Hebron University
College of Graduate studies

Groundwater Quality at Western Bethlehem District

By

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°	Degree
%	Percent
∑	Sumation
µS	Micro Siemens
A	Area
$AgNO_3$	Silver nitrate
Apr	April
Arij	Applied Research Institute-Jerusalem
Aug	August
Ca^{+2}	Calcium ion
Cl	Chloride
Cfu	Colony Formed unit
E	East
Ec	Electrical conductivity
EDTA	Ethylen Diamine Tetra Acetic acid
Evap	Evaporation
Fc	Fecal coliform bacteria
Feb	February
Fig	Figure
h	Hour
HCl	Hydrochloric acid
HCO_3^{-1}	Bicarbonate ion
Jan	January
Jun	June
K^{+1}	Potassium
Km	Kilometer
Km^{-1}	Per kilometer
L	Liter
m	meter
Mar	March
Masl	Meter above sea level
Max	Maximum
MCM	Million cubic meter
Meq	Milliequivalent
mg	Milligram
Mid	Middle
Min	Minimum
ml	Milliliter
Mon	Month
N	North
Th	Total hardness

Abstract

The study area for this research located in western Bethlehem district, about 12Km from Bethlehem and 15 Km from Jerusalem. It lies withen 120,000-130,000N and 160,000-170,000E on Palestine Grid. This study conducted at May and October (2008). This study focuses on groundwater quality, and seasons influence.

Study area construct from four catchments: Hussan, Wadi Fukeen, Battir, and Nhaleen. The annual average rainfall is 570mm, rainfall season starts from mid autumn until end of April, 70% of rainfall is in December and January.

Geology of the study area is composed of sedimentary rocks limestone, marl,dolomite limestone, Hebron , and Yatta formations.

The major contaminated sources for spring water are sewage, fertilizers, human activities as industry in neighbor settlements and livestock farms.

Samples are gathered in two seasons. First: in May. Second: in October. These samples analyzed chemically and biologically, and seasons influence on water quality for domestic and irrigation.

Majority of springs water in two samples are unsuitable for domestic uses biologically.

Springs water tested for irrigation suitability depending on SAR classification,found out that all springs suitable for irrigation. Where SSP showed that, May samples, 15% good, 65%permissible, and 20% doubtful October samples, 40% good, 50% permissible, and 10% doubtful. May samples EC show that 5% low salinity, 90% medium salinity, and 5% high salinity. October samples shown that 5% low salinity, 85% medium salinity, 10% high salinity.

Piper classification of water samples show four types for October and May samples there are earth alkaline water with increased portion of alkalis with prevailing bicarbonate, normal earth alkaline water with prevailing bicarbonate, and earth alkaline water with prevailing chloride, and earth alkaline water with increasing portion of alkaline and prevailing chloride.

There is seasonal influence on spring water shown by statistical analyses. Standard deviation and mean were used for this analysis. Springs divided to four groups, each village considered group. Each groups have special situation. But generally, statistically some parameters value not showed significant changed as K in Hussan group, others showed significant change by increasing parameters concentration for October samples, due to lowering the water table as Ca in Hussan group, and other parameters concentration values showed increase in October samples, due to it's infiltrate with rainfall in major sample.

Chapter One

Introduction

Chapter One

Introduction

The West Bank as apart of Palestine has suffered from water shortage as a subhumid and dry region. The problem worsened in the last mid century because of scarce and critical resources population growth, population momentum, household demands water resources pollution and increasing urbanization. Added to agriculture consumed 70% from of the water resource available to Palestinians in the West Bank.(Scarpa,2004) .

The hard reality is that many Palestinians have been going without water for hours and some times for days. The lack of supply is due to population growth added to above reasons.

This research will deal with the water issue in Western Bethlehem district region in the West Bank.

1.1 Location

The western Bethlehem district is located about 15 Km southwest of Jerusalem and 12 Km west of Bethlehem. It is bounded by Bethlehem district from the east, Jerusalem district from the north, Hebron district from the south and the 1948 Armistice Agreement line from the west.

This region consists of four villages. Their names and areas are tabulated below.

Table1.1: Villages population land area in dunum's (ARIJ – Applied Research Institute Jerusalem.1995)

Village	Population	Area in dunums
Battir	3500	7165
Husan	4500	7295
Nahaleen	7500	17250
Wadi Fukeen	1000	4347
Total	16000	36057

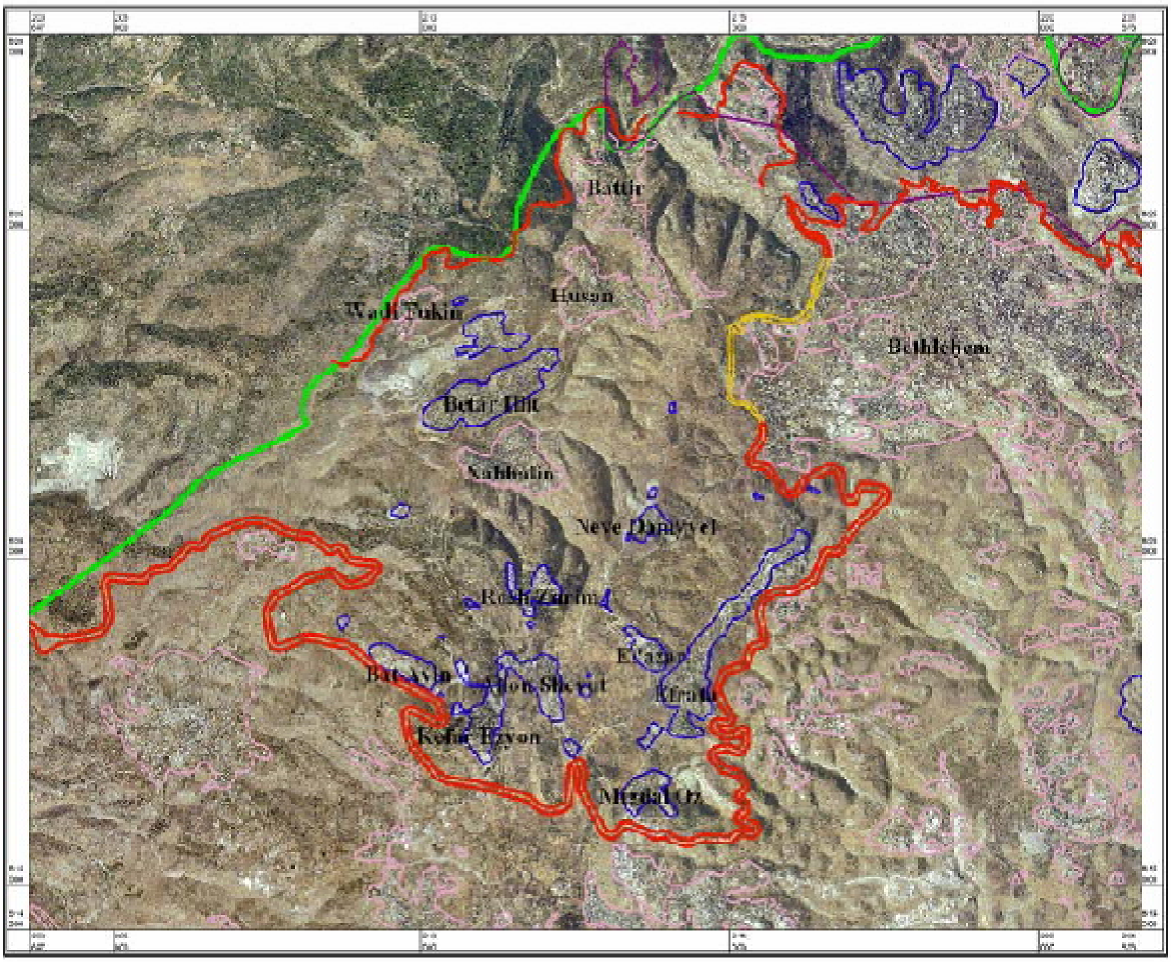


Fig.1.1: Map of the study area. (Taaysh, 2002)

Legend:

- Green Line = The Green Line
- Red and Orange Lines = The Projected Fences and Walls
- Places marked in Pink = Palestinian Villages
- Places marked in blue = Jewish Settlements
- The unnamed Palestinian village in the north-east of Battir is Wallaje, whose case is very similar to that of the other four villages, as fences shall be built separating

1.2 Problem Statement

Recently majority of the study area population depend on irrigation agriculture by springs water, and springs water use as second source for domestic uses. So that problem statement include answer of the following question.

1- Are the spring’s water in study area suitable for domestic uses?

2- Are the spring’s water in study area suitable for agriculture?

3- What are the changes on spring water quality during a year?

1.3 Research Hypothesis

The following hypothesis considers for this research:

1- Springs water influenced by the biological pollution.

2- Springs water suitable for drinking chemically.

3- Springs water quality for drinking and agriculture influenced by sewage water.

4- There is change in spring’s water quality by time.

1.4 Objectives

This study aims to provide chemical, Physical and biological parameters of ground water in the study area.

Study area springs are a second resource for drinking, domestic and irrigation use. But in recent times during the economic degradation of the society in the study area, agriculture and human activity increases. So groundwater pollution source increases.

Biological test assessment of the bacteria colony number in the water samples shows whether the springs water is suitable for drinking or not.

The objectives of this study are:

1- Testing the spring's water sampling; physical, chemical and biological.

2- Evaluating spring's water if potable or not.

3- Determining spring's water suitability for irrigation proposes using SSP and SAR parameters.

4- Concluding the recommendations that decrease water springs pollutions.

1.5 Previous Study

(Bauder et al. 2005) studied irrigation water quality criteria. They concluded that for the long-term productivity management and improvement crop productivity, the irrigation water quality is the most important factor. The irrigation water has effects on crops production, and soil categories such as:

a) Salinity hazard- total soluble salt content

b) Sodium hazard- relative proportion of sodium ions to calcium ions and magnesium ions

c) Specific ions: chloride, sulfate, and nitrate .

d) Other potential irrigation water contaminants.

But the most influential factor is water salinity hazard, which can be measured by electrical conductivity (EC). It has a direct effect on crop productivity because high (EC) means less water available to plants.

(Shalash,I.& Ghnem,M. 2007) studied the hydrochemistry of the Natuf drainage basin in Ramallah area / West Bank. They showed that the groundwater concentrated in mountain aquifers provides 70% of the West Bank needs for drinking and domestic uses. The aquifers may be influenced by natural or man-made factors such as climate, hydrogeology management practices, and pollution.

There is another important factor that affects the water quality and that pollution is the wet and dry seasons. The concentration of cations and anions in a dry season is higher than that of a wet season, due to longer pollutant resident time and lower water table in a dry season. In a wet season, water infiltration reduces the ions concentration, except for nitrate and chloride ions concentration which increases in a wet season. The higher concentration is a result of pollutants due to runoff over agriculture and urban areas.

(Scarpa,D. 2002) Studied the quality and sustainability of the water resources available to Arab villages at west southern West Bank. This region represented by seventy-five springs. Study included that available drinking water for Palestinians from all reduced quality and quantity to level, represent health danger especially for children.

(Scarpa,D. 2001) Studied the vulnerability of the southern basins of the West Bank mountain aquifer, and the measures that must be taken to protect the groundwater. This study concludes that the mountain aquifer in the southern West Bank is located within the Hebron Mountain. It much western limb than eastern limb. Range springs are classified as its drainage system westwards spring Mediterranean system and eastwards to the Dead Sea drainage system. Under the water scarcity and aquifer depletion the groundwater extraction by borehole should be used for drinking and domestic use only. Other water sources as rain water harvesting; spring's water and wastewater treatment could be used for other purposes. Non clear water policy, no water marketing regulator, low rainfall rate, the increase of water consumption and the wastewater source are founded and increased as water demands increase by promoting the above policy. But all of this and the health and environmental save become available and practical if the projected urban wastewater treatment plant is completed.

(Mizyed,N. 1997) studied the assessment of the discharge of the major springs in the West Bank with an approach to overcome discharge variability. He mentioned that 297 springs found in West Bank, with yearly discharges 56 MCM potable water. Spring discharge variability, due to rainfall variability from year to year, protects highly utilized water effectively from this large quantity. To solve this problem, he suggested that classified springs in seventy groups as the geographic latitude and well must be found in aquifer. If it not should be classified and locates nearby in the same sub-aquifer, the wells will need comprehensive and regulation development.

(Scarpa,D. 2002) Studied water supply and sanitation for a group of Palestinian villages in the southern West Bank. He seeks to determine the extent which Palestinian villages can deal with the crisis. Region springs are important source of drinking and irrigation water. In this study 61 springs sampled in each three seasons, at end dry season (1998), middle wet season (1999), and end wet season (1999).Springs sampled analyzed biological and chemical parameters. The results conclude that all springs samples were contaminated with coliform bacteria. It showed highest concentration of NO_3 in those collected at the end of the dry season, and very high readings showed hardness as would be expected in carbonate rich aquifer.

(Abed Rabbo,A, et al. 1999) Studied the water quality and chemistry of West Bank springs. The study concludes that all springs of the West Bank are usually contaminated with coliform bacteria, thus unsuitable for drinking unless disinfected properly. Majority of West Bank springs are suitable for drinking from chemical point view, no harmful concentration of heavy metals in any West Bank springs. West Bank springs water are suitable for irrigation based on SAR and SSP values except for few springs. Most abundant water type in the West Bank is earth alkaline water with prevailing bicarbonate which characterizes the recharge areas of carbonate aquifers worldwide.

(Rabe M. 2007) in his M.Sc thesis studied the hydrochemical and hydrogeological investigation of the water of Serar Al-Janobi catchment area in Palestine. The study showed that all springs in the Serar Al-Janabi emerges from perched aquifers. Rainfall is the only source of recharge and the springs aquifers are completely separated from regional aquifers in the area. There is relation found in the rainfall and each springs discharge from month to month. Springs in the area can be classified into three groups according to storage coefficient, poorly designed cesspits, animals dung, washing and agriculture fertilizers where leaching by rain water and increase the chloride and sulfate concentration in springs that closed to house and agricultural land. Seasonal variation in the water springs quality due to the recharge occurs by precipitation in winter season only, so that the winter samples should have low ions concentration due to precipitation dilution. Springs in the study area have high ions concentration because of the contaminants that accumulated on the soil by rainfall.

(Abed Rabbo,A,et al. 1998) Studied water quality and hydrochemistry of the Herodion Beit Fajjar wells. This study concludes that rainfall amounts decrease rapidly from west to the east crest of the Hebron Mountains. (750mm to600mm/year at Bethlehem and less than 100mm/year at Dead Sea).The wet season starts from September to

March. The dry season starts from April to August. There is variation in the sample chemistry collected in December and March. Samples of hardness increase were collected in December and few amounts of coliform in some samples may be the head well-pipe contaminated or human error because no such bacteria could originate at the depths from which the well water was extracted.

(Scarpa, D, et al. 2002) Studied the rainfall in Bethlehem (1992-2002). This study showed that rainfall variation found from year to year and examined the limiting factors to the crops that can be cultivated, especially the yield grown by traditional rain-fed methods. Potential evaporation is 1,874 mm/yr for Jerusalem and 1,606mm/yr for Hebron. Average annual rainfall exceeds evaporation only in January, February, and December.

(Haviv,I.,and Asaf,L. 2005) Studied the hydrological system of Wadi Fukeen springs. They show that Wadi Fukeen valley and surrounding lie at 600m-750m above the Sea Level, and the average rainfall in the area 572mm/year and 575mm/year respectively. The total annual discharge of all the springs is estimated as 85,000-110,000 m^3. Average annual rain volume over the recharge area is ~3.4 million m^3. Thus, the discharge of the springs is approximate, 2.5-3 % of the rain volume. The remaining water is lost through evapotranspiration, seepage to deeper regional aquifers, subsurface flow towards the south-west, and some surface runoff.

All the springs have very low salinity reflected in low electric conductivity values ranging from 0.545 mmohs/s to 0.884 mmohs/s with an average of 0.730 mmohs/s. These values correspond to less than ~ 400 mg/L of total dissolved solids and indicate that the water quality is very good.

Chapter Two

Methodology

Chapter Two
Methodology

This research data collection from the previous studies, activates on area around springs catchments, and laboratory samples analysis.

2.1 Literature review:

Literature review includes reports, maps; scientific papers published and unpublished, water society reports, metrological data, and hydrology study for study area.

2.2 Field work

A comprehensive sampling program concerning 20 springs in the study area was carried out at two stages. First one was in May and second was in October. Two bottles for each sampling site were collected (1000ml bottles) for chemical and physical analysis, where (250ml) bottles intended for bacterial analysis. Each bottle was sterilized in the Hebron university laboratory by autoclave. In the field, each bottles:

A- Rinsed with the spring water.

B- Kept far as possible form our respiration to avoid biological pollutions.

C-Left the bottles in the spring water at least two minutes.

D-filled completely by spring water without any space.

E-Samples placed in a cold box until arrival back at the laboratory.

2.3 Laboratory Work

The analysis of the water samples was conducted in the laboratories of Hebron University.

In these laboratories, samples were analyzed for the major cations (Ca, Mg, Na, K,NH_4) and the major anions (Cl, SO_4, NO_3, HCO_3) and biological analysis (Fecal coliform and total coliform).

Table 2.1: The analytical methods are used for determination of various parameters of samples.

Parameter	Method of analysis
EC-value	EC-electrode meter
pH value	pH-electrode meter
Ca, Mg	Titration with disodium -EDTA using Eriochrome black-T indicator
Ca	Titration with disodium-EDTA using Murexide indicator
Na and K	Flame Photometere
CO_3 / HCO_3	Titration with HCl using phenolphthalein and bromocresol-green indicators
Cl	Titration with AgNO3 using potassium chromate indicator
NO_3	UV- Spectrophotometer method (λ=220nm)
SO_4	Turbidimetric method, Spectrophotometer (λ=220nm)
NH_4	UV- Spectrophotometer method (λ=220nm)
Total and faecal coliform	Filtre membrane method

Chapter Three

Study Area

Hydrology and Climate

Metrological stations in the study area have not been found. So used data from the close neighbors metrological stations, pervious study and data from metrological stations located in the same area conditions which called index stations.

