**Deanship of Graduate Studies**

**Al-Quds University**

# Measurement of Water Quality Indicators in Treated Drinking Water in Two Palestinian Refugee Camps

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**M. Sc. Thesis**

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# Measurement of Water Quality Indicators in Treated Drinking Water in Two Palestinian Refugee Camps


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Jerusalem - Palestine

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# Dedication

*To my parents and Partner in life, Khaled, for their continuous support*

## Declaration

I certify that the thesis is submitted for the degree of master is the results of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not submitted for a higher degree to any other university or institution.

Signature:

Name: Shatha Mohammad Abed Al Fatah Alazzeh

Date: 23/4/2018

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Many thanks to my lovely parents, Mohammad and Wafaa, who were always with me, and to all my family and friends. Special thanks to my dear husband, *Khaled*, who supported me all the way to be here today.

**Abstract**

This study investigated drinking water quality in two Palestinian refugee camps (Aida and Alazzah; Bethlehem, West Bank). Water samples (n = 720) were collected at three different sampling points along the water distribution line, including community tanks, network pipes and house taps, and analyzed for total coliform and *E. coli* bacteria and residual chlorine. Samples were collected over 16 months from March 2016 to June 2017. The results show that water from the community tanks, where water is delivered to the camps, were relatively free of bacterial contamination and had the highest residual chlorine concentrations. In contrast, water quality deteriorated downstream of the tanks in both camps. A total of 15/200 and 2/77samples of network-pipe water from Aida and Alazzah Camps, respectively, had elevated levels of total coliform bacteria, and a total of 51/281 and 7/100 samples collected inside homes in Aida and Alazzah Camps, respectively, had elevated levels of total coliform bacteria. E coli was detected in 2 samples from Aida Camp and 1 samples from Alazzah Camp The average residual chlorine was 0.02 mg/L, network pipe and tap water samples, which is significantly less than WHO recommendations (0.2 - 0.8mg/L). These results indicate that the water from the community tap was mostly clean. Conversely, the drinking water in the two camps is contaminated both in network pipes and water tanks. The concentration of residual chlorine is interlinked with water quality which decreases over the distance the water travels through the system. Thus, the water samples from the households farthest from the community tap were most contaminated by bacteria. The study recommended for

Bethlehem Water Authority to increase the chlorine in drinking water according to the international standards, and should work with UNRWA to restore and replace the water

pipe networks; also they should take action for regular water testing and share the results with the residents of the camps. NGOs that work across the camps can host workshops for the community to inform the residents about water safety and conservation. Moreover, future studies shall be conducted by responsible parts from Bethlehem water authority, UNRWA, and NGOs to better understand water quality in the camps.

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## List of Abbreviations and Units

| | |
|---|---|
| BWA | Bethlehem Water Authority |
| BCIG | Bromochloroindolyl-β-D-glucuronide |
| $Ca\ (OCl)_2$ | Calcium Hypochlorite |
| CBOs | Community Based Organizations |
| $Cl_2$ | Chlorine |
| DDW | Deionized Distilled Water |
| DPD | Diethyl-p-Phenyleneiamine |
| E.coli | Escherichia Coli |
| EPA | Environmental Protection Agency |
| FAC | Free Available Chlorine |
| HOCl | Hypochlorous Acid |
| NaOCl | Sodium Hypochlorite |
| $OCl^-$ | Hypochlorite |
| PWA | Palestinian Water Authority |
| UNRWA | United Nations Relief and Works Agency |
| TTC | Triphenyltetrazolium Chloride |
| USEPA | United States Environmental Protection Agency |
| UTIs | Urinary Tract Infections |
| WHO | World Health Organization |
| WSSS | Systems, Science and Society (WSSS) program at Tufts University |

**Unit**

| | |
|---|---|
| MCM | Million Cubic Meters |
| L | Liter |
| mg/L | Milligram Per Liter |
| Ml | Milliliter |
| Ppm | Parts Per Million |
| $Km^2$ | Square Kilometer |

# Chapter One

# Introduction

## 1.1 Background

The West Bank has one of the shortage water availabilities (per capita supply) in the world. The country's water scarcity is due to both natural and man-made constraints, mainly resulting from the Israeli occupation. For 70 years, Israeli occupation has denied Palestinians their water rights, including the right to equitable and reasonable utilisation of shared water resources. As a result, Palestinians suffer from lack of adequate water (ARIJ, 2011).The long conflict between Israel and Palestinians since 1948 until the present has revolved around the elementary bonds of people and territory. Water is the most important natural resource determining the relationship between populations and the land.

Following the 1967 War, Israel took full control of water resources and, together with a water supply network, developed wells throughout the West Bank linked to the Mekorot network to serve the settlements (Stork, 2016). Israel's expropriation of water resources within areas captured during the wars of 1948 and 1967 gave Israel full control of all Palestinian water and land resources, as well as the Golan Heights. Furthermore, the first stage of Israel's water development concentrated on tapping all available renewable groundwater reservoirs, including those on the West Bank extending into Israeli property (Birzeit Strategic Studies Forum, 2013).

In 1993 and 1995, Israel began peace talks with Palestine culminating in the Oslo Treaty, which addressed water regulation (The Birzeit Strategic Studies Forum, 2013). Despite the Oslo agreement's success in recognising Palestinian water rights, these rights have never been enacted. The agreement neglected to address the Palestinian water share in the Jordan River, as well as the shared Western and Northeastern aquifers of the West Bank Aquifer System. Moreover, it ignored the issue of equitable and reasonable allocation of the available water resources, and failed to account for future population increase. Consequentially, the water quantity allocated for Palestinians has not changed since 1995 (Khairand Abu Mohor, 2017).

The future needs were estimated at 70-80 million cubic meters (MCM) a year, but there was never an indication of future demands, thus hindering socio-economic development. Palestinians have access to roughly 20% of the estimated potential of the aquifers lying beneath the West Bank, while Israel overdraws on the estimated potential by more than 50% (World Bank, 2009).

In 2002 the Israeli government started to build the annexation and expansion wall along the Green Line inside the Palestinian occupied land of 1967. The Wall is 728 kilometres long and 8 meters high, situated on undeclared borders and thus penetrating Palestinian territory. The wall depletes land and natural resources. Overall, 85% of the water wells and resources in the West Bank are controlled by Israel (MAP, 2012).

Due to the lack of sufficient available water resources, the West Bank depends on water bought from Mekorot. Ironically, this is water that Israel takes from the rightful but denied Palestinian share, before selling it back to them. Around 35% of West Bank water comes from its own well resources, and the remaining 65% is purchased from Mekorot and managed by the Palestinian Water Authority (PWA, 2011). Due to unreliable water delivery, virtually every Palestinian house has several water tanks to store additional water. Comparatively, Israeli settlements have no need for water tanks because the water comes directly from the main sources to the tap (PCBS, 2015a).

This system has granted Israel further control over Palestinian access to water. With water demand increasing in the hot spring and summer months, supplies to Israeli settlements are privileged over Palestinian areas in the West Bank. Every year, water supply to Palestinian areas is cut off for days at a time. The water consumption of Palestinians in the West Bank is 70 litres per capita per day, compared to Israelis' 300 litters per capita per day. The World Health Organization (WHO) minimum standard per capita is 100 litres per day. Thus, the water consumption of Palestine is well below the WHO's minimum standard (PWA, 2014d).

In the West Bank, water quality is placed at risk by inadequate and intermittent water supplies. Supplies are often contaminated with heavy metals, toxic organic compounds and microbial pollutants. The problem is more significant in springs and water tanks (Bellisari, 1994). Furthermore, all the biological agents enter the groundwater from sewage seepage, fertilizers and leachate from solid wastes, which then can cause disease.

Studies show that more than one third of deaths in developing countries are caused by water-borne diseases (Jalal, 1998). While the chemical agents such as heavy metal accumulation which contaminates water can result in liver, kidney and brain damage (Bellisari, 1994).

## 1.2 Literature Review

According to a field assessment of health conditions in occupied Palestine (WHO, 2016), the water quality varies widely in the West Bank. Urgent concerns have arisen about the rising bacteriological and pesticide concentrations in the water supply, as well as the lack of resources for chemical analyses and water treatment. The Environmental Health Department of the Palestinian Ministry of Health reports that 15.75% of all water network samples failed bacteriological testing in 2015, and approximately 20% of hospital reservoirs and 20% of locally produced bottled water failed faecal coliform tests in the previous year (WHO, 2016).

The environmental situation is also affected by the unstable political situation, and the declining economic situation has led to a decline in the microbiological, physical and chemical water quality in Palestine. Al-Khatib and Eshkair (2018) discovered that the annual rate of chlorine usage in the districts of West Bank is 0.483 gram/capita which is an acceptable limit according to international standards. The study indicated that 22.2% and 12.5% of the tested water samples from wells in the West Bank for total coliform and faecal coliform bacteria, respectively, exceeded the Palestinian and WHO guideline limits. Therefore, action should be taken to better characterize this problem, including the development of a suitable inspection program on water sources, sample collection and testing. To begin improving water quality, consistent distribution of chlorine to all districts is essential, and wide public awareness campaigns for water disinfection should be conducted. An initiative to rehabilitate existing water networks, particularly in the main cities, and to create new networks in communities without them will significantly improve water quality (Al-Khatib I. et al., 2018).

Relatively few studies have been published on water quality in the West Bank. The only studies found in the literature that have evaluated water quality in Palestinian refugee camps, especially Aida and Alazzah camps were conducted by the Water: Systems, Science and Society (WSSS) program at Tufts University and Lajee Center in Aida refugee camp (WSSS , 2012). Both the Bethlehem Water Municipality and UNWRA refused to share their data about water quality in the region with this research group. In this context, this study is invaluable in offering open and available data about a vital issue.

The Middle East Monitor reported on a water problem in October 2017 in Al-Fawwar refugee camp, south of Hebron in the West Bank, where more than 300 people fell ill due to contaminated drinking water. Most of the people were infected with amoebae and bacteria after sewage water was mixed with drinking water in the camp. The responsible authorities were called, and they quickly acted to prevent a larger health epidemic due to damages to the drinking water pipes (The Middle East Monitor, 2017). Likewise, in 2009, Ma'an News reported that water contamination existed in Dheisheh (a refugee camp in Bethlehem), where drinking water and sewage were mixed due to poor quality water networks.

According to the US EPA National Primary Drinking Water Regulations (2017), faecal coliforms and *E. coli* are bacteria that indicate water may be contaminated with human or animal wastes, which often contain disease-causing microbes (pathogens). These wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens pose a special health risk for infants, young children and people with severely compromised immune systems (EPA, 2017). According to WHO (2002), the standard for coliform bacteria in drinking water is less than 1 coliform colony forming unit per 100 millilitres of sample(< 1/ 100mL).

WHO reported that disinfection such as chlorination reduces pathogenic microorganisms in the water to levels that satisfy public health standards. This prevents the transmission of disease such as typhoid, cholera and hepatitis. In general, free residual chlorine should be maintained at a concentration of 0.3-0.5 mg/L (Water Research Watershed Center, 2014).

### 1.3 Study Site and Research Motivation

This study was conducted in two Palestinian refugee camps in Bethlehem, Aida and Alazzah camps (Figure 1.1).Aida Camp is a Palestinian refugee camp located in the north of Bethlehem in the West Bank between the municipalities of Bethlehem, Beit Jala and Jerusalem. Aida camp is surrounded by the Annexation and Expansion Wall and six military watchtowers, and is near to HarHoma and Gilo, two large Israeli settlements that are illegal under international law. Aida Camp has an area of 0.71 square kilometres and a population of 5,800 registered refugees (Stopwall, 2018).After the Oslo Accords, the majority of Aida camp fell under Palestinian control (Area A), while some of its periphery (such as the main road running alongside the Annexation and Expansion Wall) fell under Israeli control (Area C). Aida camp faces severe overcrowding problems. Poor personal safety and denial of access to infrastructure are also cited by camp residents as among the most urgent challenges they face.

Alazzah camp is the smallest refugee camp in Bethlehem area in both size and population, covering only 0.02 square kilometres with a population of 1337 registered refugees (UNRWA, 2017). The United Nations Relief and Works Agency (UNRWA) established the Aida and Alazzah camps in 1950 (UNRWA, 2017). The camp has one main street, approximately two hundred and fifty metres long, that runs through the entire camp. In addition to the lack of services and overcrowding, Alazzah suffers from insufficient water and sanitation infrastructure.

The camp is located within the Bethlehem municipality and is close to the main checkpoint between Bethlehem and Jerusalem. As Aida camp is only ten minutes away by foot, the two camps are served by the same UNRWA camp services officer, sanitation foreman and social worker. There are no schools or active community-based organizations (CBOs) in Alazzah Camp. Residents instead use the institutions located in Aida camp. The houses in both camps are connected to public water and electricity infrastructure (UNRWA, 2017).

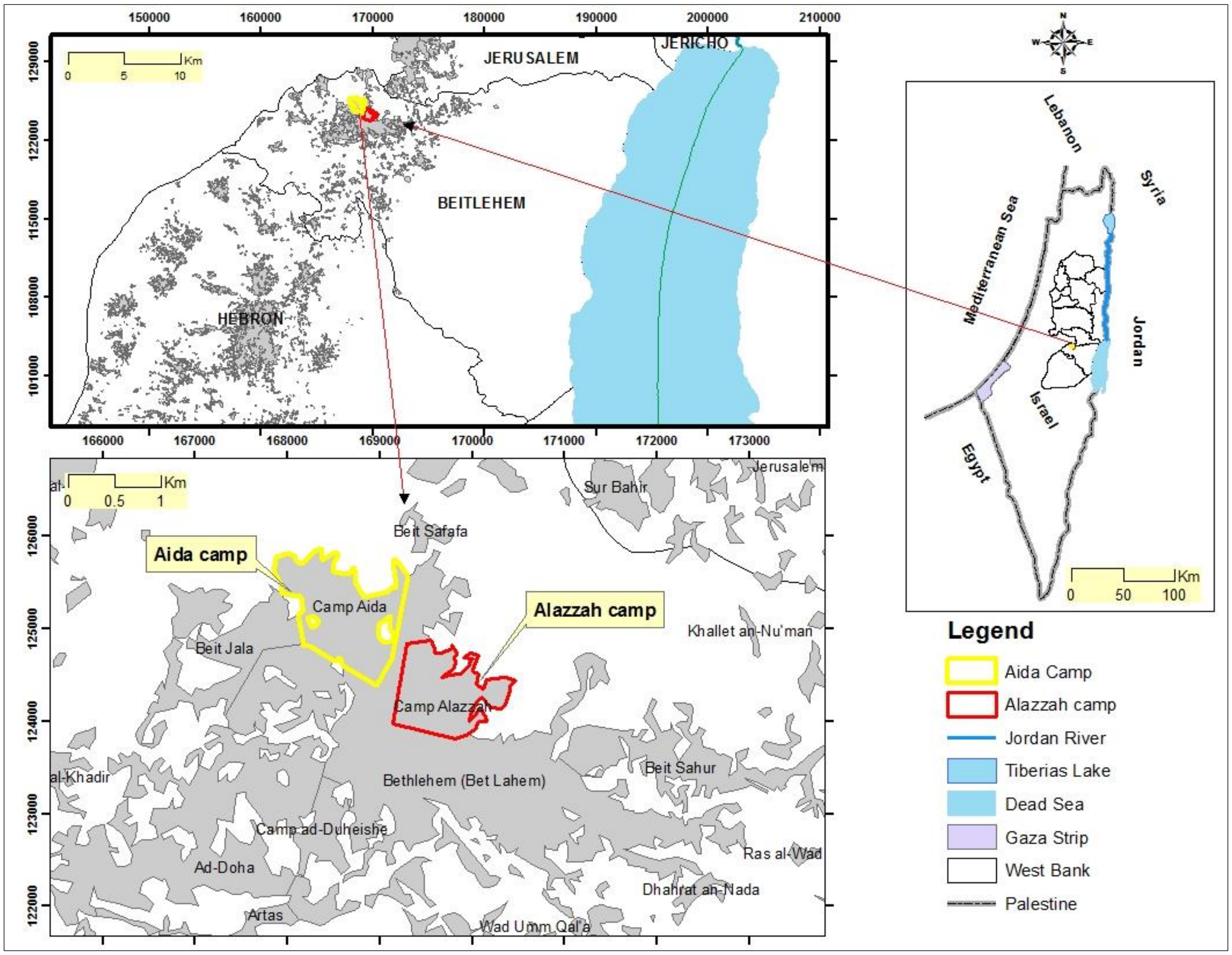


**Figure1.1**: Aida and Alazzah Camp, West Bank/Palestine (Study Area) (credit: Shatha Alazzah, 2018)

As with all refugee camps, Aida and Alazzah suffer from chronic water shortages, especially in the summer, when the water is cut off for two or three weeks between deliveries. Due to this fact, there are water tanks on every roof to store water (UNRWA, 2012). According to information provided by Bethlehem Water Authority, 9000 CM of water are delivered to Aida each month, meaning around 51 litres per capita per day. In comparison, 2500 CM of water are delivered to Alazzah each month, meaning that 62 litres per capita per day.

