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Faculty of Engineering and Information Technology

Department of Chemical and Materials Engineering

(Graduation Project II)

Water Quality Analysis of Tap Drinking Water in The Northern Regions of The West Bank

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إهداء

حمدًا لله سبحانه وتعالى ...

إلى الحبيب المصطفى محمد صلى الله عليه وسلم ...

إلى ثرى هذا الوطن وكل من عبر برفق وخدم ترابه ...

إليك فلسطين ...

إلى القدس زهرة المدائن ...

إلى أبي الذي لم يبخل علي يومًا بشيء ...

وإلى أمي التي زودتني بالحنان والمحبة ...

إلى كل من علمني حرفًا أصبح سنا برقه يضيء طريقي ...

إلى كل من أضاء بعلمه عقل غيره ...

أو هدى بالجواب الصحيح حيرة سائليه ...

إلى أهلي ...

إلى زملائي وزميلاتي ...

و إهداء خاص إلى مشرفاتنا الفاضلات المهندسة ميس شديد والمهندسة حنان كوني

أهدي هذا البحث المتواضع راجيًا من المولى

عز وجل أن يجد التوفيق و القبول والنجاح

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Disclaimer statement:

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Symbol	Definition
WHO	World Health Organization
PSI	Palestinian Standards Institution
SS	Suspended Solids
TDS	Total Dissolved Solids
EC	Electrical Conductivity
TC	Total Coliform
mS	Milli Semen's
PH	Potential of Hydrogen
Tc	Total Chlorine
T	Turbidity
FTIR	Fourier Transform Infrared Spectroscopy
TSS	Total Suspended Solids
SSC	Suspended Solids Concertation
ISIS	Indian Standards Institute Standards
COD	Chemical Oxygen Demand
BOD	Biological Oxygen Demand
BODu	Ultimate Biological Oxygen Demand
DPD	N, N-diethyl-p-phenylenediamine

Abstract:

Water is essential for development. It is crucial in human lives. In Palestine, water sources and Surface water are limited and joint with neighboring countries. Palestine depends on rainwater, which is not available all the year. Water problems varied from pollution of local sources, to lack of minerals. This project analyzes drinking tap water quality in the north of Palestine in terms of health effects, pollution and composition, to determine whether the water is drinkable and meets the international and local standards or not. So, solutions could be offered for water polluted areas. In part 1,465 individuals participated in a questionnaire. The resultsshowedthat85.81 % are using municipality water and 54.41 %don't know the source of their municipality water. 80.43 % drink directly from the tap. 59.78 % uses polluted water. Water had 47.96 % change to brown color and 22.8 % change to white color and 60.43 % of the water have unaccepted smell. 53.55 % of the families have weekly consumption of Less than 2 cubic meters.12.25 % gave the highest value of confidence in the municipality water, and23.87 % gave the highest value of water amount efficiency. The results showed that the majority of the citizens are unpleased with their tap municipal water. In part 2, municipal drinking tap water was chosen to conduct tests on, because the results in part 1 showed unsatisfaction with it. 10mainwater tests were doneon8 samples locations, the tests were repeated 3 times. The sample locations are from4 cities: Nablus, Jenin, Qalqilya, Tulkarim and 4 villages Ajja, Northern Asira, Azzoun, Illar. The tests are: PH, NO_3^-, NO_2^--, Turbidity, TDS, EC, Mg hardness, Ca Hardness, Total Chlorine and total Coliform tests. The results showed that there is excess of NO_3^- and total chlorine in some samples. A high electrical conductivity values in 4 samples was found due to increase of ions concentrations in the samples. Only Ajja sample failed the total Coliform test as there were 10 Bacterial Colonies. The Ca, Mg, PH, TDS, Turbidity and NO_2^-tests values were all in the permitted range for all the samples.

Chapter One: Introduction

1.1Overview:

Water is the most valuable natural resource on earth, it is very important to support and sustain life. As it is one of the most important resources that a person has exploited and consumed in his life more than anything else. It is an essential recourse for the living creatures including human, and it is impossible to live without it.

The water exists in three physical states of solid, liquid and vapor. In the liquid state it forms oceans, seas, lakes, rivers, fountains and rain. the liquid state is responsible of biological process within living organism. In the solid state it is in the form of snow and ice. The gaseous state is the water vapor present in the atmosphere that causes the thermal load phenomenon.

Water is the basis for the existence of life on the planet, and it covers 71%of its surface. The water of the oceans and seas represent the largest percentage of water on earth, about 96.5% the remaining percentage is distributed between ground water and polar ice (1.7% for both), what left is a small percentage in the form of water vapor suspended in the air in form of clouds and sometimes in the form of fog. the percentage of fresh water is only about 2.5% of the water on earth. The most of this amount (99%) is found in the polar regions, while 0.3% of fresh water is found in rivers, lakes and in the atmosphere(Conn & Barker, 1984).

Most of the water on the planet are stored in oceans and ice sheets that are difficult to recover and difficult to meet our diverse needs. the amount of valid water on this land is of limited use. Because of reasons like: salinity, temperature and far and harsh geographic locations(asaad, 2016).

Instead of these water resources, there are three main sources of water that are used to supply drinking water and satisfy population needs. They are: surface water, ground water, and rainwater. The majority of human water needs are met from them. Here, there is a short brief about each type:

1- surface water sources: like lakes and rivers. The rivers are a source of water supply that help us meet our local, industrial, and agricultural needs. It plays an important role in the development of any society.

2- Ground water sources: like wells and springs. For wells water to be suitable for human use, there are some conditions that are required to be met such as:

1- The location of the well should be far from any source of pollution. Such as places for collecting waste, sewage pipes and animal pens.

2- The ground and walls of the wells should be free from any cracks.

3- The water of the well should be clean and free from any harmful substances such as microbes.

4- Disinfection of the well must be done before its use and after any repairs that have been exposed to contamination of pipes and pumps.

5- The area around the well should be covered with concrete layer in order to keep it safe and clean(asaad, 2016).

However, these wells have some disadvantages; for example, the supply of water is limited due to several parameters, such as the amount of rainfall and catchment area size. There is also a fear of contamination due to many factors like sewage pipes and animal waste.

3- rain waters: the rainwater that falls on a catchment area is collected and stored inside wells to be used for drinking and other various uses. When the rain falls, itis deposited in surface and groundwater sources and regenerates the water sources. It is also used to fill huge human made structures like Dams, storage vessels and man-made water wells. It should be noticed that the method for rain water collecting was also used since ancient times. The previous technique is called rain water harvesting, which is defined as the collecting and storing of rain water. Collecting water inside wells is sorted as one of the simplest ways for supplying water that is needed for drinking and other house works such as cooking, washing, cleaning, and other things(asaad, 2016).

It is most important that the water which people drink and use is clean water. This means that the water must be free of germs, chemicals and to be clear (not cloudy). Water that is safe for drinking is called potable water. It carries nutrients and oxygen to the cells in our body. It allows the body to absorb and assimilate minerals, vitamins, amino acids, glucose and other substances. It also flushes out toxins, human wastes and helps to regulate body temperature.

Disease causing germs and chemicals can find their way into the water supplies. When this happens. The water becomes polluted or contaminated and when people drink it or come in contact with it in other ways, they could become sick. Water that is not safe to drink is said to

be non-potable. Throughout history there have been many occasions when hundreds of thousands of people have died because disease-causing germs have been spread through a community by a polluted water supply. One of the reasons this happens less frequently now is that people in many countries make sure drinking water supplies are potable. Water supplies are routinely checked for germs and chemicals which can pollute the water. If the water is not safe to drink it is treated. All these actions are taken to make sure that drinking water is potable and safe for human use**.**

1.2Global Water Situation:

In 2017, 71% of the global population (5.3 billion people) used a safety managed drinking water services, that is located in inhabited premises. It is always available when needed world's and free from contamination. 90% of global population (6.8 billion people) used at least a basic water service. A basic service is an improved drinking water source within a round trip of 30 minutes to collect water(Drinking-water, 2019). 785 million people lack even a basic drinking water services, including 144 million people who are dependent on surface water. Globally, at least 2 billion people use a drinking water source contaminated with human and animal feces. By 2025, half of the population will be living in water stressed area. In the least developed countries22% of the health care facilities have no water service, this cause that 15% of patients develop an infection during the hospital stay, with the proportion much greater in low-income countries(Drinking-water, 2019).

1.3 Water Situation in The West Bank:

Water in the West Bank consist of two main sources, which are surface water such as rivers and water valleys. And ground water Such as wells and springs. these sources are formed due to the rain falling on the mountain's peaks and the lands in the West Bank. Rain is the main feeder for these two sources(Water Authority, 2018). surface and ground water in the West Bank vary in terms of the main source, as there are many water sources that draw water from outside the borders of the west bank. Artesian wells are concentrated in the west bank in the Jordan valley, Tulkarim, Qalqilya, Nablus and to a lesser extent in Bethlehem. It is water drawn from the underground basins, so these well are spread in various regions and dug over the

underground basins. A large part of the water coming from is used to irrigate crops(Palestinian News and Information Agency).

Palestine is like any other developed country, suffers from water scarcity, pollution and quality problems. Here are the major problems in the drinking water in the north of the West Bank:

1- Pollution: Water pollution is one of the most important environmental problems, despite the constant purification of water through rain and evaporation. This pollution is due to the increase in population, urban expansion in industry and agriculture as well(Goel, 2006).The quality and quantity of the water will continue to decrease as the population and water consumption in the West Bank are increasing in a fast rate. Also, one of the causes of the pollution, is the disposal of industrial and domestic wastes in the rivers and on the land, where they reach the ground water sources like wells and spring. This leads to various pollution risks to the land, water, plants, and the nearby living community. This human made action contributed to a significant deterioration in water quality(Gaur, 2018).

These are some of the Categories of Water Pollution:(Denchak, 2018)

1- **Groundwater Pollution:** When rain falls, it penetrates deep into the ground and fills cracks in the aquifer. For example: 40% of Americans depend on groundwater that is pumped to the surface of the earth for drinking water. In rural areas, they depend on fresh water. The groundwater is polluted by the waste and sewage systems that reach it, which makes it unsafe and suitable for human use.
2- **Transboundary Pollution:** It is the result of its water pollution to the waters of another country, and is the result of pollution from a disaster such as an oil spill or slow crawl. Like what happened in the eastern cost of the US, when an oil tube owned by British petroleum broke and unleashed tons of oil into the ocean(Denchak, 2018).
3- **Energy Use Pollution:** When the population increases, the energy increases for human activities. The burning coal in power stations increases emissions of sulfur and nitrogen oxides in the atmosphere, these gases are what cause acid rain
4- **Agriculture Pollution:** Agriculture increases soil erosion, causing plowing, grazing, road state, disturbance of the soil and plants. This affects the amounts of salts and minerals in the water
5- **Industries Pollution:** Industries produce waste which is polluting, affecting:

- pH of water (whether it is acid, neutral or alkaline).

- color of water.

- amount minerals and salts (too much can cause health problems).

2- Water Scarcity: One of the water problems that people face in the West Bank is the lack of water that differs from one region to another, which may be caused by human actions or natural causes outside the human intervention, such as the difference in the level of rain. There are human conflicts over lands or over water sources, which leads to the inability of people in the areas adjacent to these lands to access the water sources located in them. Another problem is the excessive consumption of water, as areas that enjoy abundant water, which causes lack of water in other regions of the same country.

1.4DrinkingWaterQuality Standards:

The Drinking water should meet plenty of standards and parameters to be allowed for human use and consumption. These standards are written by governmental institutes and organizations. They differ from a country to another. But in general, there are huge similarities and little variations between the countries. For example, the World Health Organization, is an international institute Consist of multiple nations and countries. They have put their own Standard for drinking water that meets the majority of the world health concerns. In Palestinian territories the water authority and the Palestine Standards Institution are the one's responsible of making and writing the standards and here is some of these drinking water standards:

Table 1 :characteristic and standards of drinking water(Daghara et al., 2019)**.**

Characteristics	Unit	Range of measured value	Mean value	Percentage above acceptable limit (%)	Permission limits according to	
					PSI	WHO
Temperature	°C	18–27	23		NA	NA
Turbidity	NTU	0.05–9.9	1.57	25	Up to 5.0	Up to 5.0
Chloride content	mg/L	22.0–284	75.4	24	Up to 250	Up to 250
pH		7.08–8.19	7.55	24	6.5–8.5	6.5–8.5
Electrical conductivity (EC)	μScm^{-1}	473–1406	764	41	Up to 2000	Up to 2000
Nitrates	mg-NO_3-N/L	0–106	30	21	Up to 10	Up to 10
Total hardness		199–485	344	10	500	NA
Residual chlorine		0–1.39	0.452	16	NA	NA
Total chlorine		0.01–1.69	0.519	18	NA	NA
Na^+ concentration	mg/L	16.9–137	40.9	15	NA	Up to 200

Range of electrical conductivity (EC) in $\mu S/cm$	Water quality classification
<250	Excellent
250–750	Good
750–2,000	Permissible
2,000–3,000	Doubtful
>3,000	Unsuitable

Total hardness in mg/L	Degree of hardness
0–75	Soft
75–150	Moderately hard
150–300	Hard
>300	Very hard

Chapter Two: Literature Review:

Water quality refers to the chemical, physical, biological, and radiological characteristics of the water. It is a measure of the condition of water relative to the requirements of one or more biotic species, or to any human need or purpose. As water plays an important role in maintaining human health. Clean water for drinking and usage is basic human right for all human beings. People who do not have access to clean water and do not have adequate sanitation, suffer deaths and health problems due to water-related diseases. Therefore, water quality monitoring is a highest priority in all over the world. Water quality and suitability for the human usage are determined by multiple important factor like: its taste, odor, color, salinity, minerals percentage and concentration of organic and inorganic matters(Dissmeyer, 2000). The changes that occur to the drinking water, either because of natural factor or human factors like factories and industrial pollutions, effects the properties of water and causes damage to water quality and make it unsuitable for human use(Schweitzer & Noblet, 2018).

Globally, the most prevalent drinking water problem is the scarcity of pure water suitable for human use. More than a billion people currently live in water-scarce regions, and as many as 3.5 billion could experience water scarcity by 2025(Drinking-water, 2019). Increasing pollution degrades freshwater and coastal aquatic ecosystems. And climate change is poised to shift precipitation patterns and speed glacial melt, altering water supplies and intensifying floods and drought(Drinking-water, 2019).

