Faculty of Graduate Studies

Water and Environmental Sciences Program

Birzeit University Students' Perception and Quality Assessment of Bottled Water Available in the West Bank Market

إدراك طلبة جامعة بيرزيت وتقييم جودة المياه المعبأة المتوفرة في أسواق الضفة الغربية

Master Thesis

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Dedication

To my family,

To my friends,

To knowledge seekers.

Buthainah Abdah

September, 2019

Acknowledgement

My greatest gratitude to my supervisor Prof. Dr. Issam A. Al-Khatib for his hard work, guidance, cooperation and patience throughout the research process.

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Abstract

Water is essential in an individual's daily life, especially for drinking purpose. An increase of demand of drinking bottled water in the Palestinian markets has been observed. Accordingly, the number of bottled water companies has increased to meet the needs of the consumers. The growing rates in the demand of bottled water are attributed to several reasons, including the belief of Palestinian citizens that bottled drinking water might be of a higher quality than the public drinking water, its availability in the Palestinian markets at acceptable prices as well as the domination over the Palestinian water resources by the Israeli occupation. The study objective is to evaluate the perceptions of Birzeit University students of the quality of bottled water marketed in the West Bank and its impact on the humans and the environment. In the first part of the study, data of different quality parameters (chemical and physical) of bottled water samples from different brands available in the Palestinian local market were obtained from the records of the Central Public Health Laboratories (CPHL) of the Palestinian Ministry of Health (MoH) in West Bank from year 2014 to 2017. The chemical and physical tests' results given by the CPHL/MoH included pH, total dissolved solids (TDS), nitrate and fluoride. The results showed that 7.3% and 7.7% of the pH and nitrate measurements respectively for the tested samples were out of the Maximum Allowable Concentration (MAC) according to Palestine Standards Institution (PSI) (2005). The TDS and fluoride measurements were within the MAC. The second part of the study discussed the perceptions of Birzeit University students of the quality of bottled water and its impact on the humans and the environment. A specifically questionnaire was designed as a tool for collecting data from a statistically representative sample of Birzeit University students. The analysis of the data showed that the factors that affect the perception of the students are mainly the educational year at the university, the income, the family size and the residence type.

الخلاصة

الماء ضروري في حياة الفرد اليومية، خاصة لأغراض الشرب. لقد لوحظ في الآونة الأخيرة زيادة الطلب على المياه المعبأة في قارورات في الأسواق الفلسطينية. وفقا لذلك، زادت عدد شركات المياه المعبأة في قارورات لتلبية احتياجات المستهلكين. تُعزى المعدلات المتزايدة في الطلب على المياه المعبأة في قارورات إلى عدة أسباب، بما في ذلك اعتقاد المواطنين الفلسطينيين بأن مياه الشرب المعبأة في قوارير قد تكون ذات جودة أعلى من مياه الشرب العامة، وتوافرها في الأسواق الفلسطينية بأسعار مقبولة وكذلك السيطرة على الموارد المائية الفلسطينية من قبل الاحتلال الإسرائيلي. الهدف من الدراسة هو تقييم مدى إدراك طلبة جامعة بيرزيت لجودة المياه المعبأة في قارورات التي يتم تسويقها في الضفة الغربية وتأثيرها على الإنسان والبيئة. في الجزء الأول من الدراسة، تم الحصول على بيانات لمعايير الجودة المختلفة (الكيميائية والفيزيائية) لعينات المياه المعبأة في قارورات من مختلف العلامات التجارية المتاحة في السوق المحلي الفلسطيني من سجلات مختبرات الصحة العامة المركزية التابعة لوزارة الصحة الفلسطينية في الضفة الغربية من عام ٢٠١٤ حتى ٢٠١٧. شملت نتائج الاختبارات الكيميائية والفيزيائية التي قدمتها لنا مختبرات الصحة العامة المركزية التابعة لوزارة الصحة الفلسطينية: درجة الحموضة وإجمالي المواد الصلبة الذائبة (TDS) والنترات والفلوريد. أظهرت النتائج أن ٧,٣٪ و٧,٧٪ من قياسات درجة الحموضة والنترات على التوالي للعينات التي فحصت كانت خارج التركيز الأقصى المسموح به وفقًا للمعايير الفلسطينية للعام ٢٠٠٥. بينما كانت نتائج قياسات إجمالي المواد الصلبة والفلوريد ضمن الحدود المسموح بها. ناقش الجزء الثاني من الدراسة تصورات طلاب جامعة بيرزيت حول جودة المياه المعبأة في قوارير وتأثيرها على الإنسان والبيئة. تم تصميم استبيان كأداة لجمع البيانات من عينة ممثلة من طلبة جامعة بيرزيت. أظهر تحليل البيانات أن العوامل التي تؤثر على تصور الطلبة هي بشكل أساسي السنة الدراسية الجامعية والدخل وحجم الأسرة ونوع مكان الإقامة.

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List of Abbreviations

ANOVA	Analysis of variance
CPHL	Central Public Health Laboratories
e	The level of precision
EPA	Environmental Protection Agency
L/c/d	Liter per capita per day
L/sec	Liter per second
MAC	Maximum Allowable Concentration
MCM	Million Cubic Meters
µg/L	microgram per Liter
mg/L	milligram per Liter
mg F/kg	milligram Fluoride per kilogram
MoH	Ministry of Health
µS/cm	micro Siemens per centimeter
n	Sample size
N	Population size
NIS	New Israeli Shekel
NTU	Nephelometric Turbidity Units
p	The estimated proportion of an attribute that is present in the population
PAH	Polycyclic Aromatic Hydrocarbons
ppm	part per million
PSI	Palestine Standards Institution
Pt/Co Scale	Platinum-Cobalt Scale
q	P-1
SMCL	Secondary Maximum Contaminant Level
SPSS	Statistical Package for the Social Sciences
TDS	Total Dissolved Solids
USEPA	United States Environmental Protection Agency
Z	The critical value where the x-axis of the normal curve cuts off an area α at the tails

Chapter One
Introduction

1.1 Overview

Water is an essential element for life that affects the welfare of the individuals in their daily activities. Most governments in the world make great efforts to meet their populations' needs of safe drinking water (Ashton, 2014). And many developed countries provide safe drinking water to citizens through the tap (Ashton, 2014). However, in recent decades the rise in global consumption of bottled water has been observed (Cabejskova, 2016).

Bottled water consumption is a source of concern compared with tap water, since the production and distribution of bottled water require much more energy (Qian, 2018). Bottled water causes negative impact on the environment, especially the plastic waste which is made mainly of non-biodegradable organic materials, and most often not recycled (Makov et al., 2016; Huang and Liu, 2017). Environmental pollution, climate change and population growth are the main obvious outcomes caused by the increase in the worldwide market of bottled water (Rahman et al., 2017).

Bottled water is easily accessible with low prices in the local market of Palestine with many brand names either local or foreign (The Ibrahim Abu-Lughod Institute of International Studies, 2013). It comes in handy with the shortage of municipal water supply especially in the summer season and after some winter seasons that yield low total storage precipitation amounts or when people complain about the quality of supplied water. People live in rural areas have a limited access to piped water. Hence; they resort to harvest rainwater during the wet season in catchment areas – usually in wells – to use it when the water is scarce. However, the stored harvested rainwater does not often have a good quality for its possible microbial contamination. In this case; people have the option of resorting to dealers and buy bottled water from them (World Health Organization, 2008; Li et al., 2016). Another important reason that constricts the amount of accessible drinking water in Palestine is the controlled sources of water by the Israeli side (Palestinian Water Authority, 2012) which drives the consumer to buy bottled water as a safe and clean source of drinking water. The estimated worth of

annual volume of 89,000 million liters of the world market of bottled water is USD 22,000 million (Ferrier, 2001). In a study conducted in Gaza Strip to evaluate the quality of bottled water in according to its microbial contents, it was found that there was a serious microbial contamination due to the presence of bacteria in the investigated different brands of bottled water (Bashir and Aish, 2013). Another study emphasized that the percentage of imported bottled water in Gaza Strip reaches to approximately 80% (MacDonald et al., 2016).

With the continuous rising of consumption of bottled drinking water, many debates ascended from the local population about the quality of bottled drinking water, especially the locally filled one (Cidu et al., 2011; Diduch et al., 2016; Bulia and Enzweiler, 2018). These concerns came from the possibility of contamination in the production process, transportation and storage conditions especially storing the bottled water under the sun in front of supermarkets (Rahman at al., 2017). For example, a study was conducted in Lebanon where 32 local bottled water brands were examined for various quality parameters (Semerjian, 2011). It was found that the majority of the samples met the different national and international bottled water standards for physio-chemical parameters. Another study was conducted in Riyadh city, Saudi Arabia where 52 samples of bottled water were analyzed for its chemical quality (Al-Omran et al., 2013). It was revealed that all the chemical constituents of domestic bottled water were within the allowable limits set by Saudi Arabia standard (KSA), WHO and USEPA standards except for fluoride and bromate. The bromate concentration exceeded the permissible limits (bromate ≤ 10 µg/L) in 18% of the samples compared with its value in the labels.

Many quality parameters for bottled water are considered and tested by the competent authorities mainly the CPHL of the Palestinian MoH in the West Bank for this research. Therefore, the research has been conducted on the required tests for bottled water and to what level did these quality tests reach to determine the best quality of bottled drinking water. And for sure, the quality of the water was different for each brand according to their related sources and the methods used in water treatment. These matters and many others should be considered in the process of assessment of bottled water quality.

In general, the level of perception of the quality of bottled water and its impact on the humans and the environment has an effect on the development of transparency and credibility of the responsible institutions in the aspect of drinking water quality improvement. Media plays an essential role in advertising the bottled water, while education plays a different role in raising the awareness about the quality, negative or positive impacts of bottled water (Rahman et al., 2017).

We should consider the differences in perception of people in regards of how they assess the quality of bottled water. As some people may assess the quality of bottled water as an end product and other people may assess its quality in comparison with tap water or other source of drinking water (Dijkstra and de Roda Husman, 2014). The standards which people use to determine the quality of bottled water are useful to judge their perception (Juba and Tanyanyiwa, 2018). For example; if bottled water is more proper, cleaner, safer and tastes perfectly fine than tap water, then people will tend to think bottled water is a better choice than tap water (Juba and Tanyanyiwa, 2018). Universities play an important role in providing awareness to the students about the elements of the environment and sustainability principles. University students are thought to be more environmentally conscious than others who tend to adopt sustainability attitude (Qian, 2018). Therefore, this study is important with the contribution of Birzeit university students to determine their perceptions of drinking water. The study will serve as a starting point to understand the general behavior of the students toward the use of bottled water. In this study, drinking water options for Birzeit university students and the factors determining their choices have also been inquired.

1.2 Problem Statement

The demand of purchasing of bottled water is increasing in the Palestinian society. Comprehensive study on the quality of bottled water marketed in the West Bank and views of Palestinian university students on the reasons for consumption of bottled water was not observed. Especially since most of the drinking water supplied to households in the West Bank is somehow acceptable and suitable for drinking purpose. The importance of this study comes from bridging this research gap. In addition, this study links the results of the quality of bottled drinking water with the reasons students tend to

use bottled water. So, one can conclude the reasons behind the compatibility of water quality and trends on the use of bottled water.

1.3 Research Questions

This study was carried out to address the following research questions:

1. Is the quality of marketed bottled water in the West Bank within the permissible limits set by the Palestinian standards institute?
2. What are the students' perceptions of bottled water and other drinking water sources?
3. What are the factors that determine the drinking water choices of Birzeit university students?
4. Are Birzeit University students aware of the side effects of bottled water on the humans and the environment? Does this awareness stimulate pro-human and pro-environmental behaviors to consume less bottled water?