Aida and Alazzah camps are connected to the Bethlehem municipal water supply. However, the old, degraded water networks that were installed in the mid-1950s (UNRWA, 2012) are a major problem in the two camps. The camps sewer lines were installed in the mid-1990s, a process which damaged several branches of the water piping distribution network. (The sewage networks in Alazzah camp were changed in June 2017). The water and wastewater networks maps in Aida and Alazzah camps are included in Appendix A. When water is delivered to the camps, typically every two weeks, the community tank (Figure 1.2) is filled with water before it is pumped to households through the camp's piping network, which then distributes the water to the houses. Most houses have electric pumps that provide the necessary pressure from downstairs to the roof to fill the rooftop storage tanks. These tanks are then connected to the tap. Figure 1.3 shows the rooftops with water tanks in Aida camp. However, sometimes even with rooftop tanks, there is no water for basic daily necessities. When household water runs out, residents are forced to buy small amounts of bottled water, or in some cases to buy large amounts of expensive tanker water or collect water directly from the community tap (BWA, 2017).

**Figure 1.2:** Community water storage tanks in Alazzah Camp (left) and Aida Camp (right)(photo credit: Shatha Alazzah, 2017)

**Figure 1.3:** Rooftops with Water Tanks in the Aida Refugee Camp (photo credit: Shatha Alazzah, 2017)

## 1.4 Aim and Objectives

The main aim of this study was to investigate the quality of drinking water in two refugee camps (Aida and Alazzah) in the Bethlehem area.

Specific objectives were to:

1. Characterize the spatial and temporal distribution of *E.coli* and total coliform bacteria as well as residual chlorine in tap water samples collected throughout the two camps.

2. Identify the main factors that govern the variation of these water quality indicators.

3. Measuring the residual chlorine in order to assess its efficiency in disinfecting harmful bacteria. Furthermore, this research seeks to determine the pollution source.

# Chapter Two

## Coliform Bacteria, Health Effects and Prevention

### 2.1 Coliform Bacteria

The biological quality of drinking water is determined by tests for coliform bacteria. These organisms are found in the environment and feces of all warm-blooded animals including humans. They are also found in plant and soil material. Coliform bacteria are members of the Enterobacteria family, a group of pathogens that are defined as facultative anaerobic, non-sporulating, Gram-negative rods that can ferment lactose with the production of acid and gas when incubated at 35–37°C. Typical genera of coliform bacteria include: Citrobacter, Enterobacter, Hafnia, Klebsiella and Escherichia (DOH, 2016).

Coliform bacteria are unlikely to cause illness. Whilst they are not considered to be pathogens, their presence in water indicates potential pathogenic contamination. Because coliforms come from the same sources as pathogenic organisms, they also give a general indication of the sanitary condition of a water supply (Cabral, 2010).Most pathogens that can contaminate water supplies come from the feces of humans or animals. There are three groups of coliform bacteria. Each is an indicator of drinking water quality and each has a different level of risk. Total coliform is a combined collection of different kinds of bacteria, including bacteria found in the soil and water that has been exposed to warm-blooded animals waste or bacteria on the water surface or in contaminated water supplies. Faecal coliform are types of total coliform bacteria and they exist in the intestines and feces of humans and other animals, which are a more accurate indication of contamination than the total coliforms. *Escherichia coli* (*E. coli*) is a subgroup of faecal coliform, and is considered a better indicator of faecal pollution and the presence of human pathogens than either fecal or total coliforms. The Palestine Standards Institute, a branch of the International Organisation for Standardisation, established drinking water quality standards based on those of the WHO, which states that zero *E.coli* or other coliform colonies should be present in treated drinking water (WHO, 2001).

### 2.2 Health Effects and Prevention of Coliform Bacteria in Drinking Water

In many Palestinian urban areas, drinking water is a source of bacterial infection, mainly by pathogenic strains of coliform bacteria (Bellisari, 1994). Infections with certain coliform bacteria can result in illness. Diarrhoea is the most common result of a coliform bacterial infection, ranging from mild and watery to severe and bloody, and is responsible for an estimated two million deaths and four billion episodes of sickness worldwide each year (WHO, 2007). While *E.Coli* is a type of coliform bacterium known to cause gastrointestinal illnesses, the *E.coli O157:H7* strain produces a toxin called Shiga that can cause haemorrhagic diarrhoea and kidney failure (WHO, 2008). Also, *E.coli* can cause urinary tract infections (UTIs), primarily in women. These infections are especially common in pregnancy due to hormonal changes and physical pressure on the urinary tract. UTIs are generally treatable with antibiotics, although the number of antibiotic-resistant strains of *E. coli* is growing (Greenwood, 2012).

Pathogenic faecal coliforms in water supplies can cause gastroenteritis, characterized by vomiting, abdominal pain, fever, and diarrhea, all general symptoms of gastroenteritis, but especially common with salmonella infection. Moreover, some strains of salmonella cause typhoid fever, which is a systemic disease characterized by flu-like symptoms: headaches, abdominal tenderness, dry coughing, loss of appetite, rash, and fever.

The prevention methods for bacterial infections include boiling water in order to kill the microorganisms (and using the boiled water within 24 hours), chemical disinfection (chlorine tablets), regular cleaning of water tanks and the replacement old ones, bottled water, filtration, and changing old network pipes (WSSS, 2012).

### 2.3 Residual Chlorine in Water

Chlorine was discovered in 1774 by the chemist Karl Scheele (White, 1986). Chlorine is effective for the treatment of bacteria, viruses, and some protozoa when dissolved and mixed in water. Therefore, chlorine ensures that clean water reaches the tap, whereas other disinfection methods such as ozone, UV light and ultra-filtration are unable to prevent the regrowth of biological contaminants (Wijk, 2002; Gray, 2002).

Hypochlorous acid (HOCl) and hypochlorite ion ($OCl^-$) are suitable to protect water against infective agents from the point of chlorination to the point of use (HACH, 2015). Although the main objective is to disinfect water for necessary health reasons, the water source should also meet aesthetic criteria, including appearance, taste, and odour. It is important to add sufficient chlorine to water to meet the chlorine demand and provide residual disinfection. The most commonly used disinfectant is chlorine due to its low cost, high germicidal potency and the ability to maintain residuals (WHO, 2004).

During the treatment process, chlorine is added to drinking water as elemental chlorine $Cl_2$(g), sodium hypochlorite (NaOCl), which is available as a liquid, or calcium hypochlorite ($Ca(OCl)_2$) in the solid form. Regardless of the form of chlorine, it will react with water and produce hypochlorous acid (HOCl), and hypochlorite ($OCl^-$). The mixture of both HOCl and $OCl^-$ is considered free chlorine residual and referred to as Free Available Chlorine (FAC). The proportion of the two species (HOCl and $OCl^-$) is pH dependent (Deborade and Gunten, 2008).

The chlorine gas reacts with water producing HOCl and $OCl^-$according to equations (1) and (2) (White, 1999; Deborade and Gunten, 2008).

$$Cl_2 + H_2O \leftrightarrow HOCl + H^+ + Cl^- \quad (1)$$

$$HOCl \leftrightarrow OCl^- + H^+ \quad (2)$$

$$OCl^- + H^+ \leftrightarrow HOCl \quad (3)$$

The concentration of free available chlorine decreases for different reason as treated water moves through the water supply system. The contact time, from when chlorine is first added and reacts with any impurities in the water, until the moment in which the water is used or consumed, are the most important factors. Clearly, such a period is decreased by the time water spends in the supply system. FAC is dependent on the pH level of the water prior to addition of chlorine. At lower pH levels, the hypochlorous acid will dominate (Razieh S.et al., 2014).

Another factor affecting the concentration of FAC is constituted by the chlorine-impurity reactions. When impurities in water react with chlorine, including dissolved iron, hydrogen sulphide, bromine, ammonia, nitrogen dioxide, and organic material, it will first react with inorganic impurities (dissolved iron, bromine, ammonia, etc.) before reacting with the organic compounds (dissolved organic material, bacteria, viruses, etc) (Hancock, 2017).

FAC decreases when reacting with the pipe material itself. Especially, if the pipes are older than 55 years, the reactions with both the biofilm and tubercles formed on the pipe wall are known as pipe wall demand, which decreases the concentration of FAC when reacting with it (Muslim, 2007).

Additionally, as iron tanks corrode from the bottom, rust is produced and gives water an undesirable metallic taste. Moreover, iron is one of the inorganic compounds that react with hypochlorous acid and, as a consequence, dissolved iron will change from a soluble state to an insoluble one. At this point, a precipitate is formed as a result of the reaction as shown in equation (4) (Hancock, 2017).

$2\ Fe_2+ \text{(liquid)} + HOCl + 5H2O \rightarrow 2\ Fe(OH)_3 \text{(solid)} + 5H+ + Cl^-$

Then, Ammonia is a compound that may exist in the water from human activities including municipal wastewater treatment plants, agricultural releases, and industrial releases, such as pulp and paper mills, mines, food processing, and fertilizer production. Reactions between ammonia and FAC will decrease its concentration (Hancock, 2017).

Chlorine is the most common chemical used for disinfection of drinking water (Lenntech, 2017). The effectiveness of chlorine is based on the chemical's ability to inactivate most pathogens that cause waterborne diseases (CDC, 2008). Because of that, it is important to add sufficient chlorine to the water to provide residual disinfection. Bethlehem Water Authority has to follow specific water quality standards, including those addressing bacterial growth and residual chlorine. That is why they chlorinate the water to guarantee a range of 0.5 – 0.8 mg/L. Chlorine in the water before it is delivered to the camps. **Appendix E** includes the history of chlorine from PWA in Bethlehem reservoirs from March 2016 to May 2017. Therefore, the water entering the camps should be free of bacterial contaminants (WHO, 2006). While **Appendix F** includes general chemical analysis of Bethlehem water wells in 2016 and 2017.

## Chapter Three

## Materials and Methods

### 3.1 Water Distribution Systems in Aida and Alazzah Refugee Camps

This study was carried out in two Palestinian refugee camps in Bethlehem area, Aida and Alazzah camps. Water samples were obtained at three different points: the community tank (the main source), the distribution system prior to entering houses and in-house taps, as shown in Figure 3.1.

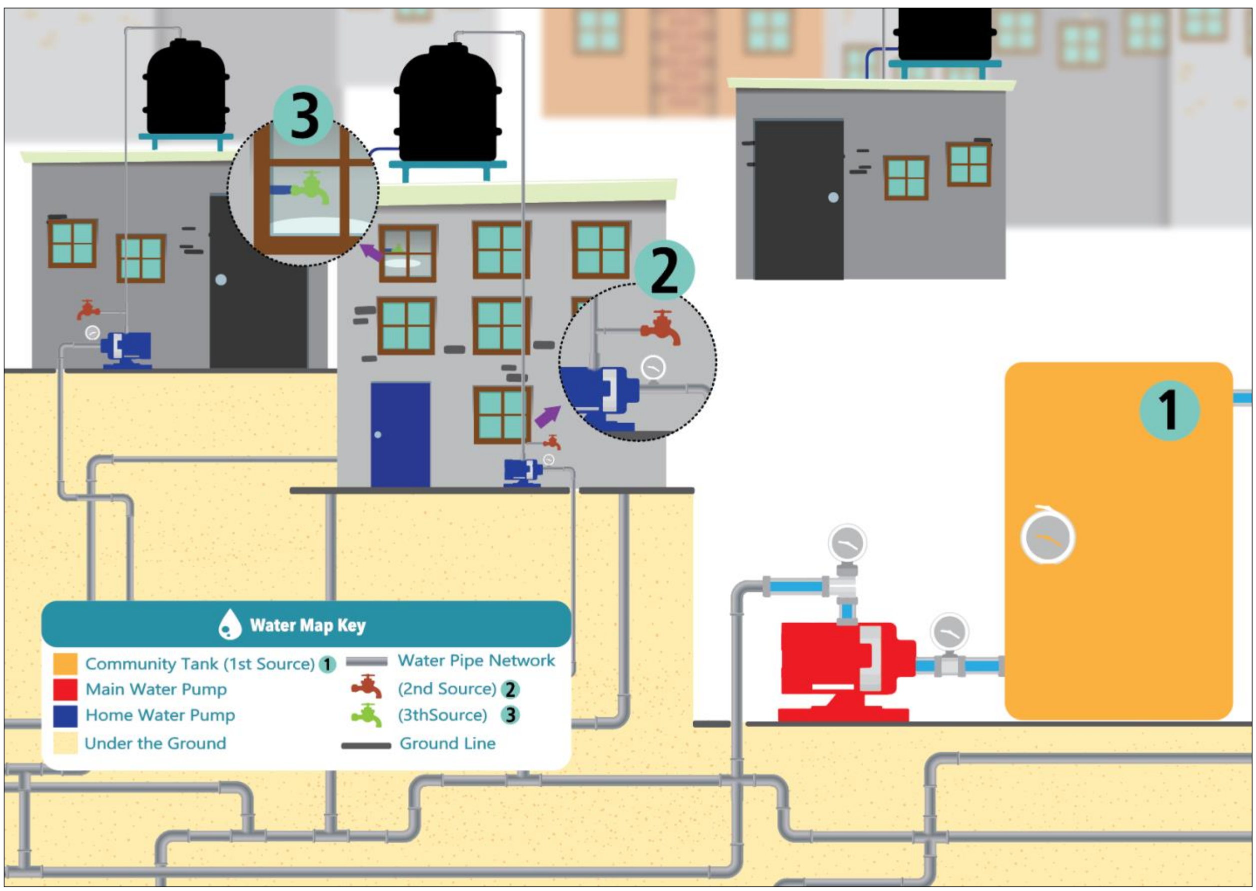


**Figure 3.1:** The locations where water samples were collected in the water distribution system (Credit: Shatha Alazzah).

The water is delivered through piping networks from the Bethlehem Water Authority to the main water tanks in the camp before it is pumped to households through the camp's distribution network. Testing this supply determines if the water that arrives in the camps is contaminated. The second source is the water tap from the water pipe networks. These samples were collected before the water was delivered to the water tanks by the electric pumps. Testing this determines if the water pipe network is contaminated. The third source is from the kitchen/bathroom/entryway taps from houses in the camps. Testing this determines if the water is contaminated in the housing tanks.

No maps of the camps were available from either UNRWA or from Bethlehem Municipality, but with the help of cartographer volunteers, maps for the camps were prepared (**Appendix B and C)**.