For drinking water quality analysis, preservation and protection has become one of the most important issues that needs attention, due to its important role in human health. Drinking Water quality analysis, are a group of scientific methods and experiments which are used to determine the composition, quality, environmental impact and the direct effect of the drinking water on human body and health(Drinking-water, 2019). For drinking tab water, these tests determine whether the water is suitable for human consumption and meets the international and domestic standards.

The issue of drinking water quality and analysis was studied by many scientists and researchers in many regions all over the world. In the year 2015, the quality of drinking water was also studied in the region of Perak State, Malaysia, in order to see if the water was safe for drinking or not. A physical and chemical analysis of drinking water was done. Some parameters were studied such as turbidity, conductivity, (TSS) and also (TDS). By comparing the results with the World Health Organization standards and National Drinking Water Quality Standards, it was found that the water is clean and safe for drinking(Rahmanian et al., 2015).

Also, in 2003, the quality of some wells of Ward No. 17 of Chikhli town, India was studied. The samples were collected and analyzed. It was found that the chemical parameters as color, taste and turbidity are within the allowed standards. The water is good for drinking due to the results that were compared with World Health Organization standards (WHO) and Indian Standards Institute Standards (ISIS)(Khadsan & Kadu, 2016).

There was also a problem that was studied from 2007 to 2010, which was the high turbidity in drinking water treatment plant in Khartoum, Sudan. The problem was noticed in the flood season. Data on turbidity were collected such as concentration of suspended materials, the amount of water produced, the type of polymer that was used in clarification and the water level in the Blue Nile. The information was analyzed by using special analysis computer programs. It was found that there is a relation between turbidity (T) and concentration of suspended materials (TSS, SSC). It was decided that using primary sedimentation basins was good solution to reduce the percentage of silt in the raw water that enters the plants (University Of Khartoum Engineering Journal, 2016).

Another study was done in 2017 in Wadi Hadramout, Yemen. Groundwater is sorted as the main supply for drinking water in most cities in Wadi Hadramout. From analyzing the water, it was found that the color, temperature and dissolved salts (TDS) of chemical, physical and biological properties were in the allowed range of Yemeni standards. However, it was shown that some cities have high level of some elements such as Mercury and Cilinum which may make drinking water unsafe(Obeidoun, 2017).

In the area of Qasmin, Latakia-Syria in the years between 2012 -2015, there were indications of contamination of drinking water sources. The citizens were forced to avoid using traditional drinking water sources in the area. Six sources of drinking water were studied. The samples were tested monthly for a whole year. The research was done to study the physical and chemical properties of water. From the results, it was shown that COD and BOD5 were not in the allowed limits according to Syrian standards of drinking water(Al-Araji, 2019).

There was a study that has been done on Al Badra city, Iraq during the period from December 2017 to May 2018. Six wells were included in the study. Many parameters were taken in consideration such as environmental factors. From the results, it was shown that three of the wells gave positive results for microbial pollution(Al-Araji, 2019).

There is a study that was done during the period from 2009 to 2014. The aim of the study was to measure the chemical, physical and hydro chemical properties of spring drinking water in the southwestern basin of Jordan. Some samples were collected and analyzed to study some parameters such as temperature, conductivity, dissolved oxygen, pH and trace metals. From the results it was shown that the trace metals of spring water do not have bad environmental or health impact, and it was noticed that groundwater is safe for drinking and agriculture uses(Al-Khashman et al., 2017).

Domestically, the Palestinian territories faces a huge drinking water problem, as it is one of the countries suffering from water scarcity. The Jordan River and the Groundwater Basin are the water resources available to Palestinians in the West Bank, where it receives most of its rain. As the majority of drinking water sources are suffering from rust problems and salinity. The quality of the drinking water in the West Bank is exposed to danger of pollution as a result of human activates and infrastructure(dooz).

In another analysis done in Palestine in the year 2009, the environmental health department in Nablus province announced the percentage of pollution in the Al-Sajour Valley is high. Which is located between the villages of Al-Badan and Al-Faraah, northeast of Nablus. The pollution

causes many diseases due to the spread of the rodents and insects. The water of the valley seeps into groundwater and is one of the most important sources of drinking water in the region for humans, animals, and as well plants. Also, in the Valley of Badan, there is drinking water pollution because of the factories and individuals who burn solid waste at the entrance of the city of Badan, the problem that Al-Badan and neighboring villages suffer from is the age of networks and tubes, ranging from 30 to 40years.The water dried up from Al-Farah as a result of digging artesian wells Illegally by citizens(dooz).On the other hand, wastewater is also mixed with ground water. The Ministry of Health committee conducted a chemical analysis of the water, and they found it contains heavy elements that are leaking into the groundwater, polluting the soil and polluting drinking water sources. As a result, it causes health problems and diseases like typhoid fever and chickenpox(dooz).

These are a couple of different tests that are used worldwide in the researches and water quality analysis projects, that uses various equipment's and instruments to determine whether the drinking water meets the international and domestic standards for water cleanliness and viability for human consumption, and are used by the drinking water quality and analysis experts, and they are:

1- Heavy metals analysis and quality assessment in drinking water: it is necessary to monitor the quality of drinking water in terms of heavy metals and toxic substances. This test determines the concentration of heavy minerals for drinking water and to determine indicators of water quality. The test determines the average concentration of heavy metals such as Zn, Pb, Cd, Cr, and Cu. It also determines The HPI and HEI (water quality indices) for Zn, Pb, Cd, Cr, and Cu. According to the indices, the targeted region drinking water quality is good in terms of heavy metals(Ghaderpoori, 2018).This analysis was conducted in the city of Khorramabad to determine the concentration of heavy metals in drinking water through the device (ICP - OES). As a result of this analysis, the quality of drinking water in the city was good in terms of heavy metals(Ghaderpoori, 2018).

2- Bacteriological analysis using fermentation technique: This technique of well water was conducted to check the microbial quality, it suits the West Bank because it depends mostly on well water for water supply. In this test water from covered and exposed wells are examined by multi-tube fermentation technique and the expected results is that wells will be contaminated with, and open wells will be more contaminated with bacterial diseases especially in areas with high population density(Idowu et al., 2011). This analysis was conducted in the Western Amhara region, and 36 samples were collected, and the results were good(Abera et al., 2017).

3- Toxicological and fluorescence analysis: It is a test that show the changes in water quality throughout the drinking water production and distribution chain using toxicological and fluorescence analyses(Han et al., 2020).This analysis of water quality is performed to know water toxicity(Han et al., 2020).

4- Quantitative analysis of asbestos in drinking water: The presence of asbestos in the environment can cause diseases such as pancreas and stomach cancer. It is advised to use multiple differential infra-red spectra method to distinguish asbestos in drinking water(Zheng et al., 2019).This test is focused on the quantitative analysis of asbestos in mixtures, especially asbestos in groundwater and drinking water, by FTIR Fourier-transform infrared spectroscopy (FTIR) is a technique used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas(Zheng et al., 2019).

5- Drinking water Manganese IQ Neuro development ototoxicity Benchmark-concentration analysis: Manganese is an essential nutrient, and can be a strong neurotoxin. Using the Bayesian Benchmark Dose Analysis to compute weight-averaged median estimates for the benchmark concentration (BMC) of manganese in water(Kullar et al., 2019). This analysis is conducted to find out the percentage of manganese in water, and the presence of this in water affects its intelligence on children.

6- TDS device: is a device that measures the quality of drinking water and the percentage of minerals. It can also identify three types of impurities, which are dissolved salts, inorganic materials and heavy metals.

7- Drinking water monitoring with voltammetry sensors Pulse voltage measurement: this method was applied to monitor drinking water(Eriksson et al., 2011).

In this project, we tried to achieve something similar to the previous mentioned researches, in a new region. Which is the norther region of the West Bank. The project conducted drinking tap water quality analysis to determine whether the drinking water is safe, healthy and meets the international and domestic standards. Also, a questioner was spread to determine the range of the citizens satisfaction with their drinking water that they use and have access to. Also, it helped to determine the problems and flaws of the drinking water that the citizens suffer from, it's source, what causes its problems. All of these parameters were taken into consideration. So, it was possible to suggest solutions for areas which suffer from water pollution, hardness or contamination. Either by recommending further filtration and purification and which is the most suitable type of filters they could use in terms of quality and price in the west bank or finding a better suitable source for drinking water.

Chapter Three: Methodology:

This project was in 2 stages. Stage 1 is a data collection was done during the 2nd academic 2019/2020 semester and stage 2 was done in the 1st academic semester 2020/2021. In the first stage, an online questionnaire delivered to the citizens of the west bank to determine the range and amount of their satisfaction about the drinking water that they have access to and are able to use (The questionnaire used questions and results details will be illustrated in elaboration in chapter 4). Also, data about filter types and drinking water and home filtration methods that are being used in the West Bank were collected from dealers and suppliers. To determine which type of filter the citizens use the most (Results and discussion in chapter 4, Part 1).

In the second stage, 10 different drinking water quality tests were conducted to determine whether the tested water is safe to drink or further filtration units are needed. The Municipal drinking tap water was chosen to be tested, based on the questioner analysis. The samples were collected from 8 different places in the northern region of the west bank. The places chosen depending on the accessibility, which was hindered by the closed down in Palestine due to Covid-19 pandemic. (Results and discussion in chapter 4, Part 2). The results of the water quality tests were compared by World Health Organization (WHO) standard in addition to the Palestinian drinking water standard document published by the Palestinian Standards Institution (PSI)

The Municipal Drinking Water Samples Regions:

Two samples were taken from each of the 4 main provinces in the north of the west bank as follows: a sample from the main city in each province and a sample from a main village in that province. This was done, so that we could cover the maximum geographical region as much as possible. The regions that were chosen were as follows:

Table 2: Study Regions:

Province:	**City:**	**Village:**
Jenin	Jenin	Ajja
Nablus	Nablus	Northern Asira
Tulkarim	Tulkarim	Illar
Qalqilya	Qalqilya	Azzoun

The samples were collected 3 different times at a clear weather and was not mixed with rain water. The tests were conducted in the same day as the sample were collected and just after a couple of hours. The samples were put in a very clean vessels and kept in the best storage conditions (Results and discussion in chapter 4, Part 2).

The Municipal Drinking Water Sample Tests:

10 main international drinking water tests were done on the samples. Those tests were chosen by their importance and the availability of the instruments in the University laboratory. The tests were as follow:

Table 3: Tests and Device used:

Tests:	Device and instrument used:	Standard Method:
1- PH Test (acidity and alkalinity range Test).	PH Meter.	Direct Measuring.
2- (NO_3^-) nitrate Test.	Nitrate and Nitrite Paper Strips.	Direct Measuring.
3- (NO_2^- Nitrite) Test.	Nitrate and Nitrite Paper Strips.	Direct Measuring.
4- Turbidity Test.	Turbidity Meter	Direct Measuring.
5- Total Dissolved Solid Test (TDS Test).	TDS and EC Meter.	Direct Measuring.
6- Electrical Conductivity Test (EC Test).	TDS and EC Meter.	Direct Measuring.
7- Total Chlorine Test.	Hach DR 1900.	Method 10070, program 88
8- Mg Hardness Test.	Hach DR 1900.	Method 8030, program 225
9- Ca Hardness Test.	Hach DR 1900.	Method 8030, program 220
10- Total Coliform Organic Bacterial Test.	Petri Dishes with Organic growth media	Violet Red Bile Agar was used as the Media.

Those were the 10 different conducted tests on the 8 different samples, and their results will be discussed and illustrated in details in chapter 4, Part 2.

Chapter 4: Results and Discussion, part 1:

Two electronic questionnaires in Arabic was published to explore the citizens range of satisfaction with their drinking water. Also, to monitor the problems related to drinking water in the West Bank in order to suggest solutions. The questionnaire was 15 different questions. 465 individuals participated in the 2nd questionnaire within the months of June and July. It was published through Facebook. It was also published in the community groups in the villages in the targeted area. The results were better geographical distributed and a lot better than the 1st questionnaire. The 2nd questionnaire was chosen to be shown and illustrated in our graduation project.

At this point, we view the main domain of the study instrument domains (questionnaire) whereby it consists of describing the personal characteristics of the random sample and the aspects related to the idioms of study.

Population of the study: the population of the study consists of the citizens at the West Bank districts in the academic year 2019/2020.

Sample of the study: the sample of the study consists of (465) of the citizens at the West Bank districts in the academic year 2019/2020. They were selected randomly and the tables from (7-20 in the appendix) illustrates the results and sample distribution based on the independent variables and their explanation.

Section (1): citizens related information's:

The percentage of the age group for the team questionnaire.