1.4 Study Objectives

The main objectives of this research are to:

1. Assess the quality of marketed bottled water in the West Bank, Palestine.
2. Determine the perception of Birzeit University students of the quality of bottled water and its impact on both humans and environment.

1.5 Significance of the Study

This research study is significant in assessing the quality of bottled water that is locally marketed in the West Bank, Palestine. In addition, it is significant in assessing Birzeit University students' perception of the quality of bottled water and its effects on both humans and environment. The outcome of this study will hopefully be a contribution in boosting the recognition of the local consumers on the quality of bottled water based on the collected data in this study. Moreover, the results of this study will trigger more

issues that could be considered by water scientists, environmental activists and water economists.

1.6 Assumptions and Limitations

As far as I know, this study is one of a few studies in this field in the West Bank. So, the reflection of many assumption and limitation will be noticed. The data which the study is based on, will give the study its credibility and it will minimize the gap at the current state. The study was limited to the population of the students of Birzeit University who by assumption, use bottled water within campus on daily activities. For the quality of bottled water, the research relied on the data from the CPHL of the Palestinian MoH in West Bank. Unfortunately, limited data were allowed to be taken from the records of the CPHL/MoH. The only obtained data from the records of the CPHL/MoH for bottled water were TDS, pH, nitrate and fluoride. The data given were not organized according to bottled water brand or number of samples for each brand. Instead, the data were given as total sum for all of the tested marketed bottled water brands in one day for each one of the previously mentioned quality parameters. Information about the numbers or names of tested bottled water brands was not allowed. Information about the tools or procedures used to measure TDS, pH, nitrate and fluoride quality parameters were not allowed either.

1.7 Scope

Bottled water is one of the drinking water sources that Palestinian people depend on. Other drinking water sources are springs, filtered water and tap water. Therefore, evaluation of the quality of bottled water was stated. An evaluation of the perception of the students of Birzeit University of the bottled water quality and its impacts on the humans and the environment was clarified too. Students of Birzeit University have different background and each individual comes from a different household, city or village in Palestine. So, the study tried to cover different areas in the West Bank.

1.8 Thesis Outline

The total chapters of this thesis sum up to four chapters. The first chapter presented a summery about the structure of the thesis by displaying an introduction to the research contents in a summarized overview, problem statement, research questions, study objectives, significance of the study, assumptions and limitations, and the scope of the study. The second chapter covered the literature review over the water status in the West Bank, Palestine, bottled water quality and perception of bottled water quality and its impact on both the humans and the environment. The third chapter covered the methodology for the study, the study area, climate and rainfall, and demography in West Bank, Palestine. Chapter four concluded the study with results and discussion. And it has two main parts, part one mentioned the results of collected data of bottled water quality from CPHL/MoH. The second part analyzed the perception of the students of Birzeit University of bottled water quality and its impacts on the humans and the environment. Finally, there was the conclusion of the study with some recommendations.

Chapter Two
Literature Review

2.1 Water Status in the West Bank, Palestine

Water is one of the main reasons for dispute between the Palestinians and the Israelis. The amount of water that is allotted from the West Bank to the Palestinians and the Israelis is about 679 mcm each year, and it is not distributed equally (Malone, 2004). By 2001, the average of the Palestinian water consumption was around 60 L/c/d, which was lower than the WHO minimum standard of 100 L/c/d (Ben-Naftali, 2011). This low water consumption by the Palestinians is considered substantially inadequate by the international standards (Zahra, 2001). While the average of the Israeli water consumption was around 350 L/c/d which is six times higher than the Palestinian consumption (Ben-Naftali, 2011). The water crisis will grow tremendously if this unequal distribution of water continued in the coming years, and the water resources in the West Bank will fail to fulfill the needs of the increasing Palestinian population (Malone, 2004). This situation could be predictable, since Israel has control over all water facilities that serve the Palestinians (Fredericksen, 2004). Israel has the access over 95% of the water of historical Palestine. Israel utilizes 2 billion cubic meters per year in addition to the recovered water mainly for irrigation, and the remaining 5% is allowed to be consumed by Palestinians (Fredericksen, 2004).

The water extracted from the mountain aquifer is shared by the Israelis and the Palestinians (Shuval & Dweik, 2007). As the recharge area is identified by where the rainwater seeps from the surface to the underground, the recharge area of the mountain aquifer is estimated to be 1,800 km2, and most of this area is located over the Green Line (Tal-Spiro, 2011). The flow of water in the aquifer is from south to north and from east to west, from the recharge area to the collecting area where the water captured (Tal-Spiro, 2011). Most of these areas are located in the Jordan Valley or within the Green Line. Because of that water movement, the rainwater that falls in the West Bank is likely flow to the Green Line region and be pumped there (Tal-Spiro, 2011). The rainfall flows underground from the mountains towards the coastal Israeli areas, forming the mountain aquifer. The Mountain Aquifer divided into three parts. Figure 1 shows the

three parts of the Mountain aquifer and Table 1 shows the three aquifers and the quantity of water that may be used by the Israeli side and the Palestinian side, as received from the Israeli Water Authority.

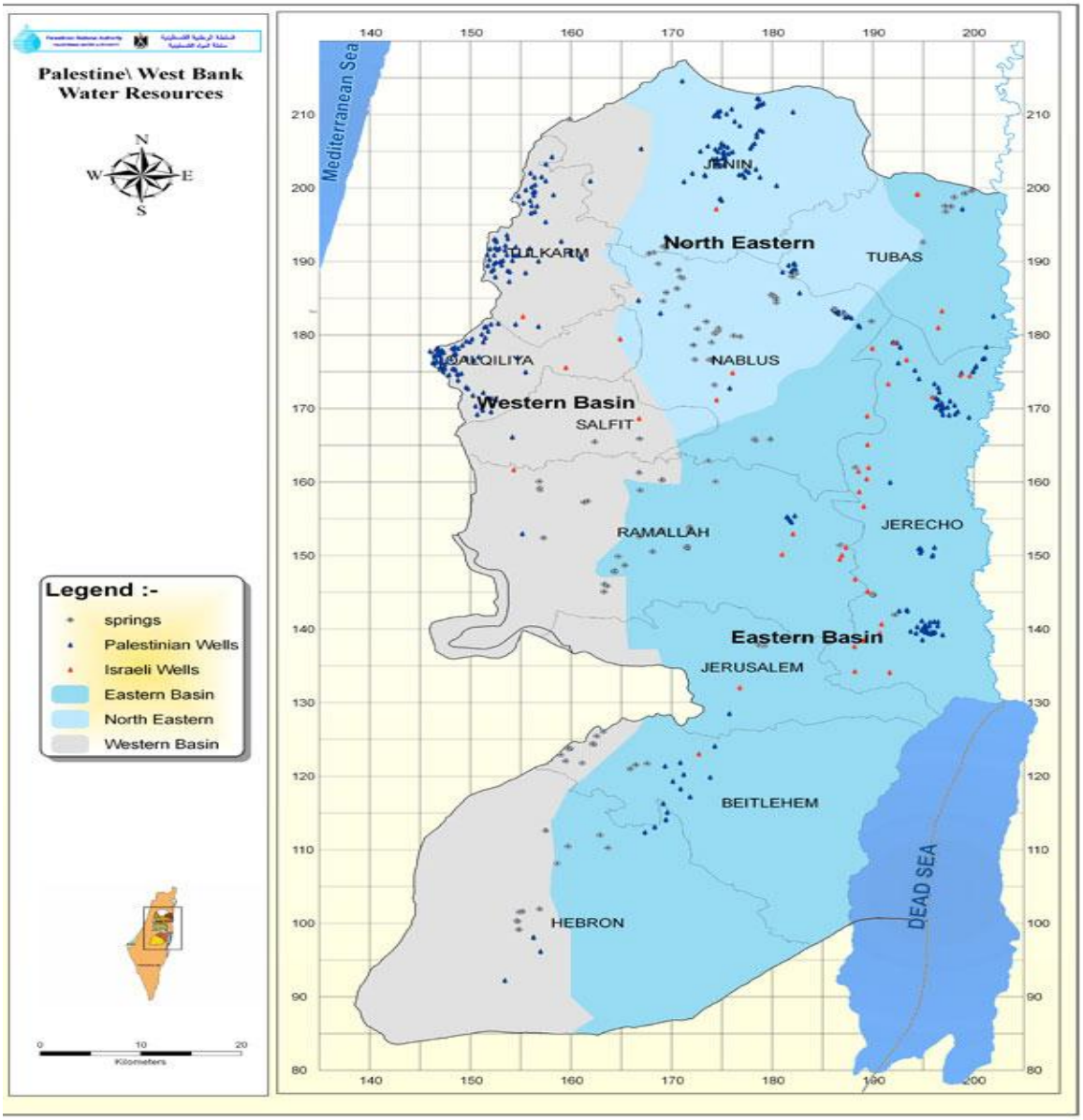

Figure 1: Water resources in West Bank, Palestine (PWA maps, published 9/7/2017, http://www.pwa.ps/ar_page.aspx?id=ecroEra1578958227aecroEr).

Table 1: The three Aquifers of the Mountain aquifer in West Bank, Palestine and the quantity of water that may be used by each side, as received from the Israeli Water Authority, 2011 (Tal-Spiro, 2011).

Aquifer name	Total of water that can be used annually (mcm/year)	Quantity of water Israel has the right to use per year (mcm/year)	Quantity of water the Palestinian Authority has the right to use per year (mcm/year)
The western aquifer	362	340	22
The northern aquifer	145	103	42
The eastern aquifer	172	40	132
Total	679	483	196

Through the previous 80 years, Jewish farmers utilized and pumped up around 80% water from the mountain aquifer (Shuval & Dweik, 2007). The claiming of the rights of Palestinians for the shared water is based on the fact that around 85% of the water is rainfall that falls over Palestinian lands. Based on the concept of water rights should go along with the land, that percentage of water should be allocated to the Palestinians (Shuval & Dweik, 2007). The claims of the Israelis are based on the fact regardless of the sources of the water; the international water law recognizes historic or prior use as a standard basis for water rights (Shuval & Dweik, 2007).

Jordan, Palestinian Authority, Syria, Lebanon and Israel share the water resources of the basin of Jordan River (Shuval & Dweik, 2007). The availability of water resources per person per year as estimated by the World Bank in 2005 is shown in Table 2.

Table 2: Availability of water resources of the Jordan River basin for its sharing parties according to the estimations of the World Bank, 2005 (Shuval & Dweik, 2007).

Country	Availability of water resources of Jordan river basin per person per year (m3/per/yr.) in 2005
Jordan	200
Palestinian Authority	70
Syria	800
Lebanon	1000
Israel	240

According to the World Bank, a minimum water requirement of 125 m^3/person/year is needed to maintain a reasonable level of economic and social life to meet vital human needs in the Middle East (Shuval & Dweik, 2007). Since Palestinians have the least share of the sources of the Jordan River basin, they obviously suffer the most.

Filling the gap of supply and demand of high-quality drinking water, the industry of bottled water has been in the rise in Palestine (Imseih, 2010). For example, bottled water providers have increased from one company in 1996 to around thirteen companies in 2010 in Ramallah and Al-Bireh city (Imseih, 2010). This increasing in bottled water providers is shown in Figure 2.

