Bacteria Detection		Fecal Coliform Bacteria Detection	
School Classification	Number of Schools	Number of contaminated Schools	Percentage of contamination	Number of contaminated Schools	Percentage of contamination
Primary school	34	6	17.6%	4	11.8%
Secondary school	25	9	36.0%	7	28.0%

4.3.6.3 Microbial Detection with respect to School Location

In light of school location, schools in urban areas had lower percentages of contamination with total coliform bacteria (20.7%) than schools in rural area (30%). The same results found for fecal coliform bacteria detection, for schools in urban area it was 13.8%, while for schools in rural area it was 23.3% as shown in Table 10.

Table 10: School drinking water microbe detection content with respect to school location

		Total Coliform Bacteria Detection		Fecal Coliform Bacteria Detection	
School Tracking To	School Quantity	Number of contaminate d Schools	Percentage of contamination	Number of contaminated Schools	Percentage of contamination
Urban	29	6	20.7%	4	13.8%
Rural	30	9	30%	7	23.3%

Results showed that schools in rural area had higher percent of contamination than schools in urban area.

Several reasons behind that:

1- Only 60% of schools in rural area depend on municipal water, and 20% purchase water tanks which are usually unknown their source of water or even if the water had been tested.

2- The absence of sewage networks and people depend on cesspits for waste disposal. Only 6.3% of educational institutions in Jenin governorate dispose wastewater into wastewater networks, while 57.3% use cesspits for wastewater disposal and 36.4% use tight cesspits for wastewater disposal (PCBs, 2016).

4.3.6.4 Microbial Detection with respect to the Geographical area affiliated with the School

In light of geographical area affiliated with the school, results revealed the presence of total coliform bacteria and fecal coliform bacteria in 9 schools of the 17 schools in villages in east Jenin with a percentage of contamination of 52.9% (TC), 41.2% (FC) respectively.For schools in villages in west Jenin, results show the presence of total coliform bacteria and fecal coliform bacteria in 3 schools of the 25 schools with a percentage of contamination of 10.7% (TC), 7.1% (FC) respectively. For schools in Jenin city, results show the presence of total coliform bacteria and fecal coliform bacteria in 3 schools of the 14 schools in this research with a percentage of contamination of 21.4% (TC), 14.3% (FC) respectively. Table 11 shows detailed description of school drinking water microbe detection content with respect to geographical area affiliated with the school.

It is clear from the above mentioned results that east Jenin villages have the highest percent of microbe detection, while west Jenin villages has the lowest value.
On the other hand, only 47.1% of tested schools in east Jenin villages depend on municipal water, while 23.5% of them purchase water tanks. And the rest of schools use water direct from Mekorot or from agricultural well or both municipal water and agricultural wells or municipal water with purchasing water tanks or purchasing water tanks plus rain water harvesting wells with 5.9% respectively for each.

The high percent of contamination in east Jenin villages is a result of the unimproved source of drinking water at the school as they depend on different resources of drinking water other than the safest source (municipal water) whish lead to high risk of contamination. Seven villages in east Jenin do not have a water network (Jalboun, Deir abu-dieef, Faqoua'a, Beit qad, Arabboune, Aaba, and Al-Mteile) and people there depend on different unsafe sources of water

82.1% of tested schools in west Jenin villages depend on municipal water. 3.6% use water direct from Mekorot and 3.6% use both municipal water plus purchasing water tanks, while 10.7% depends on municipal water and rain water harvesting well together. In Jenin city 71.4% depend on municipal water and 28.6% use both municipal water plus purchasing water tanks.

Table 4: School drinking water microbe detection content with respect to geographical area affiliated with the school

Geographical area affiliated with the school	school quantity	*Total Coliform Bacteria Detection		**Fecal Coliform Bacteria Detection	
		qualified Quantity / Percentage	Unqualified Quantity / Percentage	qualified Quantity / Percentage	Unqualified Quantity / Percentage
East_Jenin	17	8 47.1%	9 52.9%	10 58.8%	7 41.2%
West_Jenin	28	25 89.3%	3 10.7%	26 92.9%	2 7.1%
Jenin_City	14	11 78.6%	3 21.4%	12 85.7%	2 14.3%

**: (Chi-square = 10.102, df = 2, P = 0.006)
*: (Chi-square = 8.307, df = 2, P = 0.016)

It is clear that there is a significant relationship between the geographical area affiliated with the school and the presence of Total coliform and Fecal Coliform indicators in the drinking water, this is may result from the diversity of water sources in Jenin area and the existence of water network or not.