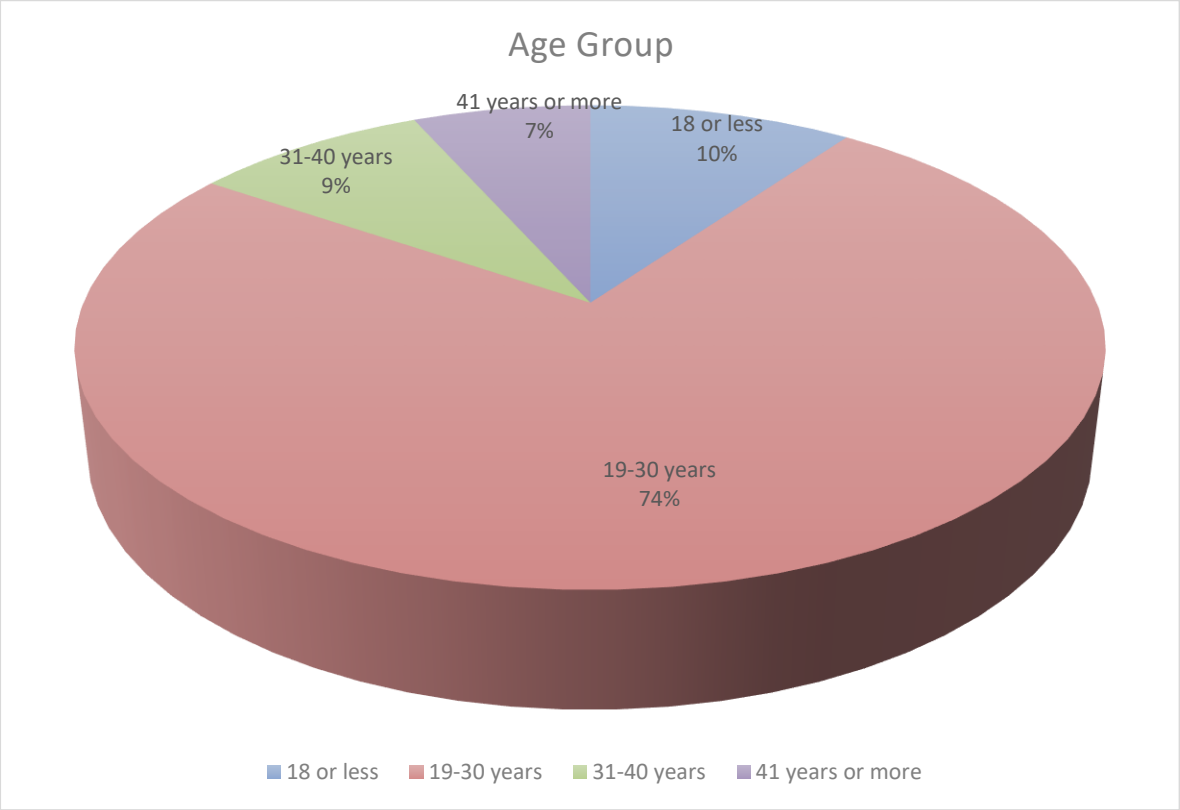

Figure 1: field survey results of age group:

Figure (1) shows percentage of age group for the sample. the percentage of the age group (18 years or less) reached 9.89%, the percentage from (19-30 years) reached 74.62%. while, the percentage of age group (31-40 years) reached 8.82%, and (41 years or more) 6.67%. So, the figure indicates that the majority of the age group from (19-30 years).

Study sample: The study sample shows the percentage of the questionnaire taken by citizens from different governorates of the West Bank.

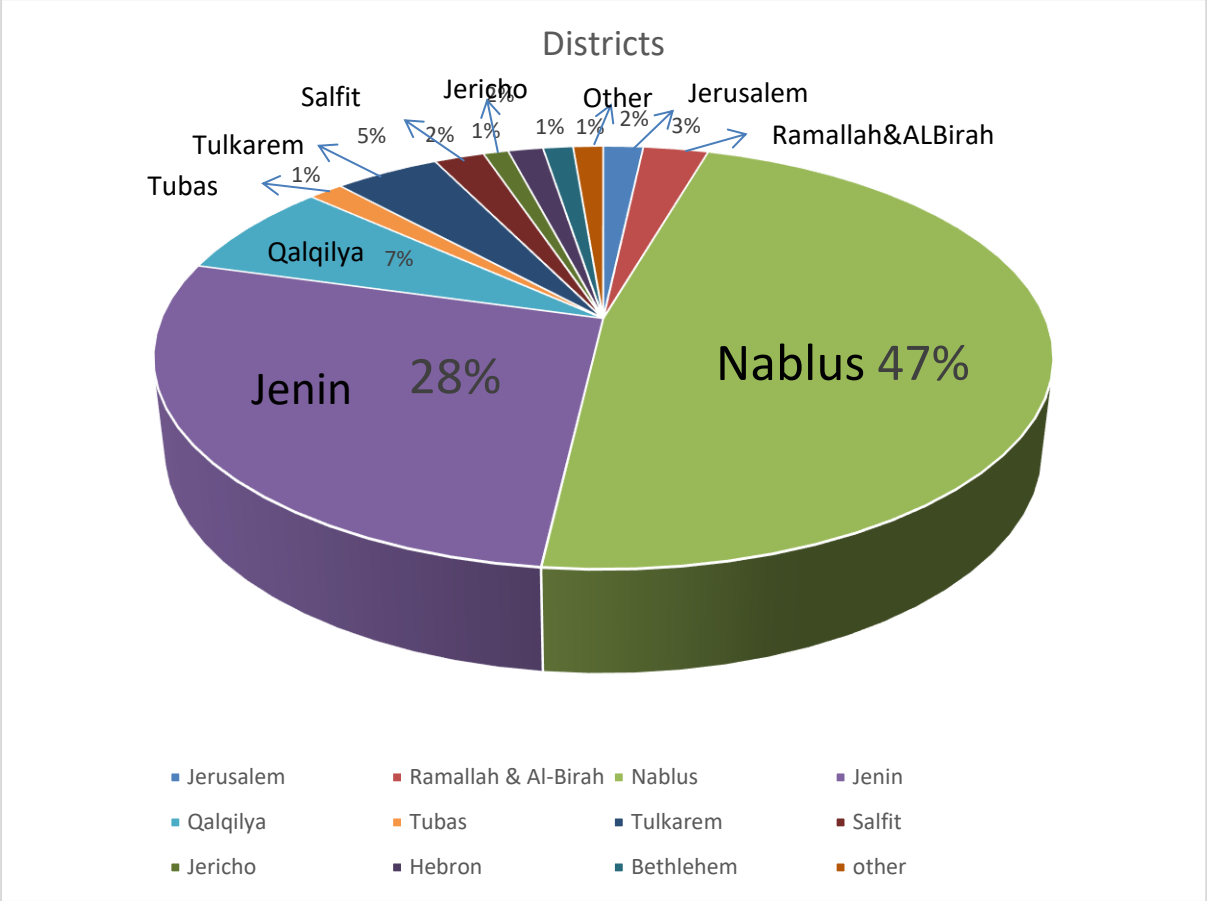

Figure 2: field survey results of District:

Figure (2) shows that field exploration results, included all the West Bank Governorates and the higher percentage of participants was from Nablus district with (47.31%) percentage of the study sample, followed by Jenin with (27.53%) percentage, while the percentages vary in the other districts between (1.08%) as the least percentage in Jericho and (7.31%) in Tulkarem.

Study sample: The study sample consisted of (465) citizens in the West Bank regions and explained about the housing variable, of whom 133 individuals are in the city, 158 individuals in the village and the same number in the town, while 16 individuals are in the refugee camp.

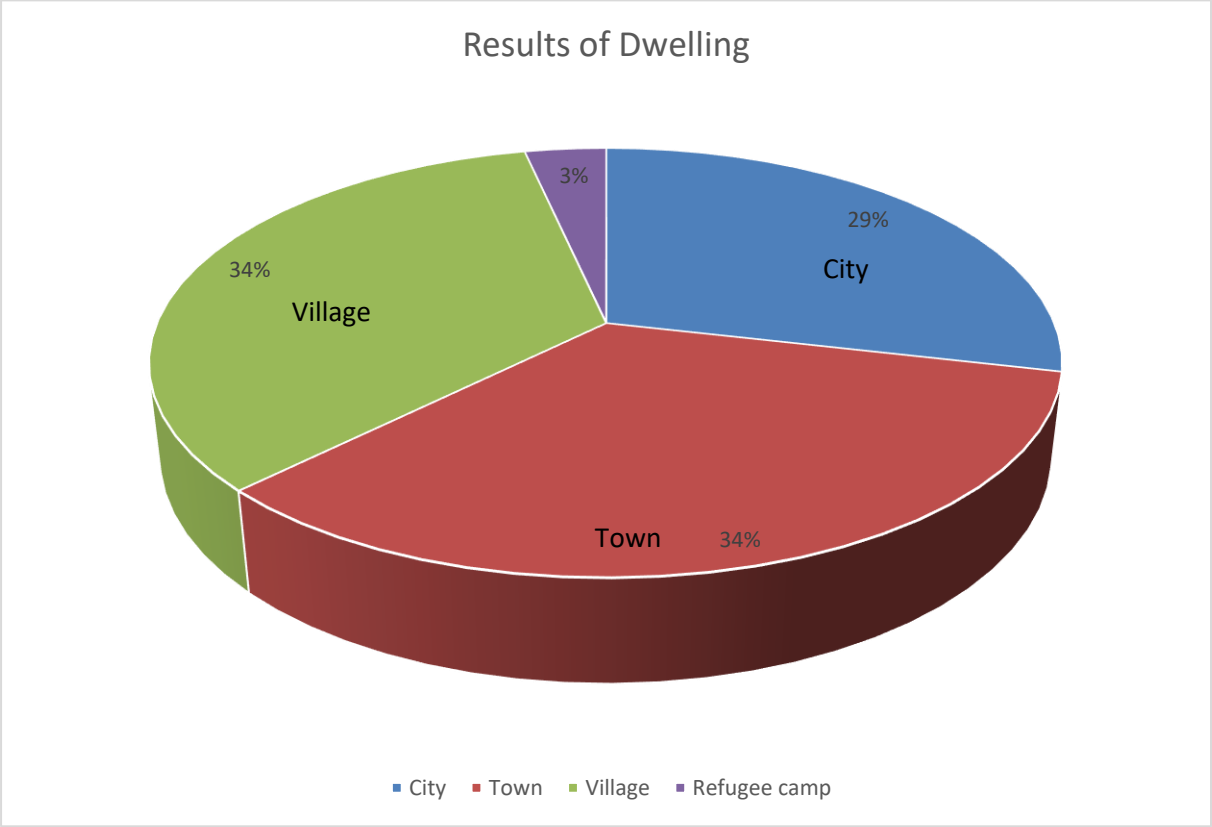

Figure 3: field survey results of dwelling:

Figure shows (3) the results of the questionnaire about the variable housing where the relative proportions of some, the proportion of (town and village) equal and the highest percentage (33.98%), while the (city) amounted to (28.6%) and the lowest. The percentage (refugee camp) was (3.44%).

Distribution of the sample according to the number of members of each family, and it is divided into 149 who are less than 5 members, 284 from 5-10 individuals, 18 from 11-15 individuals and finally 14 for those who are more than 15 members of the family.

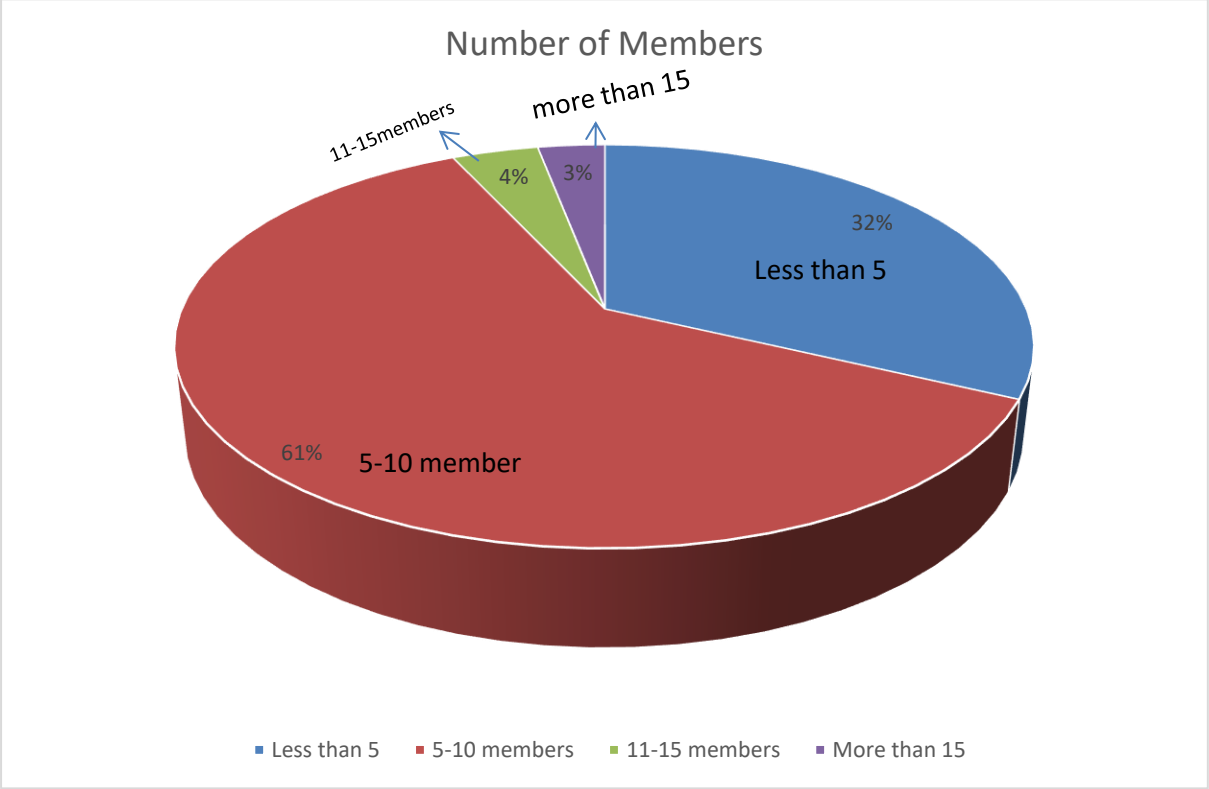

Figure 4: field survey results of number of members:

Figure (4) shows the number of individuals who use water in every household. The family that consists of (the least 5 members) is (32.04%), while the highest percentage includes the group (5-10 members) with a percentage (61.08%). The researchers relate this result to Palestinian families, which are generally characterized by the number of their members of 6-8 members, and to families that use water and contain (11-15 members) by (3.87%), and the lowest percentage was from a family that consists of (more than 15 members) and the percentage Not more than (3.01%).

Section (2): Drinking water Quality Related information's:

The study sample: shows about the sources of drinking water for the citizens, 399 individuals whose source was supplied from the municipal water network, while 66 individuals came from collecting rain water.