3 .1 Climate

Study area located at the western Hebron mountain slope shows the average annual rainfall range between 500and700mm, even though it is classified as semi arid region, may be explained by the main annual evaporation rate(2400mm-2600mm), which is larger than annual rainfall. The mountain feature of the study area and the high steepness with no water harvesting means the most quantity of rainfall is out of the utilization.(Arij,1995)

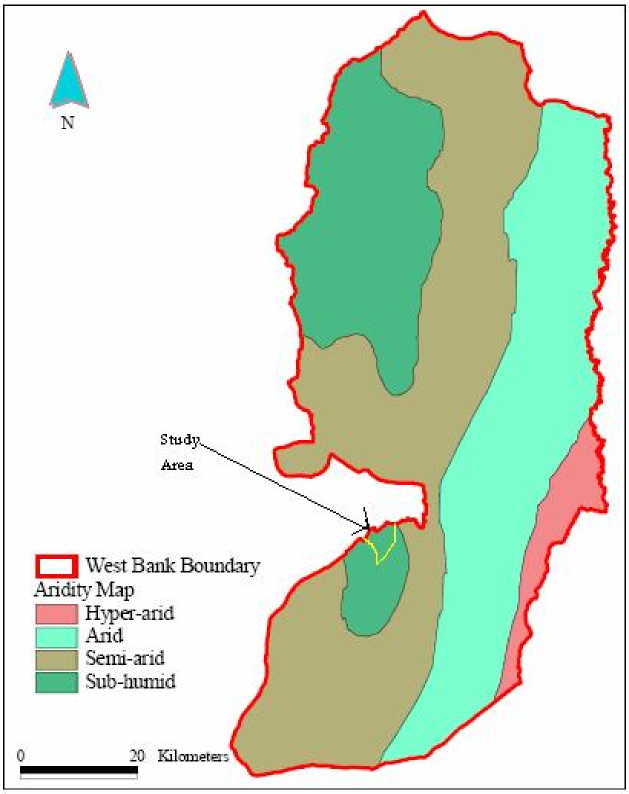


Fig3.1: Aridity map of the West Bank .(Shadeed,2008)

3.2 Wind

Study area is influenced by the western wind from Mediterranean Sea, especially in Autumn and Spring. The humidity in the western wind determines if the weather will rain or not. The average annual wind speed in study area is 3m/s (Arij, 1995)

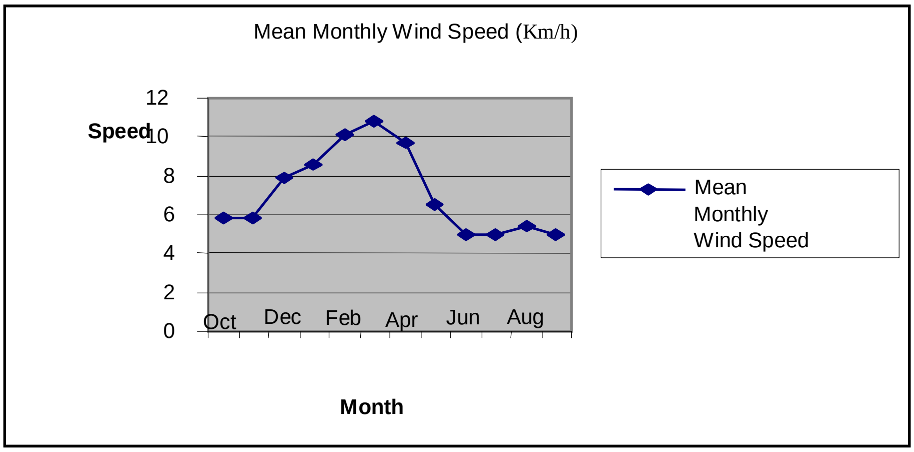


Fig 3.2: Monthly wind speed **(Km/h)** (Al-Arroub climatic station,2008)

3.3Temperature

Temperature varies according to geographical location (Tmeize, 2000). High variation in area temperature is between summer and winter and from month to month. The average annual temperature in Bethlehem is generally between 9 °C -18°C in winter and 26°C -30°C in summer (Bethlehem Municipality), but the average temperature in the study area is7°C -19°C, with maximum of 22°C in summer and a minimum of 7°C in winter. (Arij,1995). The average monthly minimum temperature ranges between 9.7°C in January and 16.2°C in July where average annual 17°C – 19°C (PWA,2002).

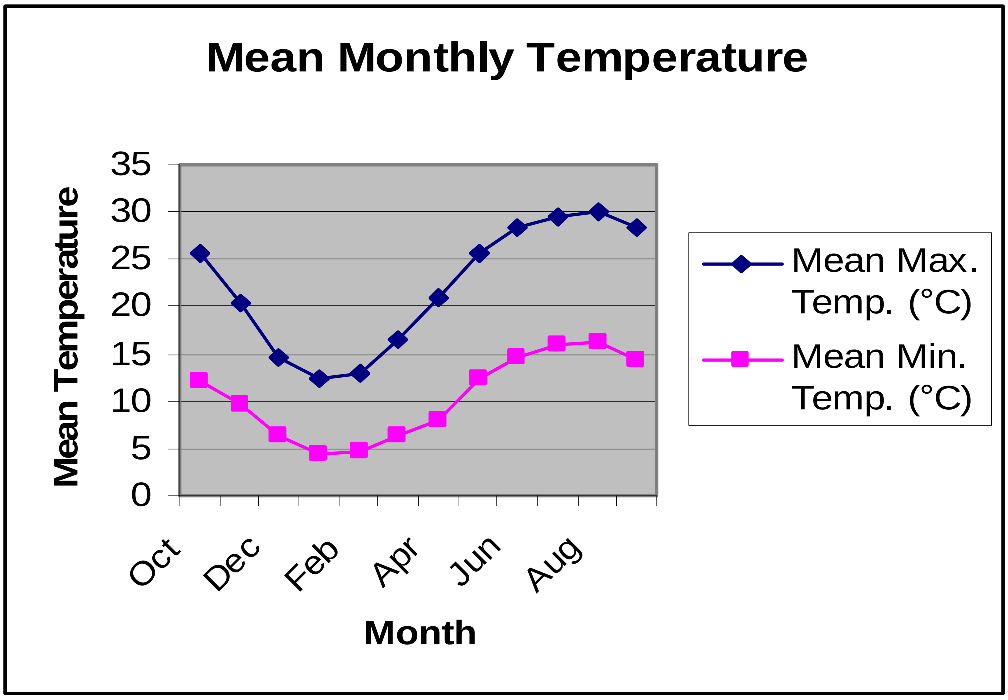


Fig3.3: Mean monthly maximum and minimum temperature (Al-Arroub climatic station)

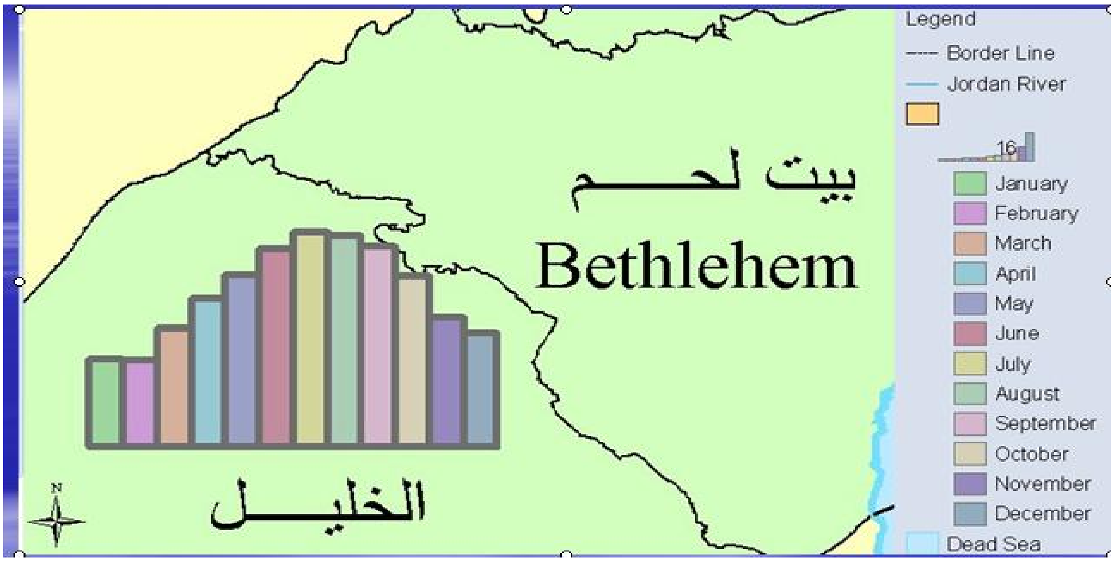


Fig3.4: Mean of Air Temperature (C°) in the Bethlehem and Hebron by Month,2005(Palestine Central Bureau of Statistics,2005)

3.4 Relative humidity

The average annual relative humidity is 60%, and reaches the highest rate during the months of January and February. The lowest relative humidity is in May. Night dew may occur up to 180 days per year (Bethlehem Municipality, 2008).

3.5Rainfall

There is variation in the rainfall in the west Bethlehem district due to the Sea Level elevation and mountain slope inspect noted in map (2.3).

The average annual rainfall in the study area is 570mm with maximum annual rainfall in 1991-1992 seasons was 1092mm, where the lowest annual average was 251mm in1998-1999 (Rabe,2007). A rain season for the study area starts in the second half of autumn (mid October) and continues until the end of April. The heavy rain is less than 50 days; however 70% of the rain falls during November to February (Arij, 1995).

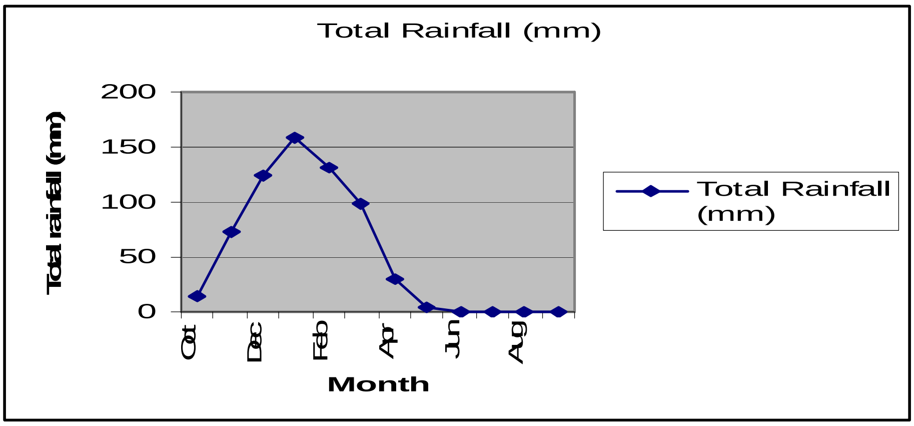


Fig 3.5:Total month rainfall (Al-Arroub climatic station)

As mentioned in the initial chapter, no metreological stations have been found in the study area. Only gages of the same features in close neighboring areas have been used (i.e in Arroub, Hebron, Cremisan, Salisian, and Beit Sahour).

Table 3.1: Names, average rainfall, coordination and elevation of index station (Qannam, 2003).

Statioin	Coordinates		Elvation	Average Rainfall		Available
	East	North	msal	1961-1990	1965-1994	Data
Arroub	162100	114700	860	624.7	649	Daily
Hebron	159350	107250	1005	591	591	Daily
Salisian	169450	123350	720	598	598	Yearly
Rosh Zurim	162000	119700	930	616	616	Monthly
Cremisan	166400	126000	820	618	618	Monthly
Beit Sahour	170750	123500	650	467	467	Yearly

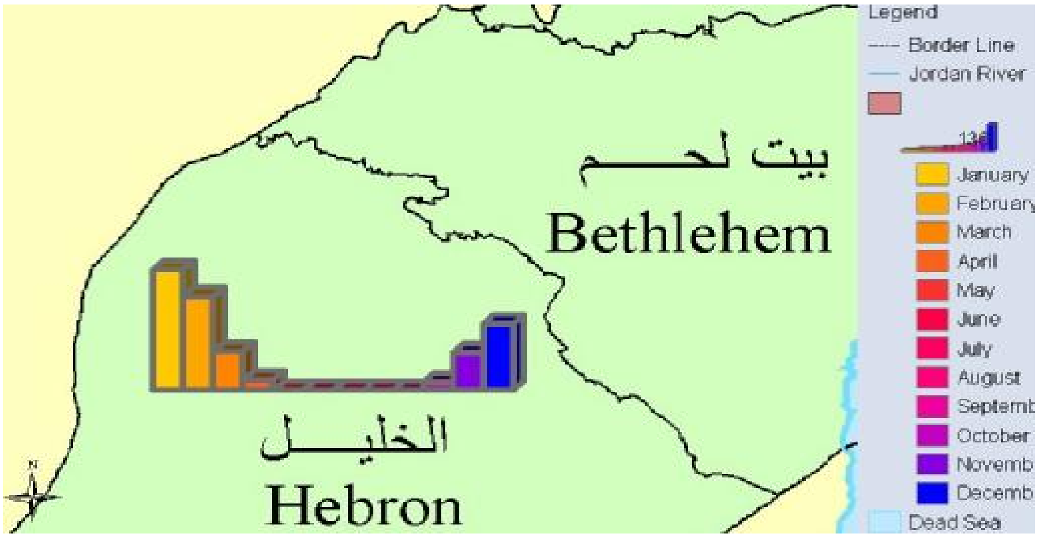


Fig3.6: Rainfall Quantity (mm) in the Bethlehem and Hebron Territory by Month2005, (Palestine Central Bureau of Statistics, 2005)

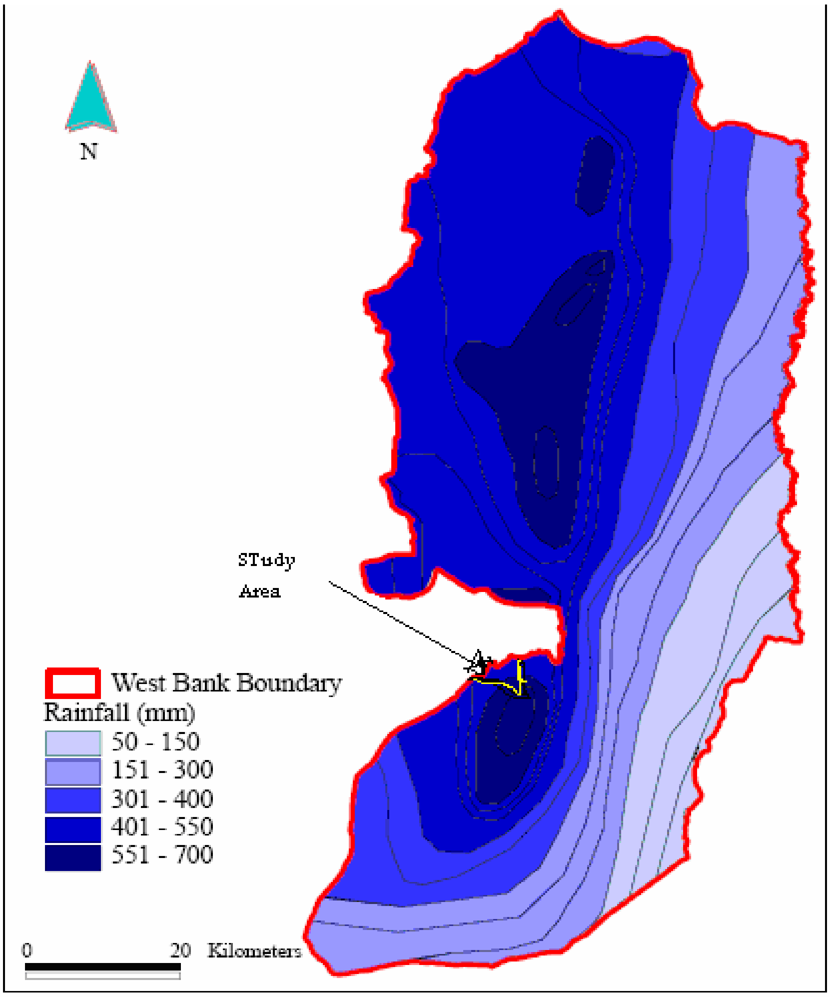


Fig 3.7: Rainfall distribution map of the West Bank (Shadeed,2008)

As illustrated in the above map (3.7), high variation in rainfall distribution between Western and Eastern Bethlehem, may be explained owing to the high spring's number found in Western Bethlehem,but Groundwater direction illustrated by Fig (3.8), explain wells founded at eastern Bethlehem.