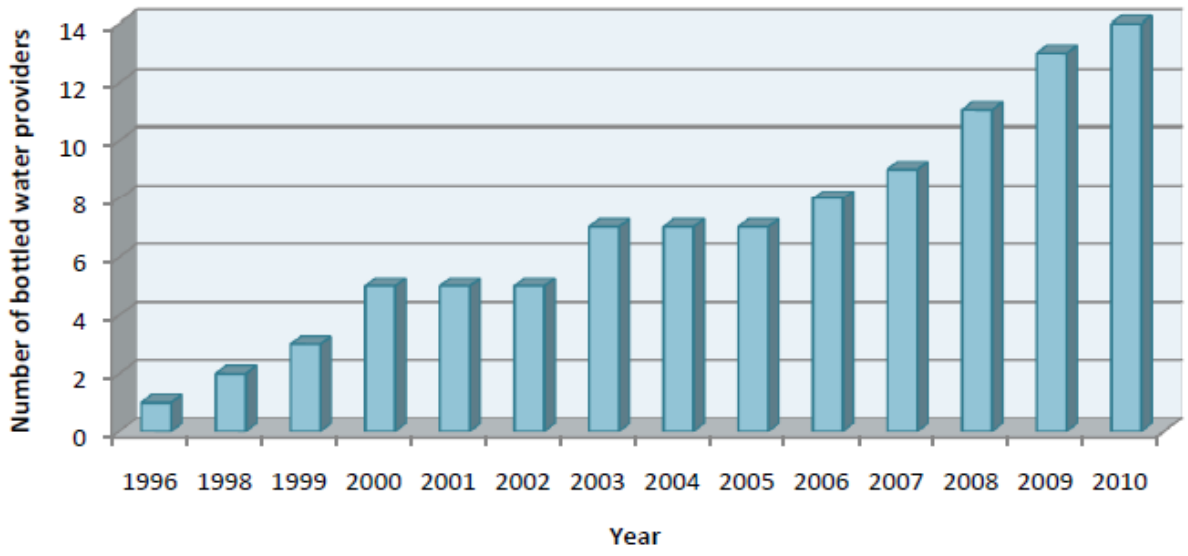

Figure 2: Bottled water providers in Ramallah and Al-Bireh city (Imseih, 2010).

Ramallah and Al-Bireh city is one of the highest consumers of bottled water in the West Bank, especially in urban areas, according to the collected information from the companies (Imseih, 2010). In addition, the sales of bottled water in winter are approximately one third of the sales in the summer as mentioned by the collected sales data of the bottled water companies in Ramallah and Al-Bireh city (Imseih, 2010).

2.2 Bottled Water Quality

The belief that bottled water is safe and has an acceptable taste compared to tap water is merely a misconception as shown in different studies (Lalumandier and Ayers, 2000; Raj, 2005). The attached “nutrition facts” label on bottled drinking water provides the consumer with few information about the water quality (Gleick, 2004). The idea of bottled drinking water has higher quality than tap water is debated with the arising number of incidents with bottled drinking water quality (Hu et al., 2011). Usually, measuring some parameters can determine the water quality to some extents. These water quality parameters can affect the human’s everyday activities in either positive or negative ways. These parameters can be important at certain concentration or they can cause some negative impacts at other concentrations. The importance and the risk of these parameters are as following:

Total Dissolved Solids (TDS)

The total dissolved solids (TDS) is a water quality indicator to the level of the lump sum of organic and inorganic matters in a liquid sample (except for pure water) without specifying the contaminant type (APEC Water, 2019). High concentration TDS can help with the formation of scale on the surface of pipes and appliances which lead to less performance efficiency and higher maintenance costs (APEC Water, 2019). Higher TDS values ARE additional load to water hardness (APEC Water, 2019). Electrically charged dissolved inorganic ions (such as calcium, magnesium, sodium, chloride, iron, manganese, sulfate, nitrate, bicarbonate and carbonate) create a good environment to conducting electricity in the water (APEC Water, 2019). Both man-caused activities (such as mining and drilling) and natural activities (such as erosion) may affect the formations of water-containers and cause more materials to dissolve in water (El-Salam

et al., 2008). Depending on the nature of the existing pollutant(s); high TDS values may result in foul odor, taste, color and health problems (El-Salam et al., 2008). A study stated that low concentration of TDS 133 – 220 mg/L was found in Saudi Arabia bottled water (Khan & Chohan, 2010). In Lebanon, TDS in bottled water was found in the range of 47.3 – 360 mg/L (Semerjian, 2011).

Acidity (pH)

The pH is an indicator to water acidity, pure water has pH value of 7. Water that has pH values less than 6.5 has corrosive, soft and acidic properties (WHO, 2011). The probability of existing metal ions increases with acidic water, which increases its toxic metal contents such as copper, zinc, iron and lead (WHO, 2011). Acidic water makes the taste of water unpleasant with sour and metallic taste. Acidic water also causes stains to the sinks, drains and washed clothes. It also has a corrosive effect on the metal pipes. In addition, it is accompanied with health risks to both human and animals (WHO, 2011). The water is considered hard if it has pH value higher than 8.5 (WHO, 2011). Hard water has an alkali taste. Hard water can cause many problems. It can cause scale layer on the sinks, utensils, laundry tubs and dishes. The detergents and soap become unable to produce suds because of hard water. No life-threatening issues were noticed on humans who consume hard water (WHO, 2011). A study conducted in Abeokuta, Nigeria, on 7 bottled water samples. The mean value of pH measurements showed that 3 out of 7 samples were below the WHO standards (6.5 – 8.5) and were slightly acidic. The rest of the samples corresponded with the WHO standards of bottled drinking water (Taiwo et al., 2010).

Nitrate (NO_3^-)

Groundwater can be contaminated with nitrate by the impact of vegetation, fertilizers or septic leakage (WHO, 2011). Other than that, the nitrate levels in groundwater are generally low (typically not more than 45 mg/L NO_3^-) (WHO, 2011). The intake of water that has high nitrate concentration within short-term can cause a case of blue baby syndrome for bottle-fed infants who are below 6 months (WHO, 2011). Blue baby syndrome (also defined as methemoglobinemia) is identified by respiratory and digestive issues, bluish mucus membrane and cyanosis (a case in which an inadequate

oxygenation of the blood or poor blood circulation causing bluish skin color) (WHO, 2011). Methemoglobinemia can be dangerous when it causes brain damage, anoxia (an absence of oxygen) or even death. If nitrate levels were between 85 – 115 mg/L, spontaneous miscarriage is highly probable for pregnant women (Taiwo et al., 2010). A study conducted in Abeokuta, Nigeria to assess the bottled water quality and to determine if the quality of the bottled water was acceptable by WHO standards (Taiwo et al., 2010). The study examined seven different brands in their local market and one of the tested parameters was nitrate. The nitrate concentration values were lower than the acceptable limit by WHO which is 50 mg/L (Taiwo et al., 2010).

Fluoride (F^-)

Fluoride levels of 1.5 mg/L are considered optimal for protection against dental caries (Warren et al., 2009). Higher levels may cause gastritis, ulcers, kidney failure, dental and bone fluorosis (mottling of the teeth and, if severe, calcification of the ligaments, and bone fractures and crippling) (Warren et al., 2009). The total daily intake of fluoride should be 0.05 – 0.07 mg F/kg of body weight as recommended by the American Academy of Pediatrics for optimal dental health and the fluoride intake should not exceed a daily level of 0.10 mg F/kg of body weight to avoid the risk of dental fluorosis (Warren et al., 2009). A study conducted in Babil, Iraq on 28 local bottled water brands and 12 imported bottled water brands (Matloob, 2011). The study showed that nine out of 28 local bottled water samples mentioned fluoride value on their respective labels, yet one out of these 9 bottles sample exceeded the fluoride concentration that is listed on the label (Matloob, 2011). The study also showed that six out of 12 imported bottled water samples mentioned fluoride value on their respective labels, yet 3 out of these 6 samples exceeded the fluoride concentration that is listed on the label (Matloob, 2011). Seemingly, none of these samples exceeded the allowable level of fluoride stated by WHO (Matloob, 2011).

Chloride (Cl^-)

Clean water has chloride levels usually below 10 mg/L and in some cases below 1mg/L (El-Salam et al., 2008). High concentration of chloride, approximately 250 mg/L, can be detected in the taste of water (El-Salam et al., 2008). Chloride in drinking water can only

be harmful to humans at high concentrations (El-Salam et al., 2008). Hence; the limitation on the chloride concentrations in drinking water comes from chloride effect on the taste of drinking water (El-Salam et al., 2008). People with kidney or heart diseases should consider taking a lower chloride intake because it poses a risk factor for them (El-Salam et al., 2008). Chloride can leak to the groundwater from different activities such as drainage from irrigation, septic tank discharge, industrial discharge, sea water intrusion, landfill leachate, animal feeds, and inorganic fertilizers (El-Salam et al., 2008). 14 different bottled drinking water samples were tested in Egypt, and the results showed that only one brand listed the chloride concentration above its actual measured value (El-Salam et al., 2008). While all of the actual measurements and the listed measurements were below the Egyptian standard for bottled drinking water (El-Salam et al., 2008).

Hardness

Hardness in water comes from the presence of both calcium and magnesium in water and is expressed as an equivalent concentration as calcium carbonate ($CaCO_3$) (Edzwald, 2010). Other insignificant ions that can take part in the formation of hardness such as divalent (ion with two valences) and trivalent (ion with three valences) ions are most of the times less than one mg/L (Edzwald, 2010). The water is considered soft when calcium carbonate concentration is less than 75 mg/L, and it is considered moderately hard when the calcium carbonate concentration is between 75 and 150 mg/L. The water is considered hard at calcium carbonate concentration between 150 and 300 mg/L, and it is considered very hard at concentrations higher than 300 mg/L (Edzwald, 2010). High concentration of calcium carbonate in the drinking water does not have dangerous effect on the humans; on the contrary, the presence of calcium and magnesium is beneficial in cases of the cardiovascular diseases (Edzwald, 2010). Also, corrosion by-products were found at higher concentrations in soft water (Edzwald, 2010). And even though the hard water can cause problems such as formation of scales on the sinks and the pipes, the USEPA suggested measures to control the corrosion by increasing the water hardness to reduce exposure to lead (Edzwald, 2010).

The study in Egypt which was conducted on 14 bottled water brands showed that the total hardness was within the range of 110 – 485 mg/L, where calcium hardness was higher than magnesium hardness (El-Salam et al., 2008).

Iron (Fe^{2+})

The reduced form of iron (Fe II) is a soluble form that exists in the reducing conditions in the groundwater and at the bottom of reservoirs (Edzwald, 2010). The corrosion of the water storage tank and the steal or iron pipes can increase the iron concentration in the drinking water (Edzwald, 2010). The high concentrations of iron can pose as a health risk factor since the daily intake requirement for a healthy adult man is in the range of 10 to 12 mg iron and for a healthy adult woman is in the range of 10 to 15 mg (Edzwald, 2010). And the long-term exposure for high concentrations of iron can also cause health problems such as heart, liver and pancreatic failure or dysfunction, especially for people who are genetically susceptible to hemochromatosis (Edzwald, 2010). The Secondary Maximum Contaminant Levels (SMCL) for iron of 0.3 mg/L was considered according to the noticeable metallic taste and the discoloration of laundry between the range of 0.1 and 1.0 mg/L (Edzwald, 2010). The physico-chemical analysis that was done for a study in Egypt concluded that 9 out of 14 bottled water samples have iron concentrations above the allowed limits stated by the Egyptian bottled water standards (El-Salam et al.,2008). While none of the brands mentioned the iron concentration in their respective labels (El-Salam et al., 2008).