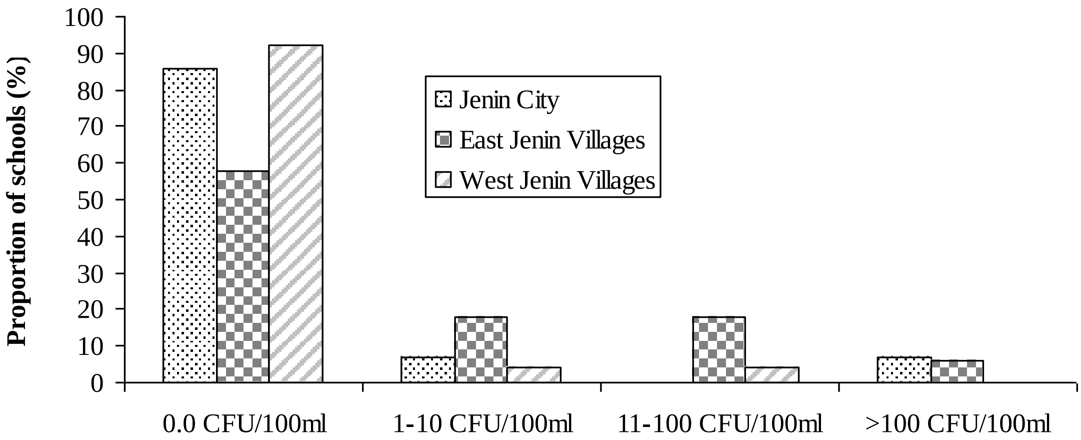

Figure 21: Proportion of public schools by level of E-coli detected according to geographical area

Figure 21 shows that the risk of contamination exists in all geographical area. However, West Jenin villages have the best results and the lowest rate of contamination, while East Jenin villages have the worst results of rate of contamination.

4.3.7 Drinking water source with respect to Geographical area affiliated with the school

As shown in Table 11, 69.5% of schools of Jenin directorate of education depend on municipal water as their drinking water source (as shown in Table 12) which is higher percent than that found by Chung *et al*. (2008) who found that 45% of schools in Pingtung county used tap water as the main source of drinking water. However, Bakir *et al*. (2015) found in his study that 93.5% of the primary schools in Ankara used community water system as the main drinking water source.

Table 5: Drinking water source with respect to Geographical area affiliated with the school.

Drinking Water Source	Geographic area affiliated with the school			Total
	East_Jenin	West_Jenin	Jenin_City	
municipal water	8 47.1%	23 82.1%	10 71.4%	41 69.5%
purchase of water tanks	4 23.5%	0 .0%	0 .0%	4 6.8%
Direct from Mekorot	1 5.9%	1 3.6%	0 .0%	2 3.4%
agricultural wells	1 5.9%	0 .0%	0 .0%	1 1.7%
municipal water + purchase water tanks	1 5.9%	1 3.6%	4 28.6%	6 10.2%
municipal water + rain water harvesting wells	0 .0%	3 10.7%	0 .0%	3 5.1%
municipal water + agricultural wells	1 5.9%	0 .0%	0 .0%	1 1.7%
rain water hervesting wells + purchase water tanks	1 5.9%	0 .0%	0 .0%	1 1.7%
Total	17 100.0%	28 100.0%	14 100.0%	59 100.0%

4.3.8 Risk Factors and Degree of Contamination

To determine the reasons behind contamination of drinking water at schools, statistical analysis were conducted to identify significant correlation between risk factors that maybe behind the contamination of drinking water and microbiological water quality (the presence of TC, FC). Cross tabulation between the risk factors in the research and the presence of TC and FC were done, the percentage of contamination was calculated when this factor was (Yes) and when it was (No), then the Chi-Square tests were done to check if the variations in percentage was statistically significant or not. The results are summarized in Table 13.