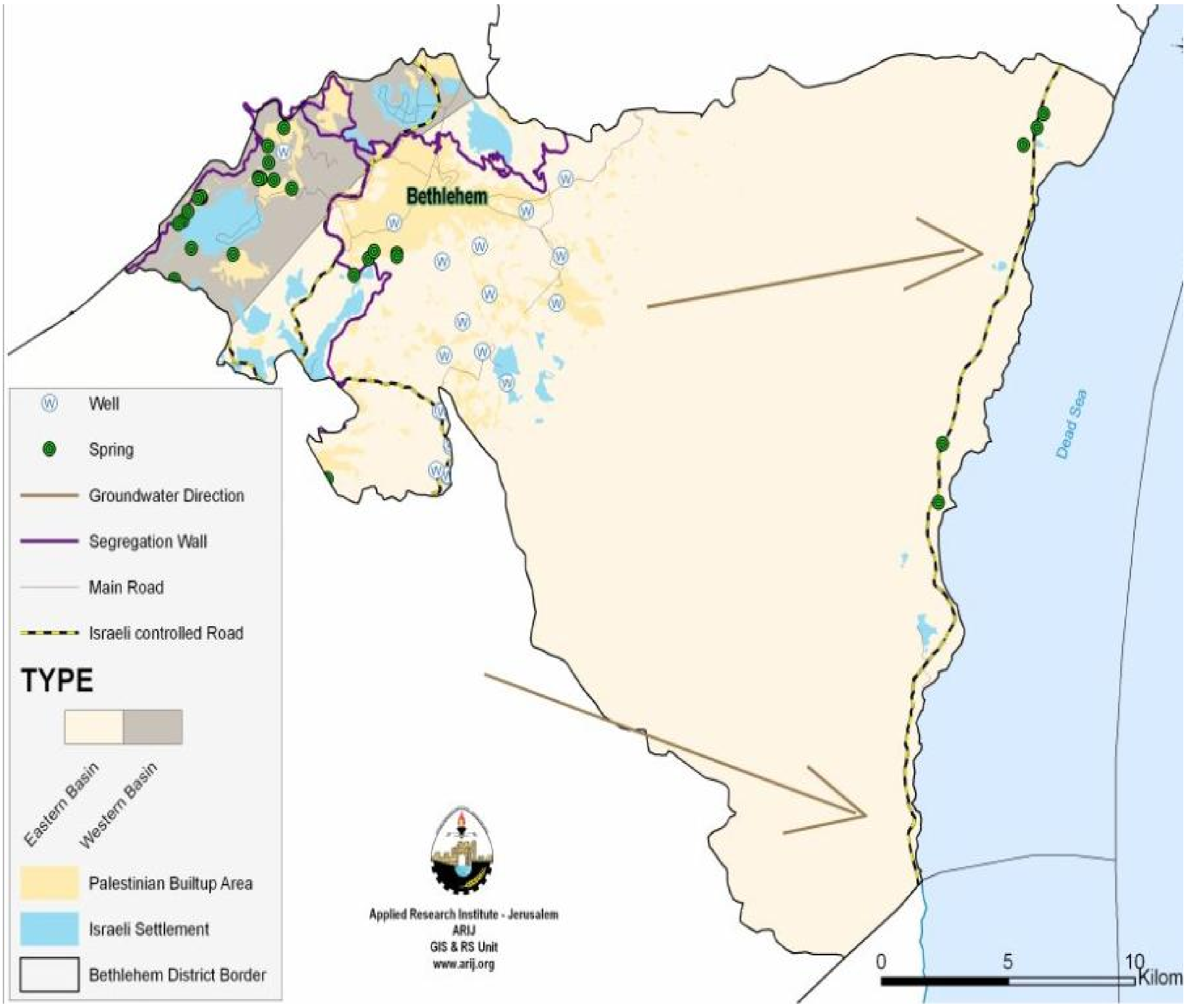


Fig 3.8: Water Resources In Bethlehem.(Arij,2008)

It is clear that rainfall is the major water source in Bethlehem district in two forms; springs and wells, groundwater flow is controlled by the anticline structure (Scarpa,1994). But the water situation seems not safe due to few springs , wells flow, decrease in average rainfall and population increase.(Rabe,2007) compares the average rainfall depth over the study area in two periods; first (1960-2005) and secondly (1975-2005). He found that rainfall depth decreases from the first period to the second by (8mm/year) and the decrease expected at periods (1960-2021) is 8-10mm/year. This is another proof about the scarcity of water in the future in the study area of Bethlehem district.

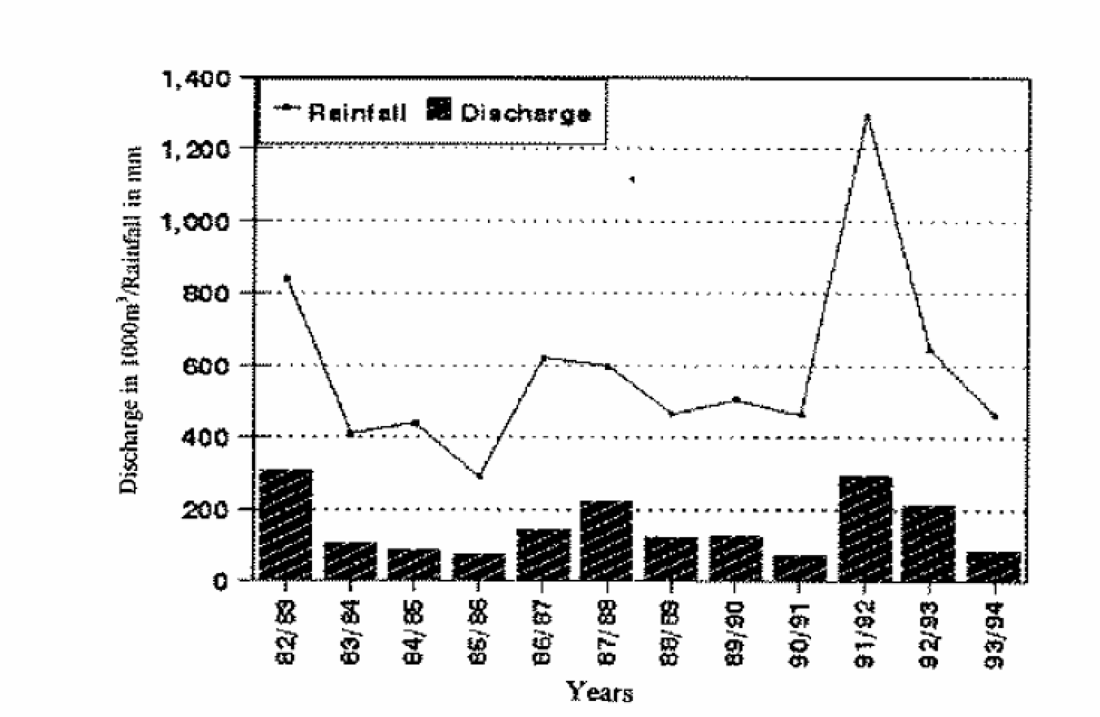


Fig 3.9: Relation Between Rainfall and Springs Discharge.(Arij,1995)

3.6. Evaporation

Evaporation is the process where the liquid is converted to gas, in this case the liquid is water. Some factors affected in evaporation process temperature are wind speed and surface area. Potential evaporation is the amount evaporated if the water is available. Actual evaporation is the real water amount evaporated.

(Rabe ,2008) estimated actual evaporation in the study area. The mean found is 494mm/year.

Evaporation value compared with the annual rainfall shows that high percentage rainfall is lost by evaporation.

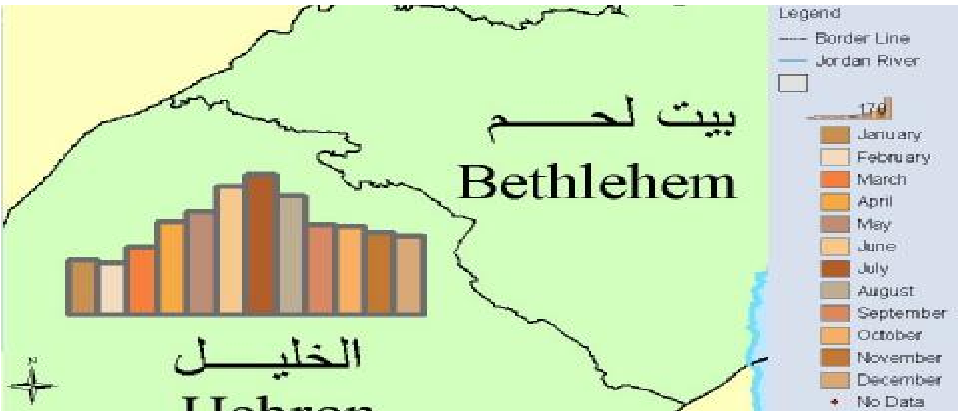


Fig 3.10: Evaporation Quantity (mm) in the Bethlehem and Hebron Territory by Month,2005 (Palestine Central Bureau of Statistics)

The major problem added to the high evaporation percentage from the rainfall is the relation between evaporation and rainfall time where evaporation is in the highest activity in the month when the fall percent is lowest or zero. As a result agriculture in this month becomes very hard because high water is lost and the soil becomes more salty.

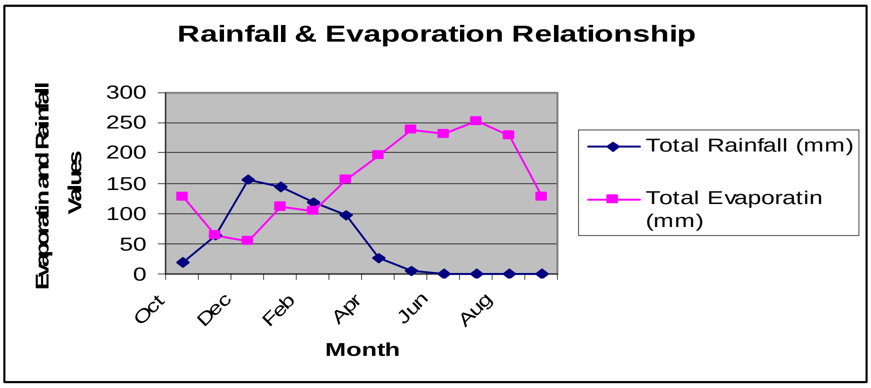


Fig 3.11Total evaporation and rainfall relation(Jerusalem climatic station,2008)

3.7. Solar radiation

Bethlehem receives an average of seven hours of sunshine a day in winter and thirteen hours in summer (Arij,1995).

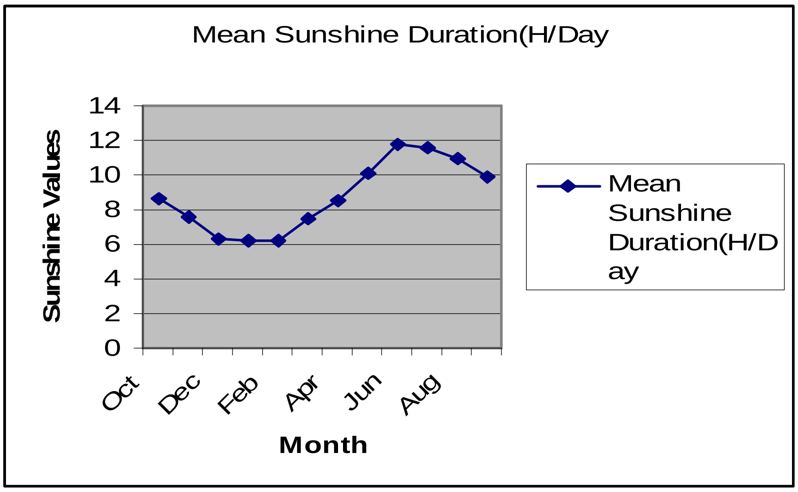


Fig 3.12: Mean sun duration hour/day(Jerusalem climatic station,2008)

3.8. Nahaleen springs

The following springs are around Nahaleen village

3.8.1 Faris spring

It is located approximately 3km away from western Nahaleen village at 555 meters above Sea Level. Its water discharge is to the west direction from Hebron formation collected in a pool to the south.

Spring water ten years ago was used for irrigation, domestic use and livestock, but now after the sewage water from time to time flows to the spring from the neighboring sewage treatment station it returns to Betar Elit settlement, sprig water is used only for irrigation and livestock today

3.8.2 .Al-Balad spring

This spring is located at 620 (masl) to the south west of the village and emerges from Hebron formation.

House is close to the springs from south and the upper mountain from east (spring catchments area). Spring water is used only for irrigation

Spring water fifteen years ago was the second source of drinking water where the pipe net becomes first source, but it is used now for livestock and recreation center.

3.9 Wadi Fukeen springs

The following springs are around Wadi Fukeen village

3.9.1 Al-Quds spring

This spring is located east of the village at 675(masl). It is a well-like spring emerge from Alluvium formation to the west dirction. Springs water is used for irrigation onl

3.9.2 Al- Balad

It is located in the village central at 647(masl). This spring emerge from Amminadav(Hebron) rocks formation to the west direction.

Spring water is used for irrigation and livestock, before the house becomes close to the spring. Spring water was potable but now it become polluted by the sewage water leakage.

3.9.3 Al-Mgara

This spring is called Al-Mgara because this spring is found in a cave called Al-Mgara.

Al-Mgara spring is found in the village center near Ein Al- Balad at 647(masl). It emerges from Hebron formation to the west direction. This spring is used for irrigation and livestock but it is considerd not potable for the reasons like Ein el- Balad.

3.9.4 Al-Tena spring

It is located neighboring to the village from southwest at 615(masl). It emerges from Alluvium formation to the west direction. It is a shallow well spring with a depth of 2m and water depth 0.5m. It is used for irrigation by a traditional channel and some time it is used for livestock.

Because water is collected in the well for a few days, it is considered not potable water.

3.9.5 Mtheq spring

This spring is located in the half of the valley about 1200m west of the village at 590(masl). It emerges from Hebron formation to the west direction discharge.

It is considered one of the major springs in the village and is used for irrigation, livestock and drinking.

3.9.6 Al-Fawar spring

It is located about 1600m western of the village at 575(masl).This spring emerges from Hebron formation to the west direction.

This spring is considered the major spring in the village, it is used for irrigation, drinking and livestock.

3.9.7 Subeh spring

Subeh spring is located 1550m western of the village at 5778(masl). It emerges from Alluvium formation to western direction.

It is like a spring under earth surface of about 0.5m depth with water depth 12cm and is used for irrigation.

3.9.8 Sediq spring

It is located 2100m western of the village at 560(masl) above Sea Level. It emerge from Alluvium formation to the west direction.

This spring water is used for irrigation, livestock and drinking.

3.10. Husan Springs

The following springs are around Husan village.

3.10.1. Al-Skonah Spring

This spring is located western of the village at 718(masl) and emerge from Yatta formation to the west direction.

Spring water is used for irrigation and livestock. In recent years the house became close to the spring so sewage water leakage to spring water that drinking used for spring water.

3.10.2. Al-Namous Spring

It is located west of the village at 715(masl). Spring water emerges from Yatta formation to the north direction. Its water is used for irrigation and livestock.

3.10.3. Al-Balad Spring

It is located to the west of the village at 714(masl). It emerge from the Yatta formation to the north direction. Spring water used for irrigation and livestock.

3.10.4. Abu Sami Spring

This spring is located to the west of the village at 720(masl). It emerge from Yatta formation to the north direction. Spring water is used for irrigation and livestock.

3.10. 5 Al-Arady Spring

It is located west of the village at 720(masl).It emerges from Yatta formation to the north direction. This spring water is used for irrigation.

3.10.6 Al-Hawea spring

It is located north west of the village at 735(masl). It emerges to the west direction. Spring water is used for irrigation, drinking and livestock.

3.10. 7 Al-Basin spring

Spring is found in the cave at the highest mountain west north of the village at 748(masl). It emerges to the east direction. It is used for irrigation and livestock.

3.10.8 Al-Kanesa spring

It is located west south of the village at 668(masl). It well like-spring with a depth 1.5m and water depth 0.3m.It emerges to west direction. It is used for irrigation and livestock.

3.11. Battir springs

The following springs are around Battir village

3.11.1 Al-Balad springs

It is located north west of the village between the house at 638(masl). It is emerges from Soreq formation to the north direction. Spring water is used for irrigation and livestock.

3.11. 2 Jame' spring

Spring is located north west of the village in the valley at 600(masl). It emerges from Upper Beit Kahel formation. Spring water is used for irrigation, drinking and livestock.

Hydrogeology

3.12 Water resources

Mountain aquifers are one of the most significant water resources for Palestinians.

Mountain aquifer is a renewable aquifer that is recharged by rainfall in the West Bank Mountains (B'Tselem, 1998). Most West Bank areas share in mountain aquifer recharge and some parts of Israel extend along the upper mountain slopes and ridges at an altitude of 500m above Sea Level(El-Fadel et.al.2004). Mountain aquifer is composed of three aquifers (Fig.3.13). The three sup-aquifers supply 600-700MCM of water per year (Tagar et.al.2004).

3.13 Groundwater aquifer system

3.13.1 The lower Cenmanian Aquifer system

This aquifer formations system is in the lower and upper Beit Kahel. It's composed of dolomite, limestone, marly and chalky limestone (Rofe&Roffety, 1963).

3.13.2 The Upper Cenomanian Aquifer system

This system is composed of limestone, chalky limestone, and dolomite.

3.14 Groundwater Basins

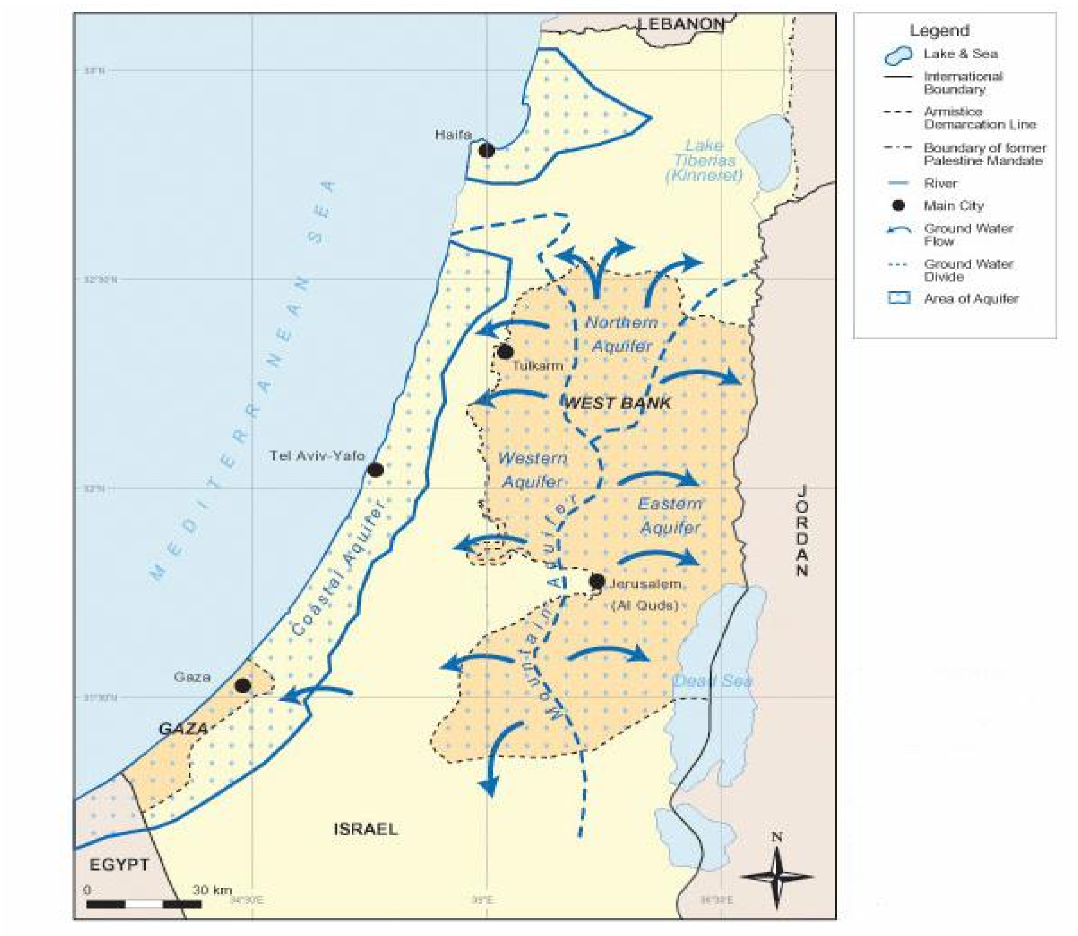


Fig3.13: Mountain and Coastal Aquifers (Anton,G.2004).