### 3.2 Sampling

The households were selected according to an Excel spreadsheet program that selects random house numbers in the camp. Water samples (n = 720) were collected and tested, 520 and 200 water samples from Aida and Alazzah respectively. From these selected houses, water samples were collected. Each collection bottle (125 mL) was triple cleaned in the lab, first with chlorinated water, and twice with deionised and distilled water (DDW). To disinfect the water tap from pathogens, it was heated by direct flame for ten seconds, and then ran the tap for five seconds before collecting the sample. Information sheet of samples includes (Sample date, sample number, collection source, house number, floor number, household name, contact phone number, and days since last water delivery) **Appendix D**.

### 3.3 Microbiological Culture

The samples were brought immediately to the lab no later than 3 hours after collection. In the lab, the samples were filtered using a hand-operated (manual) vacuum filtration apparatus, and each filter (0.45 micron pore size membrane filter) was placed in a petri dish with growth media (2 mL of m-ColiBlue24. The content of the m-ColiBlue24 includes a non-selective dye, TTC (2, 3, 5-triphenyltetrazolium chloride). A blue colour is formed as a result of the enzymatic cleavage of the substrate. The plated bacteria were incubated at 35 ºC for 22±2 hours. This period allows the bacteria to grow to the extent that colonies are visible to the naked eye. After incubation, the petri dishes were examined for coliform colonies. Blue spots indicate the presence of *E. coli* colonies; glossy red spots indicate other coliforms. Total coliforms were calculated by adding together the number of blue and red colonies. While other coliforms are not necessarily harmful on their own, they are known as "indicator bacteria," which appear in water that has been subject to some type of bacterial contamination (HACH, 2016). The positive control, which was taken from sewage water, was used to ensure that coliform bacteria will grow in the media under the incubation conditions if bacteria are present, whilst the negative control was taken from unopened bottles of drinking water, which is used to ensure that bacteria are not present in the materials used to prepare the samples for placement on petri dishes ("plating"). A negative control and a positive control were performed before every day's collection

**Figure 3.2:** Water Sample Bottles and Laboratory Equipment

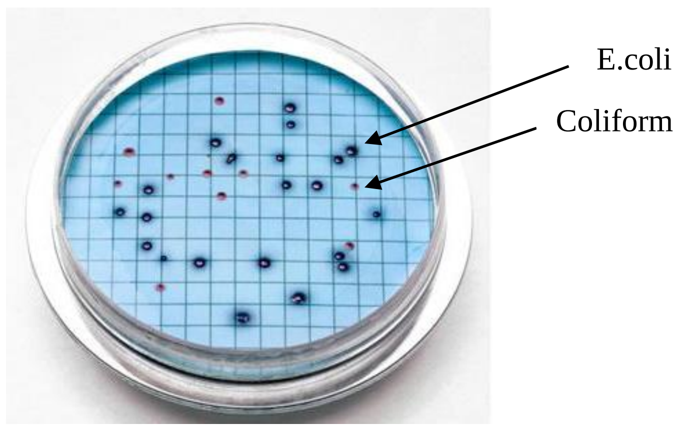


**Figure 3.3:** Coliform Colonies

### 3.5 Residual Chlorine Testing

The same water samples that were tested for bacteria were also tested for residual chlorine, by means of a portable spectrophotometer and methods describe by HAHC (2016).

Chlorine residual was measured in glass colorimeter tubes. The tubes were first triple-rinsed with water from the tap being tested, and then filled to the 10-mL line with sample water. The outside of the tube is cleaned by wiping to ensure no potentially contaminated fingerprints are left. The tube is then inserted into the colorimeter chamber, followed by pressing the ZERO button, which is held for 2 seconds until *bLA* is displayed on the screen. Then the tube is removed from the colorimeter chamber, one DPD #1 IG reagent tablet is added into the water sample (without touching the reagent), and the lid is closed. The tube is shaken for 20-30 seconds, until the reagent has been dissolved. The tube is rotated slowly five times. Consequently, through this reaction, the free available chlorine reacts with the buffered diethyl-p-phenylenediamine indicator (DPD) to produce a red colour in proportion to the amount of chlorine present DPD + residual chlorine → red colour (HACH, 2016). Then the tube is inserted into the colorimeter chamber, the lid is closed, and the READ button is pressed. The chlorine residual in mg/L will be displayed within two seconds. Lastly, the results are recorded in a data log.The range that the device can measure is 0 – 4.00 mg/L with a detection limit of 0.05 mg/L, which is the minimum concentration that can be measured with 99% confidence by the device (Lamotte, 2011).

### 3.6 Quality Assurance

Water samples were collected in sterilised bottles that were rinsed three times, first by chlorinated water, then by DDW water and finally by the same source being collected. After collection, the samples were analysed directly within one hour, and after 24 hours the samples were directly removed from the incubator. Positive and negative controls were used for quality assurance; the positive control was from sewage water while the negative control was the bottled water. The media of coliform bacteria were kept refrigerated. Two samples were collected from the same source to ensure greater accuracy.

The residual chlorine was measured directly onsite, and the external calibration was performed with different residual chlorine concentrations (0.0, 0.02, 0.05, 0.1 0, 2, 0.5 mg/L) before each test.

# Chapter Four

# Results and Discussion

## 4.1 Microbial Water Quality Results from Aida and Alazzah Camps

A total of 720 water samples (n = 720) were collected from Aida and Alazzah refugee camps at three different sampling points  including community tanks and taps outside and inside houses. Samples were collected over the course of 16 months, from March 2016 to June 2017. A comparison between the main characteristics of Aida and Alazzah camps are presented in Table 4.1.

**Table 4.1:** Comparison between the Main Characteristics of Aida and Alazzah Camps

| Characteristics | Aida Camp | Alazzah Camp |
|---|---|---|
| Area | 0.71km$^2$ | 0.02 km$^2$ |
| Population | 5800 | 1337 |
| Total samples | 520 | 200 |
| Samples contaminated with coliform | 66 | 9 |
| Samples contaminated with *E.coli* | 2 | 1 |
| Percent contaminated samples | 13% | 5% |

A total of 520 water samples (n = 520) were collected from Aida camp between May 2016 and June 2017, and 66 of these samples tested positive for total coliforms while two tested positive for *E. coli*. Positive samples indicate that one or more colonies were found. A total of 200 water samples (n = 200) were collected from Alazzah camp between March 2016 and June 2017. Nineof these samples tested positive for total coliforms while one tested positive for *E. coli*. A summary of the samples collected in Aida and Alazzah camps is presented in Tables 4.2 and 4.3.  In Aida camp, 87% of the total water samples exhibited clean water, meaning a total of 452water samples from 520 were not contaminated. In Alazzah camp, 95% of the total water samples showed clean water, meaning a total of 190 water samples from 200 were not contaminated.

**Table4.2:** Microbial Quality of Water Samples for Aida Camp

| Sample Date | Number of samples | Number of samples with colonies | |
|---|---|---|---|
| | | **E.coli** | **Total coliform** |
| May - December 2016 | 240 | 1 | 41 |
| January – June 2017 | 280 | 1 | 25 |
| **Total** | 520 | 2 | 66 |

**Table4.3:** Microbial Quality of Water Samples for Alazzah Camp

| Sample Date | Number of samples | Number of samples with colonies | |
|---|---|---|---|
| | | **E.coli** | **Total coliform** |
| March- December/ 2016 | 100 | 1 | 6 |
| January - June/ 2017 | 100 | 0 | 3 |
| **Total** | 200 | 1 | 9 |

The water samples were collected during different periods of the year in both camps, and on different dayssince the last water delivery to the water tanks as reported by the residents.The sample profiles in terms of water delivery in Aida and Alazzah Campsare shown in Figure4.3. It shows that 21% of the water samples (n = 154) were collected on the same day that the water was delivered to the water tanks from the community tank, while 16% (n = 118) of the samples were collected one day after the water was delivered to the camp. A total of 97 water samples (13%) were collected five days after the water was delivered to the water tanks. Four water samples (n = 4) 0.6% were collected during the ninth day after the water was delivered to the camp.

The water samples were collected randomly, so although most of the water samples were collected on the same day the water was delivered to the camp, it does not mean that the camp gets water most of the days. In fact, the camps usually receive water around three times a month in the summer time and four times a month in the winter. Another observation is that although less than 1% of the samples were collected eight days after the water was delivered to the camps, 75% of those were contaminated compared to only 4% of the samples collected on the same day the water was delivered to the camps. The percentages of the positive results are shown in Figure 4.2.

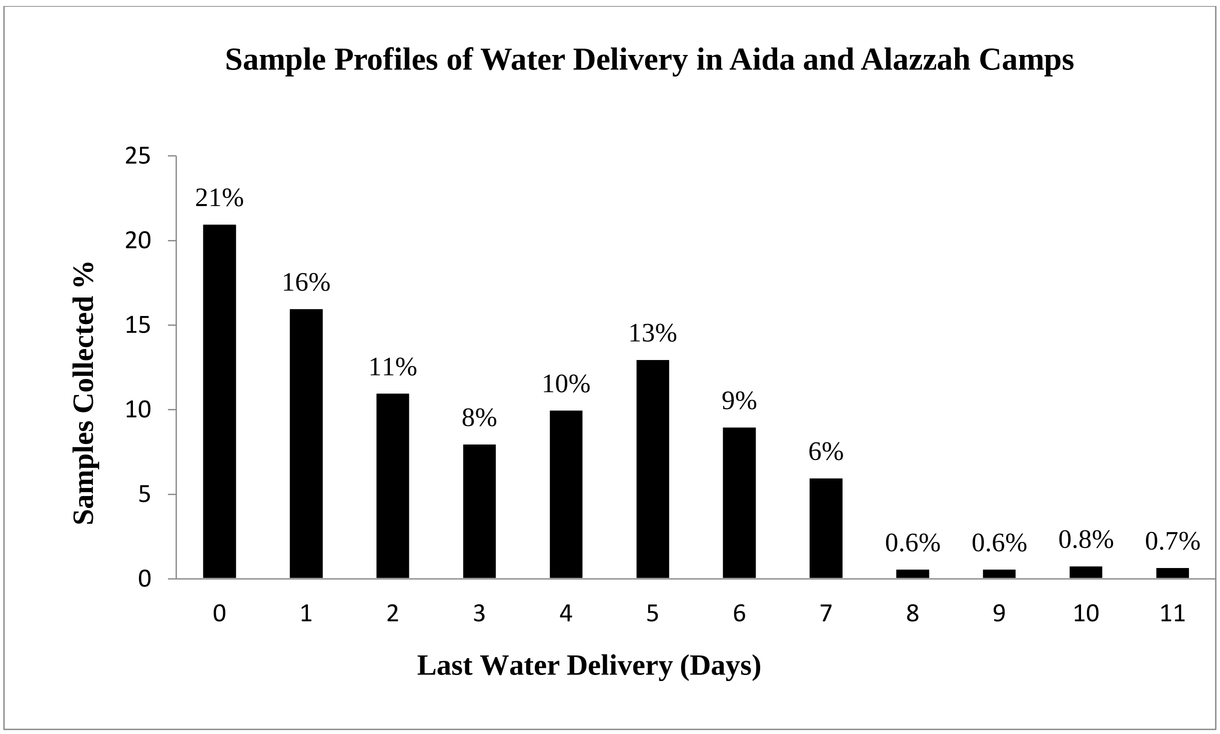


**Figure 4.1:** Percent of water samples collected since the last water delivery to Aida and Alazzah Camps

The results suggest that the water quality is affected by the frequency of water deliveries to the camps. The results in Figure 4.4 indicate that the water is contaminated by coliform and *E.coli* bacteria when there are water shortages for more than one week in the camps. Consequently, the potential for bacterial proliferation in the water tanks increases.The percentage of samples that tested positive for total coliforms was100% when the water was not delivered to the camp for 9 days, and 17% when water was not delivered to the camp for one week .By comparison, only 4% of water samples tested positive when the samples were collected on the same day the water was delivered to the tanks.

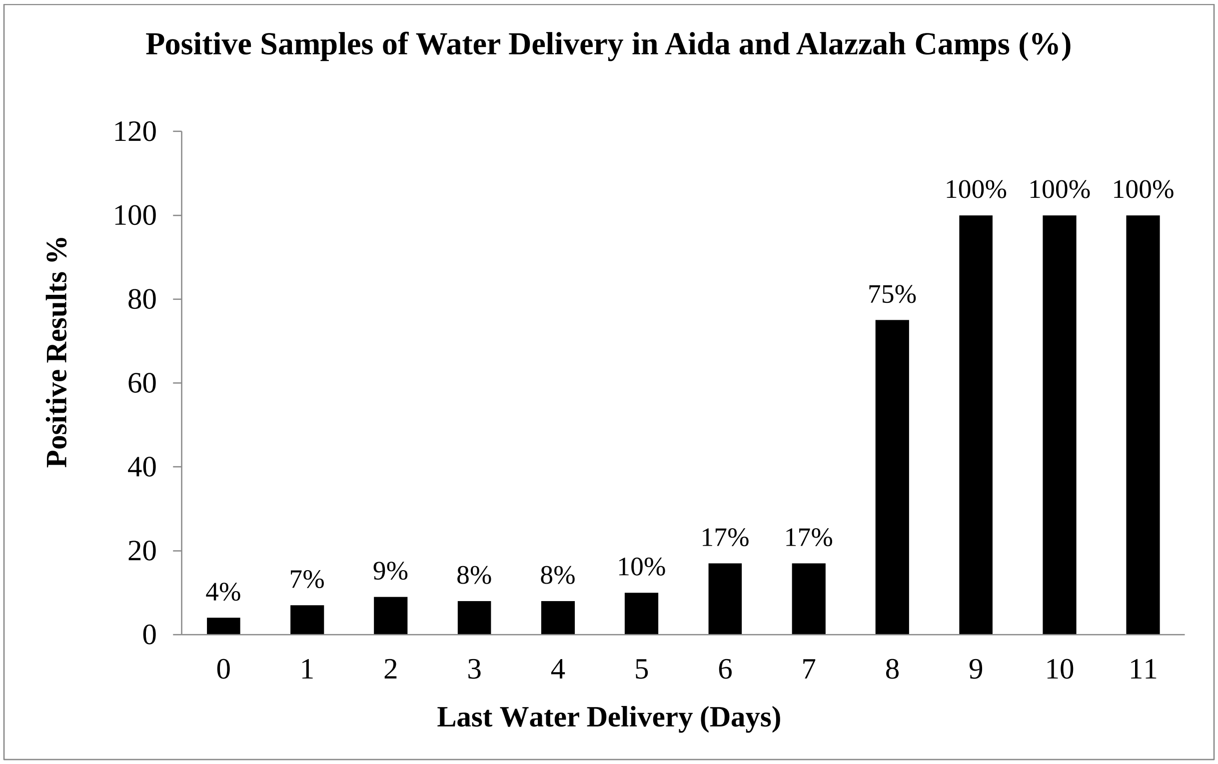


**Figure 4.2**: The Percentage of water samples that test positive as a function of days since the last water delivery to Aida and Alazzah Camps

**Table 4.4:** Samples profiles and percentages of positive samples in terms of water delivery in both camps

| **Last Day Delivery (Day)** | **No. of Collected Samples** | **% of Collected Samples** | **No. of contaminated samples** | **% of contaminated Samples** |
|---|---|---|---|---|
| 0 | 154 | 21.39 | 6 | 4 |
| 1 | 118 | 16.39 | 8 | 7 |
| 2 | 82 | 11.39 | 7 | 9 |
| 3 | 61 | 8.47 | 5 | 8 |
| 4 | 75 | 10.43 | 6 | 8 |
| 5 | 97 | 13.47 | 10 | 10 |
| 6 | 68 | 9.44 | 12 | 17 |
| 7 | 46 | 6.39 | 8 | 17 |
| 8 | 4 | 0.56 | 3 | 75 |
| 9 | 4 | 0.55 | 4 | 100 |
| 10 | 6 | 0.83 | 6 | 100 |
| 11 | 5 | 0.69 | 5 | 100 |
| **Total** | N= 720 | | N= 80 | |

The water quality data also demonstrated how the bacterial contamination in the water changes with the season. The results showed different frequencies of total numbers of coliforms in the water by season, as shown in Figure 4.3. The total number of coliforms was higher during the hot season than during the cold season. 90% of the contaminated samples from Aida were collected during the hot season, while only 10% of the contaminated samples were collected during the cold season. In Alazzah camp, 100% of the contaminated samples were collected during the hot season. This suggests that the results depend on the availability of the water in the camp, which affects the bacterial contamination of the water. During the hot months, the frequency of water is a delivery to the camps is lower compared to the cold months. If the camps get water with less frequency, the water tanks and water pipe networks also receive less water. Consequently, the frequency of water contamination with bacteria tends to be higher in the hot months likely because water sits in the tanks for longer periods (as residents try to conserve water between deliveries) and there is greater loss of chlorine residual.