Table 6: Risk Factors of microbial contamination in drinking water by the presence of TC, FC

Risk Factors		**%+TC**	**%+FC**	**Df**	**X2**	**P**
Does the school suffer from a long interruption of municipal water continuously	yes	7.7%	0.0%	1	2.765	0.096
	no	30.4%	23.9%	1	3.821	0.051
Are drinking water tanks separate from water tanks used for other purposes	yes	27.5%	21.6%	2	1.035	0.596
	no	16.7	0.0%	2	2.121	0.346
Is chlorine added to drinking water	yes	29.4%	23.5%	1	0.673	0.412
	no	20%	12%	1	1.263	0.261
Is rainwater collected in the same water tank for drinking if there is a rainwater harvesting mechanism	yes	50%	50%	1	3.357	0.187
	no	13%	12%	2	1.857	0.395
If there are wells that collect rain water or water reservoirs in the ground, how close are they to cesspits	yes	16.7	16.7%	2	2.173	0.337
	no	0.0%	0.0%	2	0.376	0.829
Is it necessary to make sure that tanks are periodically closed	yes	26.3%	19.3	1	0.706	0.401
	no	0.0%	0.0%	1	0.474	0.491
Are drinking water tanks periodically cleaned	yes	26.3%	19.3%	1	0.706	0.401
	no	0.0%	0.0%	1	0.474	0.491
Are drinking water tanks cleaned after summer vacation	yes	27.8%	20.4%	2	1.862	0.394
	no	0.0%	0.0%	2	1.252	0.535
Is the tank or well used for rain water collection is cleaned before rainy season	yes	21.1%	21.1%	2	3.667	0.160
	no	0.0%	0.0%	2	1.820	0.402
Is there a special clothing when cleaning tanks	yes	30.8%	19.2%	2	1.206	0.547
	no	22.6%	19.4	2	0.475	0.789

It is clear that there is a significant relationship between the long interruption in municipal water supply and water contamination. Drinking water supply interruptions, as a result of discontinuity sources or because of engineering inefficiencies, are a major determinant of the quality of drinking-water (WHO, 2011).

Any intermittent in water supply can result in deterioration of water quality, increasing the risk of exposure to contaminated water and consequently increasing the risk of waterborne disease. Daily or weekly interruption can result in low supply pressure and a consequent risk of contamination to occur in the pipes another time (WHO, 2011). It is also clear that there is no relation between the addition of chlorine and the presence of contamination in water.

Chapter Five - Conclusions and Recommendations

5.1 Conclusions

- Drinking water sources of the public schools in Jenin Directorate of Education of different grade levels include: municipal water only, purchased water tanks (unknown source of water), agricultural wells, direct from Mekorot Company, and rain water harvesting.

- All physical and chemical analysis conform to PSI and WHO Guidelines except for the total hardness and free residual chlorine, as 20% of schools exceeded the standards for total hardness, while 70% of schools had values less than the minimum standard of free residual chlorine.

- All of the schools that obtain water from purchasing water tanks only or rain water harvesting plus purchasing water tanks only have total coliform bacteria and fecal coliform bacteria in their water. While, the schools that obtain water from agricultural wells only have total coliform bacteria.

- Schools in urban areas use municipal water (water network) more than the schools in rural area, while both of the schools in urban and rural areas approximately the same depend on purchasing water tanks.

- Schools in rural areas have higher percentage of biological contamination with Fecal and Total Coliforms than schools in urban areas. And schools in villages in east Jenin have the highest rate of biological contamination.

- The high percentage of contamination in the villages in east Jenin is a result of the high percentage of schools there that depend on different resources of drinking water other than the safest source (municipal water) which lead to high risk of biological contamination.
- A significant relationship between the geographical areas affiliated with the school and the presence of Total coliform and Fecal Coliform indicators in the drinking water. And a significant relationship between the long interruption in municipal water supply and water contamination.

5.2 Recommendations

- The Ministry of Health should improve their programs in the follow-up of drinking water quality at schools.
- Standards and protocols for safe drinking water in schools should be set as soon as possible.
- There should be continuous monitoring and testing of schools drinking water quality by the competent authorities and the testing should cover all the schools at the directorate.
- Increase the number of times drinking water is tested at schools.
- The Ministry of Education has to authorize a number of drinking water tankers which schools have to purchase only water from them so that they are sure of the quality of water they purchase.
- A strategy must be developed in schools so that schools that obtains drinking water from sources other than municipal water to add chlorine to water at a certain rate.
- Contaminated schools should be followed up until the tanks are clean.
- Involvement of students and teachers in awareness campaigns and education about the danger of drinking contaminated water.
- The need to build cesspits in accordance with the sanitary standards, environmental and construction suitable to prevent contamination of ground water.