3.14.1 Western Basin

The Western Basin extends from Beer-Sheva northward to the Carmel Mountain foothills, and from near center of the mountain belt westward to the Coastal Plain. Total Basin area is 6000Km2**.** Where Basin has recharge area of about 1800Km^2(Eckstein and Escksten, 2003). The basin is underlain by a thick sequence of layered limestone, dolomite, chalk and marl. Precipitation recharges the groundwater system at an average volume of 366 MCM/yr, and flows in a general westward and northward direction.

This basin includes two aquifers. Firstly, the Turronian-Cenomanian

aquifer, the most productive aquifer in the basin, consisting of limestone and dolomitic limestone. Secondly, the Albian aquifer, of secondary importance, consisting of sandstone and dolomite.

Groundwaters levels are influenced primarily by precipitation and pumpage, and generally fluctuate about 1.5 m/yr to 2.5 m/yr. larger fluctuations are observed in areas influenced by local pumping. Groundwater is generally of good quality, with concentrations of chloride from 50 to 250 mg/L, and nitrate from 16 to 28 mg/L. Chloride concentrations generally increased during the last 30 years, with more

pronounced changes in the southern part of the basin. **(Water Data Banks**

Project,2007)

3.14.2 Northern Basin

The basin extends over 1,044Km2, and is underlain by a thick sequence of layered limestone, dolomite, chalk and marl. Groundwater is recharged by precipitation at an average volume of 145 MCM/yr. Groundwater levels in the Northeastern Basin are influenced by both precipitation and pumpage.(Tagar et al.2004)

This basin includes two aquifers. First, Eocene aquifer is consisting of limestone and chalk. Second, Turronian-Cenomanian aquifer is consisting of limestone and dolomitic limestone. (Tagar et al.2004)

Groundwater quality has shown some deterioration over time(Tagar et al.2004)

Groundwater direction flows initially to the north, then eastwards to the Jordan Valley direction then Dead Sea (Tagar,et,al.2004)

3.14.3 Eastern Basin

Eastern basin extends over 3080Km2, where recharge area is 2200Km2(Eckstein and Eckstein,2003). The Eastern Mountain Basin is underlain by a thick sequence of layered limestone and dolomite. Groundwater is recharged by precipitation at an average volume of 172 MCM/yr, and flows generally in a southeastward direction toward the Jordan Rift Valley.

This Basin includes two aquifers: Firstly,
the Turronian aquifer, consisting of limestone and dolomite,
secondly, the Upper Cenomanian aquifer, consisting of limestone and dolomite.

The Upper and Lower Cenomanain aquifers are the most productive, and occur at depths greater than 250 m. (Water Data Banks Project,2007).

Study's area has two aquifers type. There is Cenomanian-Turonian in the upper and Albian in the lower parts. Turonian-Cenomanian age aquifer is the most productive aquifer in the basin, consisting of karstified limestone and dolomite limestone(Rabe,2007)

3.15 Geology

Aquifers founding, activity, depth, utilization, formation, distribution, and water type controlled by geology (Lithology, Stratigraphy, and Structure).

Lithology is a rocks study, with a particular emphasis on their description, classification, and physical makeup, including mineral composition, grazing size, and grain packing, of the sediments or rocks that make up the geological system.

Stratigraphy describes the geometrical and age relation between the various lenses, beds, and formations in geological systems of sedimentary origin.

Structural features such as cleavages, folds, and faults are the geometrical properties of the geological systems produced by deformation after deposition or crystallization.

Palestine has many rocks type. These rocks are of different ages and lithology.

3.15.1 Lithology

Most West Bank rocks are Chalk, Dolomite, Marl, and limestone (Abed Rabo,et,al.1995). Jurassic rocks have limited exposures in the West Bank (Rofe&Roffety,1965).

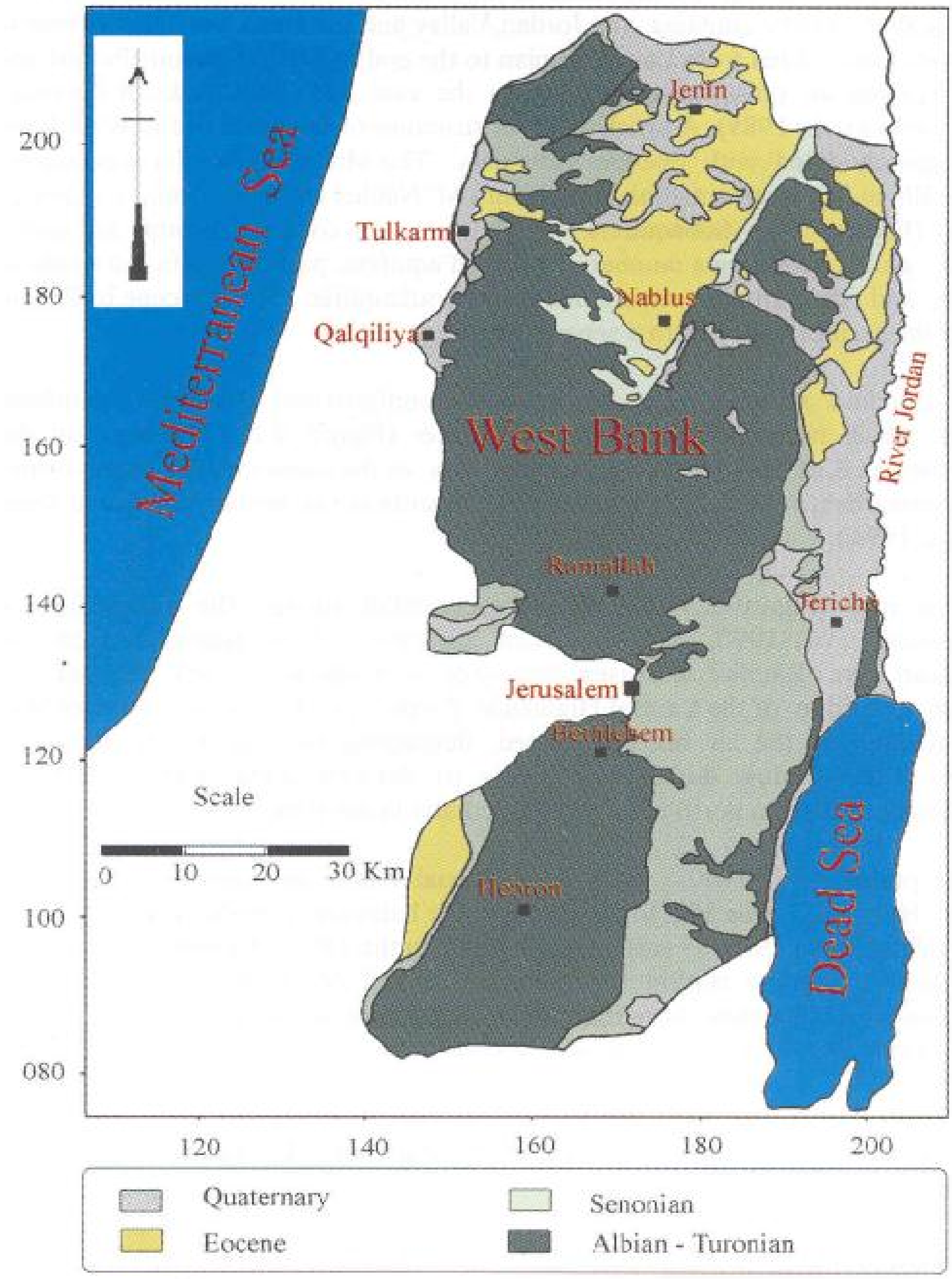


Fig.3.14: Geological Sketch Map of the West Bank.
(Abed Rabbo, et al,1999).

3. 16 Stratigraphy:

West Bank includes different stratigraphical formations. Aquifers founding depends on the rocks properties. Most of rocks exposed in the

Judean Hills are Cretaceous carbonate (Scarpa, 1990). Study area stratigraphy ranges between Lower Beit Kahil and Alluvium Formation.

The characteristics of these geological formations in the area are as followes Fig(3.15):

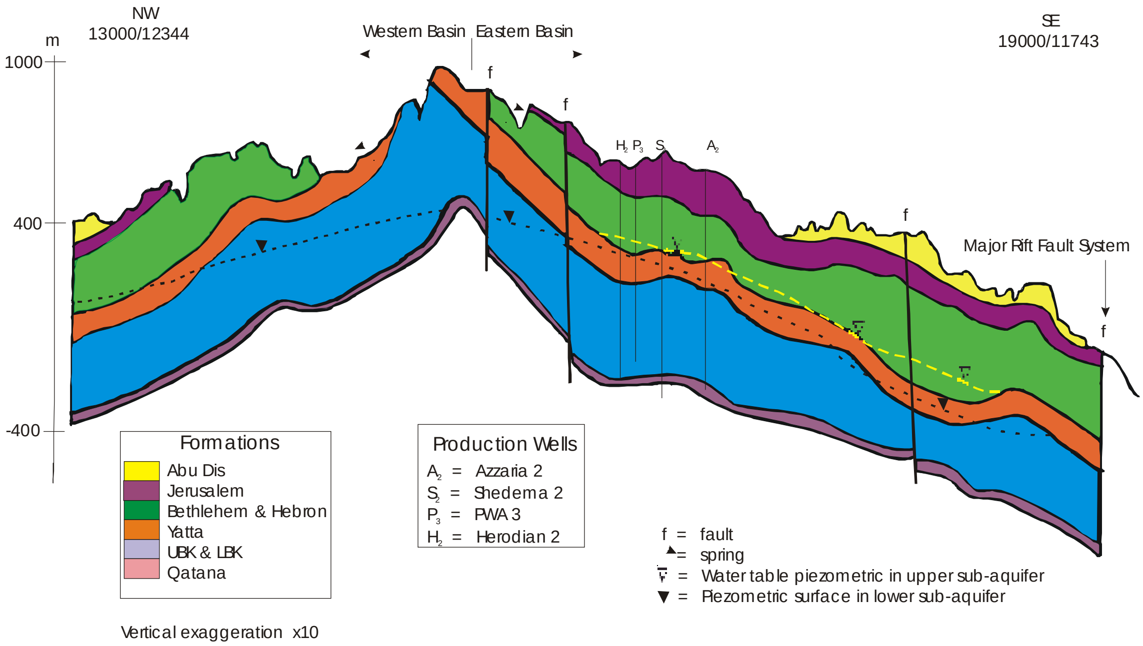


Fig3.15: Sketch geological section through the Mountain Aquifer(Scarpa,2002)

3.16.1 Lower Beit Kahil:

This formation is not a form the surface layer of the study area. It is located below upper Beit Kahil. It is formed in the upper part composed of gray to brown dolomite, and the lower part, composed of limestone and dolomite with marly limestone. The thickness of this formation is between, 120m and 180m. This age is Albian. (Guttman and Gotlibe,1996).

Lower Beit Kahel formation consists of well jointed limestone which has made it to be a good aquifer.

3.16.2 Upper Beit Kahil Formation

This is formed of two sub formations. First, Kesalon where it forms the upper part of the tow formation, made-up of dolomite and limestone. Its high porously properties form a good aquifer. (Guttman and Gotlibe,1996).

Second form is Soreq. The low part is made-up of dolomite and maral. This formation is not aquifer. Its thickness ranges between 110 and 170m(Rofe &Raffety,1963).

3.16.3 Yatta Formation

This is formed of two sub formations. Moza is the upper formation, composed of marly dolomite, limestone, and marl. The lower formation is called Bet Meir, composed of chalky limestone and marl. Yatta formation is aquiclude, so it is not a suitable aquifer, but it makes border between the lower and the upper aquifer of Jerusalem group.It's thickneses is for 50m to 125m . It's age is Cenomanian.(Guttman and Gotlibe,1996).

3.16.4 Hebron Formation

This formation composed of hard dolomite and dolomitic limestone(Rofe &Raffety,1963). High porosity of this formation doe it aquifer. Formation thickness 110-140m. It's age is Cenomanian.

3.16.5 Bethlehem Formation

This formation is composed of limestone and dolomite on top.And the lower part is composed from maral and chalk with limestone(Rabe,2007). The upper part is a good aquifer, because it is highly jointed and featured hard dolomite. Lower part is aquiclude because it is composed of chalk, limestone, and dolomite. It' thickness from 50m to 210m, and Cenomanian age. (Rofe &Raffety,1963).

3.16.6 Jerusalem Formation

This formation belongs to the Turonian age. It is composes of limestone, dolomite, and marl. Joints and fractures in this formation form a good aquifer, with thickness 40-190m.(Rofe &Raffety,1963).

3.16.7 Abu Dis Formation

This formation belongs to Senonian age. It is composed of chalk and chert. Abu Dis formation is considered aquiclude with thickness 40-170m(Rofe &Raffety,1963).

3.16.8 Alluvial Formation

This formation is part of the Holocene age. It is composed of unconsolidated clay, silt, laminated marl with thickness between0-25m. It is considered a good shallow aquifer (Rofe &Raffety,1963).

Chapter Four

Results and Discussion

(Hydrochemistry)

Chapter Four

Hydrochemistry

4.1 General

The 20 springs water checked for both chemical, physical, and biological analysis. Samples were collected twice, in May and October to compare the results. The research covers western part of Bethlehem district (Nahaleen, Husan, Bettir, and Wadi Fukeen).

Table 4.1: Descriptive statistics of chemical parameters of the springs studied in western Bethlehem district.

	May(end of Winter)				October(end of Summer)			
Variable	Minimum	Maximum	Average	Standard Deviation	Minimum	Maximum	Average	Standard Deviation
TDS	198.4	748.8	449.3	155.6	294.4	1043.2	540.16	199.3
pH-value	7.22	8.4	8.4	0.276	6.92	8	7.38	0.27
Ca ppm	5.2	30	15.49	7.346	8.4	32	19.97	6.33
Mg ppm	2.2	38	13.04	8.826	4.6	33	11.89	6.78
Na ppm	30.44	92.94	51.69	18.736	24.19	86.69	45.75	20.02
K ppm	0.061	20.64	3.61	5.31	0.0619	15.82	2.28	3.57
HCO_3 ppm	30.5	90.28	61.4	12.69	73.2	156.16	107.78	19.8
Cl ppm	40.04	153.17	81.96	33.52	30.03	150.17	69.28	37.47
SO_4 ppm	0.92	4.194	2.46	0.97	0.11	0.63	0.288	0.13
NO_3 ppm	0.299	5.99	3.36	1.61	0.27	5.88	3.45	1.4
NH_4 ppm	1.10	1.59	1.326	0.13	0.87	1.57	1.24	0.19

On the Piper diagram the majority of the water samples plot in the area of earth alkaline water with increased portions of alkalis, prevailing bicarbonate and with bicarbonate and sulfate or chloride. May and

October samples (Fig4.1). Chloride and sulfate sources, may be from agricultural activity, animals dungs, and wastewater leaking, water- rocks interaction and mixing with waste water, and agriculture effluents are the most important factors affecting the groundwater(Abdul-Jaber Q,Abed Rabbo A, Scarpa D, Qannam Z, Younger P,(1999).

It is difficult to separate and classify springs water samples dependent on Piper diagram only, because the diagram analyzes water samples as concentration percentage. It is necessary to use other analysis methods.

4.2.1 Husan Springs

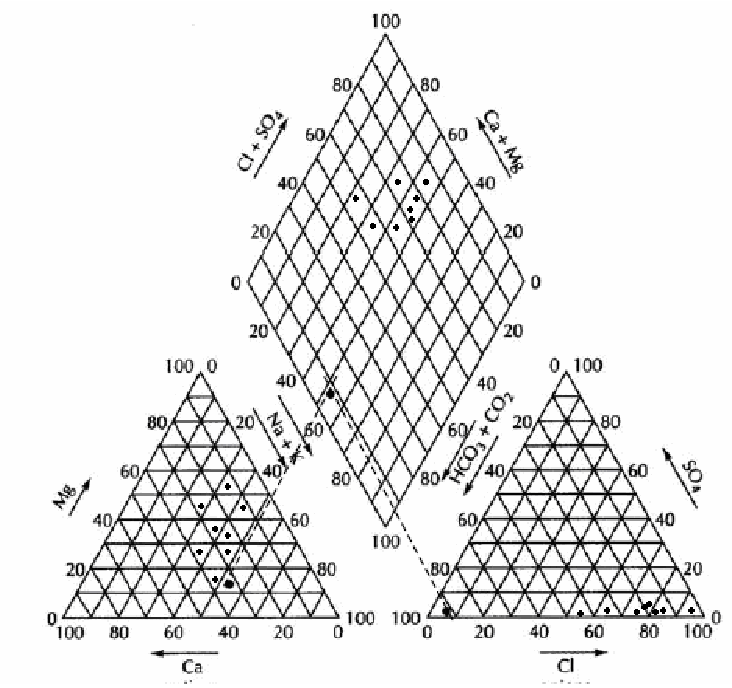
This group is represented in this study by 16 samples collected from 8 springs. The May samples chemical and physical parameters are EC which ranges from 326.4ppm and 896 ppm, Ca^{2+} from 11.4 ppm to 23.8ppm, Cl^- from 40.04 ppm to 153.17 ppm, NO_3^- from 0.299 ppm to 5.989 ppm. The October samples chemical and physical parameters are which EC ranges from 339.2 ppm to 1043.2 ppm,Ca^{2+} from 8.4 ppm to 32 ppm, NO_3^- from 0.835 ppm to 5.879 ppm, Cl^- from 30.033 ppm to 150.165ppm(Table 4.2)

On a piper diagram, the May samples of this group plot mainly in the area of " earth alkaline water with increased portion of alkaline and prevailing chloride" rain water pass through limestone in the springs area increased portion of alkaline, but sewage water and agriculture fertilizer they was source chloride. (Fig.4.1).