Nitrite (NO_2^-)

Nitrate and nitrite ions are both parts of the nitrogen cycle that occurs naturally (Edzwald, 2010). Nitrite is the unstable form and oxidation of ammonia or reducing conditions are the only two ways to produce nitrite at significant levels in chemical and biological processes that occurs in nature (Edzwald, 2010). Sodium nitrite was previously used in some food industries but such application has been greatly limited (Edzwald, 2010). In rare cases, faulty cross connections or the execution of boiler cleaning with nitrous acid can contaminate the supplied water in the buildings (Edzwald, 2010). Adverse health effects are caused by the conversion of nitrate to nitrite (or vice versa) by two chemical reactions in the human body, which they are; the induction of

methemoglobinemia mainly in infants under six months of age, and the chance of formation of carcinogenic nitrosamides and nitrosamines (WHO, 2011). Nitrite in the range of 0.4 and above 200 mg/kg of body weight can develop methemoglobinemia in infants, hence comes the nitrites' guideline of 3 mg/L (Edzwald, 2010; WHO, 2011).

Sodium (Na^+)

Drinking water contains sodium naturally (Edzwald, 2010). Water softener can elevate the sodium concentration in tap water by 1 mg for every removed hardness of 2 mg (Edzwald, 2010). Individuals who can develop hypertension (high blood pressure) easily are at risk from taking high amounts of sodium in their diet (Edzwald, 2010). Hypertension can develop into other diseases such as stroke and coronary heart disease for people who are at risk (Edzwald, 2010). The level of concentrations of sodium in drinking water that is recommended by the USEPA is between 30 to 60 mg/L according to its taste (Edzwald, 2010). One percent of the minimum requirement is acquired by taking one liter of drinking water with sodium concentration of 20 mg/L (Edzwald, 2010).

The measured sodium concentrations in 14 different brands in Egypt was identical on 3 brands, while 11 out of 14 brands sample did not match the labels (El-Salam et al., 2008). The measured values were almost the same as the listed values on the labels (El-Salam et al., 2008). Yet all of the tested samples had sodium concentrations below the maximum levels stated by the Egyptian standards for bottled drinking water (El-Salam et al., 2008).

Sulfate (SO_4^{2-})

The Sulfate anion occurs naturally in water (El-Salam et al., 2008). Sulfate has ephemeral laxative effect if it was taken in high concentration in drinking water (El-Salam et al., 2008). For most adults, more than 1000 mg/L of sulfate can cause diarrhea, while it can cause diarrhea in infants at concentrations more than 600 mg/L which can develop into dehydration, especially in young children and infants who may have conducted microbial infection that causes them to have diarrhea (El-Salam et al., 2008). However, adults who have adjusted to high concentration of sulfate in their drinking water can live a normal life without getting sick (El-Salam et al., 2008). And in according to the water taste, the SMCL is 250 mg/L (El-Salam et al., 2008). Only one

tested bottled water sample had measured sulfate concentration identical to its concentration on the label in a study in Egypt conducted on 14 bottled water brands. But still all of the samples were below the allowable Egyptian standard (El-Salam et al., 2008).

In one study conducted on 17 Iranian bottled drinking water brands to see to what degree the tested samples agreed with the data on the labels, the results were as follow: for pH measurements the average of the measured values for the 17 brands was 8.0 (min. = 7.1, max. = 8.7) and the average for the labeled value was 7.4 (min. = 7.0, max. = 7.9), for TDS measurements the average of the measured values was 186.0 mg/L (min. = 46 mg/L, max. = 319 mg/L) and the average for the labeled value was 186.3 mg/L (min. = 95 mg/L, max. = 320 mg/L), for nitrate measurements the average of the measured values was 8.4 mg/L (min. = 1.8 mg/L, max. = 16.3 mg/L) and the average for the labeled value was 5.8 mg/L (min. = 0.5 mg/L, max. = 17 mg/L), and for fluoride measurements the average of the measured values was 0.3 mg/L (min. = 0.12 mg/L, max. = 0.54 mg/L) and the average for the labeled value was 0.3 mg/L (min. = 0.07 mg/L, max. = 2.0 mg/L) (Samadi et al., 2009). In another study in Manitoba, Canada, on 40 different bottled drinking water available in the market, the average TDS value was 405 ± 97 mg/L (min. = 5 mg/L, max. = 3,400 mg/L) and the average nitrate-N value was 0.65 ± 0.12 mg/L (min. < 0.01 mg/L, max. = 4.1 mg/L) (Pip, 2000).
In 2004, one study in Riyadh city of Saudi Arabia on 21 different locally produced bottled water brands showed that all of the tested bottled water samples have fluoride levels higher than the label values except for 2 brands, all of the tested samples have higher pH values than the label values except for 2 brands, and 16 brands have lower TDS concentration than the label values (Khan & Chohan, 2010). Another separate study that was published in the same year 2010 in Riyadh city of Saudi Arabia examined15 bottled water samples the mean fluoride concentration for 12 brands was 0.79 (±0.09) mg/L with a range of 0.5 – 0.83 mg/L. While the mean fluoride concentration for the other 3 “important” brands was 0.67 (±0.02) mg/L with a range of 0.65 – 0.69 mg/L. All of the tested brands attached the fluoride values to the label except for two brands (Aldrees& Al-Manea, 2010).

In a different paper, a study also in Riyadh city of Saudi Arabia on 9 different brands, values of pH has 2 samples were above their allowable pH level of 7.2 – 7.4, nitrate has one sample on the maximum allowable level, one sample on the minimum allowable level and one sample below the allowable nitrate level of 1 – 5 ppm, and fluoride has no values above their allowable level which is ≤ 1.7 ppm (Abed & Alwakeel, 2007).

A different study in Amritsar, India; bottled drinking water was tested for its physical and chemical qualities to make sure it complies with WHO and USEPA standards. Whereas, 17 brands of the bottled drinking water that is available in the markets of Amritsar were collected and analyzed to come with the following results. For the chemical and physical quality pH and TDS respectively, pH average was 6.91 (min. = 6.73, max. = 7.91) and 17.6% of the samples violated WHO/EPA standards. And for TDS, the average was 145 mg/L (min. = 35, max. = 387 mg/L) and none of the samples were out of range of WHO/EPA standards. For the chemical quality nitrate and fluoride, the average for nitrate was 1.35 mg/L (min. = 0.21, max. = 4.93 mg/L) and none of the samples were out of range of WHO/EPA standards. And the average for the fluoride was 0.24 mg/L (min. = 0.0 mg/L, max. = 0.74 mg/L) and none of the samples were out of range of WHO/EPA standards (Mahajan et al., 2006). In a different notice, the main results of the Amritsar study were: The tested samples have a lower value of TDS, conductance and hardness in comparison with the recommended limits of WHO. Most of the brands of the tested bottled drinking water were low in essential minerals and were considered “over-treated”. The tested bottled water samples were considered good as “distilled water” since it has low concentrations of some minerals like potassium, magnesium and fluoride. In fact, people who consume only bottled water for drinking purposes, for some of the brands of the bottled water samples that contains less than 0.5 mg/L fluoride, need an extra source of fluoride. And finally, the main problem was 7 out of the 17 bottled water samples have values of lead (more than 0.015 mg/L) above the recommended values by WHO and USEPA which can expose the consumers to health risk (Mahajan et al., 2006).

A result of a study in Cleveland, Ohio showed the fluoride concentration was less than 0.74 mg/L in most of the tested bottled water samples and the study also concluded that only 5% of the bottled drinking water marketed in Ohio and 100% of examined tap water had the recommended fluoride content by the state (Lalumandier and Ayers,

2000).Another study results on 17 brands of bottled water marketed in Iran concluded fluoride content of the samples was within the range of 0.00 – 0.59 mg/L and the mean of these measurements was 0.3 mg/L. And 6 of the 17 brands that have been tested have the same fluoride concentrations measurements in the attached labels (Dobaradaran et al. 2008). The results of a study in Greece on the fluoride in bottled water has the mean fluoride concentration of 0.35 mg/L with only 4 brands of the tested bottled samples attached the fluoride concentration on its labels (Ahiropoulos, 2006). The fluoride concentration in bottled water was within the range of 0.01 – 0.37 mg/L as shown in a study in England (Zohouri et al., 2003). In a study in Australia on the content of fluoride of still bottled water, the fluoride content was variable between batches of a three of the top selling bottled water brands (Cochrane et al., 2006).

2.3 Perception of Bottled Water Quality and its Impact

Few studies have questioned and discussed the link between consuming bottled drinking water and the perception of its quality, while most of the researches have put its main objectives the process of production, the regulations, supply and demand, and review and consequences (Hu et al., 2011). Water bottling plants have negative effects on the area in its zone such as streams, rivers and groundwater. Plastic, in general, and plastic bottles are waste that represent a major problem in the landfill if it is not recycled (Glennon, 2002). One other impact of the bottled water industry on the environment is the depletion of groundwater and decreasing the flow of streams and lakes due to immense water extraction leading to environmental exhaustion (Hu, 2011). Many studies showed the differences in gender and the level of education can affect the preference of bottled water over tap water and vice versa in according to the diverse in perception of environmental risk (Anadu and Harding, 2000; Flynn et al., 1994). Education, culture, social status, economy and psychological factors are the causes of risk perception and preventive attitude (Glicker, 1992). Research also shows the relationship between supply and demand of bottled water and the environmental awareness. For example, the environmental concern in the U.S. has a role in restricting the consuming of bottled drinking water which can be noted in the drop of sales in the bottled water market in the recent years (Hu, 2011). Many aspects could affect the

process of choosing bottled water over tap water for drinking propose such as; which one has the higher quality, which one taste better, and which one is free of hazards (Rahman et al., 2017). Meanwhile, many conflicts raised from the increasing consumption of bottled drinking water due to its potential negative impacts on the environment either in the filling process or the wastes produced after consumption (Makov et al., 2016). But one cannot neglect the reasons behind the growing consumption of bottled drinking water. For example; an incident of high concentrations of lead found in tap municipal water in Flint, Michigan in United States raised safety and health concerns between the public (Ganim and Tran,2016).

The people in the Mekong delta, Vietnam depend mostly on surface water, rainwater, and groundwater to fulfill their need of drinking water and the everyday aspects of their daily life since buying an outside water source will cost them and most people of the rural areas are not willing to buy it, even though the surface water, rainwater, and ground water have a poor quality due to the activities of the people in the rural areas that lead to contamination of their water resources, such agricultural herbicides and pesticides, on the other hand; some people are compelled to buy water at least for drinking purposes in the dry season if they do not have a way to store their needs of water during the rainy season (Li et al., 2016).

The poor quality of tap water and the worn-out lead pipes in the urban areas of France raised the consumption of bottled drinking water in the early 1970s (Ferrier, 2001). Bottled drinking water is not the only alternative for tap water of poor quality, people can use filters if they have the mean to buy one (Doria, 2006). Likewise; the consumption of bottled water in Harare – Zimbabwe increased due to irregular tap water supply, but forty brands of the bottled water did not meet the standard qualities for bottled drinking water, hence; these brands deemed unsuitable for public use since 2011 (Juba and Tanyanyiwa, 2018).