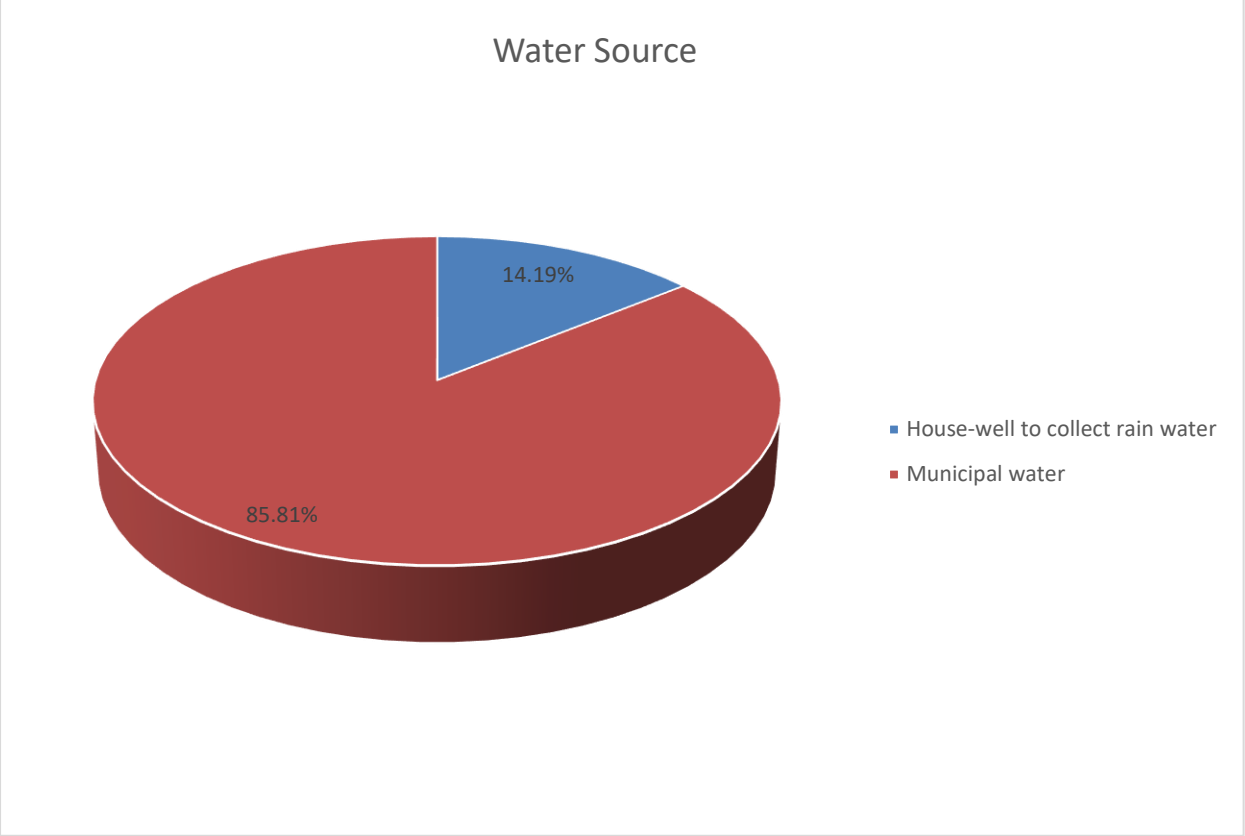

Figure 5: field survey results of water source:

Figure (5) shows that the drinking water sources for citizens in the West Bank districts largely depend on the municipal water network as the main provider of water that reaches the citizens' houses with (85.81%) percentage, while the percentage (14.19%) depends on collecting the rain water to provide another source for dinking. The house-well of rain largely spreads in the villages.

Study sample: clarifies about the municipal water sources.

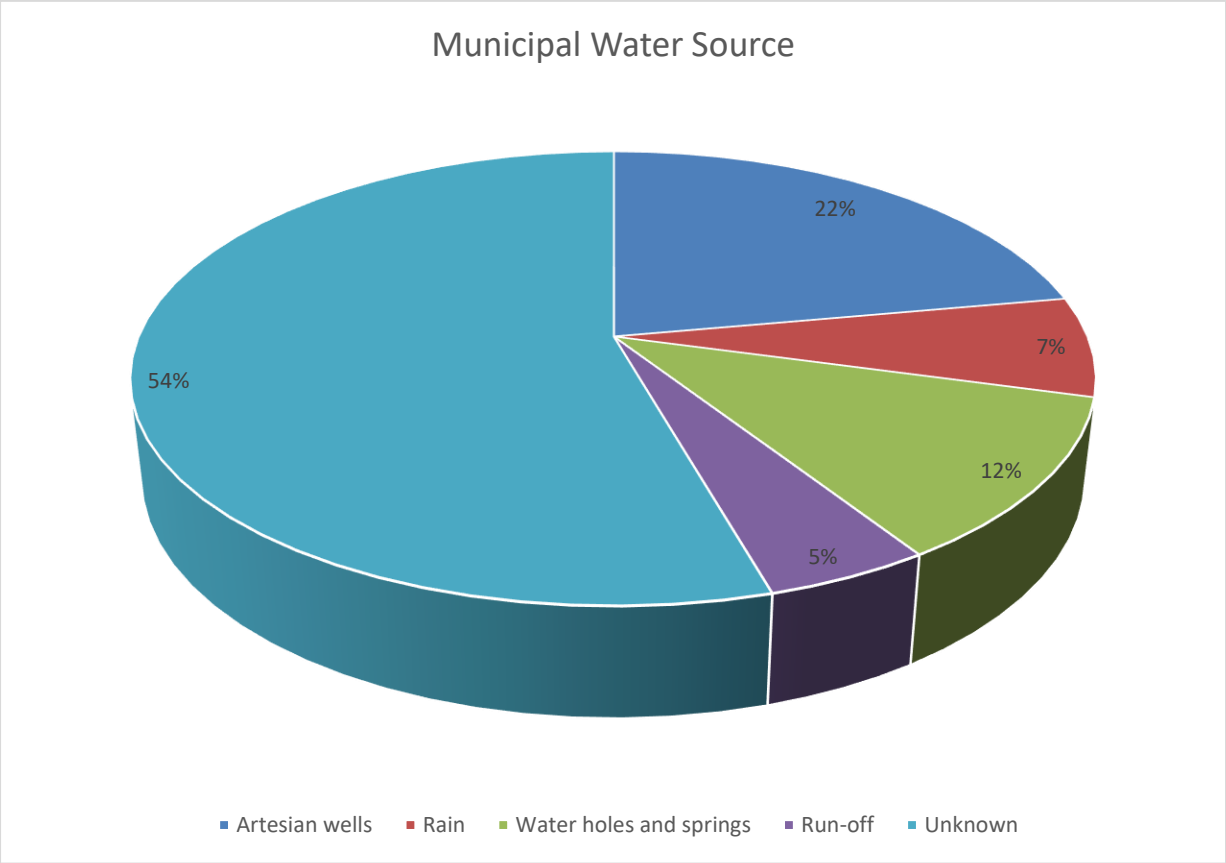

Figure 6: field survey results of municipal water source:

figure (6) shows that municipal water sources are different. Sample distribution shows that (54.41%) of citizens do not know the source of water, while (22.15%) indicated the artesian wells which largely spread in the north of the West Bank districts, however, the water holes and springs reached (11.61%), where the percentage of rain reached (7.1%) and the least percentage is the run-off which reached (4.73%). The researchers conclude from the previous percentages that most of citizens do not know the source of water they drink and largely depend on municipals to get water.

The study sample: shows about the average weekly consumption of drinking water in homes

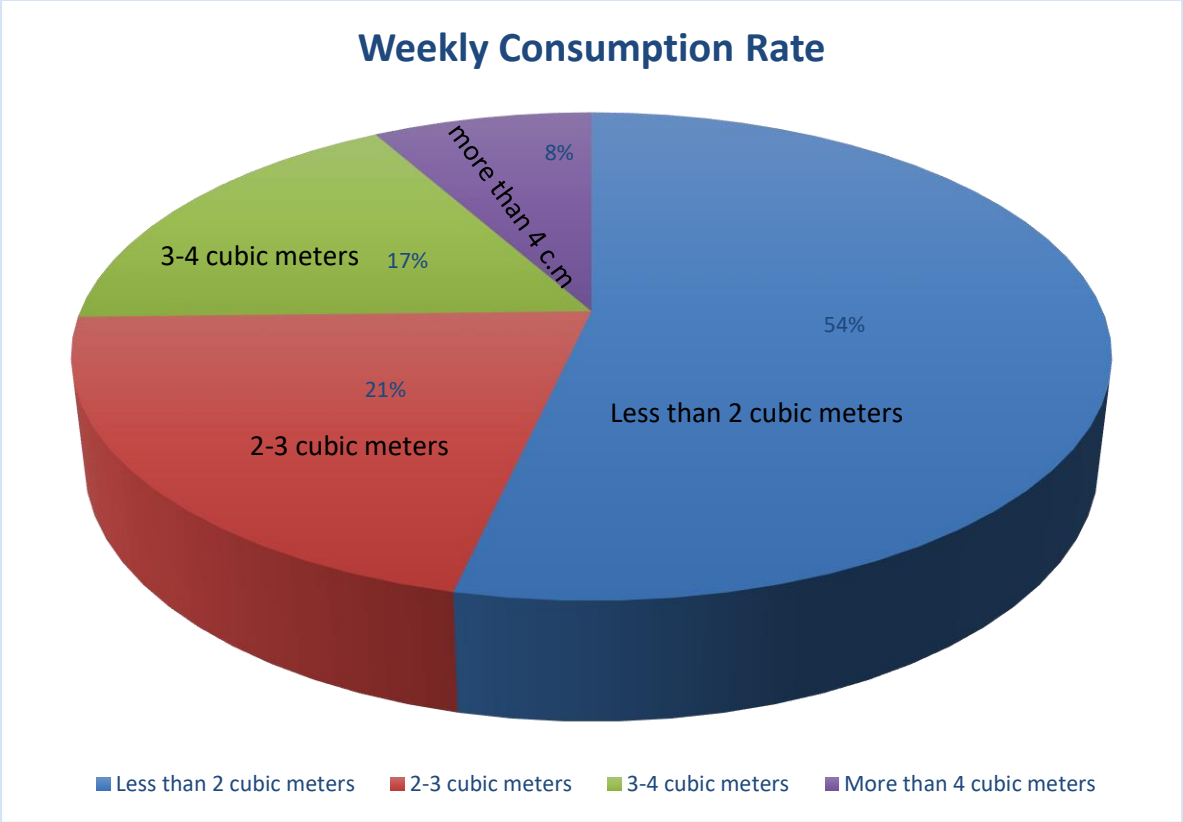

Figure 7: field survey results of weekly consumption rate:

Figure (7) shows the average weekly consumption of drinking water in homes. The highest percentage (53.55%) of the study sample indicates consumption of 2 cubic meters per week, while those who used 2-3 cubic meters of water per week were (21.08%), and those who consumed 3-4 cubic meters per week were (17.2%) While those who consumed more than 4 cubic meters per week, it was (8.17%). This led the Palestinian family to realize that the amount of water it consumes is proportional to the number of family members.

Study sample: It shows the amount of water that reaches the house

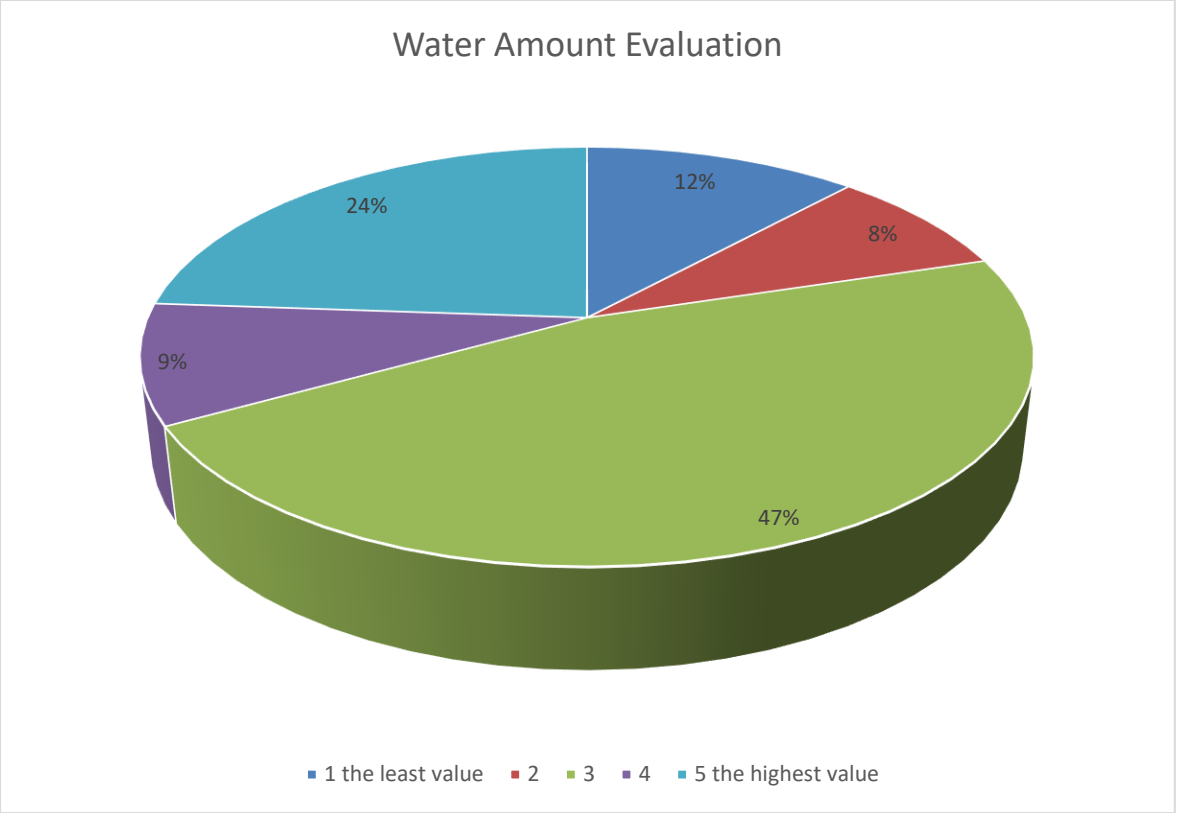

Figure 8: field survey results of water amount evaluation:

Figure (8) shows the evaluation of the amount of water that reaches the sample houses and whether it is sufficient or not. The results showed that the highest percentage was moderate (46.67%) and they chose the evaluation (3), where the evaluation was from 1-5, and the evaluation (1) was (11.83%) and a lower percentage (8.39%) for the evaluation (2). As for the evaluation (4), (9.24%) and (23.87%) chose the highest value (5). Thus, it was found that the amount of water that reaches the dwelling was saturated in about (33%) of the surveyed residents, who gave the value (4) and (5). About (20%) of the population showed dissatisfaction by choosing ratings (1) and (2) because they do not get enough water for their needs, and this may happen especially in the summer as water consumption increases with the lack of water resources in the area. The city of Nablus, to which about (47%) of the respondents belong.