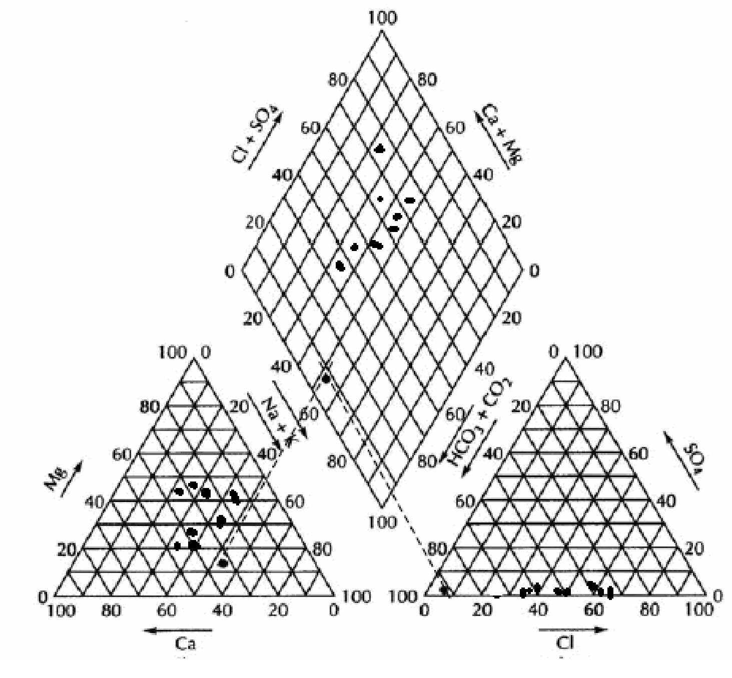
October samples of this group plot mainly in the area of " earth alkaline water with increased portion of alkaline and prevailing chloride ", as Al-Skonah, Abo- Same, Al-Namous, Al-Hawea, and Al-Balad, all of these springs are proximate from the houses, so sewage water and fertilizer used in irrigation agriculture activity are source of chloride. In the area of " earth alkaline water with increased portion of alkaline and prevailing bicarbonate", Al- Kanesah, Al-Arade, and Al-Baseen are samples of this group, these springs are influenced by rocks nature (Limestone) and these catchments agriculture dependent on trees with few fertilizer amounts, so chloride disappear . (Figure 4.2)

Table 4.2: Descriptive statistics of chemical parameters of the Husan springs.(Appendices 4.1,4.2, and4.3)

	May				October			
Variable	Minimum	Maximum	Average	Standard Deviation	Minimum	Maximum	Average	Standard Deviation
TDS ppm	326.4	896	541.44	222.48	339.2	1043.2	617.6	282.05
pH^- value	7.36	8.4	7.73	0.36	6.92	7.56	7.35	0.24
Ca^{+2} ppm	11.4	23.8	16.58	4.45	8.14	32	19.53	8.89
Mg ppm	4.8	38	14.6	11.23	5	33	14.64	8.93
Na^+ ppm	30.44	92.94	54.66	23.25	30.44	86.69	48.41	19.89
K^- ppm	0.0614	20.6	3.48	7.04	0.06	15.82	2.63	5.37
HCO_3^- ppm	47.58	90.28	63.44	14.87	73.2	156.16	109.34	27.49
Cl^- ppm	40.04	153.17	85.47	40.05	30.03	150.17	77.46	47.14
SO_4^{-2} ppm	0.92	3.94	2.28	0.94	0.11	0.587	0.28	0.15
NO_3 ppm	0.299	5.99	3.98	1.69	0.84	5.88	3.85	1.51
NH4ppm	1.1	1.50	1.29	0.15	0.87	1.41	1.23	0.19



.Fig.4.1: Piper diagram for the samples collected in May from the study area



. Fig.4.2: Piper diagram for the samples collected in October from study area.

4.2.2 Wadi Fukeen Springs

This group is represented in this study by 16 samples collected from 8 springs. The May samples chemical parameters are TDS which range from 198.4ppmto 588.8 ppm, Ca^{2+} from 5.2 ppm to 30ppm, Cl^- from 46.05 ppm to 121.13 ppm, NO_3^- from 21.7 ppm to 79 ppm. The October samples chemical and physical parameters are TDS which ranges from 294.4 ppm to 627.2ppm, Ca^{2+} from 16 ppm to 26.3 ppm, $NO3^-$ from 21.1 ppm to 92 ppm, Cl^- from 30.033 ppm to 110.121ppm(Table 4.3).

On a piper diagram, the May samples of this group plot mainly in the area of " earth alkaline water with prevailing chloride", as Al-Quds, Al-Magarah, Subeh, and Al-Balad, these springs located between the houses, so sewage water infiltrate is source of chloride , and in the area of " earth alkaline water with increasing portion of alkaline and prevailing chloride", as Sdeq, Mtheq, and Al-Fawar, these springs far from the houses, but it under intensive irrigation agriculture, chemical fertilizers uses added to animals dung and animals farm chloride source, this chloride collected in earth and infiltrate with rain water (Fig4.3). October samples of this group plot mainly in the area of " earth alkaline water with increased portion of alkaline and prevailing chloride, ", as Al-Magarah, house swage water chloride source. Other springs in the area of " earth alkaline water with increased portion of alkaline and prevailing bicarbonate", because this springs far from the houses, natural rocks (limestone) source of bicarbonate. (Figure 4.4)

Table 4.3: Descriptive statistics of chemical parameters of the Wadi Fuken Springs.(Appendices 4.4,4.5,and4.6)

	May				October			
Variable	Minimum	Maximum	Average	Standard Deviation	Minimum	Maximum	Average	Standard Deviation
TDSppm	198.4	588.8	440	117.89	294.4	627.2	464	99.97
pH-value	7.22	7.92	7.6	0.27	7.04	7.68	7.28	0.27
Ca^{+2} ppm	5.2	30	13.96	9.39	16	26.3	21.8	4.15
Mg^{+2} ppm	2.2	18.6	10.38	6.29	4.6	14.1	8.18	3.64
Na^{+} ppm	30.44	61.89	45.28	11.05	24.19	55.44	35.12	11.45
K^{+} ppm	0.38	15.17	5.206	4.35	0.38	6.814	2.71	1.97
HCO_3^{-} ppm	30.5	73.2	62.37	13.58	78.08	129.32	108.28	17.08
Cl^{-} ppm	46.05	121.13	72.26	23.86	30.03	110.12	55.67	25.60
SO_4^{2-} ppm	1.18	4.19	2.37	1.17	0.15	0.32	0.24	0.050
NO_3^{-} ppm	0.50	5.57	2.63	1.58	0.27	5.08	2.82	1.45
NH_4^{-} ppm	1.23	1.59	1.39	0.13	0.97	1.32	1.17	0.13

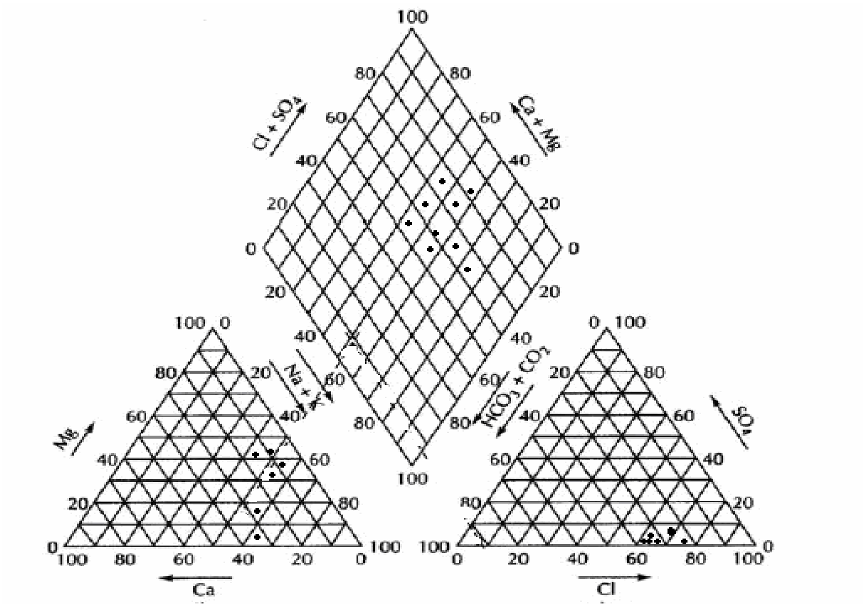


Fig.4.3: Piper diagram for the samples collected in May from Wadi Fukeen.

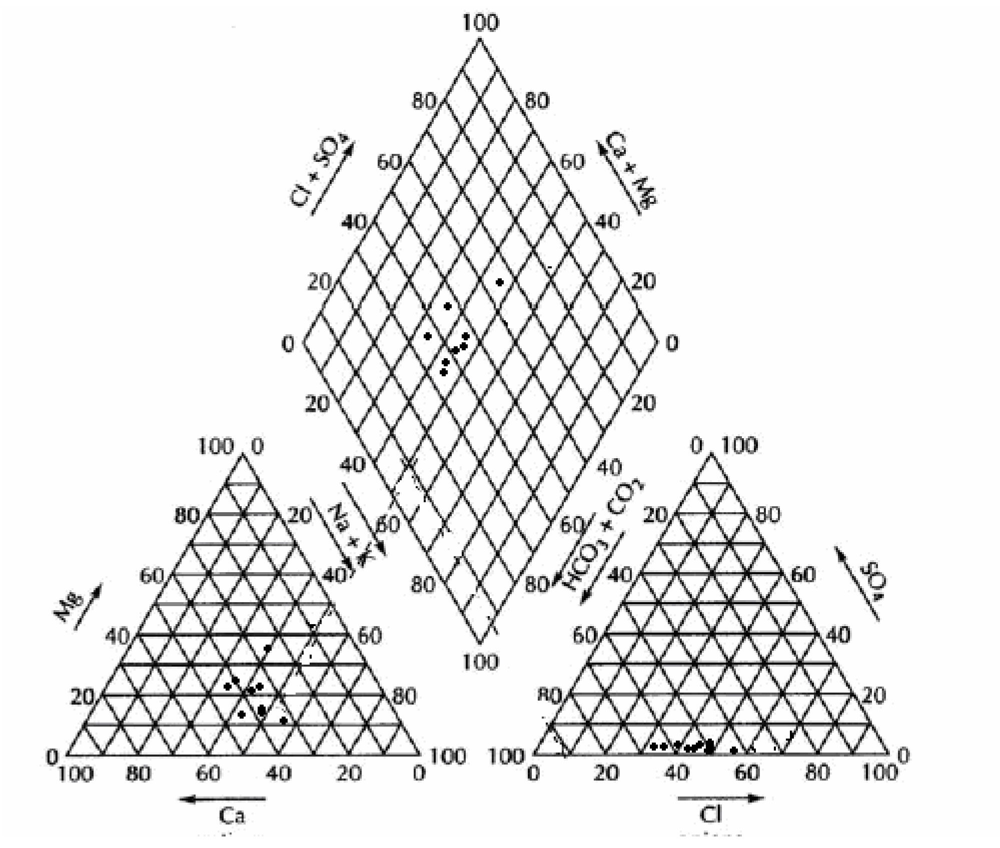


Fig.4.4: Piper diagram for the samples collected in October from Wadi Fukeen.

4.2.3 Battir Springs

This group is represented in this study by 4samples collected from 2springs. The May samples chemical and physical parameters are TDS ranges from 377.6ppmto 454.4 ppm, Ca^{2+} from 8.4 ppm to 10.6ppm, Cl^{-} from 52.06 ppm to 70.08 ppm, NO_3^{-} from 33.9 ppm to 52 ppm. The October samples chemical and physical parameters are TDSranges from 416 ppmto 467.2ppm, Ca^{2+} from 14 ppm to 21 ppm, NO_3- from 50 ppm to 56.6 ppm, Cl- from 48.0528 ppm to 50.055ppm(Table 4.4).

On a piper diagram, the May samples of this group plot mainly in the area of " earth alkaline water with prevailing chloride", as Jame' spring , and in the area of " earth alkaline water with increasing portion of alkaline and prevailing chloride", as Al-Balad spring. Two springs proximate from houses, so sewage water chloride source (Fig.4.5). October samples of this group plot mainly in the area of " earth alkaline water with increased portion of alkaline and prevailing bicarbonate", as Jame' and Al-Balad springs, chloride disappear from this samples no rain water infiltrate (Fig4.6).

Table 4.4: Descriptive statistics of chemical parameters of the Battir springs.(Appendices 4.7,4.8, and4.9)

	May				October			
Variable	Minimum	Maximum	Average	Standard Deviation	Minimum	Maximum	Average	Standard Deviation
TDSppm	377.6	430	403.8	54.31	416	467.2	441.6	36.20
pH-value	7.61	7.66	7.64	0.04	7.5	7.63	7.57	0.09
Ca^{+2} ppm	8.4	10.6	9.5	1.56	14	21	17.5	4.95
Mg^{+2} ppm	16.4	18.6	17.5	5 1.5	10.6	16	13.3	3.82
Na^{+} ppm	36.89	42.94	39.81	4.42	36.69	42.94	39.81	4.42
K^{+} ppm	0.38	0.38	0.38	0	0.38	0.38	0.38	0.38
HCO_3^- ppm	51.24	57.34	54.29	4.31	97.6	104.92	101.76	5.18
Cl^- ppm	52.06	70.08	61.07	12.74	48.053	50.01	49.05	1.42
SO_4^{-2} ppm	2.66	3.24	2.95	0.41	0.14	0.63	0.38	0.35
NO_3^- ppm	3.39	5.21	4.30	1.28	3.00	4.69	3.85	1.19
NH_4^+ ppm	1.25	1.27	1.26	0.019	1.42	1.52	1.45	0.07

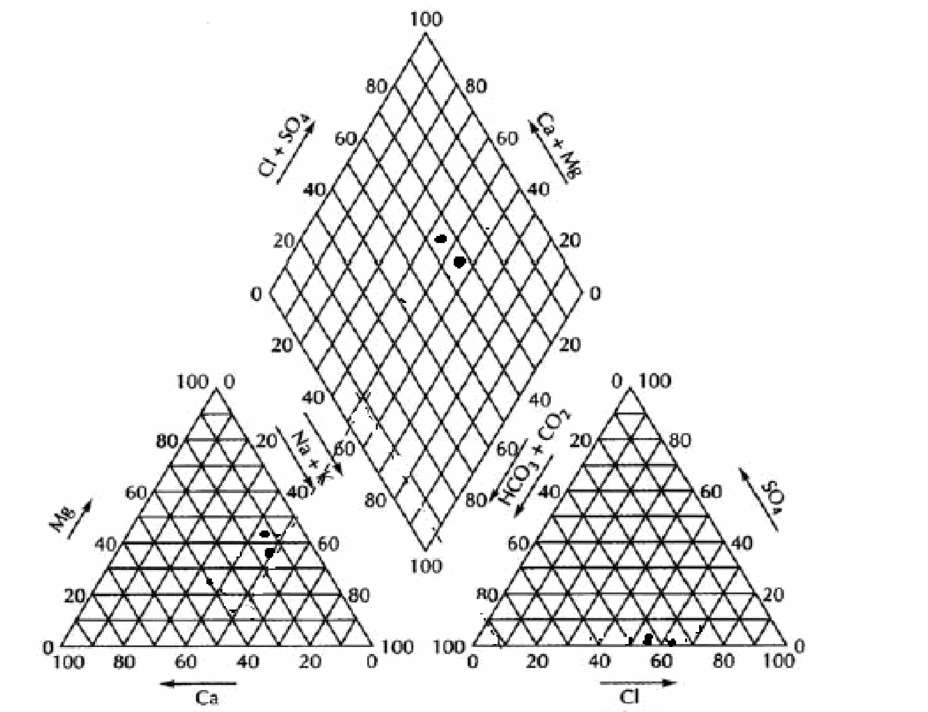


Fig.4.5: Piper diagram for the samples collected in May from Battir springs.

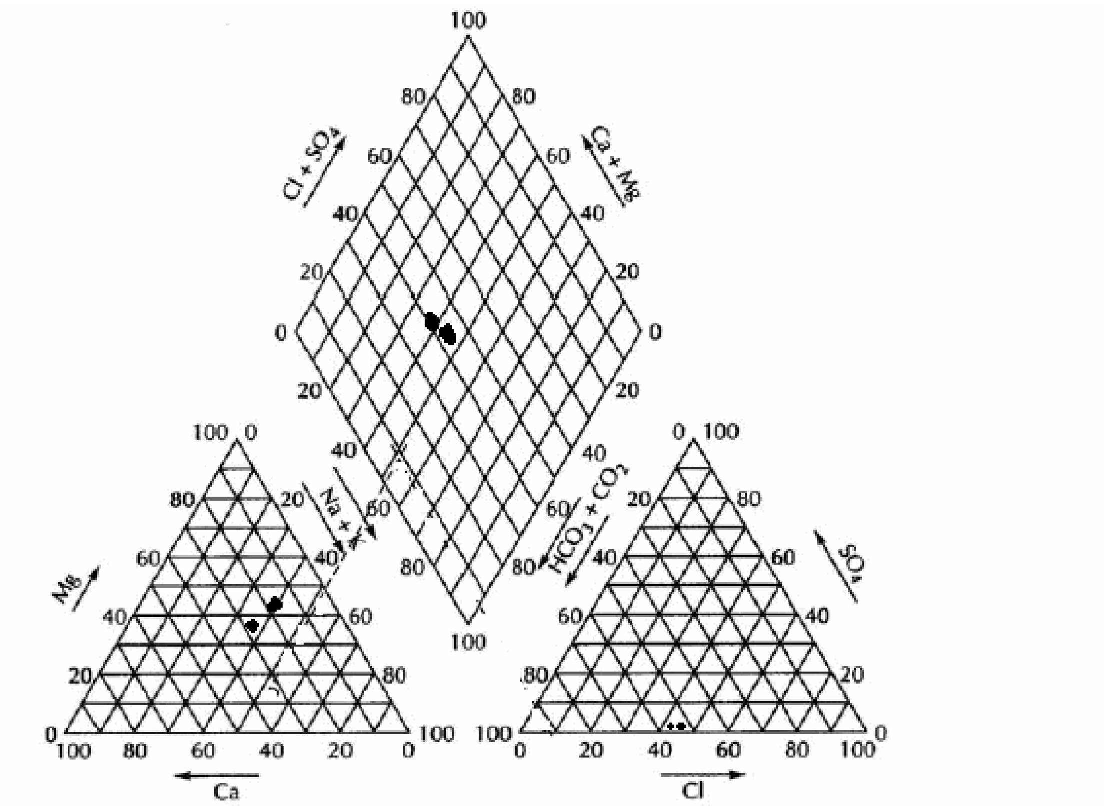


Fig.4.6: Piper diagram for the samples collected in October from Battir springs.