In another study in Vietnam which has been conducted on 384 random households in the rural areas of Trà Vinh Province (the majority of the households were poor), the data collected shows that the main source for drinking water was rainwater for the majority of the households during the dry season (77%) and rainy season (86%). The household use of bottled water was higher in the dry season (27%) in comparison with the rainy season (13%). While (65%) of the households preferred rainwater over bottled

water as a source of drinking water and (27%) preferred bottled drinking water (Li et al., 2016).

One major factor that control the decision of choosing bottled drinking water over tap water or vice versa is convenience. One study that was conducted in Switzerland and Germany showed that there were no differences in opinions between the two countries on how the consumption of bottled drinking water did not depend on its cost, but the differences in opinions were on their considerations of how much troublesome and heavy the transportation of bottled water, hence; it was not convenience. Carrying and transportation of bottled water from the store to the residential area was more troublesome for Swiss people than German people. And so; more Swiss than German people preferred consuming tap water more than bottled drinking water because - in their opinion - it was more convenient (Etale et al., 2018).

Bottled drinking water is mainly marketed in plastic bottles and hence comes their adverse effects on the environment and human beings. Alternatives have been suggested like using glass instead of plastic, but even the glass bottled water has negative effects on the environment (Orset et al., 2017). People in Switzerland thought negatively about the effects of producing, transportation, and consuming of bottled drinking water and consuming tap water has less negative impact on the environment. In comparison; German people were less responded than Swiss people in regard of the negative impact of consuming bottled water on the environment (Etale et al., 2018).

Majority of people are aware of the negative effects of producing and consuming bottled drinking water. But the countries that use waste recycling technology, such as Germany, are somehow ahead of other countries in terms of environment conversation.

Chapter Three
Methodology

3.1 Methodology

Data of different quality parameters (chemical and physical) of bottled water samples from different brands available in the Palestinian local market were obtained from the records of the CPHL of the Palestinian MoH in the West Bank. The tested chemical and physical water quality parameters included pH, TDS, nitrate and fluoride. Another data was collected about bottled water quality analysis from the attached label for eight different brands that are available in the market of the West Bank.

Another set of data was collected to analyze the perceptions of Birzeit University students of the use of bottled water. The study population was students of Birzeit University and the representative sample was measured to be 375 students from a total students' number of 14,346 students by using equation (1) and equation (2). A quantitative survey was used to analyze the behaviors and perceptions of Birzeit University students. And the survey was done by asking the participants objective questions related to this study topic to find the relationship between two variables (dependent and independent). Hence, a specifically designed questionnaire was used as a tool for collecting data from a statistically representative and non-random sample of students. The questionnaire was conducted in Arabic language (Palestinian native language). The questionnaire contained specific parameter for drinking water choices such as health safety, hygiene, convenience and availability, taste, personal and family habits and environmental concerns. Each of these factors was divided into different sub-factors. The sample of the study was distributed according to the college, gender and the academic year at the university. Table 3 and Table 4 show the distribution of the students' numbers for each collage, gender and academic year. The data were statistically analyzed by Statistical Package for the Social Sciences (SPSS) Statistics version 22.0.

Table 3: Distribution of students enrolled in Bachelor's degree and Master's degrees by college and gender for the academic year 2018/2019.

Enrolled in Bachelor's degree		Female	Male	Total
collage	Arts, music and design	48	29	77
	Business and economics	2,004	1,355	3,359
	Education	264	36	300
	Engineering and technology	1,296	1,928	3,224
	Law and public administration	1,158	584	1,742
	Literature	2,096	696	2,792
	Pharmacy, nursing and health professions	685	107	792
	Science	469	130	599
Total		**8,020**	**4,865**	**12,885**
Enrolled in Master's degree		**Female**	**Male**	**Total**
Graduate studies **(Total)**		**935**	**526**	**1,461**

Source: Planning & Development Office, Institutional Research Unit, Birzeit University.

Table 4: Students enrolled in the Bachelor's degree by college and educational year level for the academic year 2018/2019.

Collage	Year one	Year two	Year three	Year four	Year five	Year six	Total
Arts, music and design	56	11	5	5	0	0	77
Business and economics	1,380	733	643	603	0	0	3,359
Education	109	69	59	63	0	0	300
Engineering and technology	1,011	665	664	468	416	0	3,224
Law and public administration	625	366	341	410	0	0	1,742
Literature	1,052	668	490	582	0	0	2,792
Pharmacy, nursing and health professions	216	161	149	195	29	42	792
Science	219	133	98	149	0	0	599
Total	**4,668**	**2,806**	**2,449**	**2,475**	**445**	**42**	**12,885**

Source: Planning & Development Office, Institutional Research Unit, Birzeit University.

The sample size (n) was found to be 375 by following these steps:

Equation (1) was developed to calculate a representative sample for proportions for large population (Israel, 1992).

$$n_0 = \frac{Z^2 pq}{e^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where:

n_0: the sample size,

Z: the critical value where the x-axis of the normal curve cuts off an area α at the tails (for a confidence level of 95%, α is 0.05 and the critical value is 1.96),

e: the level of precision,

p: the estimated proportion of an attribute that is present in the population, and

q: is 1-p.

By assuming a maximum variability (p) of 0.5, a confidence level of 95% and precision of ±5%, the resulting sample size n_0:

$$n_0 = \frac{Z^2 pq}{e^2} = \frac{(1.96)^2(0.5)(0.5)}{0.05^2} = 385\ students$$

Correction for proportions for finite smaller population such as the students, the sample size (n_0) can be reduced by following Equation (2) (Israel, 1992).

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where,

n: the sample size,

N: the population size.

The resulting sample size:

$$n = \frac{n_0}{1 + \frac{n_0 - 1}{N}} = \frac{385}{1 + \frac{385 - 1}{14{,}346}} = 375\ students$$

Therefore, the students' sample for each collage, year, and gender for Bachelor's degree and Master's degrees is shown in Table 5. The Bachelor students are represented by 337 students, while the graduate students are represented by 38 students in total. The collected data were statistically analyzed by SPSS Statistics version 22.0.

Table 5: Sample size of students enrolled in Bachelor's degree and Master's degrees by college, educational year level and gender for the academic year 2018/2019.

College	Year one		Year two		Year three		Year four		Year five		Year six		Master's degrees		Total
	F*	M*	F	M	F	M	F	M	F	M	F	M	F	M	
Arts, music and design	1	1	0	0	0	0	0	0	0	0	0	0	0	0	2
Business and economics	21	14	11	8	10	7	10	6	0	0	0	0	0	0	87
Education	3	0	2	0	1	0	1	0	0	0	0	0	0	0	7
Engineering and technology	11	16	7	10	8	10	5	7	4	7	0	0	0	0	85
Graduate studies	0	0	0	0	0	0	0	0	0	0	0	0	24	14	38
Law and public administration	11	5	6	3	6	3	7	4	0	0	0	0	0	0	45
Literature	21	7	13	4	10	3	12	4	0	0	0	0	0	0	74
Pharmacy, nursing and health professions	5	1	4	1	3	1	4	1	1	0	1	0	0	0	22
Science	4	1	3	1	2	0	3	1	0	0	0	0	0	0	15
Total	**77**	**45**	**46**	**27**	**40**	**24**	**42**	**23**	**5**	**7**	**1**	**0**	**24**	**14**	**375**

F*: Female and M*: Male

3.2 Study Area

Geography of the West Bank

The West Bank is part of the occupied Palestinian territory (including East Jerusalem) which is located in the Middle East to the west of Jordan with a geographic coordination of 32 00 N, 35 15 E (IBP, 2017). The total area of the West Bank is 5,860 km^2 (including the northwest quarter of the Dead Sea) (IBP, 2017). The land area of the West Bank is 5,640 km^2 (including the "No-man's Land" that separates East and West Jerusalem) (IBP, 2017). The West Bank is a landlocked area that has no coastline and the total of its land boundaries is 404 km. The West Bank shares borders with Israel 307 km (1949 Armistice Line) and Jordan 97 km (IBP, 2017).

The major cities in the West Bank are Jericho, Tulkarm, Nablus, Qalqilyah, Jerusalem, Bethlehem, Ramallah, Jenin and Hebron (IBP, 2017) (see Figure 2).

The geological structure of the West Bank is mostly bumpy upland which is characterized with some vegetation in the east but barren in the west. The predominant surface rocks are chalk, marine sediments and limestone. There is an aquifer system in the West Bank. This aquifer system consists of the contained water in the underground

Figure 3: Map of West Bank, Palestine

(Source: https://www.cia.gov/llibrary/publications/the-world-factbook/geos/print_we.html)

rock layers which come through the porous rocks (IBP, 2017). The lowest and highest points in the West Bank are the Dead Sea (- 408 m) and Tall Asur (1,022 m), respectively (IBP, 2017).

3.3 Climate and Rainfall

The West Bank lies within the Mediterranean climatic zone. Although the West Bank is a very small area, it experiences significant climatic variation. The winter season in the West Bank is rainy, while the summer season is dry. Since the condition is dry steppe in the lower Jordan Valley, the Dead Sea region has an extreme desert climate (Water Fanack, 2016). The middle of October is usually the start of the rainy season in the West Bank. While most of the rain falls between November and March, the rainy season continues up until May with mild rain. A possibility of snow rarely occurs in the mountains and highlands of the West Bank region. The average annual rainfall in the West Bank is 535 mm (Isaac & Rishmawi, 2015). Table 6 shows the quantity of rainfall in different location in the West Bank between the years of 2012 and 2018.

Table 6: Rainfall Quantity (mm) in the West Bank by Month and Station Location from year 2012 to 2018 (PCBS & PMD, 2019).

Station	Rainfall quantity (mm) from year 2012 to 2018						
	2012	2013	2014	2015	2016	2017	2018
Tulkarm	NA*	743	426	667	439	NA	877
Bethlehem	508	548	346	512	NA	NA	518
Hebron	621	661	447	544	606	356	621
Jenin	545	480	263	529	548	NA	763
Jericho	136	148	103	201	107	46	213
Jerusalem	NA	549	400	NA	NA	NA	NA
Nablus	764	806	439	595	681	NA	873
Ramallah	861	771	425	612	568	NA	804

*NA: Not Available

3.4 Demography

The preliminary results of the general population census in 2017 showed that the total population in the West Bank has reached 2,881,687 individuals (PCBS, 2018). The percentage of the population who falls under the range of ages between newborn and 17 years old has reached 47.5% of the West Bank population, while 25.0% of the West Bank population falls under the range of ages between 18 - 29 years old and 5.9% are more than 60 years old (PCBS, 2018). The total illiterate males who are above fifteen years old were 15,163 males, and the total illiterate females exceeded the males' number by about three times to reach 47,732 females (PCBS, 2018). The total unemployed people in the West Bank have reached 96,420 individuals, and they represented 13.2% of the total population (PCBS, 2018). The report also mentioned that nine out of ten individuals in the West Bank used safe drinking water (PCBS, 2018).

Chapter Four
Results and Discussion

This chapter consists of the results and discussion of the study. It contains three main parts. The first part “collected quality data of bottled water from CPHL/MoH” listed the water quality data which were collected from the CPHL/MoH and compared them with the PSI and WHO standards. The second part “collected bottled water quality data from labels” consists of collected data of water quality analysis from eight different labels, which are available in the West Bank market. The third part “Birzeit University students’ perception of bottled water quality and its impact” consists of the collected data and analysis of the distributed questionnaire. This part analyzed the students’ perception of bottled water quality and its impact on humans and the environment. The chapter was concluded with a conclusion and recommendations section.