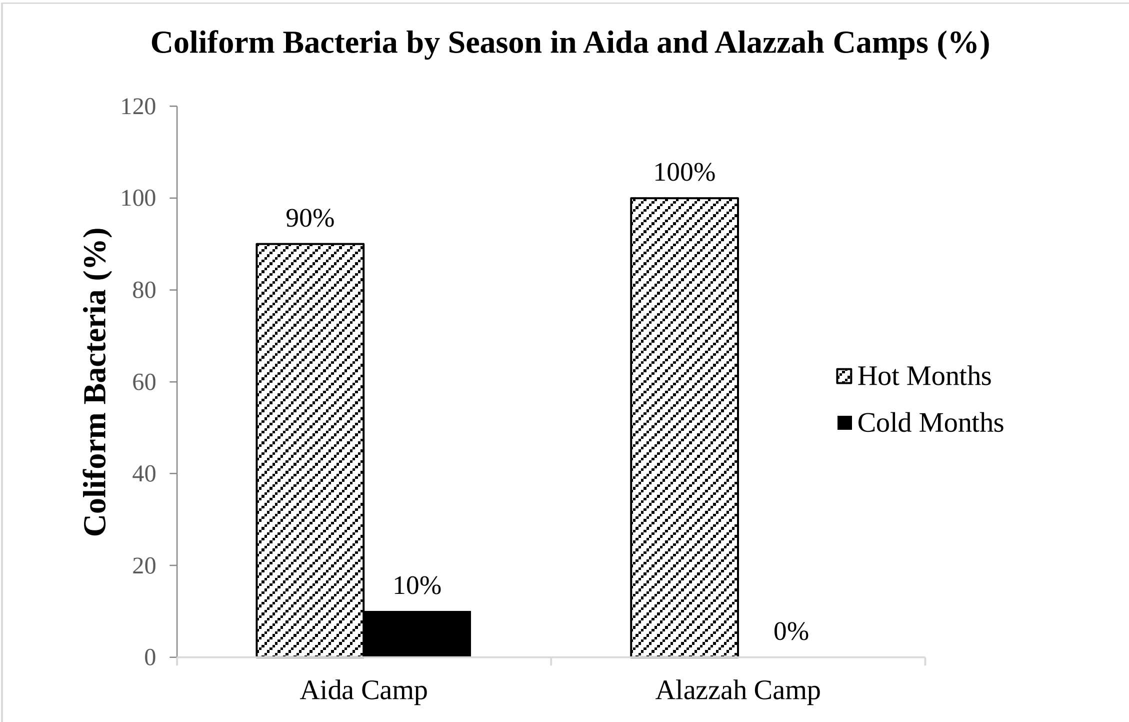


**Figure 4.3:** Frequency of coliform bacteria in water samples by season in both camps. The hot season extends from April – September; the cold season extends from October to March.

## 4.2 Microbial Water Quality Results in Aida Camp

### 4.2.1Community Tank

The results of the water quality from the main source (community tank) in Aida camp in Table 4.5 show that two out of 39 samples were contaminated with coliform bacteria (n=2). This means that 2.5% of total water samples from the community tank were contaminated by coliform bacteria during hot season in June 2017, during the lengthy water shortages.

**Table 4.5:** Data collection from the three water sources in Aida camp

| Source | Water Samples | Contaminated Samples |
|---|---|---|
| Community Tank | 39 | 2 |
| Water Pipe Networks | 200 | 15 |
| Water Tanks (Tap Water) | 281 | 51 |
| Total | N = 520 | N = 70 |

### 4.2.2 Pipe Networks

The second source (the water tap from the water pipe networks) shows that 7.5% (n = 15) of the water from network pipes was contaminated (Table 4.5). The cause of this problem is likely the condition of the water pipe networks, which are old and degrading, promoting contamination. Also, a few residents dig underground to reach the water networks and connect them directly to their houses in order to avoid shortages. Yet, doing this can break the sewage pipe network, which leads to the contamination of the clean water by the sewage water. (**Appendix B** includes the maps of water and sewage networks in both camps). This is exactly what happened in Aida camp in June 2015when drinking water at 10 homes became contaminated with high numbers of bacteria in one area of the camp. The cause was the broken water networks, located near the poor sewage networks, which led to the contamination of the water lines by the sewage water. The contaminated water was discovered when the water from the cistern of a house was tested, showing that sewage had leaked into the cistern. The water was then tested from the surrounding area by UNRWA, and was shown to be contaminated by bacteria. Consequentially, UNRWA replaced the lines of the sewage network with a new line.

Afterwards, the water was tested from the same area and all the results were negative for bacteria.

The results in Figure 4.4 show the percentage of pipe-network water samples contaminated with coliform bacteria. The water pipe networks show a very low presence of coliform bacteria 7.5% in comparison to the tap water 18%. This demonstrates that the water arrived in the camp relatively free from coliform bacteria. Therefore, the problem of the contamination of water originates in part from the water networks but with the majority caused by contamination in the water tanks within the camps. All the samples of positive results were during summer (dry season) between May and August. The results show 33.3% (n = 5) of water samples tested positive in August, while only 13% (n = 2) of water samples tested positive results in July.

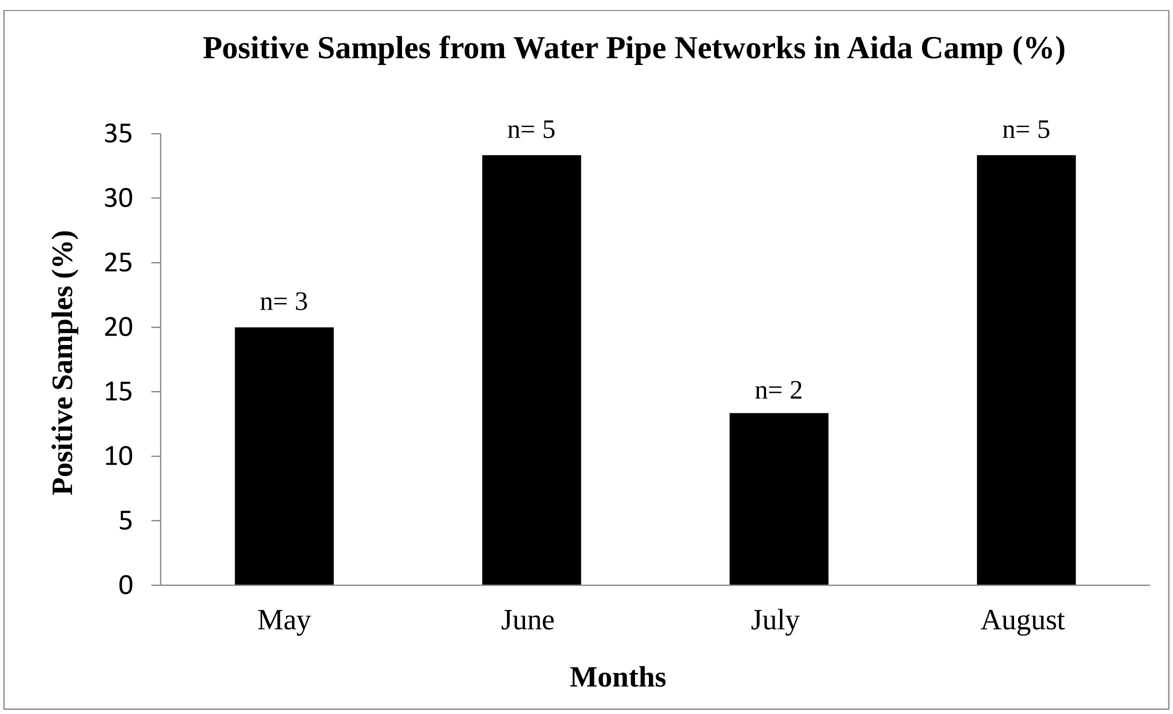


**Figure 4.4:** Percentage of pipe water samples contaminated with bacteria in Aida Camp (n = 15 samples).

### 4.2.3 Rooftop Water Tanks

The results show 51 water samples (n = 51) were contaminated with bacteria, which means 18% of the rooftop-tank-water samples in Aida camp were contaminated (Table 4.4). Regarding the results of contaminated water from the water tanks (tap water)as shown in Figure 4.5, it is may not always be due to lack of water quantity, but rather other factors, such as lack of cleanliness in the water tanks in the camp. Sometimes it is dangerous for the residents to the clean the water tanks, especially if they have many tanks on their small roof; here the results show16 water samples were positive likely because the tanks were not properly cleaned. Another factor is that some families leave tanks open, and the results show 11 water samples were contaminated by bacteria in this case. There was one incident in Aida camp when there was a dead dove and a lot of tadpoles in the water tank, which were the likely source of bacterial contamination. The members of the household had symptoms such as diarrhoea, abdominal pain, fever, and vomiting. The family was notified of the water pollution. They then took action to clean the water tanks and added chlorine tablets into the water tanks. After this, the water was tested again and the result was negative. Another factor that affects the quality of the tap water is that pieces of cloth are sometimes put over the tap, which is done due to the belief that it is a procedure to keeps the water clean as a kind of water filtration; however, the cloth filters can be a source of bacteria to the water. The results show that 8 households that used cloth filters on their taps had contaminated water. The results of water quality in Aida camp have indicated that water availability and quantity are associated with the location of the houses in relation to the distance between them and the community tap. The homes at higher elevations in the camp were the last to receive water when it flowed from the primary source (community tap). Because of this, these homes experienced longer shortages and possibly worse water quality problems. The results show 34% (n = 18) of water samples were contaminated by bacteria when there were water shortages for more than one week in water tanks, which causes water contamination from the small amount of water lying on the bottom of the tank without replenishment from pipes. Therefore, the longer the period of water shortage, the higher the rate of water contamination.

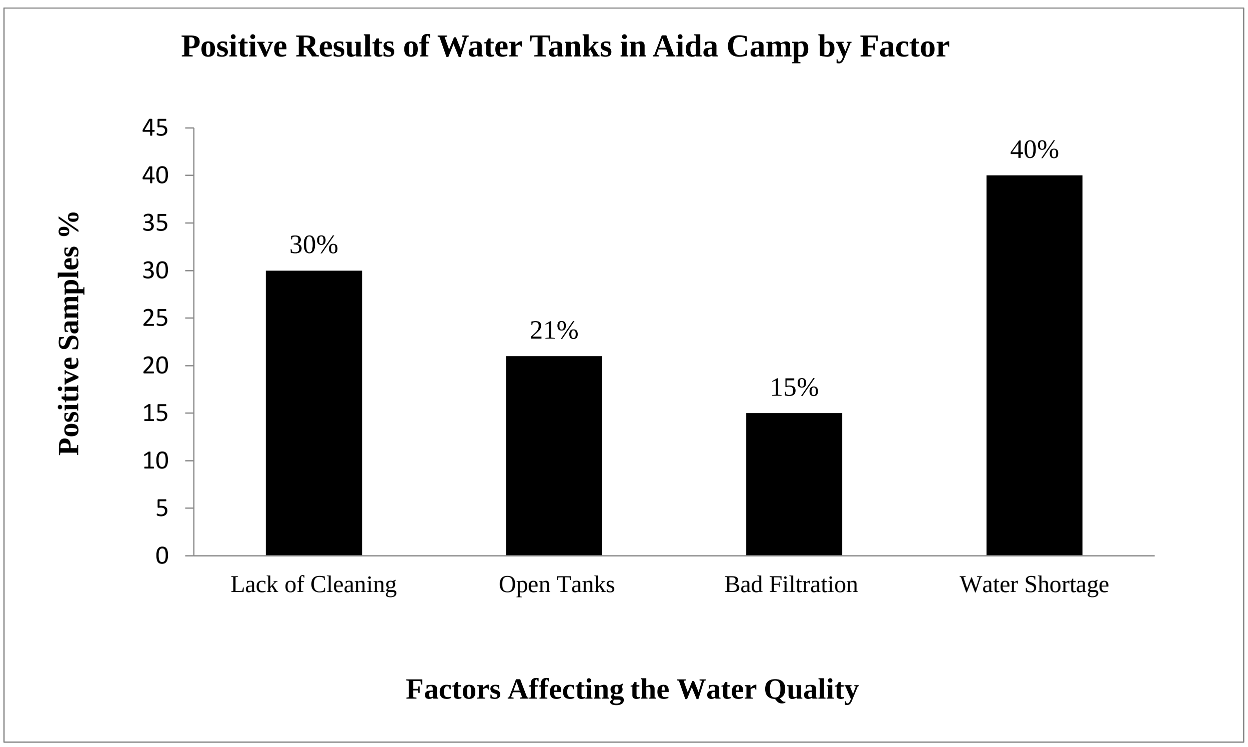


**Figure 4.5:** Percentage of Positive Samples in Water Tanks of Aida Camp Based on Different Factors

### 4.3 Microbial Water Quality Results in Alazzah Camp

#### 4.3.1 Community Tank

Alazzah camp has a different geographical location than Aida camp. The camp receives water from alternate water sources in the area besides the community tank. These additional sources mean there is a higher water quantity (BWH, 2017). The summary of data collection from three sources- the community tank, water pipe networks, and water tanks - is presented in Table 4.6. The results of the water quality from the main source (community tank) in Alazzah camp show that only one water sample out of 23 samples was contaminated by coliform bacteria.

However, there are differences in the elevations between Aida and Alazzah camps. In Aida camp, the first houses of the camp, near the community tap, have water before others, while the farthest houses are the last to receive water. Because of this, the water pumps are needed in order to push water up the hill. On the other hand, the topography in Alazzah camp, as shown in figure 4.8, is a slight downward slope. Because of that, most homes are likely to be at a lower elevation than the community tap, possibly making the pumping of water into household storage tanks faster, which means that most or all of the camp is able to fill their tanks from the primary source when the water is available.

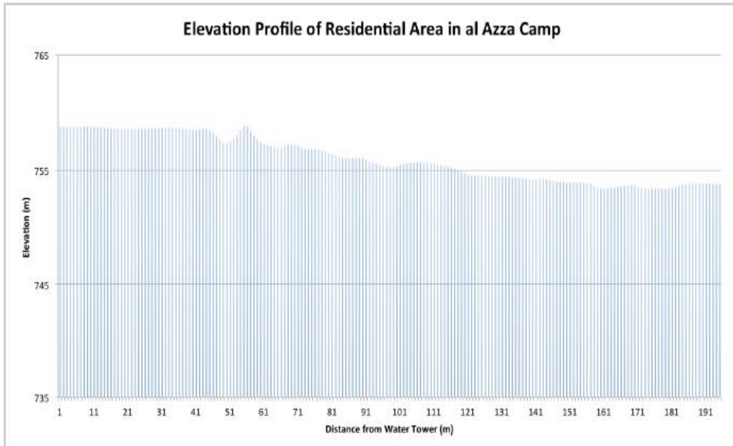


**Figure 4.8:** The elevation down the main road (line) in Alazzah Camp has a grade of about 3% from north to south (WSSS, 2016).