4.2.4 Nahaleen Springs

This group is represented in this study by 4samples collected from 2springs.

The May samples chemical and physical parameters are EC which rangefrom 608ppmto 640 ppm, Ca^{2+} from 18.4 ppm to 16ppm, Cl- from 121.13 ppm to 134.15 ppm, $NO3^-$ from 23.4 ppm to 33.6 ppm.

The October samples chemical and physical parameters are TDS ranges from 704 ppmto 710.4ppm, Ca^{2+} from 14 ppm to 17.5 ppm, $NO3^-$ from 39 ppm to 39.5 ppm, Cl^- from 101.111 ppm to 121.133ppm(Table 4.5)

On a piper diagram, the May samples of this group plot mainly in the area of, " earth alkaline water with prevailing chloride", as Faris and Al-Bala (Fig.4.7). October samples of this group plot mainly in the area of " earth alkaline water with prevailing chloride ", as Faris and Al-Balad springs. These two springs have special condition, because they are influenced by treatment sewage water all the time, so the chloride present in all samples at two seasons (Fig4.8).

Table 4.5: Descriptive statistics of chemical parameters of the Nahaleen springs.(Appendices 4.10,4.11, and4.12)

	May				October			
Variable	Minimum	Maximum	Average	Standard Deviation	Minimum	Maximum	Average	Standard Deviation
TDSppm	608	640	624	22.63	704	710.4	707.2	4.52
pH-value	7.3	7.89	7.59	0.42	7.2	8	7.6	0.57
Ca^{+2} ppm	18.4	28	23.2	6.79	16	17.5	16.75	1.06
Mg^{+2} ppm	3	23	13	14.14	11	27.7	19.35	11.81
Na^{+} pm	74.19	80.44	77.31	4.42	80.44	86.69	83.56	4.42
K^{+} ppm	0.70	1.35	1.03	0.45	0.70	1.35	1.02	0.45
HCO_3^- ppm	53.68	59.78	56.73	4.31	104.92	106.14	105.53	0.86
Cl^- ppm	121.13	134.15	127.64	9.21	101.11	121.13	111.12	14.16
SO_4^{2-} ppm	2.60	3.50	3.05	0.641	0.32	0.37	0.34	0.03
NO_3- ppm	2.34	3.36	2.85	0.72	3.90	3.95	3.93	0.04
NH_4^+ ppm	1.24	1.29	1.27	0.04	1.02	1.57	1.29	0.39

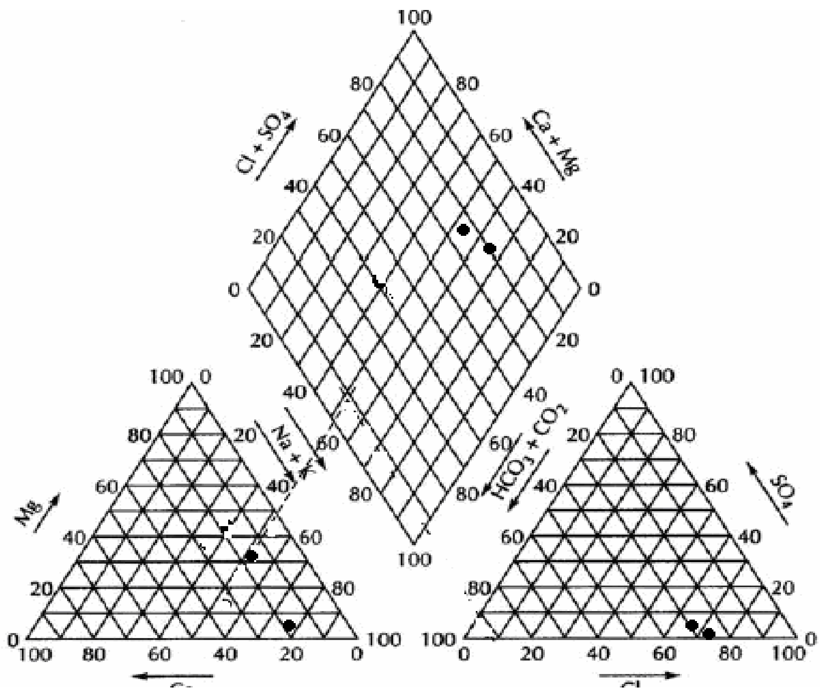


Fig.4.7: Piper diagram for the samples collected in May from Nahaleen springs.

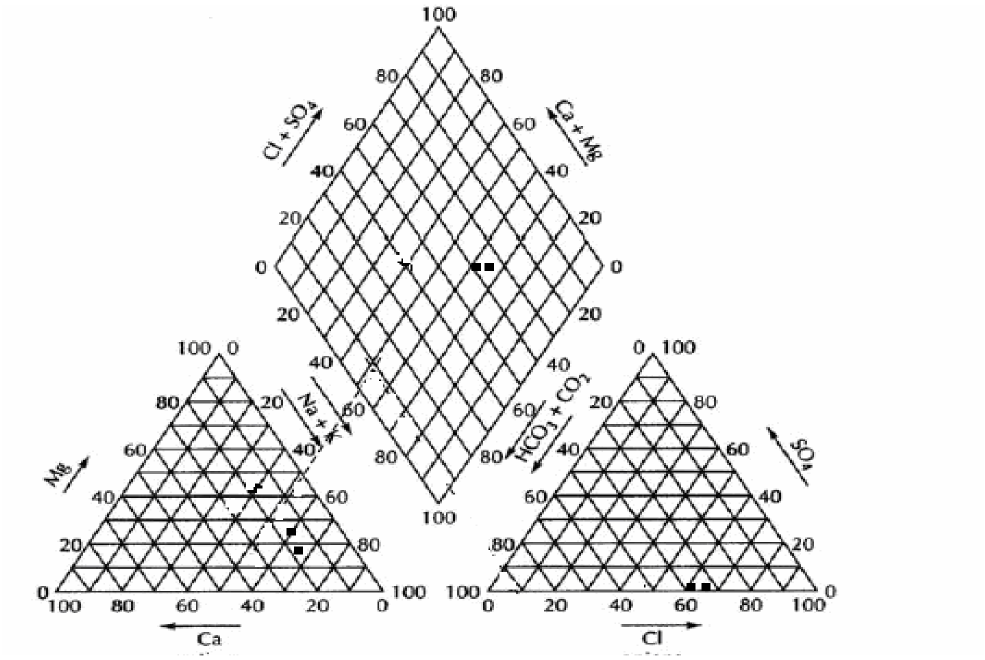


Fig.4.8: Piper diagram for the samples collected in October from Nahaleen springs.

4.3 Water Quality

4.3.1 General

Water quality is the physical, chemical, and biological characteristics of water. Quality parameter is determined by the water used for purposes such as agriculture, drinking, and industrial uses. Water quality is controlled by the water quantity available.

4.3.2 Water quality for domestic purposes

Household water used for drinking, cooking, bathing, cleaning, and recreation is referred to as domestic water.

To evaluate the domestic water quality, there are three processes. First physical characteristic, such as turbidity, total suspended solids, color, odor and taste. Second; microbiological characteristics and third chemical tests. microbiological diseases are more common than physical and chemical diseases. Detection is easy and the cost of treatment is low.

Thirdly; chemical characteristic which need high cost for detection, treatment, and high technology requires. Water consider potable, if its turbidity, color, odor, and taste is within acceptable and permissible limits. It should also be free from pathogens. It must be within permissible limits of chemicals hazardous. It must not be corrosive and free from dyeing substances.

4.3.3Microbiological Quality Evaluation

Biological test for domestic water are very important to determine its suitability because water is the fastest way for infectious, disease spread, caused by pathogenic bacteria, viruses, protoza or parasites. Water samples are evaluate microbiologically by fecal and total coliform bacteria because they are found in high numbers in the human beings and warm-blooded animals dung. WHO (1995) is recommendation confirmed that the long-term count of the total and fecal coliform must be zero.

4.3.4 Chemical Quality Evaluation

Water chemical ions concentration has influence in water suitability for domestic uses if it changes water odor, taste, and color or exceeds a certain threshold. Nitrate is the most important ion due to its negative effects on the human health, where it is become toxic. Chemical ions test can be indicate pollution sources, for example Cl, Na, SO4, and TDS high concentration indicate that human and animal pollution is found.

Hardness is the presence of multivalent cations. Hardness in water can cause water to form scales and resistance to soap. The main cation that causes hardness is calcium and magnesium, which are the most abundant in groundwater. These ions react with soap to form precipitation. As for negative ions, when the water is heated in boilers it produces solid boiler scales. (Todd, 1980).

Total hardness ($CaCO_3$)mg/L= 2.497Ca^{+2} + 4.115 Mg_{+2}. (Todd, 1980)

(Ca^{+2} and Mg^{+2} concentrations in mg/l)

Table 4.6: Palestinian standards and World Health Organization (WHO) guidelines for drinking water (Nassar, M.2005)

Parameters	Palestinian standards (2004)		WHO (2004)	Source or Cause
	Basic	Conditional		
T°C	8-25		12-25	Earth's temperature or chemical reaction
pH value	6.5-8.5	9.5	6.5-8.5	Dissolved CO2 and the organic acids
Na^{+}(mg/L)	200	400	200	All rocks and soils, found also in brines and sewage
Ca^{+2} (mg/L)	100	200	75	Dissolved from all rocks and soils, but especially from limestone, dolomite and gypsum
Mg^{+2} (mg/L)	100	120	125<	All rocks especially carbonate
K^{+} (mg/L)	10	12	12	Sedimentary rocks. Wastes from man and livestock
HCO_3^{-} (mg/L)	125-350	125-350	125-350	Carbonate rocks and soils. Present in sewage, and ancient brine
Cl^{-}(mg/L)	250	600	250	Dissolved from rocks and soil. Present in sewage, and ancient brine
SO_4^{-2} (mg/L)	200	400	250	Dissolved from rocks and soils containing gypsum sulphide ores and other sulphide ores and other sulphur compounds.
NO_3^{-} (mg/L)	50	70	50	Decaying of organic materials, legume plants,sewage and fertilizers
TDS	1000	1500	500-1000	
Hardness (mg/L)	500	500	500	
Total Coliform colony/100 ml	0	3	0	Wastes and residues of warm-blooded animals
Fecal Coliform colony/100 ml	0	3	0	Wastes and residues of warm-blooded animals

Table 4.7: Water classification based on hardness(Sawyer and McCarty,1967)

Hardness,mg/L (CaCO3)	Water Class
0-75	Soft
75-150	Moderately Hard
150-300	Hard
Over 300	Very Hard

4.3.5 Water Quality for Agricultural Purposes.

Irrigation water suitability is determined by many factors, as soil type, water quality, relative humidity, and types of crops. Plants are directly influenced by irrigation water quality. Salts in the irrigation water decrease water quantity taken up by plants, by changing the osmotic pressure in root zone. Some chemical elements as boron might influence the metabolic reactions. Salts in irrigation water may affect soil structure, permeability, and aeration which affect the growth of plants,too. Irrigation water quality is evaluated by , Sodium adsorption ratio and , soluble Sodium percentage. (Todd,1980)

4.3.5.1 Soluble Sodium Percentage(SSP)

Sodium concentration is an important index in the evaluation of irrigation water as it has influence on soil permeability. Using water with high sodium concentration and ratio increases the sodium concentration in the soil and allows the sodium to exchange other ions in the soil particles. SSP expresses the percentage of sodium out of the total cations. It is calculated by the following formula:

$$SSP= ((Na^{+} +K^{+})/(Ca^{2+}+Mg^{+2} +Na^{+} + K^{+}))*100$$

Where: Cations concentration is in meq/L

Table 4.8: Classification of irrigation water based on SSP (Todd, 1980)

Water Class	**SSP**	**EC (µS/cm)**
Excellent	20<	250<
Good	40-20	250-750
Permissible	40-60	750-2000
Doubtful	60-80	2000-3000
Unsuitable	80>	3000>

4.3.5.2 Sodium Adsorption Ratio (SAR)

This index quantifies the portion of sodium (Na^{+}) to calcium (Ca^{+2}) and disperses magnesium (Mg^{+2}) ions in sample. Calcium will flocculate soil particles. Sodium disperses soil particles. This dispersal increases infiltration and permeability problems. Sodium in irrigation water can also cause toxicity problems to some crops. Many factors influence how sodium in irrigation water affects the soil as soil texture, organic mater, crop type, climate, irrigation system, and management impact.(Bauder et.al. 2005)

Sodium Adsorption Ratio(SAR), is calculated according to the equation:

$$SAR = Na/[(Ca+Mg)/2]^{1/2}$$

Where cations are expressed in milliequivalent per liter.

Table 4.9: Irrigation water classification, based on SAR values (Wilcox,1995).

SAR Range	Water Class	Comments
10<	S1	Low sodiumn: can be used for irrigation on almost all soils with little danger.
10-18	S2	Medium sodium: can cause an appreciable sodium hazard, fine-textured soils having high cation exchange capacity under low loading condition. It can be used on coarse-textured soil with good permeability.
18-26	S3	High sodium: may produce harmful levels of exchangeable sodium in most soils.
26>	S4	Very high sodium: unsatisfactory for irrigation purposes, except for waters with low and medium salinity.

4.3.5.3 Total Dissolved Solids/ Electrical Conductivity

Osmotic pressure effects are caused by the total dissolved solids which are a function of electrical conductivity. The water uptake rate into plants is affected by any change in the osmotic pressure in root zone.

Table 4.10: Grouping of irrigation water, based on EC and TDS (Richard,1954)

TDS ppm	EC μS/cm	Water Class	Remarks
200<	250<	C1	Low salinity: can be used for irrigation with most crops on most soils.
200-500	250-750	C2	Medium salinity: can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs.
500-1500	750-2250	C3	High salinity: can't be used on soils with restricted drainage. Can be used to irrigate plants with high salts tolerance.
1500-3000	2250-5000	C4	Very high salinity: not suitable for irrigation under ordinary conditions. It can be used for irrigation occasionally under very special circumstances.

4.3.5.4 Chloride

Chloride is very important for plants at low amounts, but it is toxic for plants if it is used in large amounts.

Table 4.11: Chloride Classification of irrigation water (Bauder et.al. 2005)

Chloride(ppm)	Effect on crops
Below 70	Generally safe for plants
70-140	Sensitive plants show injury
141-350	Moderately tolerant plants show injury
Above 350	Can cause severe problems

4.3.5.5 pH and alkalinity

Acidity or basicity of irrigation water is expressed as pH higher than 7.0 basic, lower than 7 acidic. The normal pH for irrigation is from 6.5to8.4. (Bauder et.al. 2005)

4.3.6 Suitability of water for domestic and irrigation purposes

4.3.6.1 General

Water from springs is used for domestic purposes and agriculture in western Bethlehem district as first source until thirty years ago,but now as second source. Husan, for example depends on Al-Balad and El-Haweah springs for people potable water. Al-Balad and Faris springs flow in Nahaleen village. All springs in the study area are used for irrigation. Yet because population natural growth, agriculture development, and industry increase water problems.

4.3.6.2 Possible sources of contamination

Any water content increasing or new contents affect water contamination. Water contamination may be physical, chemical, and biological.

Physical contamination evolves from increasing gases changing water taste, odor, and color. Chemical contamination is due to increase of

NO_3^-, k^+, Na^+, and SO_4^{-2} concentration. Biological contamination can be coliform and total coliform.

All of these contamination sources are produced from human activates, sewage, animals dung, and agriculture fertilizers.

4.3.7. Quality Evaluation

The factors which will be considered in evaluating the suitability of spring water for drinking uses are the total coliform and feacal coliform bacteria, and ions concentration as Cl^- and $NO3^-$, where as SSp,EC, and, SAR are used for irrigation suitability.

4.3.7.1 The springs of Husan village

The microbiological and chemical characteristics of water quality of the springs of the Husan village for May sample are shown in Table 4.12. The results show that all springs except El-Hawea springs are contaminated with fecal and total coliform bacteria, and thus they are unsuitable for drinking. Chemically, all Husan springs have not show any deviation from the WHO(2004) guidelines and the Palestinian Standard (2004), so it is considered potable from the chemical point view.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that Al-Kanesa, Al-Baseen, and Abu-Sami springs have "Soft" water. Other springs have "Moderately hard" water, except for Al-Baseen springs which have "Hard" water.

Springs water for irrigation purposes, (classification based SSP) shows that El-Bassen, Al-Kanesa, and Al-Balad have good irrigation water. Others springs have Permissible irrigation water. All springs water shows that "Low sodium can be used for irrigation on almost all soils with little danger". By SAR classification. Springs water classification depending on TDS parameters shows that all springs that have " Medium salinity can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs' to water, except for Al-Balad, Al-Skona, and Al-Haweah springs which have " High salinity and can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance".

Depending on(Bauder et.al. 2005), classification for Chloride concentration, springs show that, El-Namous, Al-Baseen, and Al-Kanesa have water safe for all groups. Other springs showed that have water for "sensitive plant show injures" , except for Al-Balad spring showed that have water " Moderately tolerant plants showed injury". According to pH parameter for all springs water are suitable for irrigation.