4.1 Collected Quality Data of Bottled Water from CPHL/MoH

The collected bottled drinking water quality data (see Table 7) from the Palestinian CPHL/MoH were from the year 2014 to 2017. The data acquired were the physical parameter (TDS) and the chemical parameters (pH, nitrate and fluoride).

Total Dissolved Solids (TDS)

According to the World Health Organization, the taste of drinking water is considered good as long as the TDS level is less than 600 mg/L (WHO, 2011). The taste of drinking water becomes unlikable when the TDS level is higher than 1000 mg/L (WHO, 2011). There is no established guideline for TDS, since there were no reported health effects related to the ingestion of TDS within concentrations usually found in drinking water (WHO, 2011). The only concerns that come from high levels of TDS in water are the unlikable taste of drinking water and its effect on heaters, water pipes and household appliances (WHO, 2011). The PSI standard for TDS is up to 1000 mg/L (PSI, 2005). Through the years of 2014 – 2017, as shown in Table 7, none of the samples were out of MAC.

Acidity (pH)

The pH parameter is one of the most important operational water parameters, yet it does not have a direct effect on consumers (WHO, 2011). The importance of the pH parameter in the operational aspect is noticed in the water treatment stages of clarification and disinfection (WHO, 2011). The pH should be less than 8 for efficient disinfection with chlorine, but pH value of 7 or less can be corrosive (WHO, 2011). Also, pH level should be controlled to minimize any damages to water pipes and appliances (WHO, 2011). If pH level was not maintained and corrosion occurred, the drinking water could be contaminated affecting its taste and appearance (WHO, 2011). The optimum pH level that is required for operational purposes is within the range of 6.5 – 8.5 (WHO, 2011). The pH parameter is not of health concern at levels found in drinking water, so no established guideline value has been proposed (WHO, 2011). The PSI standard for pH is between 6.5 – 8.5 (PSI, 2005). Through the years of 2014 – 2017, as shown in Table 7, the average percentage of the out of MAC samples for pH was 7.3%. As the pH value has no direct effect on the consumer, the out of range samples are of no concern, based on WHO explanation. In 2014, 4.4% of the measured pH values were out of MAC, while 8% of the samples were out of MAC in 2015. In 2016, 7.5% of the samples were out of MAC. Lastly, in 2017, 8.6% of the samples were out of MAC.

Nitrate (NO_3^-)

The occurrence of the blue baby syndrome (or methemoglobinemia) in bottle-fed infants was the base to set the guideline value of nitrate which is 50 mg/L (WHO, 2011) (see Section 2.2). The PSI standard for nitrate is less than 50 mg/L (PSI, 2005). Through the years of 2014 – 2017, as shown in Table 7, the average percentage of the out of MAC samples for nitrate was 7.7%. As there was a slight number of samples that are out of MAC, people should be aware that using bottled water in long period for bottle-fed infants could be harmful. None of the samples were out of MAC in 2014. While 14.3%, 4.7% and 10.8% of the samples were above the MAC in 2015, 2016 and 2017 respectively.

Fluoride (F^-)

Fluoride is one of the chemicals which their presence in drinking water contributes in preventing disease (WHO, 2011). Intake of fluoride from drinking water is important in protecting against dental caries (WHO, 2011). There is no attempt to define minimum desirable concentrations for minerals in drinking water as the consumed amount of water and the intake from other sources should be considered when setting the guidelines (WHO, 2011). The PSI standard for fluoride is less than 1.5 mg/L (PSI, 2005). Through the years of 2014 – 2017, as shown in Table 7, none of the samples were out of MAC.

4.2 Collected Bottled Water Quality Data from Labels

Labels data were taken from eight different brands of bottled water which are marketed in the West Bank, Palestine. Alphabetical codes were chosen instead of the original brands' names for privacy policy. Since there were only four quality parameters data obtained from the CBHL/MoH, it was a good idea to attach other quality parameters data from some bottled water labels.

Since the parameters listed on each label differ from one another, comparing one brand with another is somehow dispersed and not limited to one parameter for all brands. In general, the data listed in the bottled water labels samples, which are taken from the marketed bottled water in the West Bank (see Table 8), shows no violation of the Palestinian standards for bottled water.

Table 7: Collected bottled water quality from CPHL/MoH (CPHL/MoH, 2018).

Year	Statistics of obtained data	pH	TDS (mg/L)	Nitrate (mg/L)	Fluoride (mg/L)
2014	Number of samples	69	65	10	7
	Readings range	5.9 - 8.4	97 - 558	2.4 - 19.4	0.12 - 0.23
	Readings mean	7.6	289.1	10.3	0.20
	Standard deviation	0.4	96.4	6.4	0.05
	Samples out of MAC*	3	0	0	0
	Samples out of MAC %	4.4	0	0	0
2015	Number of samples	75	74	14	13
	Readings range	5.9 - 8.3	96 - 679	0 - 65.9	0.04 - 0.37
	Readings mean	7.6	264.5	14.6	0.14
	Standard deviation	0.5	106.1	21.1	0.11
	Samples out of MAC	6	0	2	0
	Samples out of MAC %	8	0	14.3	0
2016	Number of samples	93	93	43	43
	Readings range	5.9 - 8.4	121 - 513	1 - 67	0.04 - 0.37
	Readings mean	7.7	259.4	14.4	0.15
	Standard deviation	0.5	94.4	14.6	0.07
	Samples out of MAC	7	0	2	0
	Sample out of MAC %	7.5	0	4.7	0
2017	Number of samples	93	96	37	43
	Readings range	5.8 - 8.6	127 - 486	0.3 - 66.8	0.02 - 0.4
	Readings mean	7.8	252.1	16.1	0.15
	Standard deviation	0.6	83	18.9	0.09
	Samples out of MAC	8	0	4	0
	Samples out of MAC %	8.6	0	10.8	0
Total samples	Number of samples	330	328	104	106
	Readings range	5.8 - 8.6	96 - 679	0 - 67	0.02 - 0.4
	Readings mean	7.7	266.3	13.9	0.16
	Standard deviation	0.5	94.9	15.3	0.08
	Samples out of MAC	24	0	8	0
	Samples out of MAC %	7.3	0	7.7	0
PSI (2005)		6.5 - 8.5	≤1000	≤50	1.5
WHO (2011)		NA**	NA	≤50	1.5

*MAC: Maximum Allowable Concentration according to PSI (2005)

**NA: Not Available

Table 8: Collected bottled water quality data from labels.

Parameter	Unit	Bottled water brand code								PSI (2005)
		A	B	C	D	E	F	G	H	
pH	-	6.6	8	8.15	8.05	7.5	7.86	7.12	7.71	6.5 – 8.5
TDS	mg/L	163	350	NA	390	300	300	NA	161	≤1000
Color	Pt/Co scale	NA	NA	none	NA	NA	NA	NA	NA	15
Conductivity	µS/cm	NA	NA	160	NA	NA	NA	NA	NA	NA
Odor	-	NA	NA	none	NA	NA	NA	NA	NA	Palatable
Oxidation Potential	mg/L O_2	NA	NA	0.64	NA	NA	NA	NA	NA	NA
Taste	-	NA	NA	suitable	NA	NA	NA	NA	NA	Palatable
Turbidity	NTU	NA	NA	none	NA	NA	NA	NA	NA	1
Total Hardness	mg/L	114	NA	NA	NA	NA	NA	NA	93	≤500
CO_3^-	mg/L	NA	NA	NA	NA	NA	NA	NA	0.00	NA
HCO_3^-	mg/L	<25.0	250	NA	313.5	290	239	NA	90	NA
H_2CO_3	mg/L	<1	NA	NA	NA	NA	NA	NA	NA	NA
NO_3^-	mg/L	1.2	16	NA	26.3	<0.1	NA	2.52	4.2	≤50
Ca^{++}	mg/L	20	55	NA	75.85	50	50	NA	20	≤100
Mg^{++}	mg/L	18.0	25	NA	28.7	28	25	NA	9.6	≤100
K^+	mg/L	<1.0	1	NA	2.9	1.8	0.79	NA	0.35	≤10
Cl^-	mg/L	72	44	<0.43	50	NA	NA	1.52	20.6	≤250
SO_4^{--}	mg/L	<0.5	30	2.71	20.5	NA	23	15.65	8.0	≤200
Na^{++}	mg/L	3.0	26	0.78	25.3	NA	27	2.4	12.43	≤200
F^-	mg/L	<0.1	0.4	NA	0.2	NA	NA	0.002	0.066	≤1.5
Fe^{++}	mg/L	<0.001	= 0.0	<0.001	0	NA	NA	0	NA	≤0.3
NO_2^-	mg/L	<0.1	= 0.0	NA	0	NA	NA	NA	NA	NA
Al^{+++}	mg/L	NA	NA	<0.002	NA	NA	NA	0	NA	≤0.2
NH_4^+	mg/L	NA	NA	<0.02	NA	NA	NA	NA	NA	NA
Mn^{++}	mg/L	NA	NA	<0.001	NA	NA	NA	NA	NA	≤0.1
PO_4^{---}	mg/L	NA	NA	NA	0.16	NA	NA	NA	NA	NA

*NA: Not Available

4.3 Birzeit University Students Perception of Bottled Water Quality and Its Impact

The study has been conducted on 375 students of Birzeit University (see Chapter 3), where questionnaire was distributed on them (see Appendix 1). Table 9 represents the distribution of the independent factors of the students of the surveyed sample by numbers and percentages based on collage, academic year, gender, number of family members, city, residence type and family income.

The business and economic major has the highest percentage of participated students with a percentage of 26.1%, while the arts, music and design major came with the least participated students' percentage of 0.5%. The highest participants' percentage according to the academic year was for the first-year students with percentage of 32.5%, while the Master's degrees students have the least percentage of 10.1%. The male participants represented the minority of the students with a percentage of 37.6%, while the female participants represented the majority of students with a percentage of 62.4%. The highest percentage of number of family members was within the range of (6 to 8 individuals) with a percentage of 56.8%, followed by (2 to 5 individuals) with a percentage of 31.2%, while 12% of the participants have families with (more than 9 individuals).

The highest percentage of participants was from Ramallah and Al-Bireh city with a percentage of 58.4%, while the next highest percentage of participants was from Jerusalem city with a percentage of 18.9%. The main reason for this percentage is mainly because Birzeit University is located in Ramallah and Al-Bireh city. There are many different universities, colleges and academic institutions distributed though out the governorates of the West Bank, which can contain enormous numbers of students in each respective city. Students' families who reside in urban areas came with a percentage of 58.7%, while 37.3% of the families reside in rural areas and 4% of the families reside in refugee camps.

Table 9: Surveyed sample distribution (numbers and percentages) based on collage, academic year, gender, number of family members, city, residence type and family income.