**Table 4.6:** Data collection from the three sources in Alazzah

| Source | Water Samples | Contaminated Samples |
|---|---|---|
| Community Tank | 23 | 1 |
| Water Pipe networks | 77 | 2 |
| Water Tanks (Tap Water) | 100 | 7 |
| Total | 200 | 10 |

### 4.3.2 Water Pipe Networks

The results suggest that bacterial contamination of drinking water from water pipe networks are not a widespread problem in Alazzah camp. The results of water pipe networks show a very low presence of coliform bacteria (n = 2) 2.6% from the total 77samples. One possible cause of lower percentages of water contamination from the pipe networks compared to Aida isthe location of Alazzah,as it is in the middle of the city (the water is delivered from the Bethlehem Water Authority and Bethlehem Municipality), and there are several branches of water piping along the camp from many sources. Moreover, the sewage networks in Alazzah camp were changed in June 2017.

### 4.3.3 Rooftop Water Tanks

The results show that water samples from seven rooftop tanks in Alazzah camp (7%) were contaminated with bacteria. Regarding the results of contamination from the water tanks (tap water), all occurred during the hot season. The source of contamination is likely due to several factors, the first being the lack of cleanliness in the water tanks, and another factor being that some families leave their water tanks open. Also, the relatively low percentages of residual chlorine affect the water quality in the camp (see section 4.4).

## 4.4 Spatial and Temporal Distribution of Residual Chlorine in Aida and Alazzah camps

Measuring the residual chlorine in a water supply is a simple but important method of checking that the water that is being delivered is safe to drink. The results in Figure 4.9 show inadequate levels of residual chlorine in the water. Only a few results showed adequate levels of residual chlorine from the community tap as shown in figure 4.9. The average concentration of free residual chlorine at the beginning of water distribution line is 0.03 mg/l, and some samples of the households have high levels of residual chlorine in both camps, especially when located near the main source. Figure 4.9 shows different concentrations in different areas according to the distance from the main source. The average value of the residual chlorine in both camps is 0.02mg/L. According to the WHO free residual chlorine should not be ≥0.2 mg/L and is preferably ≤0.8 mg/L in water at the consumers' homes (WHO, 2006).

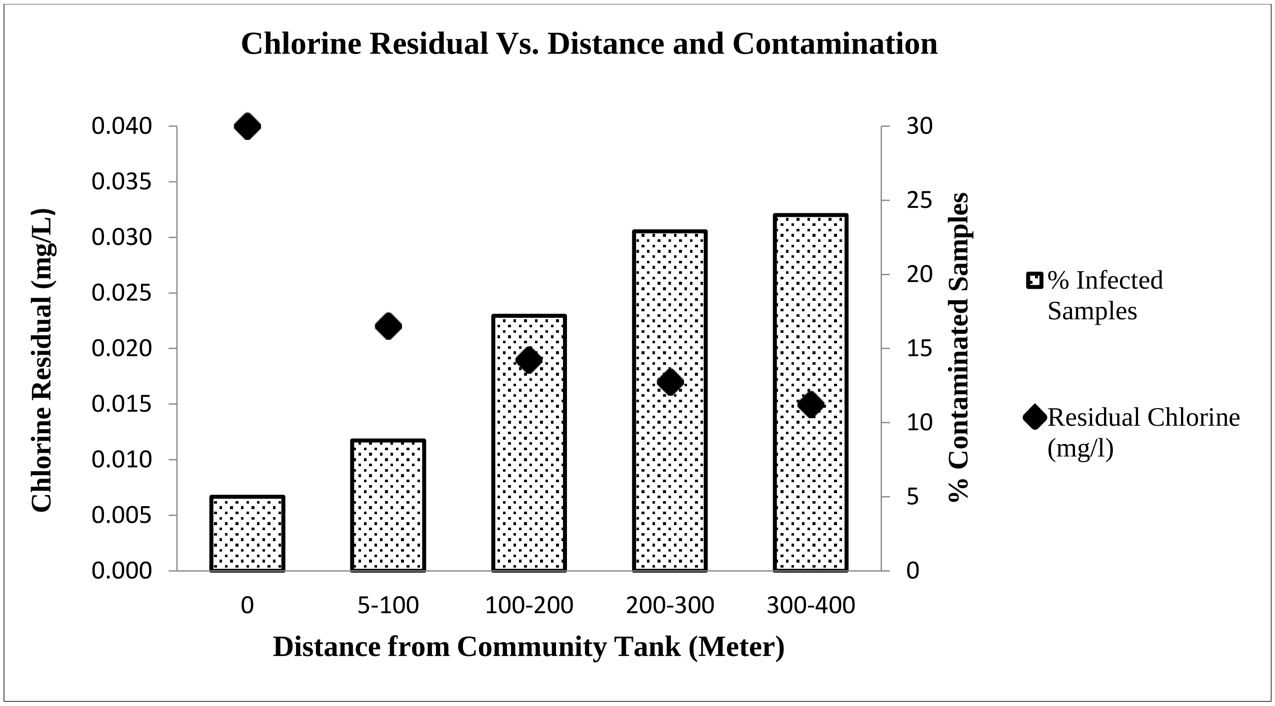


**Figure 4.9:** The Concentration of Residual Chlorine and Percentages of Positive Results in rooftop tank water samples with Distance from the Community Tap in Aida and Alazzah Camps.

When the water was tested directly after delivery, the amount of residual chlorine was at its highest concentration, and it decreased with distance from the community tanks. The concentration of the residual chlorine gradually decreases over time through the water pipes networks as well as in the water tanks due to reaction with the materials such as faeces of warm blooded animals and rust of the pipe networks and tanks (Goyal, 2014).

When the result of the water sample was positive, the household members were informed directly about the result in order to take measures to disinfect the water. Moreover, UNRWA has been informed of the positive results to work directly with the affected households

# Chapter Five

## Conclusions and Recommendations

Water delivery by the Bethlehem Water Authority is governed by specific water quality standards, including tests related to bacterial growth and residual chlorine. Also, the water is chlorinated before being pumped to the camps. That explains why the water from the community tap was mostly clean, and the levels of coliform, when detected, were very low. Moreover, continued sampling of the community tap (every week) gave a more detailed understanding of the water quality from the community tap as well as from the pipe networks. 87% of taps sampled in Aida camp and 95% in Alazzah camp had clean water. Therefore, it follows that the water entering the camp is mostly free of bacterial contaminants.

The Bethlehem Water Authority and UNRWA mentioned that the water pipe networks must be repaired and replaced, especially in Aida camp, as they have not been changed since their implementation. The water pipe networks in Alazzah camp, on the other hand, were repaired and replaced in June 2017.

The sewage networks have not been replaced in both camps since 1992, and there has been cross-contamination between the sewage and the water supply networks. Moreover, UNRWA mentioned the poor infrastructure, its effects on the water quality and, consequently, the potential risks for the health of residents inside both camps (BWA and UNRWA, 2017). For this contamination to have occurred, the structural integrity of both the sewer and water networks must be compromised.

Another potential source of water contamination is the household water tanks, almost all of which have been in use for several years, leading to rust formation that can contaminate the water. Also, many of the water tanks lack tightly fitted covers, allowing the entrance of foreign contaminants, including visible organisms such as birds or frogs. Another factor that affects the water quality is that the water in these tanks sits for weeks in the sun on the roofs of the houses before being consumed. The warm and dark conditions are ideal for bacterial growth, especially in the summer when the temperature is between 35 and 40ºC (WHO, 2007). Moreover, many camp residents are unable to clean their tanks properly, as their roofs are crowded with water tanks, making it a dangerous area to walk on, let alone to fill or wash a tank. According to the results in both camps, 16% of the water samples could be contaminated because of the water tanks.

Water quality results are affected by the distance between the community tap and the water tanks of the households, especially those located further away and at a high elevation, particularly in Aida Camp. As indicated by Figure 4.11 residual chorine decreased over time through the water pipes networks as well as in the water tanks. Thus, the water samples from the households farthest from the community tap in the camp were most contaminated by bacteria.

UNRWA and Bethlehem Water Authority must take action to restore and replace the water pipe networks. Until this is done, all the household water tanks and all associated pumps, hoses and piping, which are critical aspects of the camp water infrastructure, are potential sources of bacterial contamination and until now have had no organizational oversight. Cooperation between them and communities can be advantageous to both parties.

The organizations that work across the camps can host workshops for the community to inform the residents about water safety and conservation, and provide easily accessible information, such as brochures or pamphlets. They should show ways in which to treat the harmful bacteria by using simple procedures, including boiling water, chemical disinfection by adding chlorine tablets, regular cleaning of water tanks, and filtration. Moreover, social media platforms, such as Facebook, could provide a new way to alert residents to new systems available, or to changes being made to the camps' water infrastructure. This could be implemented by NGOs to encourage community volunteers to act on the problem and share information about the program.

The information shared by community volunteers will educate the populations of the camps, which will then act as a pressure tool on the decision-making powers, such as UNRWA, to solve water quantity and quality problems. Particular effort should be made to educate students at local schools about the procedures which should be undertaken to clean the water.

Fostering a relationship between UNRWA, Bethlehem Water Authority and the non-governmental organizations in the camps, including the sharing of results and information, will help to find a solution for the water quality in the camps. For example, they can collaborate on methods such as distributing new water tanks to the residents and repairing and replacing the water and sewage pipe networks, and should take action for regular water testing and share the results with the residents of the camps.

Additionally, a relationship should be created between the Bethlehem Ministry of Health and the camp population in order to intervene on matters of contamination, as well as providing additional materials to educate those on the relationship between water contamination and health.

Lastly, a water planning committee must be established as a part of a long-term planning strategy in both camps. The committee would include several community members of different ages, roles, and occupations; students, employees of the UNRWA lab; science teachers from local schools; interested local residents; and mothers from both camps. Gradually, an information base or water education manual should be created, with the possibility of amendment based on feedback from the community members in order to benefit the camp residents. Moreover, future studies shall be conducted by responsible parts from Bethlehem water authority, UNRWA, and NGOs to better understand water quality in the camps.

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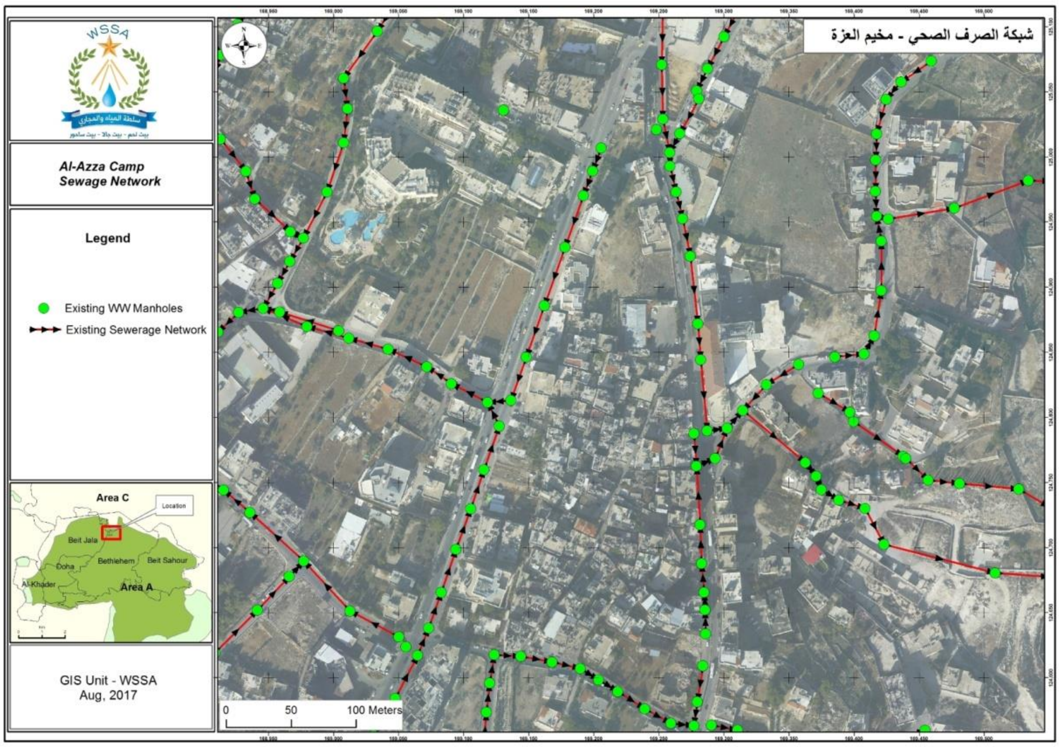
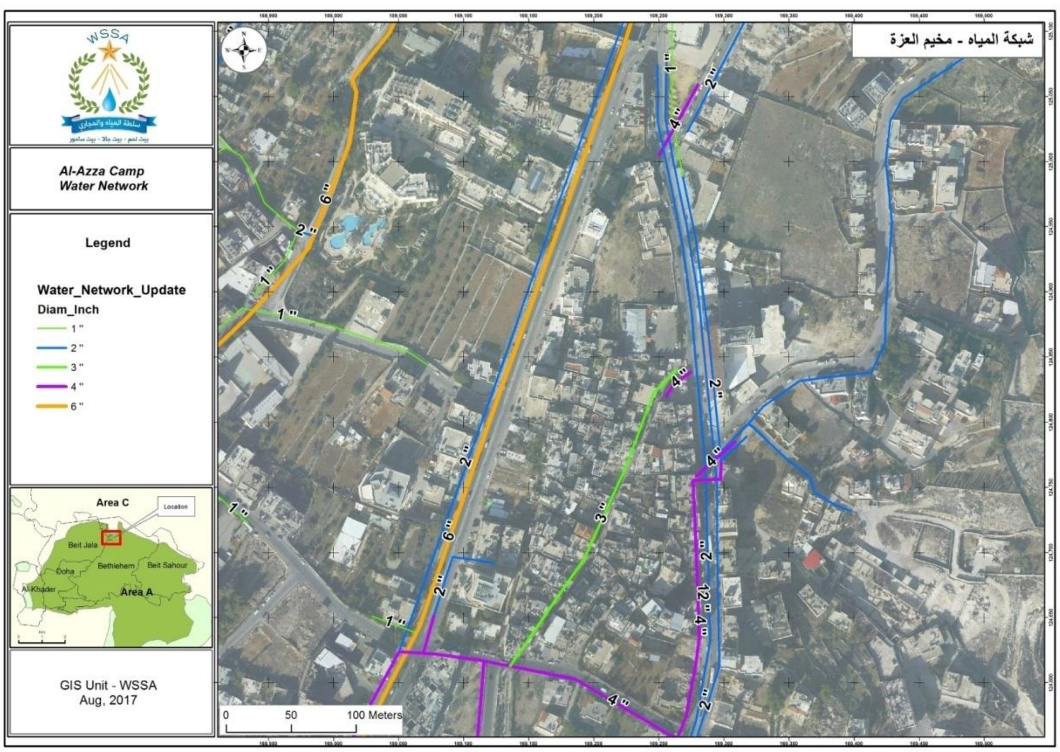
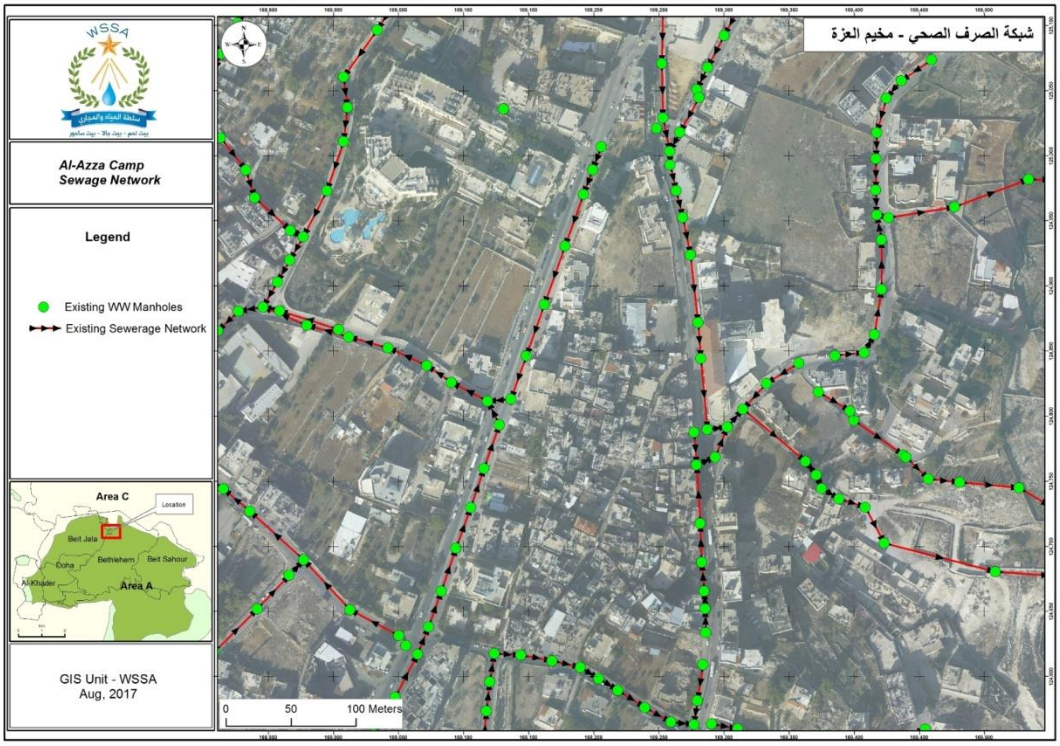
## Appendices:

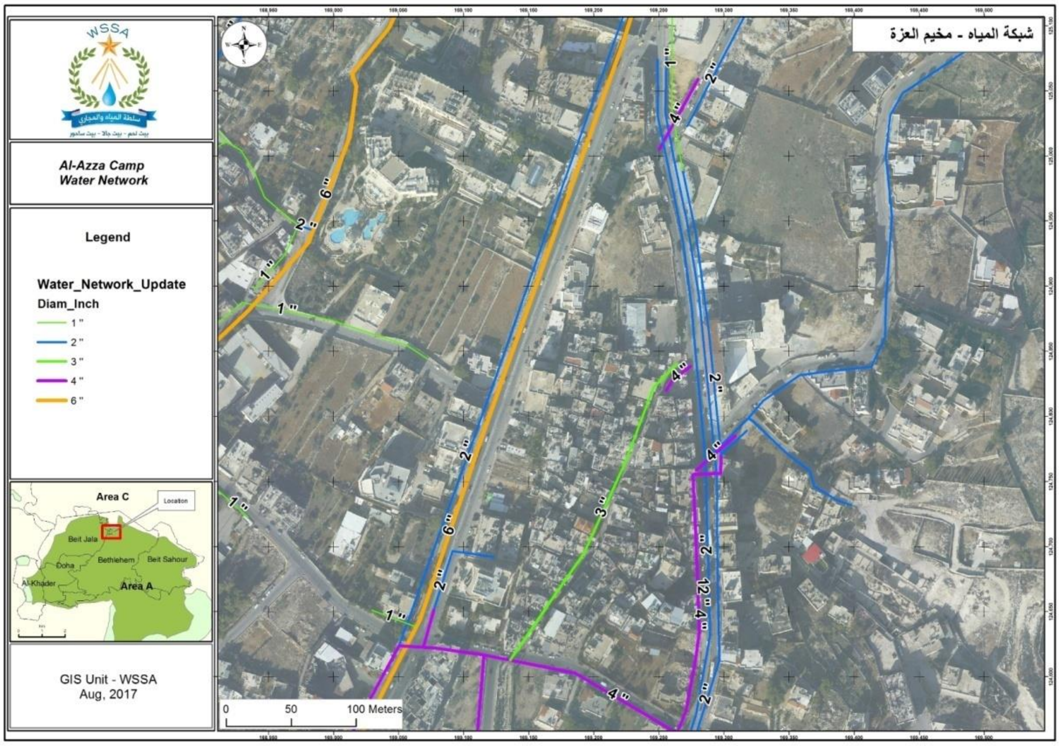
## Appendix A: The Maps of Water- and Sewage-pipe Networks in Aida and Alazzah Camps



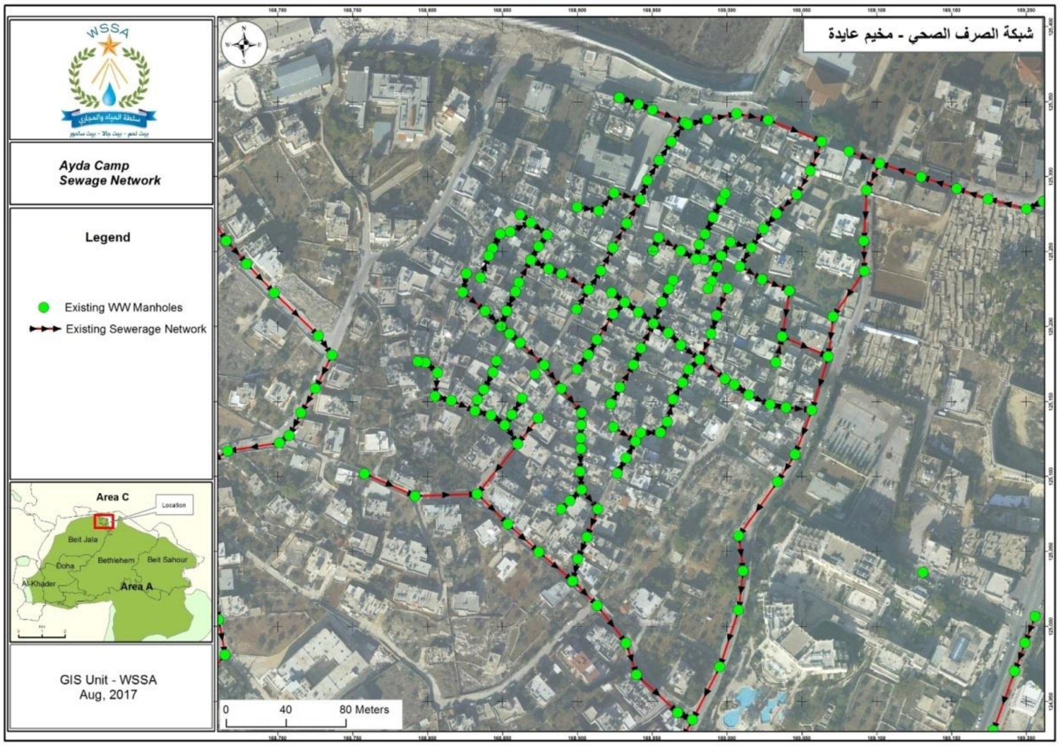



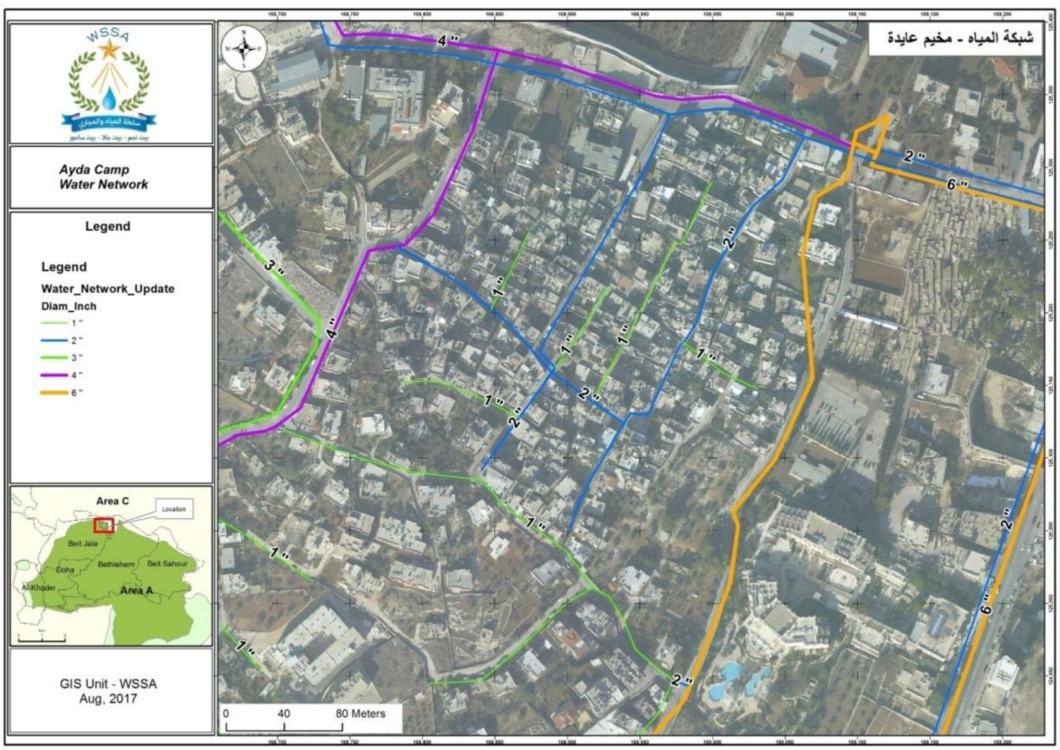


شبكة الصرف الصحي - مخيم العزة
Al-Azza Camp
Sewage Network
Legend
Existing WW Manholes
Existing Sewerage Network
Area C
Location
Beit Jala
Doha
Bethlehem
Beit Sahour
Al-Khader
Area A
GIS Unit - WSSA
Aug, 2017
0
50
100 Meters

شبكة المياه - مخيم العزة
Al-Azza Camp
Water Network
Legend
Water_Network_Update
Diam_Inch
1 "
2 "
3 "
4 "
6 "
Area C
Location
Beit Jala
Doha
Bethlehem
Beit Sahour
Al-Khader
Area A
GIS Unit - WSSA
Aug, 2017
0
50
100 Meters


شبكة الصرف الصحي - مخيم عايدة
WSSA
Ayda Camp
Sewage Network
Legend
Existing WW Manholes
Existing Sewerage Network
Area C
Location
Beit Jala
Doha
Bethlehem
Beit Sahour
Al-Khader
Area A
GIS Unit - WSSA
Aug, 2017
0
40
80 Meters


شبكة المياه - مخيم عايدة
WSSA
Ayda Camp
Water Network
Legend
Legend
Water_Network_Update
Diam_Inch
1 "
2 "
3 "
4 "
6 "
Area C
Location
Beit Jala
Doha
Bethlehem
Beit Sahour
Al-Khader
Area A
GIS Unit - WSSA
Aug, 2017
0
40
80 Meters

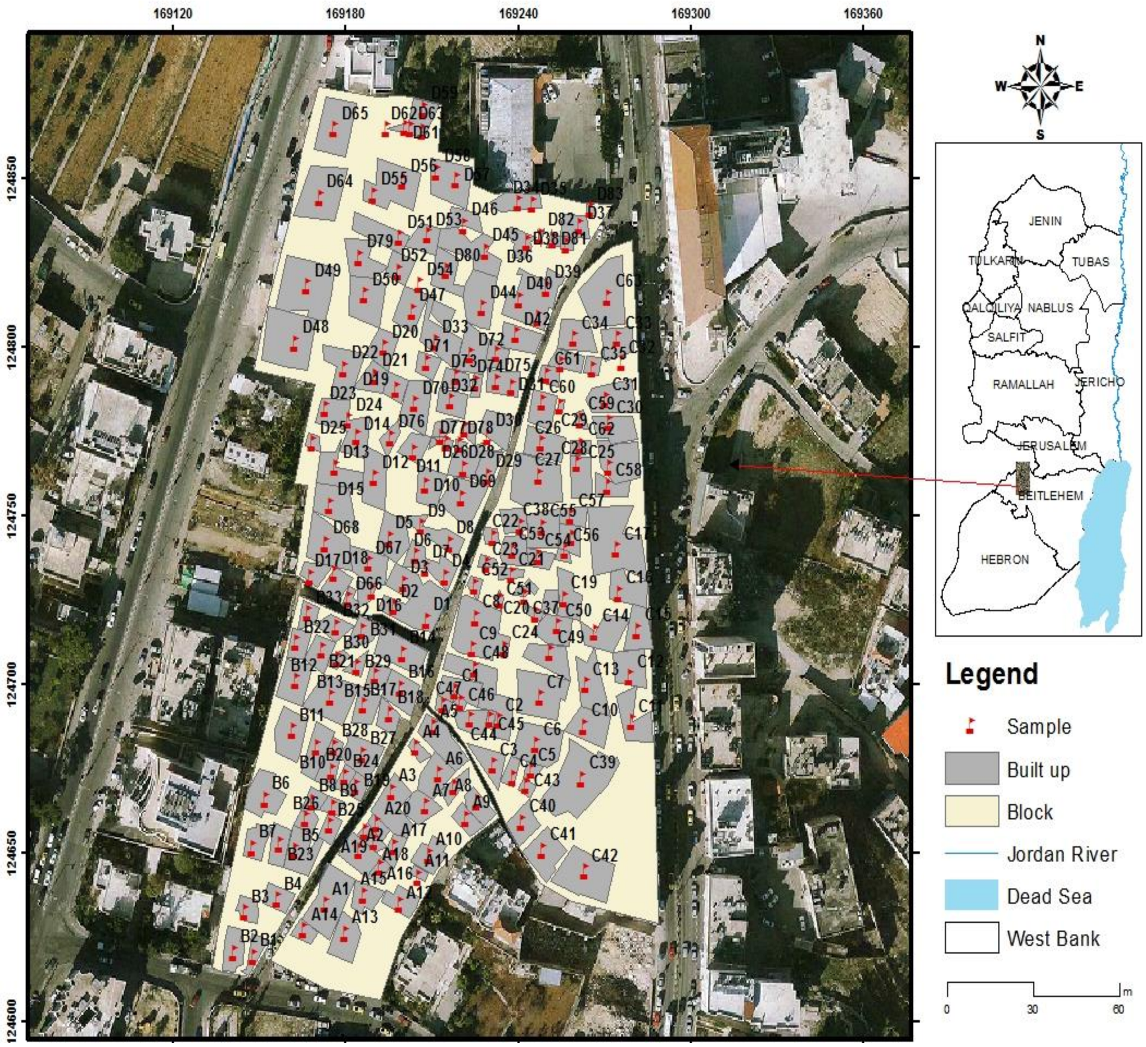
## Appendix B: The Maps of Aida Refugee Camp



Group C
Version: July 15, 2012


Group D
Version: July 15, 2012

## Appendix C: The Map of Alazzah Camp



## Appendix D:Water quality and Houshold data sheet templates

| Sample No. | Date (d/m/y) | House No. | Floor No. | Household Name | Contact Phone Number | #Plastic Tanks | #Metal Tanks | Days Since Last Water Delivery | No Water Available for Testing ("x" if true) | Retest ("x" if true) | Sampler's Name | Volume Plated (mL) | Time of Incubation Start (hh:mm) | Residual Chlorine (mg/L) | No. of Colonies per Plated Sample: Other Coliforms (red) | No. of Colonies per Plated Sample: *E. coli* (blue) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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## Appendix D:The history of chlorine from PWA in Bethlehem reservoirs