Table 4.12: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes(in may,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
AL-Skona	1.105	36.4	98.9	652.8	1.35	103	34.9	1000>	400
AL-Namos	1.672	44.7	107.9	409.6	0.38	56	36.2	400	200
AL-Balad	1.697	38.7	196.3	896	3.91	153	96.5	1000>	800
AL-Hawea	1.769	48.9	135.3	748.8	20.6	128	43.6	0	0
AL-Kanesa	0.917	35.1	72	326.4	0.06	40	42.8	300	200
AL-Baseen	0.963	37.7	65.2	332.8	0.38	48	29	1000>	1000>
Abu-Sami	1.422	48.1	59.7	441.6	0.38	72	59.9	1000>	1000>
Al-Arade	1.443	45.6	76.1	384	0.7	83	41.2	1000>	1000>

The microbiological and chemical characteristics of water quality of the springs of the Husan village for October samples are shown in Table 4.13. The results show that all springs are contaminated with fecal and total coliform bacteria, and thus they are unsuitable for drinking. Chemically, all springs have not shown any deviation according to WHO (2004) guidelines and the Palestinian Standard (2004), so it is considered potable and free from chemicals.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that. Al-Arade and Al-Skona, springs have "Soft" water. Al-Namos, Al-Hawea, Al-Kanesa, Al-Bassen, and Abu-Sami are have "Moderately hard" water. Al-Balad spring has "Hard" water.

Springs water for irrigation purposes:Classification based on SSP shows that Al-Bassen, Al-Kanesa,Al- Namous, Abu-Sami and Al-Balad have good irrigation water; other springs have Permissible irrigation water. All springs water shows that "Low sodiumn can be used for irrigation on almost all soils with little danger". By SAR classification, springs water classification depending on TDS parameters shows that all springs have " Medium salinity which can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs" to water, except Al-Balad, Al-Skona and Al-Hawea springs have " High salinity which can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance" water. .

Depending on(Bauder et.al. 2005), classification for Chloride concentration, all springs show that water is" generally safe for all groups. Except Al-Balad and Al-Hawea springs show that water "sensitive plant show injury", except Al-Balad spring showed that have water on" Moderately tolerant plants showed injury". According to pH parameter all springs water is suitable for irrigation.

Table 4.13: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes (in October, 2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
AL-Skona	1.372	50.8	46.8	787.2	1.02	110	29.7	1000>	1000
AL-Namos	1.48	38.9	137.5	441.6	0.38	48.0	34.6	1000>	1000>
AL-Balad	0.971	25.7	213.2	1043.2	2.31	150	108.8	1000>	1000>
AL-Hawea	1.85	47.7	143.9	928	15.8	135	50.8	26	0
AL-Kanesa	1.09	38.7	74.63	339.2	0.06	30	42.8	1000>	1000>
AL-Baseen	0.771	28.1	101.79	390.4	0.7	35	34	1000>	1000>
Abu-Sami	0.992	34.7	89.4	403.2	0.38	56	41.6	1000>	1000>
Al-Arade	1.168	42.3	64.6	460.8	0.38	55	41.2	1000>	1000>

4.3.7.2 Wadi Fukeen springs

The microbiological and chemical characteristics of water quality of the springs of the Wadi Fukeen village for May sample are shown in Table 4.14. The results show that all springs are contaminated with fecal and total coliform bacteria, except for Sedeq spring which is contaminated with total coliform bactera only. Thus they are unsuitable for drinking. Chemically, all Wadi Fukeen springs have not shown any deviation from the WHO (2004) guidelines and the Palestinian Standard (2004). So they are considered potable and free from chemicals, except Al-Balad spring which shows potassium deviation.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that. Al-Quds and Al-Balad springs have "Soft" water. Other springs have "Moderately hard" water.

Springs water for irrigation purposes, classification based SSP shows that Al-Quds, Mtheq,Sdeq, Al- Fawar, Subeh, and Al-Magarh have "permissible " irrigation water; other springs have "doubtful "irrigation water. All springs water shows that "Low sodiumn: can be used for irrigation on almost all soils with little danger". By SAR classification. Springs water classification depending on TDS parameters shows that all springs which have " Medium salinity: can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs". Water, except Al-Quds springs has " Low salinity it can be used for irrigation with most crops on most soils. " water, and Al-Balad Shown " High salinity and can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance".

Depending on(Bauder et.al. 2005), classification for Chloride concentration, springs show that, Al-Quds, Mtheq,Al-Fawar, Subeh, and Al-Magarah have safe water for all groups. Other springs show that water on "sensitive plants show injury". According to pH parameter all springs water are suitable for irrigation.

Table 4.14: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Wadi Fukeen(in May,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Al-Quds	1.830	56.0	52.3	198.4	0.38	46.0	50	1000>	200
AL-Balad	3.71	76.8	42.3	537.6	15.1	73.8	79	1000>	1000
Mtheq	1.87	49.6	100	467.2	3.91	69.8	40.4	1000>	1000>
Sedeq	1.72	49.4	85.6	396.8	2.95	121	21.7	400	0
Al-Fawar	1.71	49.3	78.9	396.8	4.56	50.0	30.1	1000>	600
Subeh	2.12	56	78	441.6	4.56	60	13.8	1000>	600
AL-Tenah	3.07	65	7.6	588.8	6.17	88.1	22.2	1000>	400
AL-Magara	2.44	56.2	97.95	492.8	3.91	69.0	55.7	1000>	1000 >

The microbiological and chemical characteristics of water quality of the springs of the Wadi Fukeen village for October sample are shown in Table 4.15. The results show that all springs are contaminated with fecal and total coliform bacteria, except for Sedeq springs which are contaminated with total coliform bacteria only. Thus they are unsuitable for drinking. Chemically, all Wadi Fukeen springs do not show any deviation according WHO(2004), guidelines and the Palestinian Standard (2004), so it considered potable, chemically.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that. Al-Quds spring has "Soft" water. Other springs have "Moderately hard" water.

Springs water for irrigation purposes. Classification based on SSP shows that Sedeq and Al- Fawar have "good " irrigation water, other springs have "permissible "irrigation water. All springs water shows that "Low sodium can be used for irrigation on almost all soils with little danger". By SAR classification. Springs water classification depending on TDS parameters shows that all springs have " Medium salinity that can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs" in water, except Al-Quds springs have " Low salinity that can be used for irrigation with most crops on most soils. ", and Al-Balad and Al-tenah " High salinity and can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance".

Depending (Bauder et.al. 2005), classification for Chloride concentration,all springs show that, water is safe for all groups. Only Al-Tenah and Al-Magarh springs show that water "sensitive plants show injured". According to pH parameter all springs are suitable for irrigation.

Table 4.15: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Wadi Fukeen (in October, 2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Al-Quds	1.25	43.4	70.8	294.4	1.34	30.3	27	1000>	1000>
AL-Balad	2.14	55.2	76.1	537.6	0.38	59	92	1000>	1000>
Mtheq	1.62	46.4	96.6	467.2	2.95	52	36	1000>	1000>
Sedeq	1.15	39.3	83.7	396.8	1.34	40	22.1	900	0
Al-Fawar	1.02	34.4	107.2	396.2	2.95	40	28.9	1000>	1000>
Subeh	1.45	45.2	83.85	441.6	2.31	42	21.2	1000>	1000>
AL-Tenah	2.56	59.2	89.12	588.8	6.81	72	23.5	1000>	1000>
AL-Magara	1.89	50.0	97.84	492.8	3.59	110	50.4	1000>	1000>

4.3.7.3 Battir springs

The microbiological and chemical characteristics of water quality of the springs of the Battir village for May sample are shown in Table 4.16. The results show that Al-Balad springs contaminated with fecal and total coliform bacteria, Jame springs contaminated with total coliform bactera only. Thus they are unsuitable for drinking. Chemically, all springs not showed any deviation from the WHO(2004) guidelines and the Palestinian Standard (2004), so it conceder potable from chemically.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that all springs have "Moderately hard" water.

Springs water for irrigation purposes, classification based SSP shows that all have "permissible "irrigation water. All springs water shows that "Low sodium: can be used for irrigation on almost all soils with little danger". By SAR classification. Springs water classification depending on TDS parameters shows that all springs have " Medium salinity: can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs" water.

Depending on(Bauder et.al. 2005), classification for Chloride concentration, all springs show that, water safe is for all groups.. According to pH parameter all springs water is suitable for irrigation.

Table 4.16: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Battir (in May,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Jame	1.62	45.1	97.51	377.6	0.38	52.0	33.9	1000	0
Al-Balad	1.93	49.9	93.95	430	0.382	70.0	52	600	200

The microbiological and chemical characteristics of water quality of the springs of the Battir village for October sample are shown in Table 4.17. The results show that Al-Balad springs are contaminated with fecal and total coliform bacteria, Jame springs are contaminated with total coliform bacteria only. Thus they are unsuitable for drinking. Chemically, all springs do not show any deviation according WHO(2004) guidelines and the Palestinian Standard (2004), so it is considerd free from chemicals.

Depending on Sawyer and McCarty (1967) classification of water based on total hardness shows that all springs have "Moderately hard" water.

Springs water for irrigation purposes: Classification based SSP shows that Al-Balad spring have "permissible "irrigation water, Jame' spring have "good" irrigation water. All springs water shows that "Low sodium: can be used for irrigation on almost all soils with little danger". By SAR classification: Springs water classification depending on TDS parameters shows that all springs that have " Medium salinity can be used to irrigate plants with moderate salt tolerance if moderate amount of leaching occurs" in water.

Depending on(Bauder et.al. 2005) classification for Chloride concentration, all springs show that, water is safe for all groups.. According to pH parameter all springs water is suitable for irrigation.

Table 4.17: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Battir (in October,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Jame	1.41	38.3	128.98	416	0.38	48.0	56.9	1000>	0
Al-Balad	1.51	41.8	111.49	467.2	0.38	50	50	1000>	1000

4.3.7.4 Nahaleen springs

The microbiological and chemical characteristics of water quality of the springs of the Nahaleen village for May sample are shown in Table 4.18. The results show that all springs are contaminated with fecal and total coliform bacteria. Thus they are unsuitable for drinking. Chemically, all springs do not show any deviation according to WHO(2004) guidelines and the Palestinian Standard (2004), so they are considered potable, chemically.,

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that all springs have "Moderately hard" water.

Springs water for irrigation purposes: Classification based SSP shows that Al-Balad spring has "permissible "irrigation water, and Faris spring has "doubtful" irrigation water . All spring's water shows that "Low sodium: can be used for irrigation on almost all soils with little danger". By SAR classification, springs water classification depending on TDSparameters shows that all springs that have " High salinity and can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance".

Depending on(Bauder et.al. 2005), classification for Chloride concentration,Al-Balad springs shows that, have water" sensitive plants show injury", and Faris spring shows that have water "moderately plants show injury". According to pH parameter all springs water suitable for irrigation

Table 4.18: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Nahleen (in May,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Al-Balad	2.72	53.7	140.58	640	1.34	121	33.6	1000>	200
Faris	3.86	68.1	82.26	608	0.70	194	23.4	1000>	100

The microbiological and chemical characteristics of water quality of the springs of the Nahaleen village for October sample are shown in Table 4.19. The results show that all springs are contaminated with fecal and total coliform bacteria. Thus they are unsuitable for drinking. Chemically, all springs have not shown any deviation according to WHO(2004) guidelines and the Palestinian Standard (2004), so they considered potable, chemically.

Depending on Sawyer and McCarty (1967) classification of water, based on total hardness, shows that Al-Balad springs have "Moderately hard" water, and Faris have "Soft water".

Springs water for irrigation purposes: Classification based SSP shows that all springs have "doubtful "irrigation water.. All springs water shows that "Low sodium: can be used for irrigation on almost all soils with little danger". By SAR classification, springs water classification depending on TDS parameters shows that all springs that have " High salinity and can't be used on soils with restricted drainage. They can be used to irrigate plants with high salts tolerance".

Table 4.19: Chemical and biological characteristic used in determination water quality for domestic and agricultural purposes of Nahleen (in October,2008 samples)

Spring	SAR	SSP %	TH (mg/LCaCO3)	TDS ppm	K^+ mg/L	Cl^- mg/L	NO_3^- mg/L	TC cfu/100ml	FC cfu/100ml
Al-Balad	3.24	60.2	116.5	704	1.34	101	39	>1000	>1000
Faris	4.09	68.9	58.22	710	0.70	121	39.5	>1000	1000

4.4 Statistical analysis

To distinguish between the concentration difference for the May and October (2008), samples statistical analysis was used. In this analysis standard deviation method was dependent.

4.4.1Husan springs

There is significant difference is between all concentration parameters except for nitrate $NO3^-$ and k^+ concentration, it leached with rain water in wet season and with irrigation water in dry season, sewage, and fertilizer uses. Other ions change as the follows.

Concentration ions of Mg^{+2} ,Ca^{+2}, and HCO_3^- increased in dry season(October sample) due to the water table lower, it well presently increase ions concentration except some springs affected by human activates, agriculture activates as fertilizers, and sewage leakage.

Values of pH,SO_4,NH_4, Cl^-,and Na^+ was increased in wet season. The higher concentration is due to pollutant due to pollutant resulting from human, agricultural, and urban infiltration with rainfall. However, some springs are affected by sewage and irrigation water leakage.

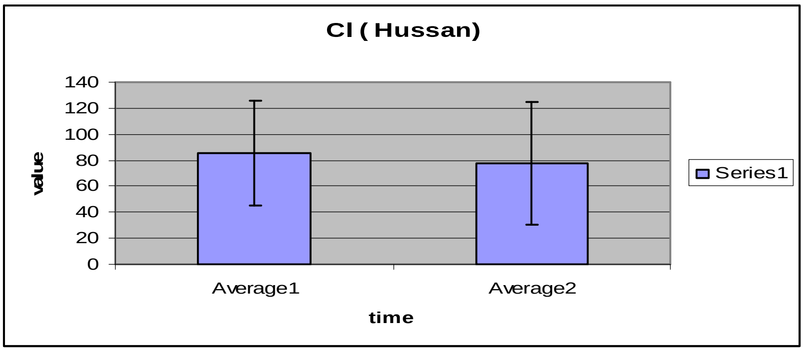


Fig.4. 9 Chloride standard deviation statistical analysis

4.4.2 Wadi Fukeen spring

Springs in this group have special conditions, because irrigation agriculture is an important income, so these springs are under intensive irrigation agriculture and fertilizers uses. It's ions leaching with rain water.

There is no significant difference noticeable for ions concentration parameters for nitrate (NO_3^-),Magnesium(Mg^+) Potassium(K^+), and Bicarbonate ion(HCO_3^-). Concentration. It is because in wet season these ions infiltrate with rainfall. In the dry season they infiltrate with irrigation water. Intensive fertilizers are used in agriculture, but sewage leakage in this village is the major cause for these results.

Concentration ions of TDS and Ca, increased in the dry season(October sample) due to the drop in the water table. An increase in ions concentration except some springs. Is affected by human, agricultural , and urban infiltration.

The value of pH,SO_4,NH_4, Cl^-,and Na^+ increased in the wet season. The higher concentration is due to pollutant (Resulting from human, agricultural , and urban infiltration.) . only some springs are affected by sewage and irrigation water leakage.

4.4.3 Battir springs

There is no significant difference noticeable for ions concentration parameters for $K^+$and Na^+concentration as the following. It is because in the wet season the ions infiltrate with rainfall. In dry season they infiltrate in the rocks elements with irrigation water. Sewage leakage in this village is the major cause for these results.

Values of TDS and, NH_4^+, HCO_3^- and Ca^{-2}. It increased in the dry season(October sample) due to adrop in water table. It well presently increases ions concentration except some springs affected by human activites, agriculture activites as fertilizers, and sewage leakage.

The value of pH,SO_4^{-2},Mg^{+2}, Cl^-,and NO_3^- increased in the wet season. The higher concentration is due to pollutant (Resulting from Human, agricultural, and urban infiltration). only some springs are affected by sewage and irrigation water leakage.

4.4.4 Nahaleen springs

Nhaleen springs have special situation. They are under continuous water infiltration all the time from houses, irrigation, and sewage treatment units. Al-Balad spring is under continuous pollutants from houses located in the springs catchments and fertilizers. Both springs are infiltrated by irrigation water used from pipe nest and housing sewage treatment unit constructed by Arij. Faris spring is contagiously polluted by fertilizes and sewage water from the neighboring treatment unit.

Statistically there is no significant changes noticeable for EC, TDS, Mg^{+2}, Na^+, K^+, SO_4^{2-} ,NO_3^-, NH_4^+, and HCO_3^-.

Any significant change noticeable for pH, Ca^{+2}, and Cl^-. increases in the wet season.

Chapter Five

Conclusion and Recommendation

Chapter Five

5.1Conclusion

The study area is located in Western Bethlehem district, about 12 km, and 16Km from Bethlehem and Jerusalem respectively. It is constructed from four villages (Nahaleen, Husan, Battir, and Nahaleen). Sacran.

Samples from twenty springs analyzed chemically, physically, and biologically, to answer question, are springs water suitable for domestic and agriculture.

The average rainfall of the study area is 570mm. The rainfall season starts from mid Autumn until the end of April. 70% from rainfall in November and February.

The major sediments in the rocks of the study area are limestone, dolomite, and marl limestone, it is carbonate source in groundwater. Main formations in study area are Bethlehem, Hebron, and Yatta formation which back to Cenomanian age. Where others formation founded as Jerusalem and Abu Dis formation. The oldest formation back to albian age.

Sewage is the major pollutant of spring’s water.. Agriculture fertilizers and others human activities is a second major problem.

In the study area parts of western catchments; two aquifers are found: lower aquifer (Albian), which consist of dolomite limestone and lime stone, and upper aquifer which consist of karstified limestone and dolomite limestone. The springs studied were as the following eight springs from Husan, two springs from Nahaleen, eight springs from Wadi Fukeen, and two springs from Battir. All springs emerge from perched aquifers.

A previous study proves that there is a relationship between rainfall quantity and springs discharge, and there is variation in springs discharge with seasons. These studies try to found season influence on spring water quality. If no factor effects the springs, ions concentration in October sample shows higher concentration than May samples, because decrease in water table so that ions concentration increase. This variation in ions is due to increase in water recharge, and the water table become highest.

Twenty samples for October and May(2008) gathered were analyzed chemically, physically, and biologically. Piper classification of water samples show four types for October and May samples. There is earth alkaline water with increased portion of alkalis with prevailing bicarbonate, normal earth alkaline water with prevailing bicarbonate, earth alkaline water with prevailing chloride, and earth alkaline water with increasing portion of alkaline and prevailing chloride.

Water quality evaluation for drinking purposes shows that all springs in the two seasons are unsuitable for potable biologically, but potable chemically. Contaminated sources are waste water, irrigation water, and fertilizers.