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Appendices

Appendix 1: The Questionnaire

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بسم الله الرحمن الرحيم

تقوم الطالبة ريم خليل في برنامج ماجستير هندسة المياه والبيئة في جامعة بيرزيت بإجراء بحث لإعداد رسالة الماجستير حول جودة مياه الشرب في المدارس التابعة لمديرية التربية والتعليم-جنين. نأمل من حضرتكم تعبئة هذه الاستمارة.
نأمل أن يكون بحثنا هذا فيه منفعة للمدرسة و داعما لجهودكم في مجال المحافظة على صحة أبنائنا وبناتنا في المدارس.

ملاحظة : نتعهد باستخدام هذه المعلومات لأغراض علمية وعدم البوح بأي معلومات تتعلق بالمدرسة.

اسم المدرسة: ....
التاريخ: ....
المنطقة الجغرافية التابعة لها المدرسة: ....

Q1	تصنيف المدرسة: أ- أساسي ب- ثانوي
Q2	المدرسة تتبع: أ- المدينة ب- القرية ت- المخيم
Q3	مصدر مياه الشرب الرئيسي في المدرسة: أ- مياه الشبكة (البلدية) ب- آبار ارتوازية ت- آبار جمع مياه الأمطار ث- شراء مياه (تنكات) ج- مصادر أخرى (مع ذكرها): ....
Q4	هل تعاني المدرسة من انقطاع مياه البلدية بشكل مستمر: أ- نعم (مع ذكر مدة الانقطاع): .... ب- لا
Q5	ما هو عمر شبكة المياه التي تزود مياه البلدية للمدرسة: أ- اقل من 10 سنوات ب- 10 - 20 سنة ت- 20 – 30 سنة ث- أكثر من ذلك
Q6	هل خزانات المياه المخصصة للشرب منفصلة عن خزانات المياه المستخدمة لأغراض أخرى : أ- نعم ب- لا
Q7	هل يتم إضافة الكلور لمياه الشرب: أ- نعم ب- لا
Q8	أماكن وجود خزانات مياه الشرب: أ- على سطح المدرسة ب- على أرضية المدرسة ت- غير ذلك
Q9	هل تحتوي المدرسة على بئر أو خزان جمع مياه الأمطار: أ- نعم ب- لا
Q10	هل يتم جمع مياه الأمطار بنفس خزان المياه المخصص للشرب في حال وجود آلية لجمع مياه الأمطار: أ- نعم ب- لا

Q11	في حال وجود آبار جمع مياه أمطار أو خزانات مياه في باطن الأرض ما مدى قربها من الحفر الامتصاصية (في حال وجدت في المدرسة): أ- قريبة ب- بعيدة ت- لا فكرة لدي
Q12	ما هو عمر خزانات مياه الشرب: أ- اقل من 10 سنوات ب- 10 – 20 سنة ت- 20 – 30 سنة ث- لا فكرة لدي
Q13	ما هي المادة المصنوع منها خزان مياه الشرب: أ- بلاستيك ب- معدن ت- باطون
Q14	هل يتم التأكد من إغلاق الخزانات بشكل دوري: أ- نعم ب- لا
Q15	هل يتم تنظيف خزانات مياه الشرب بشكل دوري: أ- نعم ب- لا
Q16	ما هو عدد مرات تنظيف خزانات مياه الشرب: أ- مرة واحدة في أول العام الدراسي ب- مرة واحدة في بداية كل فصل دراسي ت- لا فكرة لدي
Q17	هل يتم تنظيف خزانات مياه الشرب بعد فترة إجازة الصيف مباشرة: أ- نعم ب- لا
Q18	هل يتم تنظيف خزان جمع مياه الأمطار قبل موسم المطر: أ- نعم ب- لا
Q19	هل يتم ارتداء ملابس خاصة عند عملية تنظيف الخزانات: أ- نعم ب- لا
Q20	هل يتم فحص مياه الشرب بشكل دوري: أ- نعم ب- لا
Q21	كم عدد المرات التي يتم فيها فحص مياه الشرب: أ- مرة واحدة خلال العام الدراسي ب- مرتين خلال العام الدراسي ت- لا فكر لدي