The study sample shows the degree of confidence of citizens in the water used in their homes

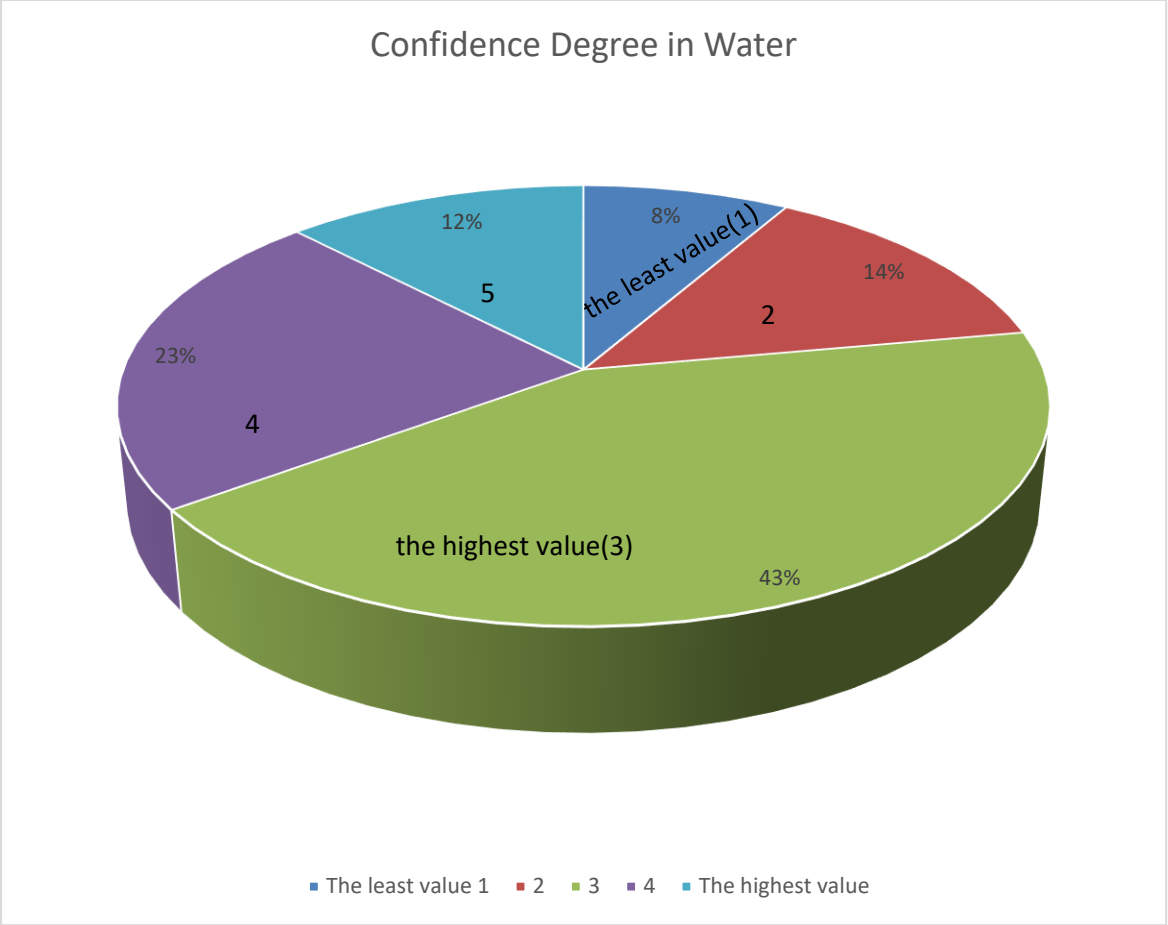

Figure 9: field survey results of confidence degree in water:

Figure (9) shows the degree of water confidence for the study sample used in households. The highest percentage of evaluation was (3) with a percentage (42.8%), where the evaluation was from 1-5, and the second rank for evaluation (4) with (22.8%), while the percentage was (13.76%) for evaluation (2). Evaluation (5), as it was chosen by the citizens, and it was (12.25%), where the lowest percentage of value (1) was (8.39%). These results show that about (35%) of the citizens feel a high degree of confidence in the drinking water that comes from the municipality. (22%) of the respondents showed a lack of confidence in the municipal water they can access. While (43%) decided to give a moderate value.

The study sample shows whether or not the net water reaches them.

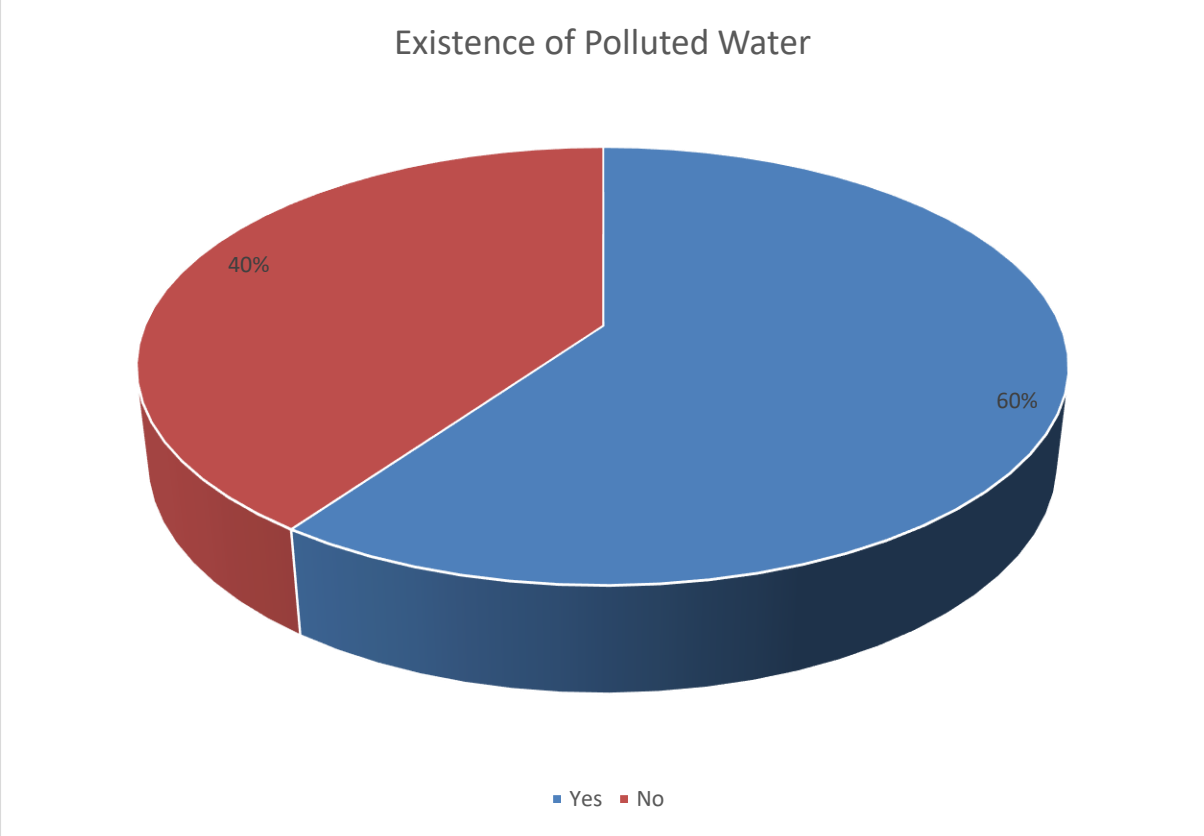

Figure 10: Results of the field survey for the presence of suspended substances in drinking water:

Figure (10) shows that (59.78%) believes that their water is polluted. Where (40.22%) deny the existence of polluted water. As it seems that the majority of the citizens believes that there is pollution to an extent in the water that reaches them. These results relate to the different sources of water reaching houses and the different environmentits industrial surroundings.

Study sample: About the color of the water that reaches the citizens, 106 of whom were the water that reaches them in white, 223 individuals, the water is red, and 136 individuals reach them with colorless.

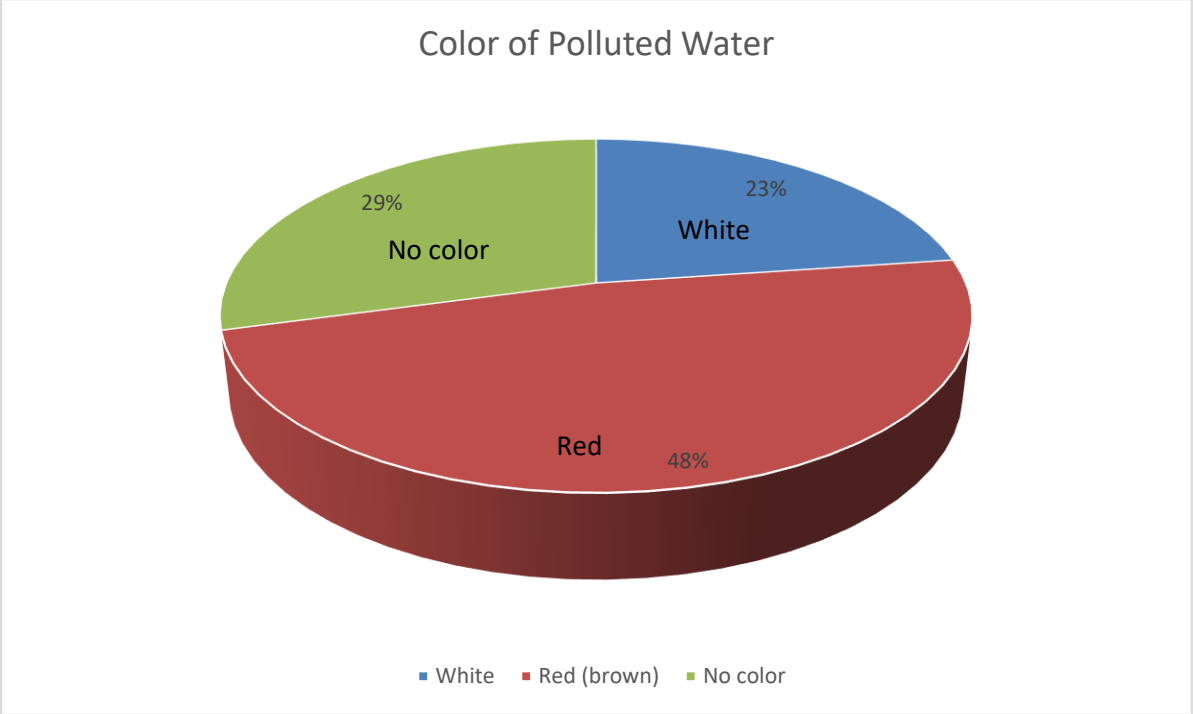

Figure 11: field survey results of color of polluted water:

Figure (11) shows that the color of polluted water (red / brown) reached (47.96%) from the study sample, as this question was answered by (223 people). Pollutant from sediments in water lines over time, as the results showed that (29.24%) the percentage indicates that there is no color for polluted water (136 people), while the white color (22.8%) of the study sample (106 people). Researchers have linked this to municipal use of water disinfectants.

The study sample represents the degree of smell of water that reaches citizens, and whether it is acceptable or not. 184 individuals had the smell of water that reached them, and 281 individuals were not acceptable to them.

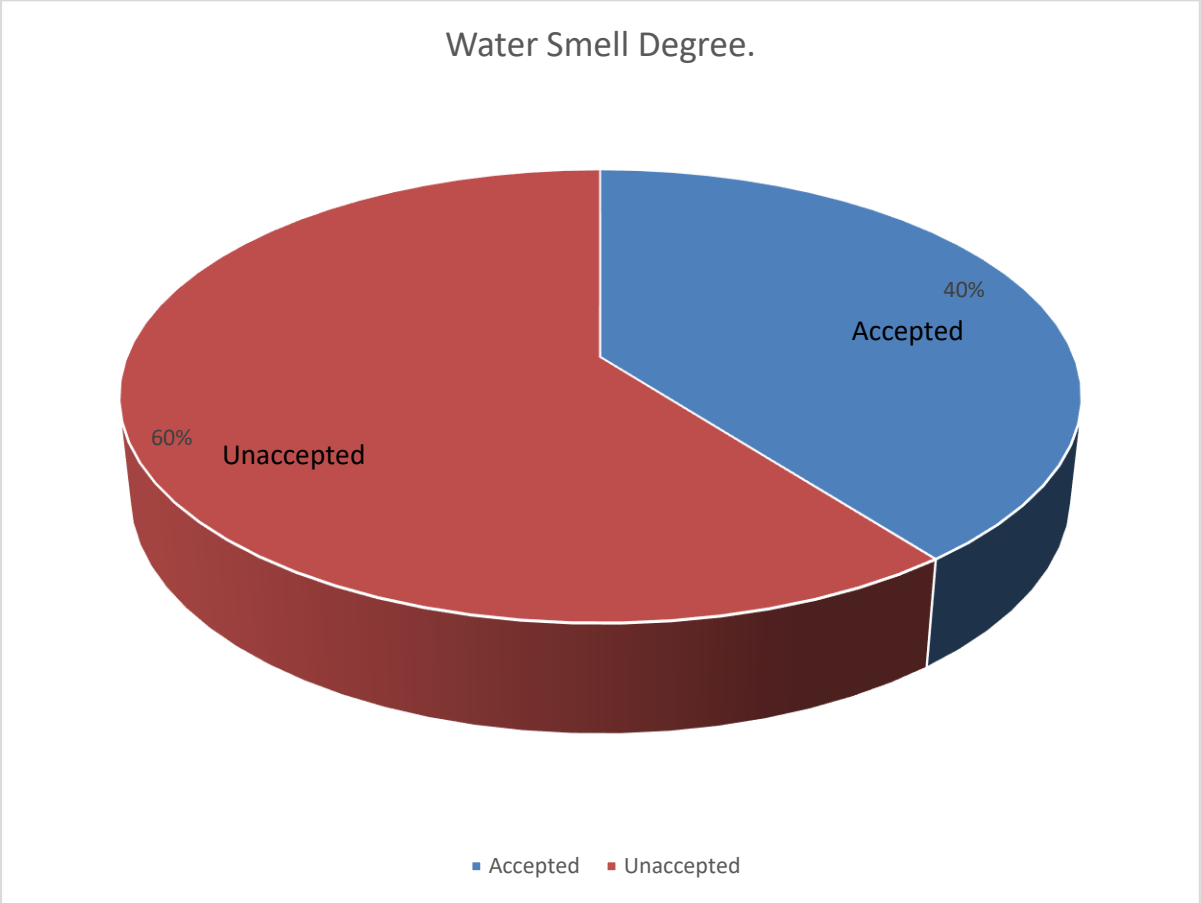

Figure 12: field survey results of water smell degree:

Figure (12) shows the degree of water odor that the residents suffer from. It was found that (60.43%) suffer from an unacceptable water smell, while (39.57%) they have an acceptable water smell. The researchers have linked this result to the study sample that indicates some problems in drinking water with regard to the smell of water, which requires searching for the cause of this smell.