Independent Factors		Number of respondents	Percentage of respondents (%)	total
Collage	Arts, music and design	2	0.5	375 (100%)
	Business and economics	87	23.2	
	Education	7	1.9	
	Engineering and technology	85	22.7	
	Graduate studies	38	10.1	
	Law and public administration	45	12.0	
	Literature	74	19.7	
	Pharmacy, nursing and health professions	22	5.9	
	Science	15	4.0	
Academic year	First year	122	32.5	375 (100%)
	Second year	73	19.5	
	Third year	64	17.1	
	Fourth year and above	78	20.8	
	Master's degrees	38	10.1	
Gender	Male	141	37.6	375 (100%)
	Female	234	62.4	
Number of family members	2-5	117	31.2	375 (100%)
	6-8	213	56.8	
	≥9	45	12	
City	Bethlehem	11	2.9	375 (100%)
	Hebron	24	6.4	
	Jenin	8	2.1	
	Jericho	0	0	
	Jerusalem	71	18.9	
	Nablus	15	4	
	Qalqilya	2	0.5	
	Ramallah and Al-Bireh	219	58.4	
	Salfit	9	2.4	
	Tubas	4	1.1	
	Tulkarm	12	3.2	
Residence type	Urban	220	58.7	375 (100%)
	Rural	140	37.3	
	Refugee camp	15	4	
Average family income (NIS/month)	≤2000	19	5.1	375 (100%)
	2001 - 2500	42	11.2	
	2501 - 3000	94	25.1	
	3001 - 4000	93	24.8	
	>4000	127	33.9	

1 USD = 3.4769 NIS (September 30, 2019).

The percentage of the average family income for the students of Birzeit University was as the following; 33.9% of the students have family income that was higher than 4000 NIS/month while the next highest average family income was within the range of 2501 – 3000 NIS/month with 25.1% of the students and the next highest average family income was within the range of 3001 – 4000 NIS/month with a slightly lower percentage of the previous income range with a percentage of 24.8% and the rest of the students' sample has family income below 2500 NIS/month. This section of the questionnaire was added to assess the ability of the families of the students to add other drinking water source(s) to their home and/or add filter for the tap water if they thought it was needed. Table 10 represents the dependent factors of the main source of drinking water at home and Birzeit University and the overall students' response to the survey questions.

Table 10: Overall responses of the students to the survey questions.

Question number	Question (Dependent factors)	Answer	Percentage of respondents (%)
1	What is the main drinking water source at your home	Tap water	66.4
		Filtered tap water	18.1
		Bottled water	8.8
		Others	6.7
2	What is the main drinking water source at Birzeit University	Tap water	3.5
		Filtered tap water	2.7
		Bottled water	92
		Others	1.9
3	Do you think the bottled water is cleaner than the tap water?	Yes	85.9
		No	14.1
4	Do you think the bottled water is safer than the tap water?	Yes	82.4
		No	17.6
5	Do you think the bottled water has acceptable taste more than the tap water?	Yes	76.5
		No	23.5
6	Do you think the bottled water is more convenient than the tap water within Birzeit University campus?	Yes	87.7
		No	12.3
7	Do you think the bottled water has a negative impact on the human?	Yes	29.3
		No	70.7
8	Do you think the bottled water has negative impact on the environment?	Yes	94.9
		No	5.1

The main drinking water source for the families of the students of Birzeit University back at home was the tap water with a percentage of 66.4% followed by filtered tap water with a percentage of 18.1% and bottled water with a percentage of 8.8%. Meanwhile, 6.7% of the families relied on other drinking water sources such as harvested rainwater and buying water from vendors. Most families depended on tap water which might be an indication for the high quality of tap water (in their opinion) or they cannot afford extra expenses for external drinking water source. Some people think there is no difference in the quality between tap water and bottled water.

The main drinking water source that Birzeit University students rely on was bottled water with a percentage of 92.0%. The students who consume tap water and filtered tap water were 3.5% and 2.7%, respectively. While the percentage of the students who used other sources of drinking water at the university was 1.9%, such as bringing tap water or filtered tap water from the drinking water source they use at home.

The outcome of the opinion of Birzeit University students about the bottled water quality in comparison with tap water and the bottled water impact on both the human beings and the environment varied between agreement and disagreement. In regard of the quality of bottled drinking water, 85.9% of the students' sample thought the bottled drinking water is cleaner than tap water and 82.4% of the students agreed that the bottled water is safer than the tap water. In regard of the taste of bottled water, 76.5% of the students agreed that the bottled water has a better taste than the tap water. The previous three statements about cleanliness, safety and taste of bottled drinking water contradicted with the percentage of the main source of drinking water at home, which showed a majority for using tap water as a source of drinking water at home with a percentage of 66.4%. Meanwhile, the three statements go along with the percentage of the main drinking water source within Birzeit University which is 92.0% for bottled water. The reasons for these differences can be explained as follows:

- The water drinking available at home is according to its availability, accessibility and the financial capacity and options for the families of the students of Birzeit University.
- The students, generally, have the freedom to choose their drinking water source within Birzeit University campus.

- The ease of access to bottled drinking water (the main choice for the students within the University) as noticed in Table 10. The percentage of the students who agreed that the bottled water is more convenient and easier to reach within Birzeit University was 87.7%.

Regarding the impacts for consuming bottled drinking water, the majority of the students with a percentage of 70.7% thought the bottled drinking water has no effect on humans. Some of the students thought a high concentration of sodium could negatively affect people who suffer from high blood pressure. Other students thought a high concentration of calcium could negatively affect people who suffer from kidney disease. Moreover, few students thought the plastic material of the bottle could seep into the water and negatively affect human health. Regarding the impact of bottled drinking water on the environment, 94.9% of the students agreed that the bottled drinking water has an impact on the environment, mostly because of the plastic waste.

A cross-tabulation was applied using SPSS. The purpose of applying cross-tabulation is to determine which of the dependent factors are correlated to the independent factors, within a confidence limit of 95%. The following dependent factors were found to be significant to a specific independent factor, where P-value was less than 0.05. Hence; the factors are not independent of each other, and a statistical relationship between these variables exists.

4.2.1 Effect of Academic Year on the Students' Perception

After performing the ANOVA test, only two out of eight dependent factors in Table 10 were found to be significant to the independent factor "Academic year" where P-value < 0.05 as shown in Table 11. A cross-tabulation test was performed in order to see the effect of the academic year on the dependent factors of perception of the students about the convenience of bottled water within the campus and the impact of bottled drinking water on humans.

Table 11 shows the variation in students' response based on the independent factor "academic year." The relatable dependent factors were found to be "the bottled drinking water is more convenient than the tap water within Birzeit University campus" and "the bottled drinking water has a negative impact on the human." The answers varied for

both cases for the different academic year levels and the percentage of students who agreed and disagreed were almost equal to each other in some cases.

Table 11: Variation in students' response based on academic year.

Question	Answer	Percentage of respondents (%)				
		First year	Second year	Third year	Fourth year and above	Master's degrees
Do you think the bottled water is more convenient than the tap water within Birzeit University campus? P-value = 0.032, chi-square = 10.296, df = 4	Yes	31.0	19.1	17.9	20.4	11.6
	No	43.5	21.7	10.9	23.9	0.0
Do you think the bottled water has a negative impact on the human? P-value = 0.000, chi-square = 28.386, df = 4	Yes	29.1	19.1	11.8	17.3	22.7
	No	34.0	19.6	19.2	22.3	4.9

In respect of the convenience of reaching the bottled water within the campus, it was found this dependent factor was actually related to the academic year of the students since P-value = 0.032. The opinion of first-year students came with the most gap, since the majority of them thought the bottled water is less convenient than tap water within the university campus. The same pattern was observed in the second-year students where the students who disagreed were more than the students who agreed. But the students' perspective divided between agreement and disagreement into almost two equal groups. The opinions of the third-year students were reversed since the highest percentage of them agreed that the bottled water is more convenient than tap water within the campus. The opinions of the fourth-year and above students followed the pattern of the second-year students while all of the Master's degrees students agreed that the bottled water is more convenient than the tap water within the university campus. This variation in the opinions for the different academic years comes from many reasons. Many students are not satisfied with the variety of bottled water available in the vending machines or its selling spots. Since almost all of these vending machines provide one brand of bottled water. So, they prefer bringing tap water from home or drinking from fountain water in the university. Other students trusted the quality of

bottled water more than the tap water available at the campus so they preferred to buy bottled water from its selling spots.

A variation in the opinions between agreement and disagreement for “the bottled drinking water has a negative impact on the human” in the different academic years. Most of the students who agreed that the bottled water has a negative effect on the humans were from the first year then they were followed by the Master’s degrees students, second year students, and fourth year and above students and third year students in a descending order. While most of the students who disagreed that the bottled water has a negative effect on the humans were also from the first year then they were followed by the fourth year and above students, second year students, third year students and the Master’s degrees students also in a descending order.

In a study conducted in Suriname to evaluate the consumers buying behavior of bottled drinking water, it was found out that there is no considerable relationship between the behavior of buying bottled drinking water and the demographic variables of education, age and gender. The consumers also had a positive perception of bottled water quality than tap water since they described it with positive characteristics such as reliable, refreshing, convenient, safer, healthier, available item, socially accepted and a good substitute to other beverages (Durga, 2010).

In another study, the participants of a students’ sample had thought highly of the tap water over the bottled water regarding its quality and the pro-environmental behavior for water consumption. Meanwhile, they confirmed using reusable plastic drinking water bottles to refill them with tap water. In addition, the sales of bottled water were common because of the availability of bottled water selling points at all university facilities, which confirmed the undeniable existence of bottled water (Díez et al., 2018).

4.2.2 Effect of Number of Family Members on the Students’ Perception

When the ANOVA test was performed, only one out of eight dependent factors in Table 10 was found to be significant to the independent factor “number of family members” where P-value $<$ 0.05 as shown in Table 12.

The cross-tabulation test showed the relationship between the independent factor of “number of family members” and the dependent factor of “bottled drinking water is more

convenient than the tap water within Birzeit University campus" where P-value = 0.029, (see Table 12). Most of the students thought the bottled water is more convenient than tap water within the university campus have family members between 2 – 5 individuals. While the highest percentage of the students who have family members more than 9 individuals also agreed. The highest percentage who disagreed was the students who have family members between 6 – 8 individuals.

Table 12: Variation in students' response based on number of family members.

Question	Answer	Percentage of respondents (%)		
		2 – 5 family members	6 – 8 family members	≥ 9 family members
Do you think the bottled water is more convenient than the tap water within Birzeit University campus? P-value = 0.029, chi-square = 7.052, df = 2	Yes	33.4	54.4	12.2
	No	15.2	73.9	10.9

The results of a study which was carried out in the Philippines showed that the households that came to realize that their different drinking water source at home were to be harmful preferred to consume bottled water or purified water instead (Francisco, 2014). Factors other than the drinking water safety were found to have a significant effect on buying bottled water, such as the number of individuals in a household, household income, bottled water price, the presence of children younger than 5 years old and the education level of the household heads. However, the income was not a significant factor in deciding to buy or not to buy bottled water (Francisco, 2014).

4.2.3 Effect of Residence Type on the Students' Perception

The ANOVA test showed that only two out of eight dependent factors in Table 10 were significant to the independent factor "residence type" where P-value < 0.05 as shown in Table 13. The relation between the independent factor "residence type" and the dependent factors "the main drinking water source at home" and "the bottled drinking water is cleaner than the tap water" was analyzed by cross-tabulation, where P-value equals to 0.022 and 0.05, respectively, (see Table 13).

Table 13: Variation in students' response based on residence type.

Question	Answer	Percentage of respondents (%)		
		Urban	Rural	Refugee camp
What is the main drinking water source at your home? P-value = 0.022, chi-square = 15.153, df =6	Tap water	62.2	32.5	5.2
	Filtered tap water	55.9	42.6	1.5
	Bottled water	57.6	39.4	3.0
	Others	32.0	68.0	0.0
Do you think the bottled water is cleaner than the tap water? P-value = 0.050, chi-square = 5.626, df =2	Yes	60.9	35.7	3.4
	No	45.3	47.2	7.5

The majority of the students' residence was in the urban areas in the West Bank then it was followed by the rural areas and the lowest percentage was of the students who live in the refugee camps. So, the different water sources used at home were chosen by the students mostly from the urban areas. The students who use tap water as a main source of drinking water at home in the urban areas were as twice as the students in the rural areas, while they were the least in the refugee camps. The same pattern was noticed for the homes that use filtered tap water and tap water but with a less gap between the urban and rural areas (around 15%) than that for the houses that use tap water, while the refugee camps have the least percentage. In regard to the homes that use other drinking water sources; the rural areas have the highest percent then the urban areas come next with almost half of the percentage, while the refugee camps' homes have no other water sources than the tap water, filtered tap water and bottled water. The highest percentage in the other water sources in the rural areas was mostly because of using wells.