Q22	من أين تؤخذ عينات المياه: أ- من المشربيات ب- من الخزان ت- من ما قبل عداد المياه ث- لا فكرة لدي
Q23	هل سبق وان حدثت حالات مرضية في المدرسة ارتبطت بوجود تلوث في مياه الشرب: أ- نعم ب- لا

Appendix 2: Physiochemical and Biological Parameters

FC (cfu/100ml)	TC (cfu/100ml)	Grade level	School name	
150	1000	secondary	بنات جنين الثانوية	1
0	1	primary	عمر بن الخطاب	2
zero	zero	primary	جنين الاساسية	3
zero	zero	primary	برهـــان الــــدين العبوشي	4
zero	zero	primary	الماليزية	5
zero	zero	secondary	الابراهيميين	6
zero	zero	primary	الجابريات	7
10	60	primary	بنات حيفا	8
zero	zero	secondary	الخنساء	9
zero	zero	primary	قدورة موسى	10
zero	zero	primary	الزهراء	11
zero	zero	secondary	الزهراء	12
zero	zero	primary	منتهى الحوراني	13
zero	zero	primary	فاطمة خاتون	14
zero	zero	primary	مسقط	15
zero	1	secondary	عرانة	16
zero	zero	primary	دير غزالة	17
4	85	primary	عربونة	18
22	1000	secondary	بيت قاد	19
44	1000	secondary	جلبون	20
2	9	primary	فقوعة اساسي	21
11	1000	secondary	فقوعة ثانوي	22
zero	zero	primary	المطلة	23
zero	zero	primary	المغير اساسي	24
zero	zero	secondary	المغير ثانوي	25
zero	zero	secondary	ام التوت	2
zero	zero	primary	جلقموس اساسي	27
1000	1000	secondary	جلقموس ثانوي	28
zero	25	primary	ديــر ابــو ضــعيف اساسي	29
3	13	secondary	ديــر ابــو ضــعيف ثانوي	30
zero	zero	primary	عابا	31
zero	zero	primary	امنة بنت وهب	32
zero	zero	primary	شهداء اليامون	33
zero	zero	secondary	اليامون الثانوية	34
zero	zero	primary	نسيبة المازنية	35
zero	zero	primary	خديجة بنت خويلد	36
zero	zero	primary	كفردان اساسي	37
zero	zero	secondary	كفردان ثانوي	38

zero	zero	secondary	سيلة ثانوي	39
zero	zero	primary	سيلة اساسي	40
zero	zero	primary	ميمونة	41
zero	zero	primary	تعنك	42
zero	zero	secondary	رمانة	43
zero	zero	secondary	زبوبا	44
zero	zero	primary	الطيبة اساسي	45
zero	zero	secondary	الطيبة ثانوي	46
zero	zero	primary	عانين	47
zero	zero	secondary	الهاشمية	48
zero	zero	secondary	كفر قود	49
zero	zero	secondary	كفيرت	50
24	62	primary	برقين اساسي	51
4	8	secondary	برقين ثانوي	52
zero	25	primary	بنات فلسطين	53
zero	zero	secondary	طورة الغربية	54
zero	zero	secondary	بنات زبدة	55
zero	zero	secondary	ام الدار والخلجان	56
zero	zero	primary	ظهر العبد	57
zero	zero	primary	يعبد اساسي	58
zero	zero	secondary	يعبد ثانوي	59