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دائرة مياه الضفة الغربية

# التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية

| | |
|---|---|
| اليوم : | الخميس |
| التاريخ : | 31/3/2016 |

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| اسم المحطة | كمية الكلور / لتر | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|
| Pwa1 | 360 | 0.53 | - | _ |
| Pwa11 | 0 | 0.42 | _ | لا يوجد كلور+مضخة البئر متوقفة عن العمل |
| Pwa3 | 670 | 0.33 | - | _ |
| Hundaza | 420 | 0.44 | - | _ |
| Sair | 700 | 0.3 | _ | _ |
| IZZ1 | 540 | 0.46 | - | _ |
| IZZ2 | 820 | 0.42 | - | _ |
| IZZ3 | 1810 | 0.41 | - | _ |
| JWC4 | 660 | 0.01 | - | النسبة قليلة |
| BS1 | 600 | 0.42 | - | _ |
| Alrehea | 640 | 0.73 | - | _ |
| Alrashaedeh | 940 | 0 | - | النسبة صفر- مضخة البئر متوقفة |

| | |
|---|---|
| ملاحظات | |

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دائرة مياه الضفة الغربية

# التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية

الى : السيد عصام عرمان المحترم / مسوول منطقة الجنوب
من : م. عزات سباتين

| | |
|---|---|
| اليوم : | الأربعاء |
| التاريخ : | 4/5/2016 |

| اسم المحطة | كمية الكلور / لتر | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|
| Pwa1 | 900 | 0 | - | مضخة الكلور عطلانة |
| Pwa11 | 0 | 0.67 | _ | لا يوجد كلور+مضخة البئر متوقفة عن العمل |
| Pwa3 | 740 | 0.57 | - | _ |
| Hundaza | 1100 | 0.22 | - | _ |
| Sair | 1070 | 0.62 | _ | _ |
| IZZ1 | 950 | 0.51 | - | _ |
| IZZ2 | 910 | 0.41 | - | _ |
| IZZ3 | 1050 | 0.26 | - | _ |
| JWC4 | 1200 | 0.35 | - | _ |
| BS1 | 890 | 0.52 | - | _ |
| Alrehea | 1420 | 0.75 | - | _ |
| Alrashaedeh | 1270 | 0.06 | - | النسبة قليلة |

| ملاحظات | |
|---|---|

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| | | |
|---|---|---|
| **State of Palestine**<br>Palestinian Water Authority<br>West Bank Water Department | | **دولة فلسطين**<br>سلطة المياه الفلسطينية<br>دائرة مياه الضفة الغربية |

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الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| | |
|---|---|
| اليوم : | الثلاثاء |
| التاريخ : | 7/6/2016 |

| اسم المحطة | كمية الكلور / لتر | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|
| Pwa1 | 1140 | 0.54 | - | _ |
| Pwa11 | 0 | 0 | _ | لا يوجد كلور/مضخة البئر متوقفة عن العمل |
| Pwa3 | 1020 | 0.48 | - | _ |
| Hundaza | 1290 | 0.01 | - | النسبة قليلة |
| Sair | 1160 | 0.42 | _ | _ |
| IZZ1 | 1200 | 0.39 | - | _ |
| IZZ2 | 700 | 0 | - | مضخة البئر واقفة |
| IZZ3 | 1000 | 0.18 | - | النسبة قليلة |
| JWC4 | 1190 | 0.11 | - | النسبة قليلة |
| BS1 | 1090 | 0.4 | - | _ |
| Alrehea | 985 | 0.7 | - | _ |
| Alrashaedeh | - | - | - | - |

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|---|---|
| ملاحظات | |

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دائرة مياه الضفة الغربية

**<u>التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية</u>**

**الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب**
**من : م. عزات سباتين**

| | |
|---|---|
| الأحد | **اليوم :** |
| 3/4/2016 | **التاريخ :** |

| ملاحظات | عطل في نظام الكلور | نسبة الكلور | كمية الكلور / لتر | اسم المحطة |
|---|---|---|---|---|
| _ | - | 0.44 | 270 | **Pwa1** |
| لا يوجد كلور+مضخة البئر متوقفة عن العمل | _ | 1.46 | 0 | **Pwa11** |
| _ | - | 0.38 | 610 | **Pwa3** |
| _ | - | 0.27 | 350 | **Hundaza** |
| _ | _ | 0.31 | 610 | **Sair** |
| _ | - | 0.49 | 470 | **IZZ1** |
| _ | - | 0.43 | 740 | **IZZ2** |
| _ | - | 0.51 | 1770 | **IZZ3** |
| النسبة قليلة | - | 0.04 | 620 | **JWC4** |
| _ | - | 0.47 | 640 | **BS1** |
| _ | - | 0.65 | 580 | **Alrehea** |
| النسبة صفر - مضخة البئر متوقفة | - | 0 | 940 | **Alrashaedeh** |

| | |
|---|---|
| | **ملاحظات** |

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دائرة مياه الضفة الغربية

**<u>التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية</u>**

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| اليوم : | الأثنين |
|---|---|
| التاريخ : | 5/9/2016 |

| اسم المحطة | كمية الكلور / لتر | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|
| Pwa1 | 1340 | 0.5 | - | _ |
| Pwa11 | 1550 | 0.57 | _ | - |
| Pwa3 | 1330 | 0.67 | - | _ |
| Hundaza | 940 | 0.63 | - | _ |
| Sair | 700 | 0.54 | _ | _ |
| IZZ1 | 1000 | 0.22 | - | _ |
| IZZ2 | 980 | 0.52 | - | _ |
| IZZ3 | 950 | 0.47 | - | _ |
| JWC4 | 980 | 0.38 | - | _ |
| BS1 | 530 | 0.37 | - | _ |
| Alrehea | 555 | 0.75 | - | _ |
| Alrashaedeh | 250 | 0.72 | - | _ |

| ملاحظات | |
|---|---|

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دائرة مياه الضفة الغربية

**التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية**

**الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب**

**من : م. عزات سباعين**

| | |
|---|---|
| **اليوم :** | الاثنين |
| **التاريخ :** | 7/11/2016 |

| اسم المحطة | كمية الكلور / لتر | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|
| Pwa1 | 560 | 0.5 | - | _ |
| Pwa11 | 460 | 0.51 | _ | - |
| Pwa3 | 380 | 0.29 | - | _ |
| Hundaza | 470 | 0.28 | - | السحب كبير(50) |
| Sair | 180 | 0.18 | _ | النسبة قليلة |
| IZZ1 | 645 | 0.25 | - | _ |
| IZZ2 | 390 | 0.44 | - | _ |
| IZZ3 | 960 | 0.37 | - | تم سحب كلور 15 لتر كلور من قبل عبد احميدون |
| JWC4 | 450 | 0.31 | - | _ |
| BS1 | 490 | 0.2 | - | _ |
| Alrehea | 910 | 0.72 | - | _ |
| Alrashaedeh | 370 | 0.22 | - | _ |

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| **ملاحظات** | |

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دائرة مياه الضفة الغربية

# التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| اليوم : | الخميس |
|---|---|
| التاريخ : | 26/1/2017 |

| اسم المحطة | كمية المياه المسحوبة | كمية الكلور في الموقع / لتر | كمية الكلور اليومية المستهلكة | Litre/m3 | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|---|---|---|
| Pwa1 | 0 | 400 | 0 | - | 0 | - | مضخة البئر قيد التركيب |
| Pwa11 | 2712 | 890 | 20 | 0.01 | 0.74 | - | _ |
| Pwa3 | 3840 | 910 | 20 | 0.01 | 0.48 | - | _ |
| Hundaza | 3482 | 680 | 20 | 0.01 | 0.78 | _ | _ |
| Sair | _ | 1150 | 0 | _ | 0.47 | - | _ |
| IZZ1 | 0 | 820 | 5 | - | 0 | - | محول الضغط العالي معطل |
| IZZ2 | 3810 | 710 | 30 | 0.01 | 0.58 | - | _ |
| IZZ3 | 1996 | 1085 | 10 | 0.01 | 0.25 | - | _ |
| JWC4 | 4416 | 530 | 20 | 0.00 | 0.51 | - | _ |
| BN2 | 0 | 625 | 0 | - | 0 | - | لا يوجد مضخة بئر |
| Alrehea | 627 | 885 | 15 | 0.02 | 0.8 | - | النسبة عالية |
| Alrashaedeh | 2830 | 1020 | 20 | 0.01 | 0.35 | - | _ |

| ملاحظات | | |
|---|---|---|

إعداد نائب مدير صيانة الجنوب : م.عزات سباتين

State of Palestine
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West Bank Water Department

دولة فلسطين
سلطة المياه الفلسطينية
دائرة مياه الضفة الغربية

## التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية

| | |
|---|---|
| اليوم : | الخميس |
| التاريخ : | 9/2/2017 |

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| اسم المحطة | كمية المياه المسحوبة | كمية الكلور في الموقع / لتر | كمية الكلور اليومية المستهلكة | Litre/m3 | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|---|---|---|
| Pwa1 | 0 | 400 | 0 | - | 0 | - | مضخة البئر متوقفة عن العمل |
| Pwa11 | 2683 | 600 | 20 | 0.01 | 0.44 | - | _ |
| Pwa3 | 3234 | 610 | 20 | 0.01 | 0.49 | - | _ |
| Hundaza | 3456 | 395 | 0 | 0.00 | 0 | - | النسبة صفر |
| Salr | _ | 1050 | 0 | _ | 0.65 | - | نظام الكلور لايعمل |
| IZZ1 | 2697 | 690 | 30 | - | 0.51 | - | _ |
| IZZ2 | 3555 | 390 | 20 | 0.01 | 0.63 | - | _ |
| IZZ3 | 2677 | 870 | 20 | 0.01 | 0.63 | - | _ |
| JWC4 | 3896 | 120 | 30 | 0.01 | 0.51 | - | _ |
| BN2 | 0 | 625 | 0 | - | 0 | - | مضخة البئر متوقفة عن العمل |
| Alrehea | 463 | 700 | 15 | - | 0.95 | - | النسبة عالية |
| Alrashaedeh | - | - | - | - | - | - | _ |

| | |
|---|---|
| ملاحظات | |

إعداد نائب مدير صيانة الجنوب : م.عزات سباتين

State of Palestine
Palestinian Water Authority
West Bank Water Department

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سلطة المياه الفلسطينية
دائرة مياه الضفة الغربية

## التقرير اليومي لكمية الكلور في محطات دائرة مياه الضفة الغربية

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباتين

| اليوم : | الخميس |
|---|---|
| التاريخ : | 9/3/2017 |

3-May

| اسم المحطة | كمية المياه المسحوبة | كمية الكلور في الموقع / لتر | كمية الكلور اليومية المستهلكة | Litre/m3 | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|---|---|---|
| Pwa1 | 4296 | 660 | 40 | 0.01 | 0.65 | - | _ |
| Pwa11 | 2662 | 1070 | 30 | 0.01 | 0.5 | - | _ |
| Pwa3 | 3719 | 960 | 20 | 0.01 | 0.36 | - | _ |
| Hundaza | 3366 | 760 | 20 | 0.01 | 0.72 | - | _ |
| Sair | _ | 1140 | 0 | - | 0.59 | - | المضخة للكلور واقفة |
| IZZ1 | 3139 | 600 | 50 | 0.02 | 0.75 | - | _ |
| IZZ2 | 3812 | 720 | 30 | 0.01 | 0.56 | - | _ |
| IZZ3 | 3285 | 1130 | 15 | 0.00 | 0.62 | - | _ |
| JWC4 | 4426 | 810 | 50 | 0.01 | 0.39 | - | _ |
| BN2 | 0 | 625 | 0 | - | 0 | - | مضخة البئر متوقفة عن العمل |
| Alrehea | 780 | 810 | 20 | 0.03 | 0.72 | - | _ |
| Alrashaedeh | - | - | - | - | - | - | _ |

| ملاحظات | |
|---|---|

إعداد نائب مدير صيانة الجنوب : م.عزات سباتين

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**دولة فلسطين**
سلطة المياه الفلسطينية
دائرة مياه الضفة الغربية

## التقرير اليومى لكمية الكلور فى محطات دائرة مياه الضفة الغربية

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب
من : م. عزات سباعين

| | |
|---|---|
| اليوم : | الخميس |
| التاريخ : | 13/4/2017 |

| اسم المحطة | كمية المياه المسحوبة | كمية الكلور في الموقع / لتر | كمية الكلور اليومية المستهلكة | Litre/m3 | نسبة الكلور | عطل في نظام الكلور | ملاحظات |
|---|---|---|---|---|---|---|---|
| Pwa1 | 3929 | 950 | 50 | 0.013 | 0.78 | - | _ |
| Pwa11 | 2699 | 1140 | 30 | 0.01 | 0.47 | - | _ |
| Pwa3 | 3767 | 1100 | 20 | 0.01 | 0.62 | - | _ |
| Hundaza | 3288 | 980 | 20 | 0.01 | 0.43 | - | _ |
| Sair | _ | 790 | 30 | - | 0.45 | - | _ |
| IZZ1 | 3029 | 1000 | 0 | 0.00 | 0.01 | - | النسبة قليلة |
| IZZ2 | 3633 | 980 | 20 | 0.01 | 0.49 | - | _ |
| IZZ3 | 2955 | 1350 | 0 | 0.00 | 0 | - | النسبة صفر |
| JWC4 | 0 | 360 | 0 | - | 0 | - | توقف مضخة البئر - صيانة |
| BN2 | 2783 | 450 | - | - | 0 | - | مضخة البئر تحت التشغيل التجريبي |
| Alrehea | 1082 | 700 | 0 | 0.00 | 0.65 | - | _ |
| Alrashaedeh | 2609 | 380 | 30 | 0.01 | 0.45 | - | |

| ملاحظات | |
|---|---|
| | |

إعداد نائب مدير صيانة الجنوب : م.عزات سباعين

**State of Palestine**
Palestinian Water Authority
West Bank Water Department

**دولة فلسطين**
سلطة المياه الفلسطينية
دائرة مياه الضفة الغربية

## التقرير اليومى لكمية الكلور فى محطات دائرة مياه الضفة الغربية

| | |
|---|---|
| الاربعاء | اليوم : |
| 3/5/2017 | التاريخ : |

الى : السيد عصام عرمان المحترم / مسؤول منطقة الجنوب

من : م. عزات سباعين

| ملاحظات | عطل في نظام الكلور | نسبة الكلور | Litre/m3 | كمية الكلور اليومية المستهلكة | كمية الكلور في الموقع / لتر | كمية المياه المسحوبة | اسم المحطة |
|---|---|---|---|---|---|---|---|
| _ | - | 0 | 0.000 | 0 | 680 | 3369 | Pwa1 |
| _ | - | 0.61 | 0.019 | 50 | 580 | 2699 | Pwa11 |
| _ | - | 0.49 | 0.003 | 10 | 640 | 3798 | Pwa3 |
| _ | - | 0.55 | 0.010 | 30 | 570 | 3130 | Hundaza |
| لا يوجد كلور | - | 0.36 | - | 50 | 0 | _ | Sair |
| _ | - | 0.31 | 0.003 | 10 | 740 | 2871 | IZZ1 |
| _ | - | 0.63 | 0.005 | 20 | 480 | 3800 | IZZ2 |
| _ | - | 0.78 | 0.005 | 15 | 565 | 2945 | IZZ3 |
| النسبة صفر +رفع المضخة للبئر لعملية الصيانة | - | 0 | - | 0 | 760 | 0 | JWC4 |
| _ | - | 0.26 | 0.005 | 20 | 830 | 3806 | BN2 |
| _ | - | 0.69 | 0.009 | 10 | 420 | 1059 | Alrehea |
| _ | - | 0.25 | 0.003 | 10 | 700 | 2889 | Alrashaedeh |