The students who thought the bottled drinking water is cleaner than tap water were mostly from the urban regions in the West Bank while more than the half of them were from the rural region and the least were from the refugee camps. While the students who did not think the bottled water is cleaner than the tap water were almost equal for the urban and the rural areas. The high percentage of the students who did not agree on "the bottled water is cleaner than the tap water" in the rural area might be because of comparing their quality with other water sources used at their homes. For example; if the quality of extracted water from wells (which they use as a main source of drinking

water) was lower compared with tap water, the idea of “the tap water has a high quality” will be the standard.

In the early 1970s, the consumption of bottled water in the urban areas was much higher than other regions in the French cities. That was due to the poor state of the worn lead pipes and the low quality of the urban tap water (Doria, 2006). Another study between two countries (United Kingdom and Portugal) was done to compare the effect of the perceptions of drinking water quality and risk on the consumers’ behavior. It was found that the people who use the bottled water as the main source of drinking water are 53% of the Portuguese respondents and 34% of the United Kingdom respondents (de França Doria, et al., 2009).

A survey conducted at an urban clinic, where 208 participants were a convenience sample of caretakers of teenagers and younger generations regarding their perceptions of the bottled water and tap water qualities, their choices between tap water and bottled water, and their awareness about fluoride (Huerta-Saenz, 2012). The percentage of participants who depended on bottled water as an only source of drinking water was 38% and the percentage of participants who depended on tap water as an only source of drinking water was 17%. While 42% depended on both bottled drinking water and tap water as a source of drinking water. So, the bottled water was the preferred source of drinking water in the pediatric population at the urban clinic. The driving force over the type of drinking water preferences seemed to be the perceptions of the qualities of the different sources of drinking water (Huerta-Saenz, 2012).

4.2.4 Effect of Average Family Income on the Students’ Perception

The ANOVA test showed that three out of eight dependent factors in Table 10 was significant to the independent factor “average family income” where P-value < 0.05 as shown in Table 14.

The relation between the independent factor “average family income” and the dependent factors “the main drinking water source at home”, “the main drinking water source at Birzeit University” and “the bottled drinking water has negative impact on the environment” was analyzed by cross-tabulation, where P-value equals to 0.005, 0.032 and 0.025, respectively, (see Table 14).

Table 14: Variation in students' response based on average family income (NIS/month).

Question	Answer	Percentage of respondents (%)				
		≤2000 NIS/month	2001-2500 NIS/month	2501-3000 NIS/month	3001-4000 NIS/month	>4000 NIS/month
What is the main drinking water source at your home? P-value = 0.005, chi-square = 23.377, df = 12	Tap water	4.8	12.9	29.3	26.9	26.1
	Filtered tap water	1.5	4.4	14.7	22.1	57.4
	Bottled water	6.1	9.1	15.2	18.2	51.5
	Others	16.0	16.0	24.0	20.0	24.0
What is the main drinking water source at Birzeit University? P-value = 0.032, chi-square = 10.296, df = 4	Tap water	23.1	15.4	30.8	23.1	7.7
	Filtered tap water	0.0	0.0	10.0	50.0	40.0
	Bottled water	4.6	10.4	25.8	24.1	35.1
	Others	0.0	57.1	0.0	28.6	14.3
Do you think the bottled water has a negative impact on the environment? P-value = 0.025, chi-square = 7.367, df = 2	Yes	5.3	11.5	25.6	24.4	33.1
	No	0.0	5.3	15.8	31.6	47.4

The highest percentage of students who used tap water at their homes has an average family income in the range of 2501 – 3000 NIS/month. The highest percentage of students who used filtered tap water and bottled water at their homes has an average family income more than 4000 NIS/month. The highest percentage of students who used other drinking water sources at their homes has an average family income in the range of 2501 – 3000 NIS/month and more than 4000 NIS/month.

The highest percentage of students who used tap water in Birzeit University campus has an average family income in the range of 2501 – 3000 NIS/month. While the highest percentage of students who used filtered tap water in Birzeit University campus has an average family income in the range of 3001 – 4000 NIS/month. Furthermore, the highest percentage of students who used bottled water in Birzeit University campus has an average family income more than 4000 NIS/month. The highest percentage of students who used other drinking water sources in Birzeit University campus has an average family income in the range of 2001 – 2500 NIS/month.

The highest percentage of the students who agreed that the bottled water has negative impact on the environment has an average family income more than 4000 NIS/month while the least percentage was for the students who have an average family income less than 2000 NIS/month. While the highest percentage of the students who disagreed

that the bottled water has negative impact on the environment has an average family income more than 4000 NIS/month and the least percentage was for the students who have an average family income in the range of 2001 – 2500 NIS/month. None of the students whose families' income was less than 2000 NIS/month thought that the bottled drinking water has an impact on the environment. In general, the factors that affect the students' perception of the bottled water quality and its impact on the humans and the environment are their education level and awareness, the financial status of their families and their residence type.

A study conducted in Parral, Mexico, showed that the willingness of the households to pay for an addition service of drinking water (e.g., bottled water, filtered water, cisterns, etc.) which is reliable and safe is within the range of 1.8 - 7.55% above their usual water bill (Vásquez et al., 2009). Considering the bottled water as a luxury item, a research concluded that there is a relation between the income and the behavior of buying bottled water (Durga, 2010). Independent youngsters and students in the range of 16 – 25 years old with relatively high-income show tendencies to buy bottled water as a luxurious item they can get anytime they want. Even though the people in the range of 16 – 25 years old usually have low income yet they are also devoted consumers of bottled drinking water. This category of people is affected by the intense bottled water marketing and the luxury items that are socially accepted (Durga, 2010).

One study conducted in two different universities (University of Vermont and Washington University in St. Louis) to assess the effectiveness of decreasing the plastic waste by banning the bottled water showed different results of the ban of bottled water (D'Altrui, 2017). Whereas the consuming of bottled beverage decreased because of the ban of bottled beverages in some of the studies, the consuming of sugar sweetened beverages which can cause weight gain has increased in other studies. Two different solutions that were suggested to solve this problem, which they are; partial ban of bottled beverages and adding a plastic bottle tax to the coat (D'Altrui, 2017).

A survey about water quality and safety, and preference between bottled water and tap water was conducted in Pennsylvania with a total of 143 participants from the parents of child care centers (Merkel et al., 2012). The majority of the participants preferred tap water over bottled water for its higher quality and safety in their opinions. They were also concerned over both the impact of bottled water on the environment and the

potential pollution resulted from nuclear power plants and the process of natural gas drilling (Merkel et al., 2012).

Conclusion and Recommendations

The study demonstrated the level of bottled water quality and Birzeit University students' perception of bottled water quality and its impact on humans and environment. The bottled water quality data which were collected from CPHL/MoH covered only four water quality parameters. The collected data were TDS, pH, nitrate and fluoride. The percentage of the parameters that went out of MAC were pH (7.3%) and nitrate (7.7%), while the TDS and fluoride levels were within the acceptable limits of PSI (2005) standards. According to the WHO standards, nitrate was the only parameter that has some samples with higher nitrate concentrations than the one allowed by WHO – 2011. The percentage of the samples that did not fall under the WHO standards was 7.7%. High nitrate intake by bottle-fed infants can cause blue baby syndrome, which was the main health concern for high nitrate levels in bottled water. A questionnaire was distributed on the students of Birzeit University to assess their perception of bottled water quality and its effect on humans and environment. The analysis of the data showed that the factors that affect the perception of the students are mainly the educational year at the university, the income, the family size and the residence type.

Even though the percentages of the out of MAC parameters were relatively low (less than 8%), their respective water samples were still considered not subjected by the PSI standards. Students with different residence type showed variation of responses in respect to the cleanliness of bottled water in comparison with tap water. So, it could be that the students are aware of the quality of bottled and tap water. The same case with students of different academic years, who had variation of opinions on whether the bottled water has a negative impact on humans. Also, many students with different family income, showed variations of opinions on whether the bottled water has a negative impact on the environment.

The obtained data (pH, TDS, nitrate and fluoride) from the records of the CPHL of the Palestinian MoH in West Bank shows a wide variety of measurements for each parameter. That is likely due to the different sources of each water brand, which has a variety of geological structures for different water resources or due to the method used to produce the bottled water (e.g. added or removed minerals). Regular measurements are good follow up, especially for the parameters that show wide variation in its measurements. Also, further parameters could be obtained, tested and compared for other elements (e.g. calcium, magnesium, chloride, sulfide, PAHs, fecal coliform, total coliform and several heavy metals) for further wide range studies. Protection of water resources from pollution should be considered. There is a need for more deterrent measures & supervision over the bottled water market, particularly in regard with quality control, labeling and regular monitoring.

Information about the water source (e.g. spring, wells, etc.), type of water (e.g. natural mineral water, purified water, etc.), mineral composition and the method used for treatment should be mentioned on the bottles' labels and accessible to the consumers.

Protection of water resources from pollution should be considered and there is a need for more deterrent measures & supervision over the bottled water market, particularly in regard with quality control, labeling and regular monitoring.

As the education level increases, the awareness about the water quality in general will also increase. So, a variety of opinions will be noticed for different students. Also, as the financial status for the family increase, there will be a wide range of options for additional water resources at home and other facilities. The residence may be the main effect on the main water source at home. The supplied water in the urban, rural and the refugee camps should be of high quality and sampled and tested in regular bases. And if it was not of a high quality or it was not available in sufficient quantities, filters can be applied or another water source can be added if the financial status allowed to.

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Appendix 1: Questionnaire

The questions in the questionnaire were as follow:

1- Choose your collage

1- Literature
2- Arts, music and design
3- Business and economics
4- Education
5- Engineering and technology
6- Law and public administration
7- Pharmacy, nursing and health professions
8- Science

2- Choose your academic year in the university

1- First year
2- Second year
3- Third year
4- Fourth year and above
5- Graduate studies (Master and Ph.D.)

3- Choose your gender

1- Male 2- Female

4- State the number of your family members _____

5- State which city you are from _____ and choose one of city/village/refugee camp

6- Choose your family monthly income

1- Less or equal to 2000 NIS
2- 2001 – 2500 NIS
3- 2501 – 3000 NIS
4- 3001 – 4000 NIS
5- More than 4000 NIS

7- Choose the main drinking water source at your home

1- Tap water
2- Filtered tap water
3- Bottled water
4- Others

8- Choose the main drinking water source at Birzeit University

1- Tap water
2- Filtered tap water
3- Bottled water
4- Others

9- Do you think the bottled water is cleaner than the tap water?

1- Yes 2- No

10- Do you think the bottled water is safer than the tap water?

1- Yes 2- No

11- Do you think the bottled water has acceptable taste more than the tap water?

1- Yes 2- No

12- Do you think the bottled water is more convenient than the tap water within Birzeit University campus?

1- Yes 2- No

13- Do you think the bottled water has a negative impact on the human?

1- Yes 2- No

14- Do you think the bottled water has a negative impact on the environment?

1- Yes 2- No