The study sample shows the number of times the tank was cleaned for each family, 229 individuals clean the tank once a year, 88 individuals cleaned more than once a year, while 148 people did not clean their water tanks.

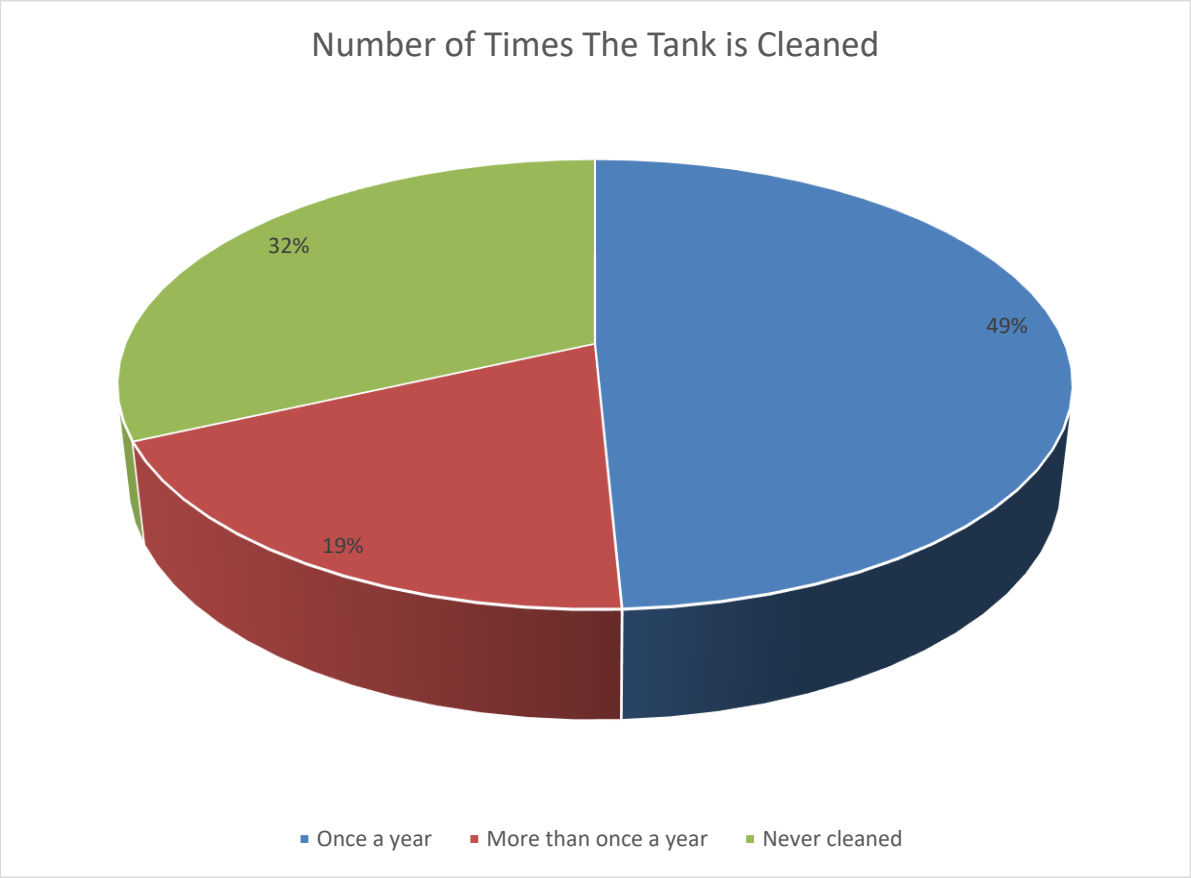

Figure 13: field survey results of number of times the tank is cleaned:

Figure (13) shows that most of citizens clean their water tanks once a year which reached (49.25%) percentage, while citizens who clean their water tanks more than once a year reached (18.92%) percentage of the study sample, and there was medium percentage of citizens who never clean their water tanks reached (31.83%) of the study sample.

The study sample shows how citizens drink water, of whom 374 individuals drink water directly from the tap, while 91 individuals use water filters.

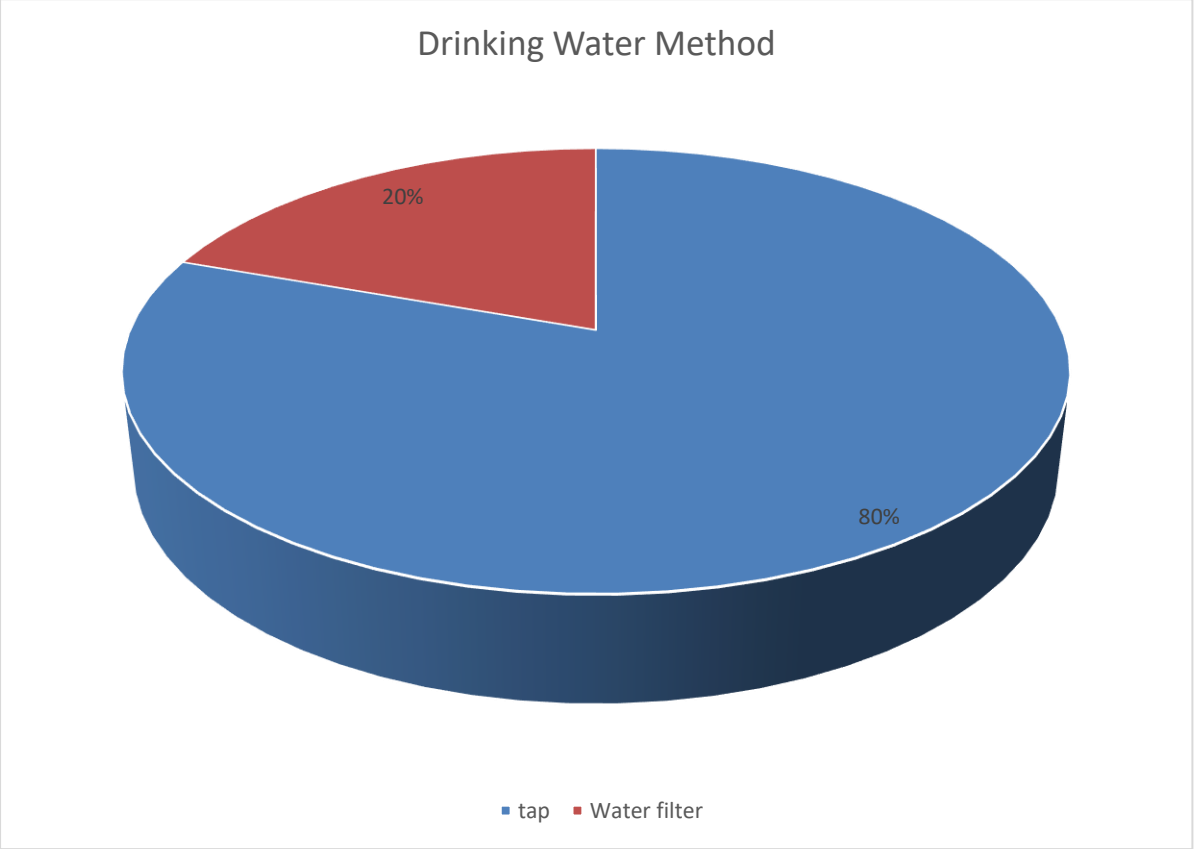

Figure 14: field survey results of drinking water method:

Figure (14) shows that (80.43%) of citizens drink directly from the tap despite the problems in water such as (polluted water, change of water color and unaccepted smell). While (19.57%) of citizens depend on the water filters. The results indicate the necessity of using water filters to overcome the problems of polluted water.

Chapter 4: Results and Discussion, part 2:

In part 2, tap municipal drinking water was chosen to conduct the tests on, because they are the most used and the most complained from in part 1. Samples from the northern cities and villages in the North of the West Bank were collected, and a group of tests conducted on them multiple times in different times, weathers and circumstances. To determine the water properties and if there is any kind of flaws, pollution, Hardness or any kind of organic or inorganic contaminants that effects the quality of the water that the citizens are using.

Table4: Results of Physicochemical and Microbial Analysis of Drinking Water of The Northern Regions of The West Bank, first, second and third batch of tests:

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Nablus(1)	7.9	50	0	0.63	0.17	0.3	0.1	0.51	2.88	..
Nablus(2)	7.9	50	0	0.63	0.22	0.4	0.1	0.55	2.8	..
Nablus(3)	8	50	0	0.63	0.29	0.14	0.18	0.51	2.88	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Asira AL-Shamaliya(1)	8.1	50	0	0.22	0.22	0.44	0.1	0.95	0.13	..
Asira AL-Shamaliya(2)	8.1	40	0	0.22	0.23	0.45	0.1	0.9	0.22	..
Asira AL-Shamaliya(3)	8.1	25	0	0.36	0.42	0.9	1.1	1.12	0.7	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Qalqilya(1)	7.3	100	0	0.3	0.43	1.4	1.05	0.56	0.2	..
Qalqilya(2)	7.9	100	0	0.6	0.13	0.85	0.15	0.18	0	..
Qalqilya(3)	7.4	100	0	0.2	0.48	1.2	1.08	0.3	0.18	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Azzoun(1)	7.4	100	0	4.36	0.34	0.68	0.6	1.95	0.24	..
Azzoun(2)	7.7	75	0	5.66	0.29	0.48	1.5	2.27	0.29	..
Azzoun(3)	7.7	15	0	1.57	0.39	0.76	0.4	1.19	0.24	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Tulkarim(1)	7.1	100	0	2.35	0.49	0.26	0.7	0.34	2.08	..
Tulkarim(2)	7.1	100	0	2.35	0.49	0.26	0.7	0.34	2.08	..
Tulkarim(3)	7.1	100	0	1.07	0.37	1.31	0.6	0.92	0.08	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Illar(1)	7.8	50	0	5.79	0.46	0.62	0.7	0.45	2.44	..
Illar(2)	7.6	50	0	3.31	0.32	0.53	0.2	0.33	1.93	..
Illar(3)	7.6	50	0	0.15	0.35	0.7	1.3	0.76	0.04	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Jenin(1)	7.1	15	0	1.02	0.5	1.07	0.1	0.5	0.14	..
Jenin(2)	7.5	20	0	1.56	0.34	0.6	0.4	2.4	2	..
Jenin(3)	7.4	12	0	0.7	0.58	1.41	0.16	0.54	0.1	0

Study Area	PH	Nitrate(mg/LNO3-)	Nitrite(mg/LNO2-)	Turbidity(NTU)	TDS(ppt)	EC(ms/cm)	Total Chlorine(mg/L)	Mg Hardness(mg/L)	Ca Hardness(mg/L)	TC(CFU/100ml)
Ajja(1)	7.7	25	0	1.52	0.12	0.88	0.1	1.11	0.05	..
Ajja(2)	7.9	12	0	2.26	0.15	0.3	0.1	2.1	0.04	..
Ajja(3)	8	15	0	0.28	0.21	0.43	0.1	2	0.09	10

Standards:	PH	Nitrate(mg/L) NO_3^-	Nitrite(mg/L) NO_2^-	Turbidity (NTU)	TDS (ppt)	EC (ms/cm)	Total Chlorine(mg/L)	Mg Hardness (mg/L)	Ca Hardness (mg/L)	TC (CFU/100ml)
Standards (PS)	6.5-8.5	50	>0.1	4	0-1	1.08	0-0.5	150	100-200	0
Standards (WHO)	6.5-8.5	45	0	0-5	0-1	1.08	0-0.5	<75mg/L	<75mg/L	3

Those are the results we got from the 3 repeated test batches. The first batch of tests were conducted without the Total Coliform test. The 2nd Time we conducted all the tests on all of the samples. But unfortunately, the media that was used for the total coliform test in the petri dishes was spoiled and invalid and gave unreal results. Which made us repeat all the test for a third time with new valid and good media. Table 6 shows the results of the third and final batch of tests that were conducted as perfectly as possible on all the sample tests without any errors, and they are the most accurate and reliable and were used in the discussion.

1- The PH Test Results:

Table 6show that the PH values of the eight tested samples were ranged between 7.1 and 8.1. All the values were within the WHO and PS limits. Also, in the 2 previous PH tests, all the sample tests were in the range. pH is a quantitative measure of the acidity or basicity of water and it is defined as the negative logarithm of the hydrogen ion concentration of a solution(Rahmanian et al., 2015). (6.5–8.5) is the preferable range for the pH values of drinking water. most of drinking water should be lied within that range (international srandards for drinking-water, 1971). The PH meter instrument was used to determine the PH values for all the sample

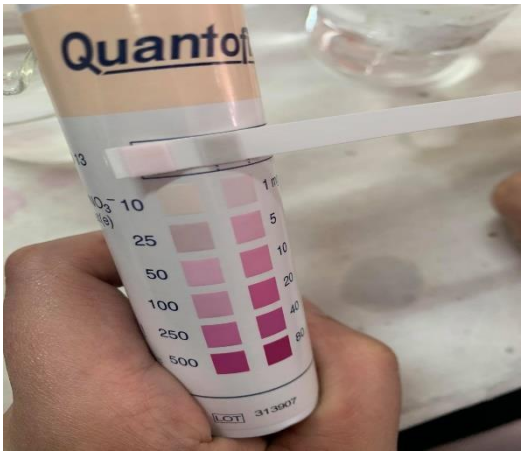

Figure 15: The PH Meter: **Figure 16: Nitrate and nitrite paper strips:**

2- The Nitrate Results:

Table6 shows that the results of nitrate tests were ranged between 12 and 100 mg/L. Only two of the results of the tested samples exceeds the PS and WHO standards. the samples were Qalqilya and Tulkarim samples. High levels of nitrate in water can be caused by leakage from fertilized soil, wastewater, landfills, animal feedlots, septic systems, or urban drainage. There are many possibilities that make it difficult to pinpoint where the nitrate in drinking water comes from(Ghafari et al., 2008). The test was conducted using Nitrate and nitrite paper strips

3- The Nitrite Test Results:

High levels of nitrites are toxic to humans and animals, especially infants(Kazmi & Khan, 2005). Nitrite levels in drinking-water are usually below 0.1 mg/L based on WHO standards for drinking water. The table6 shows that for all tested samples the values of nitrite were below 0.1 mg/L. This test was also conducted using Nitrate and nitrite paper strips.