Hardness (ppm)	EC (µs/cm)	pH	Residual Cl_2	Turbidity (NTU)	Grade level	School name	
406.76	859.8	8.226	0.04	0.84	secondary	بنات جنين الثانوية	1
89.48	858.4	8.314	0.09	3.55	primary	عمر بن الخطاب	2
406.76	842.5	7.491	0.02	1.46	primary	جنين الاساسية	3
406.76	935.2	8.002	zero	0.89	primary	برهان الدين العبوشي	4
89.48	259.7	8.101	0.09	0.91	primary	الماليزية	5
235.92	455.5	8.27	zero	0.41	secondary	الابراهيميين	6
325.4	607.2	8.043	zero	0.54	primary	الجابريات	7
345.75	915.5	8.13	0.01	0.71	primary	بنات حيفا	8
122	322.4	8.107	0.15	0.59	secondary	الخنساء	9
142.36	345.4	8.081	zero	0.88	primary	قدورة موسى	10
406.76	886.9	7.97	0	0.54	primary	الزهراء	11
406.76	939.6	7.991	0	0.42	secondary	الزهراء	12
410.8	912.4	8.194	0	0.38	primary	منتهى الحوراني	13
142.3	314.9	8.107	0.02	0.23	primary	فاطمة خاتون	14
386.4	1396.4	7.619	0.18	1.08	primary	مسقط	15
325.41	944.6	8.245	0.13	1.82	secondary	عرانة	16
463.7	1735.5	8.209	0.15	1.72	primary	دير غزالة	17
341.68	1208.1	8.23	zero	0.56	primary	عربونة	18
138.3	377.6	8.308	zero	0.38	secondary	بيت قاد	19
239	761.9	8.252	0.03	0.5	secondary	جلبون	20
73.2	169.8	7.984	0.02	1.14	primary	فقوعة اساسي	21
85.42	168.2	7.821	0.07	2.05	secondary	فقوعة ثانوي	22
309.1	574.4	8.362	zero	0.66	primary	المطلة	23
203.38	594.3	8.301	0.26	0.69	primary	المغير اساسي	24
325.4	608.5	8.244	0.02	0.59	secondary	المغير ثانوي	25
284.7	599.5	8.294	zero	0.86	secondary	ام التوت	2
305.1	598	8.419	0.1	0.5	primary	جلقموس اساسي	27
240	592.1	8.331	zero	0.58	secondary	جلقموس ثانوي	28
219.65	657.3	8.277	0.03	1.11	primary	دير ابو ضعيف اساسي	29
122	321.8	8.131	0.03	1.21	secondary	دير ابو ضعيف ثانوي	30
101.69	252.2	8.073	0.67	0.25	primary	عابا	31
244	426	8.106	0.02	0.48	primary	امنة بنت وهب	32
309.14	545	8.248	zero	0.63	primary	شهداء اليامون	33
183	307	7.902	0.56	0.42	secondary	اليامون الثانوية	34
203.4	397	8.226	0.22	0.5	primary	نسيبة المازنية	35
207.45	439.6	8.003	0.33	0.49	primary	خديجة بنت	36

						خويلد	
451.5	611	7.868	0.15	4.09	primary	كفردان اساسي	37
309.14	550.2	8.068	zero	0.48	secondary	كفردان ثانوي	38
223.72	420.4	7.961	0.21	0.55	secondary	سيلة ثانوي	39
191.18	399.2	8.006	0.48	0.35	primary	سيلة اساسي	40
260.33	398.8	8.038	0.29	0.33	primary	ميمونة	41
244	405.8	8.117	0.42	0.32	primary	تعنك	42
183	325.4	8.173	0.07	0.39	secondary	رمانة	43
101.69	207.4	8.193	0.28	0.55	secondary	زبوبا	44
105.75	216.2	8.212	0.35	0.31	primary	الطيبة اساسي	45
101.69	215.6	8.208	0.21	0.27	secondary	الطيبة ثانوي	46
101.69	221	8.231	0.56	0.27	primary	عانين	47
162.7	294	8.117	0.39	1.64	secondary	الهاشمية	48
199.3	363.6	8.292	0.03	0.77	secondary	كفر قود	49
386.4	606.2	7.813	0.25	0.86	secondary	كفيرت	50
406.76	614	7.949	zero	0.75	primary	برقين اساسي	51
386.42	743.6	7.989	0.04	0.68	secondary	برقين ثانوي	52
427.1	878.2	7.877	0	0.68	primary	بنات فلسطين	53
223.6	458.9	7.693	0.63	0.4	secondary	طورة الغربية	54
467.7	879.1	7.598	0.21	0.68	secondary	بنات زبدة	55
341.6	727.1	8.103	0.15	0.63	secondary	ام الـــــدار والخلجان	56
380.3	789.2	7.879	0.03	1.65	primary	ظهر العبد	57
387	825.1	7.715	0.02	0.52	primary	يعبد اساسي	58
406.76	736.9	8.325	0.03	1.4	secondary	يعبد ثانوي	59