| | |
|---|---|
| | ملاحظات |

إعداد نائب مدير صيانة الجنوب : م.عزات سباعين

# Appendix F: General Chemical Analysis of Bethlehem Wells

| # | Sample | Ph | EC | $Cl^-$ | $HCO_3^-$ | $NO_3^-$ | $NO_3^-$–N | $SO_4^{-2}$ | $NH4^+$ | $NH3^+$ | $NH3^+$–N | $Mg^{+2}$ | $Ca^{+2}$ | $K^+$ | $Na^+$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | µS/cm | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l | mg/l |
| 1 | هيروديون 1 | 7,38 | 515 | 43 | 317 | 22,3 | 5 | 10 | 0,5 | 0,5 | 0,4 | 30,2 | 56,1 | 1,99 | 15,5 |
| 2 | هيروديون 2 | 7,52 | 571 | 43 | 366 | 12,9 | 2,9 | 16 | 0 | 0 | 0 | 36,3 | 72,1 | 2,6 | 13,02 |
| 3 | هيروديون 3 | 7,15 | 576 | 28 | 391 | 14,7 | 3,3 | 14 | 0 | 0 | 0 | 30,2 | 88,2 | 2,6 | 12,1 |
| 4 | هيروديون 4 | 7,93 | 584 | 28 | 342 | 12,5 | 2,8 | 15 | 0 | 0 | 0 | 30,2 | 80,2 | 2,9 | 13,02 |
| 5 | سعير PWA - 1 | 7,52 | 588 | 28 | 391 | 14,9 | 3,4 | 14 | 0 | 0 | 0 | 36,3 | 80,2 | 2,4 | 13,02 |
| 6 | عساكرة PWA - 3 | 7,33 | 552 | 28 | 317 | 16,2 | 3,7 | 14 | 0 | 0 | 0 | 30,2 | 72,1 | 2,6 | 13,02 |
| 7 | PWA - 11 | 7,07 | 603 | 43 | 317 | 9 | 2 | 12 | 0 | 0 | 0 | 30,2 | 64,1 | 2,4 | 11,6 |
| 8 | عبيات JWC - 4 | 7,21 | 528 | 28 | 317 | 21,3 | 4,8 | 9 | 0 | 0 | 0 | 24,2 | 56,1 | 2,3 | 14,5 |
| 9 | عرب الرشايدة | 7,39 | 649 | 43 | 317 | 7,3 | 1,6 | 93 | 0,3 | 0,03 | 0,02 | 36,3 | 80,2 | 3,03 | 8,7 |
| 10 | عيزرية دار صلاح | 7,33 | 520 | 28 | 317 | 12,9 | 2,9 | 16 | 1,3 | 1,03 | 1,02 | 36,3 | 64,1 | 2,7 | 12,5 |
| 11 | د.عامر / عيزرية 3 | 7,22 | 598 | 43 | 342 | 21,6 | 4,9 | 15 | 0,06 | 0,05 | 0,04 | 30,2 | 64,1 | 3,3 | 19,8 |
| 12 | بيت فجار | 7,63 | 586 | 35 | 342 | 20,4 | 4,6 | 9 | 0,07 | 0,06 | 0,05 | 36,3 | 80,2 | 2,29 | 11,6 |
| 13 | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | Date of Sampling : 10/09/2016 | | | |
| 15 | | | | | | | | | | | | Test : General Chemisry | | | |

**Bethlehem governorate**

**Water Quality Sampling Programme b**
**October-2017**

| Sector | Municipality | Location | Category | Frequency | Date | Temp. 15-25C | EC 500-2000 µs/cm | pH 6.5 8.8 | 0.40 | Residual Chlorine (0.2-0.8) mg/l | Filtrating membrance: Total Coliform (colony count) <1 | Filtrating membrance: Fecal Coliform (colony count)<1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WSSA | Bethlehem | Bethlehem 2" | Production | Trimonthly | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour 3" | Production | Trimonthly | 12/10/2017 | 23.90 | 56 | 6.90 | 0.32 | 0.45 | 0 | 0 | Sample was taken from customer house. |
| WSSA | Bethlehem | Wadi Shahin 12" | Production | Monthly | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour 10" | Production | Monthly | 12/10/2017 | 23.90 | 456 | 6.90 | 0.32 | 0.45 | 0 | 0 | Sample was taken from customer house. |
| WSSA | Duhaisha Camp | Al Duhaisha 10" | Production | Monthly | | | | | | | | | |

| Sector | Municipality | Location | Category | Frequency | Date | Temp 15-25C | EC 500-2000 µs/cm | pH 6.5 8.8 | 0.40 | Residual Chlorine (0.2-0.8) mg/l | Total Coliform (colony count) <1 | Fecal Coliform (colony count)<1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WSSA | Beit Jall | Marah | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Metaleh | Reservoir | weekly | 12/10/2017 | | | | | | | | no water available |
| WSSA | Al Doha | Al Doha Res | Reservoir | weekly | 12/10/2017 | | | | | | | | no water available |
| WSSA | Duhaisha Camp | Al Duhaisha | Reservoir | weekly | 12/10/2017 | 22.30 | 420 | 6.50 | 0.86 | 0.36 | 0 | 0 | |
| | Aida Camp | Aida Res | | | | | | | | | | | |
| WSSA | Bethlehem | University | Reservoir | weekly | 03/10/2017 | 21.30 | 601 | 6.50 | 0.39 | 0.36 | 0 | 0 | |
| 3 | Beit Fajjar | Beit Fajjar Well | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Marah | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Metaleh | Reservoir | weekly | | | | | | | | | |
| WSSA | Al Doha | Al Doha Res | Reservoir | weekly | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha | Reservoir | weekly | | | | | | | | | |
| | Aida Camp | Aida Res | | | | | | | | | | | |
| WSSA | Bethlehem | University | Reservoir | weekly | 10/10/2017 | 23.60 | 560 | 6.20 | 0.42 | 0.32 | 0 | 0 | |
| 3 | Beit Fajjar | Beit Fajjar Well | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Marah | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Metaleh | Reservoir | weekly | | | | | | | | | |
| WSSA | Al Doha | Al Doha Res | Reservoir | weekly | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha | Reservoir | weekly | | | | | | | | | |
| | Aida Camp | Aida Res | | | | | | | | | | | |
| WSSA | Bethlehem | University | Reservoir | weekly | 17/10/2017 | 22.60 | 510 | 6.10 | 0.23 | 0.34 | 0 | 0 | |
| 3 | Beit Fajjar | Beit Fajjar Well | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Marah | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Metaleh | Reservoir | weekly | | | | | | | | | |
| WSSA | Al Doha | Al Doha Res | Reservoir | weekly | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha | Reservoir | weekly | | | | | | | | | |
| | Aida Camp | Aida Res | | | | | | | | | | | |
| WSSA | Bethlehem | University | Reservoir | weekly | 24/10/2017 | 22.30 | 500 | 6.1 | 0.45 | 0.35 | 0 | 0 | |
| 3 | Beit Fajjar | Beit Fajjar Well | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Marah | Reservoir | weekly | | | | | | | | | |
| WSSA | Beit Jall | Metaleh | Reservoir | weekly | | | | | | | | | |
| WSSA | Al Doha | Al Doha Res | Reservoir | weekly | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha | Reservoir | weekly | | | | | | | | | |
| | Aida Camp | Aida Res | | | | | | | | | | | |
| WSSA | Bethlehem | University | Reservoir | weekly | 31/10/2017 | 22.60 | 540 | 6.20 | 0.36 | 0.32 | 0 | 0 | |
| 3 | Beit Fajjar | Beit Fajjar Well | Reservoir | weekly | | | | | | | | | |

| Sector | Municipality | Location | Category | Frequency | Date | Temp 15-25C | EC 500-2000 µs/cm | pH 6.5 8.8 | 0.40 | Residual Chlorine (0.2-0.8) mg/l | Total Coliform (colony count) <1 | Fecal Coliform (colony count)<1 | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WSSA | Bethlehem | Bethlehem S1 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Bethlehem | Bethlehem S2 | Distribution | Bimonthly | | | | | | | | | |
| | | Bethlehem S3 | | | 04/10/2017 | 25.00 | 600 | 6.50 | 0.45 | 0.29 | 0 | 0 | |
| | | Bethlehem S4 | | | | | | | | | | | |
| WSSA | Bethlehem | Bethlehem S5 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour S1 | Distribution | Bimonthly | 12/10/2017 | 23.60 | 550 | 7.01 | 0.45 | 0.33 | 0 | 0 | |
| WSSA | Beit Sahour | Beit Sahour S2 | Distribution | Bimonthly | 12/10/2017 | 23.40 | 560 | 5.40 | 0.45 | 0.33 | 0 | 0 | |
| | | Beit Sahour S3 | | | 12/10/2017 | 24.00 | 650 | 6.01 | 0.23 | 0.32 | 0 | 0 | |
| | | Beit Sahour S4 | | | 12/10/2017 | 23.60 | 600 | 6.20 | 0.55 | 0.31 | 0 | 0 | |
| WSSA | Beit Sahour | Beit Sahour S5 | Distribution | Bimonthly | 12/10/2017 | 24.10 | 650 | 6.10 | 0.23 | 0.32 | 0 | 0 | |
| WSSA | Duhaisha Camp | Al Duhaisha S1 | Distribution | Bimonthly | | | | | | | | | |
| | | Al Duhaisha S2 | | | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha S3 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Bethlehem | Bethlehem S1 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Bethlehem | Bethlehem S2 | Distribution | Bimonthly | | | | | | | | | |
| | | Bethlehem S3 | | | 19/10/2017 | 22.30 | 560 | 7.01 | 0.35 | 0.31 | 0 | 0 | |
| | | Bethlehem S4 | | | | | | | | | | | |
| WSSA | Bethlehem | Bethlehem S5 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour S1 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour S2 | Distribution | Bimonthly | | | | | | | | | |
| | | Beit Sahour S3 | | | | | | | | | | | |
| | | Beit Sahour S4 | | | | | | | | | | | |
| WSSA | Beit Sahour | Beit Sahour S5 | Distribution | Bimonthly | 27/10/2017 | 23.60 | 560 | 6.10 | 0.56 | 0.29 | 0 | 0 | |
| WSSA | Duhaisha Camp | Al Duhaisha S1 | Distribution | Bimonthly | | | | | | | | | |
| | | Al Duhaisha S2 | | | | | | | | | | | |
| WSSA | Duhaisha Camp | Al Duhaisha S3 | Distribution | Bimonthly | | | | | | | | | |
| WSSA | Beit Jall | Beit Jala S1 | Distribution | Monthly | | | | | | | | | |
| WSSA | Beit Jall | Beit Jala S2 | Distribution | Monthly | | | | | | | | | |
| | | Beit Jala S3 | | | | | | | | | | | |
| WSSA | Beit Jall | Beit Jala S4 | Distribution | Monthly | | | | | | | | | |
| WSSA | Al walaje | Al Walaje S | Distribution | Monthly | | | | | | | | | |
| WSSA | Al Doha | Al Doha S1 | Distribution | Monthly | | | | | | | | | |
| | | Al Doha S2 | | | | | | | | | | | |
| WSSA | Aida Camp | Aida Camp S | Distribution | Monthly | | | | | | | | | |
| WSSA | Artas | Artas S | Distribution | Monthly | | | | | | | | | |
| WSSA | Bethlehem | Shaababon S | Distribution | Monthly | | | | | | | | | |
| WSSA | Al Khader | Al Khader S1 | Distribution | Trimonthly | | | | | | | | | |
| | | Al Khader S2 | | | | | | | | | | | |
| | Al Khader | Al Khader S3 | Distribution | Trimonthly | | | | | | | | | |

**نوعية مياه الشرب في مخيمي بيت لحم للاجئين الفلسطينيين/ مخيم عايدة والعزة، فلسطين**

**إعداد: شذا محمد عبدالفتاح العزة**

**المشرف: د. عامر كنعان**

**المُلخَص**

الضفة الغربية/فلسطين واحدة من أكثر المناطق في العالم عرضة لندرة المياه. وأن هذه الأزمة المستفحلة مرتبطة بعدم كفاية إمدادات المياه من الاحتلال الإسرائيلي للمناطق الفلسطينية، فهذه المشكلة أثرت على نوعية المياه والتي تتعرض لخطر التلوث البيولوجي، بالكائنات الحية الدقيقة المُمرضة، مثل البكتيريا؛ مما يؤدي في الغالب إلى آثار سلبية على صحة المواطن الفلسطيني.

إن هذه الدراسة أجريت للتحقق من نوعية مياه الشرب، في مخيمي عايدة والعزة للاجئين الفلسطينيين في منطقة بيت لحم، حيث تم جمع 720 عينة مياه من ثلاث نقاط على طول نظام توزيع المياه في المخيمين على مدى 16 شهراً، من(آذار 2016 وحتى تموز 2017). و ذلك من أجل ربط التلوث البكتيري "البكتيريا القولونية" (E.coli و Coliform)بمكان وزمان جمع العينات، بالإضافة إلى علاقة الكلور المتبقي في المياه بنسبة تلوثها البكتيري، وتم تحديد العوامل الرئيسية التي تغير من مؤشرات نوعية المياه.

طبقا لمعايير منظمة الصحة العالمية ووكالة حماية البيئة الأمريكية، فإن وجود البكتيريا القولونية في المياه تشير إلى أن المياه قد تكون ملوثة، بالنفايات البشرية (الصرف الصحي)، أو الحيوانية، والتي تتسبب في نمو الميكروبات المسببة للأمراض والتي بدورها تسبب الإسهال وتشنجات في منطقة الأمعاء والمعدة،والغثيان،والصداع، وأعراض أخرى. وتشكل هذه العوامل المُمرضة خطرا صحيا، خاصة على الرضع والأطفال والأشخاص الذين يعانون من أمراض نقص المناعة. ووفقا لمنظمة الصحة العالمية، فإن معيار البكتيريا القولونية في مياه الشرب هي أقل من مستعمرة بكتيرية واحدة لكل 100 ملليلتر من العينة (<100/1 مل).

أكدت منظمة الصحة العالمية أن تعقيم المياه مثل الكلورة، يمنع نمو الكائنات الحية الدقيقة المسببة للأمراض إلى مستويات تفي بمعايير الصحة العامة.وهذا يمنع انتقال الأمراض مثل التيفوئيد والكوليرا والتهاب الكبد الوبائي. وبوجه عام، ينبغي الحفاظ على الكلور المتبقي بتركيز (0.3-0.5) ملغم / لتر.

أظهرت نتائج الدراسة أن مياه الشرب في المخيمين لم تكن ملوثة من المصدر الرئيسي للمياه، بينما أظهرت بأنها ملوثة في كل من أنابيب شبكة المياه وخزانات المياه المنزلية، حيث أظهرت النتائج تلوثا بكتيريا بنسبة 7.5% في مخيم عايدة وبنسبة 3% في مخيم العزة، وأظهرت النتائج بأن نسبة تلوث المياه 100% في فصل الصيف في مخيم العزة. أما النتائج المرتبطة بخزانات المياه فبلغت 18% في مخيم عايدة و بنسبة 7% في مخيم العزة، وأشارت النتائج بأن 40% من نتائج تلوث المياه في الخزانات مرتبطة بنقص كمية المياه الواردة إليها وذلك بسبب انقطاعها لمدة طويلة حيث وصلت إلى أكثر من أسبوعين في فصل الصيف. وهنالك عامل آخر ارتبط بنوعية المياه وهو تركيز الكلور المتبقي.وكان متوسط الكلور المتاح أقل من التوصيات المحلية والدولية، حيث بلغ معدل الكلور المتبقي 0.02-0.001 ملغم/لتر؛ الأمر الذي أدى إلى ارتفاع نسبة المياه الملوثة بالبكتيريا القولونية بنسبة 17%.

و في الختام، فلا بد من اتباع عدة إجراءات قد يتم من خلالها تقليل مشكلة تلوث المياه ومنها تنظيف خزانات المياه وإغلاقها، وكلورة المياه حسب معايير الصحة العالمية وغلي المياه في حال عدم التأكد من صحتها.