4- The Turbidity Test Results:

Turbidity is the measure of relative clarity of a liquid. Turbidity in water is caused by the presence of suspended matter such as clay, silt, organic and inorganic matter, plankton, and

other microscopic organisms(LeChevallier et al., 1981).(0–5NTU) is the preferable range for the turbidity values of drinking water. The best values are between (0-1NTU). from the results, all samples turbidity values were within the range and where ranged from (0.15-1.57NTU). A turbidity meter was used to measure the turbidity for all samples.

Figure 17: The Turbidity Meter:

5- The Total Dissolved Solid Test (TDS) Results:

The total dissolved solids (TDS) values were in the range of 0.21 and 0.58 ppt. For all tested samples the TDS values were within the desirable limits of the PS and WHO standards. The TDS tests were conducted using the electrical conductivity and TDS meter.

6- The Electrical Conductivity Test Results:

the electrical conductivity and Total Dissolved solid meter was used in this test. The results showed that 3 samples were above the WHO and PS standard value of 1080 semen's = 1.08

milli semen's. those samples were: Jenin = 1.41mS, Tulkarim = 1.31mS and Qalqilya = 1. 20mS.these results indicate high concentration of metal ions in the water, maybe obtained from bad and collapsed piping system, while the water is flowing through them.

Figure 18: The TDS and EC Meter:

7- The Total Chlorine Test Results:

Total chlorine is simply the sum of the free and combined chlorine in the water. Its range is between (0-0.5) mg/L by the world health organization and the Palestinian standards. It was tested using the HACH company DR 1900 device using the DPD powder method. The results showed higher concertation than the recommended in 4 different samples and they are: Illar = 1.3 mg/L, Northern Asira = 1.1 mg/L, Qalqilya = 1.08 mg/L and Tulkarim = 0.6 mg/L. these results are due to the excess usage of the chlore as a disinfectant and purifier by the municipalities. As they dump excess amounts of it into the storage tanks without any precis calculations. Which cause the water taste to change, and its color will become whiter. Also, the water becomes more toxic and bad for the health. There are real, clear statistics that show

chlorinated water increases the chances of bladder cancer. Drinking chlorinated water over a long period of time may also cause a person to develop asthmatic condition. Trihalomethanes are one of the more dangerous byproducts of chlorine that have been proven to have a negative effect when coming into contact with humans. Inhaling THMs can affect the body central nervous system and cause abnormalities to the liver and kidney.

8- The Mg Hardness Test Results:

The magnesium (Mg) concentration value by WHO shouldn't exceed 75 mg/L $CaCO_3$ and 150 mg/L $CaCO_3$ by the Palestinian standards. For this test HACH DR1900 device was used to determine the magnesium concentration in the drinking water. The results for all the test on all the samples showed very minimum results which at most was about 2 mg/L $CaCO_3$. Those results were in the range.

9- The Ca Hardness Test Results:

The Ca hardness test result are also so much low, the highest value was 2.88 mg/L $CaCO_3$. As the WHO standard mentioning that it must be less than 75 mg/L $CaCO_3$. Which is in the range.

Figure 19: HACH DR1900 Device:

10- Total Coliform Test (TC):

This test was conducted twice, the first time it was done by using ready commercial petri dish with already cooked media. as you only have put about 1-3 milliliters of the drinking municipal water sample inside the petri dish and leave it for about 24 hours in the incubator. The results were extremely bad, and it was even worse than the industrial and sewage water bacterial colonies growth. The test was repeated with new Media and new petri dishes prepared by ENG. Yousef Ratrout. We put about 16 plate in the incubator, each municipal water sample have 2 plates. To make sure of the results. The results were that all the samples water were clean except of Ajja sample. There was an undesired bacterial growth and it was unhealthy to drink as it had 10 Bacterial colonies and the maximum permitted by WHO to consider the Water is allowed for human consumption is three bacterial colonies at max(Mastroianni, 2011).

Figure 20: First TC with spoiled and invalid ready petri dishes Results:

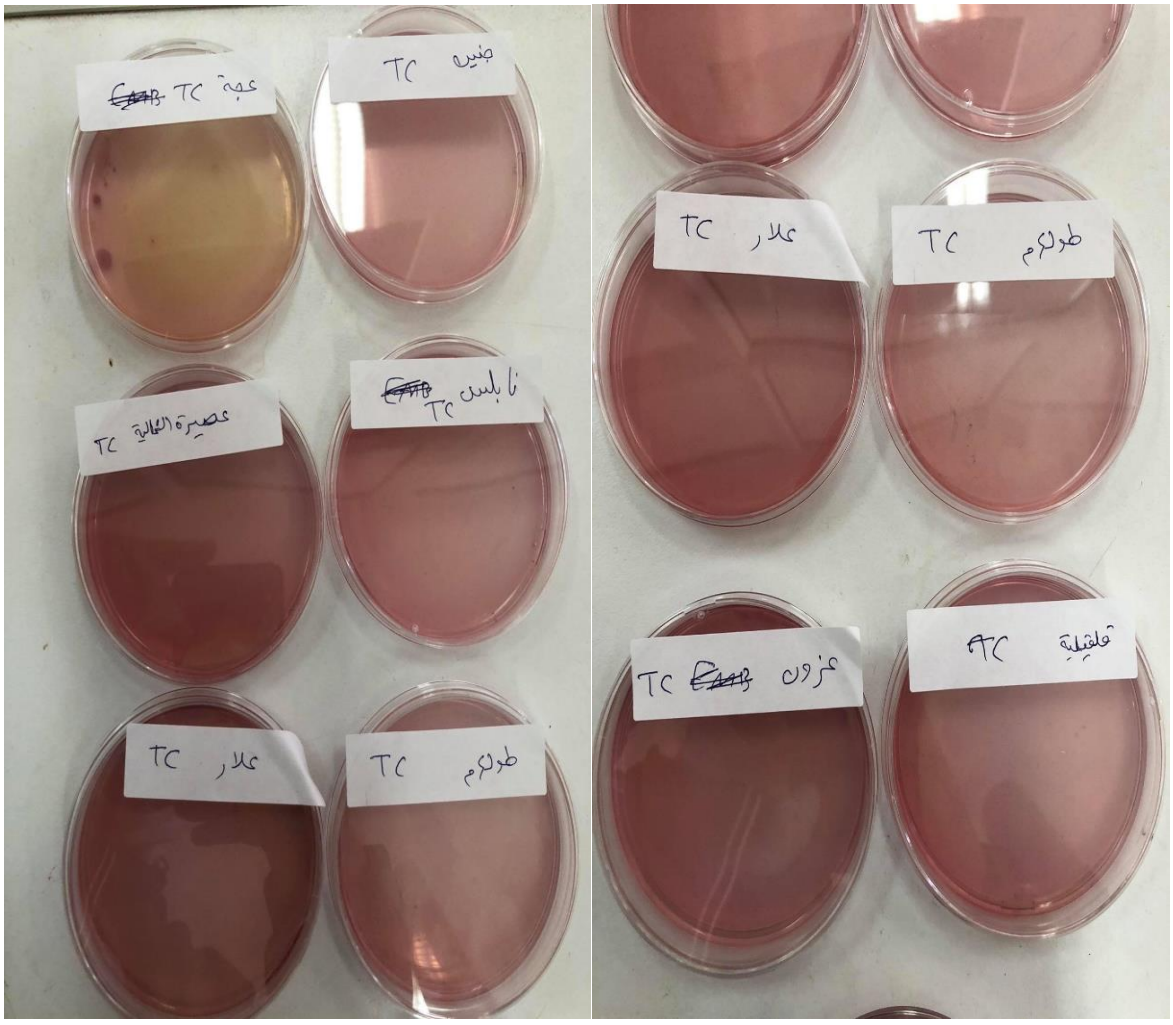

Figure 21: Second TC with the new and cooked Valid Media Results:

Types of Drinking Water Filtration:

As the results shows, the majority of people are unsatisfied with the drinking water that reaches them. One of the solutions is to use water filters for purification and filtration. Some the water won't cause any harms to the citizens. As the Water filters have now become one of the essentials of the home after it became difficult to rely on tap water for drinking, for fear of pollution and the microbes that are often in the water, especially after many observed a change in the taste and smell of water.

Various types of drinking water filters flood the entire market and online today. For this reason, it is difficult for consumers to choose the type of drinking water filter that best suits their needs. Each type of water filter has its own advantages according to one's need.

It is best to choose water filters through their performance, features, and importance for your health, the length of the warranty period, if they are easy to use and if they are also easy to install.

It is very important to diagnose the current quality of tap water before choosing a filter, as tap water varies by region.

1- Activated carbon

Good for removing chlorine, chloroform, agricultural chemicals, organic matter, sediment and magnesium.

2- ION EXCHANGE

Good for removal of hard water and radioactive material.

3- REVERSE OSMOSIS (RO)

Good for effective removal of a high percentage of toxins including fluoride, hexavalent chromium, arsenic, nitrates/nitrites, copper, radium, salt, and more.

4- MECHANICAL

Good for removal of physical particles and waste matter.

5- ULTRA VIOLET FILTERS

Good for removal of bacteria and viruses. An environmentally friendly option, UV filters will clean water using different frequencies of ultraviolet light.

In Palestine there are stages for the types of filters from two stages to six stages, the type of filter and stages is chosen according to the nature of its water quality and the degree of turbidity and also the money available to the customer.

- Three-stage water filter

Each stage of the filter works differently, the first stage works to remove impurities from water, insects, rust and solid objects, while the second stage removes the taste, color, smell and chlorine and everything that may change the nature of water, and the third stage removes the rest of the organic and biological materials from the water. The three-stage filter differs from the rest of the water filters in that it is easy to install and maintain as well in terms of removing and changing the candles and you can change them yourself(Abdulhameed).

Figure 22: three - stage water filter:

- The five-stage water filter The two additional stages in the five-stage filter work to separate the pure water from the polluted water, and store the water in a special tank that comes with the filter and is installed under the basin and you can rely on water even with the water being cut off from the filter, also the fifth stage guarantees you Remove any odors or gases that might change the taste of water. The five-stage filter needs regular maintenance of the tank and wax and is relatively large in comparison to the three-stage filter(Abdulhameed).

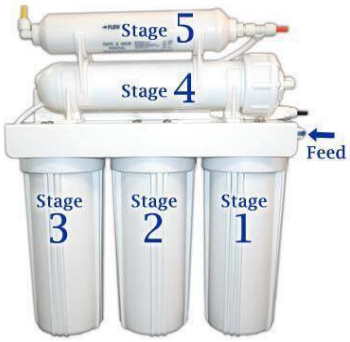

Figure 23: five stage water filter:

- Six-stage water filter: The sixth stage is known as the infrared stage, which helps to excrete wastes and activate oxygen in the water(Abdulhameed).

Figure 24: six stage water filter:

- The seven-stage water filter, the seventh stage in the seven-stage water filter, is the stage that permanently eliminates bacteria and makes the water safe to drink(Abdulhameed).

Figure 25: seven stage water filter:

After communicating with companies, dealers and suppliers about the types of filters and the most used, it was found out that the REVERSE OSMOSIS (RO) filter in Palestine(Company, Ramallah, 2020), which has five stages where it purifies water from impurities and harmful salts `and its capacity is 200 liters per day. Is the most suitable for people in terms of purification, filtration and has an affordable price for the majority of population. As this filter is placed for tap water to get clean water and free from any pollutants.

The rate of household water consumption from 4-7 liters per day(Company, Ramallah, 2020).

Figure 26: reverse osmosis (RO) filter:

The prices of the filters that were mentioned above are in range of 600 Nis to 2300 NIS, as were given and mentioned by the suppliers. As the number of the filtration stages increase their filtration efficiency increase and as well their price. The buyer should choose the filter that give him the required filtration with the minimum stages, as it will be the most affordable price. Extra purification and properties like using UV light and reverso osmosis in the filters increase their prices. So, it is better to test the water needed filtration to determine the most suitable and economical filter for that water. Another parameter that plays a role in the filter price and should be take in consideration when buying a filter is the company and the origin of the manufacture. As Americans and Germans filter have high quality and higher prices thang Chinees and Indian filters.

Chapter Five: Discussion Summary:

From Part 1 results, it was showed in general that about (85%) of citizens are using municipal drinking tap water, and about 80% percent of the questionnaire participant drinks directly from the tap without using any filter, regarding that(71%) of people are complaining from color change. Also, (60%) are complaining of pollution in their tap drinking water and (60%) are having unpleasant smell change in their water. Viewing these results, it was chosen to conduct the water quality tests on the tap municipal drinking water as they are most used by the citizens and the majority of defects occur in them. 10 tests were conducted and repeated 3 times on 8 water samples which were collected from the 4 main cities and 4 main villages provinces in the northern of the west bank. We chose those 8 places, so we could have a geographic estimated overview for the water quality in those regions and because we had access to it and were able to obtain water samples from.

From part 2, the repeated tests showed that there was unhealthy drinking water in some regions, because of either excess in the nitrate concentration above the allowed upper limit by WHO and PSI, or because there was access in total chlorine and electrical conductivity. The excess nitrate is extremely dangerous for the health, as it causes reaction with the hemoglobin in the blood streams. Also, the high excess Chlorine cause kidney and nervous system diseases. For the total coliform test, in the second batch of tests it appeared that the commercial petri dishes were kept in bad conditions for their storage, which cause them to spoil and gave bad and wrong results. For the third batch of results, only Ajja sample had bacterial colonies that made its water undrinkable. So, it is apparent that the main 3 tests that there was access concentration in are: total Chlorine test, Nitrate NO_2^- and electrical conductivity.

We determine the sample to have defects if one of the values is not in the recommended range. the unacceptable water municipal tap drinking water samples in third time where: Ajja sample as it contains bacterial colonies and growth, Qalqilya and Tulkarim samples as they have excess nitrate NO_3^- concentration and Northern Asira as it contains excess total chlorine.

In chapter 8 recommendations and solutions will be offered for the end municipal drinking water user to improve their home water quality through using certain kind of filters. As we try to offer solutions for any one suffering from those problems related to their water in their homes.

Chapter Six: Standards and Constrains:

During working on this project, plenty of hardships faced us. But we managed to fight through these hardships. These were unusual times that affected all of our lives. As, Covid-19 pandemic effected our life style that we were used to so much. The pandemic changed our plans for the project. As we were going to spread physical copies of the questionnaire to get better results. Unfortunately, that didn't happen. So, we had to improvise. During the months of April and May we published our first electronic questionnaire. The results weren't very good. We had to learn from our mistakes and improve more. Which we did. We prepared a second and a better questionnaire. The second questionnaire results were much better and adverse. Another problem that faced us, was the hardness of communication and coordination. As, before the pandemic we had two casual meeting each week. One with supervisors, and the other one with our Colleagues. Which we couldn't do later on because of the pandemic. Regarding the standards we followed for this project and for the water quality and standards that the drinking water must meets. It was essential to follow the standards and constrain of the Palestine Standards Institution (PSI). As it is the only governmental institute that are allowed to determine the required standards and properties for the water to be allowed for human consumption in the West Bank. We also took the worldwide standards of the World Health Organization (WHO) as it is an international trusted standard all over the world. In the second of this project, we faced plenty of challenges and problems but we overcome them. The second part of the project had to be practical work in the laboratories at the university and sample collecting from various locations in a pandemic and lockdown period. Also working and conducting the tests in these circumstances inside the University was in an extreme tight schedule, because there were lectures and other classes inside the labs and the Lab's supervisors were only available in very limited times in comparison to the past semesters. The only days we were able to conduct the tests were just Wednesday's and Thursday's. Also, plenty of our friends who told that they will bring municipal drinking water sample, forget the bottle and we have to delay or to repeat the tests again at a different time and date.

Chapter Seven: Conclusion:

The Results of part 1 showed that:

1- the majority of the people of west bank are dependent on the municipality water for drinking and daily usage.

2- 80% drink directly from the tap, despite that the majority of them believes that the water they get from the municipality is polluted and suffer from bad smell and unpleasant colors.

3-only 20%uses filters despite the water problems they suffer from. Which may cause disease and illness in the near or far future.

These results, made us advise the citizens to use filters, and specially the RO five stages filter. Which is the most preferred type, because it does the required purification and filtration perfectly and its affordable by the general public for a good price. It's highly recommended for the citizens who have water problems to purchase and install it.

Building on these results, the second part of the project was determined to conduct the water quality tests on the municipal drinking tap water as the majority of people use it and have a problem with it. The results of part 2 were as follow:

1-The PH, TDS, Turbidity andNO_2^-tests were always in the permitted ranges for all the samples.

2-The Ca and Mg tests were also in the range, but in extreme low values.

3-The total Coliform test showed that only Ajja municipal drinking tap water was polluted and contaminated. This maybe was because there is a crack and leakage between the sewage pipeline and the drinking water pipelines in Ajja village.

4-The EC test showed higher concertation of ions in the regions of: Jenin, Qalqilya and Tulkarim, this rise may be because the amount of dissolved metal ions is higher because of the rusty water pipe line.

5-The total Chlorine was in excess in Illar, Tulkarim, Qalqilya and Northern Asira, this is due to the municipalities access usage of chlore for purification and disinfection. The nitrate was in excess in Qalqilya and Tulkarim water sample only by a small margin.

Chapter Eight: Recommendations and solutions:

This chapter offers general solutions for the people who suffer from polluted or bad tap drinking water quality in their homes. As tables 4, 5 and 6 illustrated the water samples suffered from different defects and pollutants. Each sample and house have different circumstances and pipe lines connection that could be the reason of the problem. In this section we try to offer general economical solution for the end user depending on their tap drinking water defects. These are a group of solutions and recommendations for each specific problem:

1-It is preferable to use the activated carbon filter for tap drinking water samples with high chlorine concentration in the drinking water, as it works to remove sediments and organic materials and reduces the high chlorine concentration. This type of filter could be used in Illar sample water, as it will reduce the concentration of total chlorine.

2-it is preferable to use an ion exchange filter for the samples that have a high rate of turbidity, as it works to remove the hard water represented by gypsum and chalk deposits that can cause turbidity of the water.

3-The reverse osmosis filter is the best type for disposal of toxic substances like nitrate, it could be used for both Qalqilya and Tulkarim samples water.

4- Ultra violet filters, are best to get rid of bacteria and viruses using ultraviolet rays, it is best to use it if there are coliform bacteria in drinking water, it could be used to treat Ajja sample tap drinking water by the end user.

As mentioned before, the prices of those filters depend on the stages and their specific and special purpose. Also, the price varies depending on the supplier, the company and the country of origins.

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Appendix:

1- The Questionnaire that was spread in Arabic:

عزيزي القارئ، هذا الاستبيان من متطلبات اعداد مشروع تخرج في كلية الهندسة ويهدف لرصد المشاكل المتعلقة في مياه الشرب ووضع حلول مقترحة لها، لذلك نرجو منك التكرم بالاجابة عليه:

(1)- الفئة العمرية؟

1 18 سنة أو أقل.

2 من 19 إلى 30.

3 من 31 إلى 40.

4 فوق 40.

(2)- المحافظة التي تقيم بها؟

1 محافظة القدس.

2 محافظة رام الله والبيرة.

3 محافظة نابلس.

4 محافظة جنين.

5 محافظة قلقيلية.

6 محافظة طوباس.

7 محافظة طولكرم.

8 محافظة سلفيت.

9 محافظة أريحا.

10 محافظة الخليل.

11 محافظة بيت لحم.

(3)- موقع اللإقامة بداخل المحافظة؟

1 مدينة.

2 بلدة.

3 قرية.

4 مخيم.

(4)- اسم موقع الإقامة؟ .....

(5)- ما هو المصدر المغذي لمياه الشرب في بيتك؟

1 بئر تجميع مياه أمطار منزلي.

2 مياه البلدية.

(6)- في حال كانت مياهك من البلدية، ماهو مصدر هذه المياه؟

1 الابار الارتوازية.

2 الأمطار.

3 العيون والينابيع.

4 الجريان السطحي.

5 لا أعلم.

(7)- عدد أفراد العائلة الذين يستعملون نفس خزان المياه؟

1 أقل من 5 أفراد.

2 من 6-10 أفراد.

3 من 11-15 فرد.

4 أكثر من15 فرد.

(8)- ما هو معدل استهلاك عائلتك للمياه اسبوعياً؟

1 أقل من 2 متر مكعب.

2 بين 2 - 3 متر مكعب.

3 بين 3 – 4 متر مكعب.

4 أكثر من 4 متر مكعب.

في حال استخدامك مياه البلدية اجب عن الاسئلة رقم 9 و10 التالية:

(9)- هل كمية المياه التي تصلك من البلدية كافية ووافرة؟

أقل قيمة أعلى قيمة

1 2 3 4 5

(10)- هل تثق بنوعية المياه التي تصلك من البلدية؟

أقل قيمة أعلى قيمة

1 2 3 4 5

في حال وجود مشاكل في نوعية المياه التي تستخدمها، قيم الإسئلة من 11-13 التالية:

(11)- هل هنالك عكورة أوضبابية في المياه؟

1 نعم.

2 لا.

(12)- في حال وجود عكورة، ماهو لونها؟

1 أبيض.

2 أحمر(بني).

3 لا يوجد.

(13)-هل رائحة المياه مقبولة ؟

1 نعم.

2 لا.

(14)- كم مرة سنويا تقوم بتنظيف خزان المياه الخاص ببيتك ؟

1 مرة واحدة سنوياً.

2 أقل من مرة واحدة سنوياً.

3 أكثر من مرة واحدة سنوياً.

4 لا نقوم بتنظيفه.

(15)- هل تقوم بشرب المياه من الحنفية أم من فلتر الماء؟

1 الحنفية.

2 فلتر الماء.

شكراً لحسن تعاونكم

2- The questionnaire translated to the English language:

Dear reader, this questionnaire is one of the requirements for preparing a graduation project in the College of Engineering and aims to monitor problems related to drinking water and develop and suggests solutions to them, so we kindly ask you to answer it:

(1) - Age range?

1 18 years old or younger.

2 from 19 to 30.

3 from 31 to 40.

4 over 40.

(2) - The province in which you reside?

1 Jerusalem Governorate.

2 Ramallah and Al-Bireh Governorate.

3 Nablus Governorate.

4 Jenin Governorate.

5 Qalqilya Governorate.

6 Tubas Governorate.

7 Tulkarem Governorate.

8 Salfit Governorate.

9 Jericho Governorate.

10 Hebron Governorate.

11 Bethlehem Governorate.

(3) - The residency location within the governorate?

1 city.

2 townships.

3 village.

4 camp.

(4) - Name of the residence location? .....

(5) - What is the nutritious source of drinking water in your home?

1 Domestic rainwater collection well.

2 municipal water.

(6) - If your water is from the municipality, what is the source of this water?

1 artesian wells.

2 rains.

3 eyes and springs.

4 Runoff.

5 I don't know.

(7) - The number of family members who use the same water tank?

1 less than 5 people.

2 out of 6-10 individuals.

3 out of 11-15 individuals.

4 more than 15 individuals.

(8) - What is the weekly average of your family's water consumption?

1 is less than 2 cubic meters.

2 between 2 - 3 cubic meters.

3 between 3 - 4 cubic meters.

4 more than 4 cubic meters.

If you use municipal water, answer the following questions 9 and 10:

(9) - Is the amount of water that you receive from the municipality sufficient and abundant?

The lowest value the highest value

1 2 3 4 5

(10) - Do you trust the quality of water that you receive from the municipality?

The lowest value the highest value

1 2 3 4 5

If there are problems with the quality of the water you use, rate the following questions from 11-13:

(11) - Is there turbidity or cloudiness in the water?

1 yes.

No 2.

(12) - If there is turbidity, what is its color?

1 white.

2 red (brown).

3 there is no.

(13) -Is the smell of water acceptable?

1 yes.

No 2.

(14) - How many times a year do you clean your water tank?

1 time per year.

2 Less than once a year.

3 more than once a year.

4 we don't clean it.

(15) - Do you drink water from the tap or from the water filter?

1 tap.

2 water filter.

Thank you for your cooperation

3- Tables From (5-18):

Table 5: sample distribution according to the age group.

Age group	Frequency	Percentage
18 or less	46	9.89%
19-30 years	347	74.62%
31-40 years	41	8.82%
41 years or more	31	6.67%
Total	465	100%

Table 6:sample distribution according to the district.

district	Frequency	Percentage
Jerusalem	8	1.72 %
Ramallah & Al-Birah	13	2.8 %
Nablus	220	47.31 %
Jenin	128	27.53 %
Qalqilya	34	7.31 %
Tubas	7	1.51 %
Tulkarem	21	4.52 %
Salfit	10	2.15 %
Jericho	5	1.08 %
Hebron	7	1.51 %
Bethlehem	6	1.28 %
other	6	1.28 %
Total	**465**	**100%**

Table 7: sample distribution according to the dwelling.

dwelling	Frequency	Percentage
City	133	28.6 %
Town	158	33.98 %
Village	158	33.98 %
Refugee camp	16	3.44 %
Total	**465**	**100%**

Table 8: sample distribution according to the number of members in each family.

number of members	Frequency	Percentage
Less than 5	149	32.04 %
5-10 members	284	61.08 %
11-15 members	18	3.87 %
More than 15	14	3.01
Total	**465**	**100%**

Table 9: sample distribution according to the drinking water source in the house.

Drinking water source in the house	Frequency	Percentage
House-well to collect rain water	66	14.19 %
Municipal water	399	85.81 %
Total	**465**	**100%**

Table 10: sample distribution according to the municipal water source.

municipal water source	Frequency	Percentage
Artesian wells	103	22.15 %
Rain	33	7.1 %
Water holes and springs	54	11.61 %
Run-off	22	4.73 %
Unknown	253	54.41 %
Total	**465**	**100%**

Table 11: sample distribution according to the weekly consumption rate.

weekly consumption rate	frequency	Percentage
Less than 2 cubic meters	249	53.55 %
2-3 cubic meters	98	21.08 %
3-4 cubic meters	80	17.20 %
More than 4 cubic meters	38	8.17 %
Total	**465**	**100%**

Table 12: sample distribution according to the water amount evaluation.

water amount evaluation	Frequency	Percentage
1 the least value	55	11.83 %
2	39	8.39 %
3	217	46.67 %
4	43	9.24 %
5 the highest value	111	23.87 %
Total	**465**	**100%**

Table 13: sample distribution according to the confidence degree in municipality water.

confidence degree in water	Frequency	Percentage
The least value 1	39	8.39 %
2	64	13.76 %
3	199	42.8 %
4	106	22.8 %
The highest value	57	12.25 %
Total	**465**	**100%**

Table 14: sample distribution according to the existence of polluted water.

existence of polluted water	Frequency	Percentage
Yes	278	59.78 %
No	187	40.22 %
Total	**465**	**100%**

Table 15: sample distribution according to the color of polluted water.

colour of polluted water	Frequency	Percentage
White	106	22.8 %
Red (brown)	223	47.96 %
No color	136	29.24 %
Total	**465**	**100%**

Table 16: sample distribution according to the water smell degree.

water smell degree	frequency	Percentage
Accepted	184	39.57 %
Unaccepted	281	60.43 %
Total	**465**	**100%**

Table 17: sample distribution according to the number of times the tank is cleaned.

number of times the tank is cleaned	frequency	Percentage
Once a year	229	49.25 %
More than once a year	88	18.92 %
Never cleaned	148	31.83 %
Total	**465**	**100%**

Table 18: sample distribution according to the drinking water method

drinking water method	frequency	Percentage
tap	374	80.43 %
Water filter	91	19.57 %
Total	**465**	**100%**