Depending on the SSP parameters, springs water suitability for irrigation is as follows; May samples: 15% good, 65%permissible and 20% doubtful. October samples: 40% good, 50% permissible and 10% doubtful. All springs water is suitable for irrigation depending on SAR parameters. May samples by TDS show 5% low salinity, 65% medium salinity, and 30% high salinity. October samples show 5% low salinity, 60% medium salinity, 35% high salinity. All samples provide suitable percentage for irrigation water by pH parameter.

5.2 Springs analysis

5.2.1 Springs of Husan villages

5.2.1.1 Al- Skonah springs

Table5.1: Al-Skonah spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	744	34.9	73.2	103	>1000	400
October	864	29.7	120.7	110	>1000	1000

The water of this spring is not good and biological contamination found in it, because fertilizers uses in agriculture and sewage water infiltrate to spring aquifer from houses in its catchments.

TDS is higher in October samples, due to the dilution caused by rain fall on the spring catchments area, and the spring aquifer is shallow, and full of fractures.

5.2.1.2 Al-Namos spring

Tale5.2: Al-Namos spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	624	36.2	54.9	56	400	200
October	870	34.6	91.5	48.05	>1000	>1000

The water of this spring is not good and biological contamination found in it, because of fertilizers used in agriculture and sewage water infiltrate to spring aquifer from houses in its catchment.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.3 Al-Balad spring

Tale5.3: Al-Balad spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	938	96.5	90.28	153	>1000	800
October	1114	108.8	156.1	150.16	>1000	>1000

This spring water is contaminated by fecal and total coliform, because sewage water from houses located in its catchments infiltrate to spring aquifer. At May sample spring not good according to TDS parameter, it is upper than Palestinian and WHO organization guideline, because large number of houses located in spring catchments, fertilizers used in irrigation agriculture, and limestone in spring catchments. Chemical contamination founded in spring water by NO_3^- at two samples due to sewage water from houses in spring catchments and fertilizers.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.4 Al- Hawea spring

Tale5.4: Al-Hawea spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	782	43.6	74.42	128	0	0
October	1102	50.8	128.1	135.15	26	0

The water of this spring is good and no contamination in it, because no housing in spring catchments at May sample. But at October sample biological contamination by total coliform and chemical contamination by NO_3 in spring water because the fertilizers uses for agriculture in spring catchment.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.5 Al-Kanesa spring

Tale5.5: Al-Kanesa spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	384	42.8	47.58	40.04	300	200
October	426	42.8	73.2	30.03	>1000	>1000

The water of this spring is not good and contaminated by total and fecal coliform. Contamination source from the spring nature, where it discharge in pool with large open (spring like-well), so that dust, animals dung, and microbiology living in it are the contamination source.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.6 Al-Baseen spring

Tale5.6: Al-Baseen spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	348	29	63.44	48	>1000	>1000
October	812	34	120.7	35	>1000	>1000

Sprig water contaminated by total and fecal coliform. Spring discharge in pool with large opening in cave and it uses directly from animals, so that spring contamination sources are dust, animal's dung, and microbiology lived in spring water.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.7 Abu-Same spring

Tale5.7: Abu-Same spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	452	59.9	54.9	72.08	>1000	>1000
October	462	41.6	80.52	56.06	>1000	>1000

The water of this spring is not good and contaminated by total and fecal coliform. Contamination source from the spring nature, where it discharge in pool with large open (spring like-well), so that dust, animals dung, and microbiology living in it are the contamination source. Chemical contamination by NO_3^- founded at May sample due because fertilizers, microbiology live in spring pool, and animals dung.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.1.8 Al-Arade spring

Tale5.8: Al-Arade spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	432	48.7	48.8	83.09	>1000	>1000
October	966	41.2	103.7	55.06	>1000	>1000

The water of this spring is not good, because it contaminated by total and fecal coliform. Contamination sources are fertilizers uses in agriculture, animal dung, dust, and microbiology lived in spring water because spring is well-like spring.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2 Wadi Fukeen springs

5.2.2.1 Al-Quds spring

Tale5.9: Al-Quds spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	214	50	30.5	46.05	>1000	200
October	362	27	78.08	30.03	>1000	>1000

The water of this spring is not good and contaminated by total and fecal coliform. Contamination source from the spring nature, where it discharge in pool with large open (spring like-well), so that dust, animals dung, and microbiology living in it are the contamination source.

TDS is less in samples taken during May, due to the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2.2 Al-Balad spring

Tale5.10: Al-Balad spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	584	79	73.2	73.8	>1000	>1000
October	640	92	109.8	59.06	>1000	>1000

The water of this spring is not good and contamination found in it, because hoses located in spring catchments sewage water infiltrate to spring aquifer so that spring water contaminated by fecal and total coliform. Chemical contamination founded by NO_3^- at tow samples, because sewage water from houses in spring catchments.

TDS is more in October samples, due to the dilution caused by rain fall on the spring catchments area, and the spring aquifer is shallow, and full of fractures.

5.2.2.3 Mtheq spring

Tale5.11: Mtheq spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	566	40.4	62.22	69.8	>1000	>1000
October	554	36.0	91.5	52.06	>1000	>1000

Spring water is not good because total and fecal coloform found. Spring water discharge in large pool, and contamination sources are dust, fertilizers, animal's dung, and microbiological living in spring water.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2.4 Sedeq spring

Tale5.12: Sedeq spring analysis

	TDS	$NO3^-$ ppm	$HCO3^-$ ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	406	21.7	62.22	121.13	400	0
October	456	22.1	108.58	40.04	900	0]

Water of this spring is contaminated by total fecal coliform, because intensive irrigation agriculture in it's catchment and fertilizers contamination infiltrate with rainfall and irrigation water to spring aquifer.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2.5 Al-Fawar spring

Tale5.13: Al-Fawar spring analysis

	TDS	NO_3- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	420	30.1	54.66	50.06	>1000	>1000
October	500	28.9	111.02	40.04	>1000	>1000

Spring water is not good because total and fecal coloform found. Spring water discharge in large pool, and contamination sources are dust, fertilizers, animal's dung, and microbiological living in spring water.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2.6 Subeh spring

Tale5.14: Subeh spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	526	13.8	73.2	50.07	>1000	>1000
October	630	21.2	129.32	42.05	>1000	>1000

Water of this spring is not good because total and fecal coliform founding. This spring shallow well so that contamination sources are dust,animal dung's, fertilizers uses for trees in spring catchments, and microbiology lived in spring.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

2.2.2.7 Al-Tenah spring

Tale5.15: Al-Tenah spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	660	22.2	67.1	88.1	>1000	>1000
October	688	23.5	128.1	72.08	>1000	>1000

The water of this spring is not good and contaminated by total and fecal coliform. Contamination source from the spring nature, where it discharge in pool with large open (spring like-well), so that dust, animals dung, and microbiology living in it are the contamination source.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.2.8Al-Magara spring

Tale5.16: Al-Magara spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	534	55.7	65.88	69.08	>1000	>1000
October	540	50.4	102.8	110.12	>1000	>1000

The water of this spring is not good and contamination in it, because houses located in spring catchment and sewage water infiltrate in spring aquifer. Chemical contamination founded in spring water by NO_3^-, because sewage water from houses in spring catchments.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.3 Battir springs

5.2.3.1 Jame spring

Tale5.17: Jame spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	408	33.9	51.24	52.06	1000	0
October	452	56.9	104.92	48.05	>1000	0

The water of this spring is not good and total coliform contamination in it, because fertilizers uses for trees in spring catchment. At October sample chemical contamination found by NO_3^-, because fertilizers, legume plants, and water table elevation decrease.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.3.2 Al-Balad spring

Tale5.18: Al-Balad spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	455	52	51.24	52.06	600	200
October	510	50	104.92	50.06	>1000	1000

The water of this spring is not good and biological contamination in it, because the houses located in spring catchment and sewage water infiltrate to spring aquifer. Chemical contamination founded in spring water by NO_3^-, because sewage water from houses in spring catchments.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.4 Nahaleen spring

5.2.4.1 Al-Balad spring

Tale5.19: Al-Balad spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	696	33.6	59.78	121.13	>1000	200
October	768	39	104.92	101.11	>1000	>1000

Water of this spring is not good and biological contamination in it, because houses located in spring catchment and intensive irrigation agriculture by water from houses treatment unit, so that sewage water infiltrate to spring aquifer.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.2.4.2 Fares spring

Tale5.20: Faers spring analysis

	TDS	NO_3^- ppm	HCO_3^- ppm	Cl^- ppm	TC Cfu/100ml	FC Cfu/100ml
May	634	23.4	53.68	134.15	1000	100
October	754	39.5	406.14	121.13	>1000	1000

Water of this spring is not good and biological contamination in it, because sewage treatment unit in spring catchment and treatment water run through its catchments, so that sewage water infiltrate to spring aquifer.

TDS is less in samples taken during May, due ti the dilution caused by rainfall on the spring catchment's area, and because the aquifer is shallow and fractured.

5.3 Statistical analysis

Statistical analysis was done by using standard deviation and mean. Each village is considered as group. Springs water quality is influenced by seasons and water tables. This influence causes change in the springs quality as explained in these results:

5.3.1 Husan springs

A significant change has not been found for NO_3^- and K^+. significant increase is found in October sample for TDS,Mg^{+2},Ca^{+2},and HCO_3^-, because the water table decreases and elements concentration increase. A significant change was found for May sample by increase concentration for pH, SO_4^{2-}, NO_3^-, NH_4^-, Cl^-, and Na^+.

5.3.2 Wadi Fukeen springs

A significant change has not been found for NO_3^-,Mg^{+2} and K^+. A significant increase found in October sample for TDS,and Ca^{+2}. because the water table decreased and the elements concentration increased. Due to elements infiltration with rainfall, significant increase for pH, SO_4^{2-}, Na^+, NH_4^+, Cl^-, and Na^+ was shown.

5.3.3 Battir springs

A significant change has not been found for Na^{+1} and K^+.A significant increase found in October sample for TDS,NH_4^+,HCO_3^-, and Ca^{2+}. because water table decreased and the elements concentration increased. Due to elements infiltrate with rainfall, a significant increase for pH, SO_4^{-2}, Mg^{+2},Cl^-, and NO_3^- was shown.

5.3.4 Nahaleen springs

A significant change has not been found for TDS, Mg^{+2}, Na^+, K^+, SO_4^{-2}, NO_3^-, NH_4^+, and HCO_3^-, between two May and October samples.

. Due to elements infiltrate with rainfall, a significant increase for pH, Ca^{+2}, and, Cl^- was shown, because ions leaching and limestone in springs area.

5.4 Recommendations

-Sewage treatment system must be found for these villages, to avoid spring water contamination.

- Housing, farmer's livestock and factories in neighbor settlements must be constructing out of the springs catchments.

- Agriculture fertilizers used must be organizing to avoid springs pollution.

- Regular biological tests for springs to evaluate springs water situation.

- Society activities should be organized to increase population awareness about important of spring's water.

-Founding legislation to protect springs.

- Regular spring's water should be tested for wet and dry season, to evaluate water quality and put future planning.

-Any industrial projects on spring's catchments should be protected.

- Springs catchments rocks and environment should be kept without any change

5.5 Further Studies

The influence of springs water on the aquifers below the springs, and the measurement of water quantity of springs.

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5.7 Appendices

Appendices 4.1: The Chemical analysis of the Husan springs during May and October 2008 .

Springs	Location	pH May	pH October	TDS ppm May	TDS ppm October	Total solid ppm May	Total solid ppm Octpber
AL-Skona	Husan	7.55	7.44	652.8	787.2	744	864
AL-Namos	Husan	7.71	7.56	409.6	441.6	624	870
AL-Balad	Husan	7.42	7.47	896	1043.2	938	1114
AL-Hawea	Husan	7.69	7.37	748.8	928	782	1102
AL-Kanesa	Husan	7.36	7.23	326.4	339.2	384	426
AL-Baseen	Husan	7.65	6.92	332.8	390.4	348	812
Abu-Same	Husan	8.4	7.51	441.6	403.2	452	462
AL-Grade	Husan	7.76	7.56	384	460.8	432	966

Appendices 4.2: The chemical analysis of the Hussan springs during May 2008 in (ppm).

Springs	Location	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
AL-Skona	Husan	22.8	10.2	42.94	1.35	103.11	1.184	34.9	1.50	73.2
AL-Namos	Husan	23.8	11.8	67.94	0.38	56.06	2.42	36.2	1.10	54.9
AL-Balad	Husan	16	38	92.94	3.92	153.17	2.29	96.5	1.18	90.28
AL-Hawea	Husan	13	25	80.44	20.64	128.14	2.19	43.6	1.14	74.42
AL-Kanesa	Husan	11.4	10.6	30.44	0.06	40.04	3.94	42.8	1.27	47.58
AL-Baseen	Husan	15.6	6.4	30.44	0.38	48.05	0.92	29	1.40	63.44
Abu-Same	Husan	16	4.8	42.94	0.38	72.08	2.49	59.9	1.29	54.9
AL-Arade	Husan	14	10	49.19	0.70	83.09	2.76	48.7	1.45	48.8

Appendices 4.3 The chemical analysis of the Hussan springs during October 2008 in(ppm).

Springs	Location	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
AL-Skona	Husan	10.5	5	36.69	1.02	110.12	0.34	29.7	1.30	120.78
AL-Namos	Husan	32	14	67.94	0.38	48.05	0.17	34.6	1.12	91.5
AL-Balad	Husan	31	33	55.44	2.31	150.16	0.20	108.8	1.39	156.16
AL-Hawea	Husan	23.7	20.6	86.69	15.82	135.15	0.28	50.8	1.39	128.1
AL-Kanesa	Husan	20	6	36.69	0.06	30.03	0.11	42.8	0.87	73.2
AL-Baseen	Husan	17.2	14.3	30.44	0.70	35.04	0.34	34	1.27	120.78
Abu-Same	Husan	13.4	13.6	36.69	0.38	56.06	0.21	80.52	1.13	80.52
AL-Arade	Hussan	8.4	10.6	36.69	0.38	55.06	0.58	41.2	1.41	103.7

Appendices 4.4 The physical analysis of the Wadi Fukeen springs during May and October 2008.

Springs	Location	TDS ppm May	TDS ppm October	Total solid ppm May	Total solid ppm October	pH May	pH October
Al-Quds	Wade Fuken	198.4	294.4	214	362	7.92	7.54
AL-Balad	Wade Fuken	537.6	563.2	584	640	7.78	7.55
Mtheq	Wade Fuken	467.2	441.6	566	554	7.42	7.68
Sedeq	Wade Fuken	396.8	416	406	456	7.57	7.08
Al-Fawar	Wade Fuken	396.8	422.4	424	500	7.77	7.13
Subeh	Wade Fuken	441.6	473.6	526	630	7.33	7.04
AL-Tenah	Wade Fuken	588.8	627.2	660	688	7.22	7.05
AL-Magara	Wade Fuken	492.8	473.6	534	540	7.89	7.14

Appendices 4.5 The chemical analysis of the Wadi Fukeen springs during May 2008 in (ppm).

Springs	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
Al-Quds	5.8	9.2	30.44	0.38	46.05	3.36	50	1.23	30.5
AL-Balad	12	3	55.44	15.17	73.8	1.24	79	1.59	73.2
Mtheq	9.4	18.6	42.94	3.92	69.8	1.75	40.4	1.46	62.22
Sedeq	13.2	12.8	36.69	2.95	121.13	3.56	21.7	1.39	62.22
Al-Fawar	9.2	15.8	36.69	4.56	50.06	2.23	30.1	1.54	64.66
Subeh	5.2	15.8	42.94	4.56	60.07	4.19	13.8	1.29	73.2
AL-Tenah	27	2.2	61.69	6.17	88.1	1.47	22.2	1.29	67.1
AL-Magara	30	5.6	55.44	3.92	69.08	1.18	55.7	1.27	65.88

Appendices 4.6 The chemical analysis of the Wadi Fukeen springs during October 2008 in(ppm).

Springs	Ca2	Mg2	Na2	K2	Cl2	SO4 2	NO3 2	NH4 2	HCO3 2
Al-Quds	16	7.5	24.19	1.35	30.03	0.26	27	1.32	78.08
AL-Balad	22.1	5.1	42.94	0.38	59.06	0.22	92	1.20	109.8
Mtheq	16.6	13.4	36.69	2.95	52.06	0.15	36	0.97	91.5
Sedeq	22	7	24.19	1.35	40.04	0.27	22.1	1.21	108.58
Al-Fawar	19.7	14.1	24.19	2.95	40.04	0.19	28.9	1.29	111.02
Subeh	26	4.6	30.44	2.31	42.05	0.22	21.2	1.08	129.32
AL-Tenah	26.3	5.7	55.44	6.81	72.08	0.32	23.5	1.02	128.1
AL-Magara	26	8	42.94	3.59	110.12	0.26	50.4	1.296	109.8

Appendices 4.7 The physical analysis of the Battir springs during May and October 2008 .

Springs	Location	TDS ppm May	TDS ppm October	Total solid ppm May	Total solid ppm October	pH1	pH2
Jame	Bater	377.6	416	408	452	7.66	7.63
Al-Balad	Bater	430	467.2	455	510	7.61	7.5

Appendices 4.8 The chemical analysis of the Battir springs during May 2008 in (ppm).

Springs	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
Jame	8.4	18.6	36.69	0.38	52.06	3.24	33.9	1.25	51.24
Al-Balad	10.6	16.4	42.94	0.38	70.08	2.66	52	1.27	57.34

Appendices 4.9 The chemical analysis of the Battir springs during October 2008 in (ppm).

Springs	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
Jame	21	10.6	36.69	0.38	48.05	0.63	56.6	1.52	97.6
Al-Balad	14	16	42.94	0.38	50.06	0.14	50	1.42	104.92

Appendices 4.10The physical analysis of the Nhaleen springs during May and October 2008 .

		TDS ppm May	TDS ppm October	Total solid ppm May	Total solid ppm October	pH1	pH2
AL-Balad	Nahaleen	640	704	696	768	7.89	8
Fares	Nahaleen	608	710.4	634	754	7.3	7.2

Appendices 4.11The chemical analysis of the Nahaleen springs during May 2008 in (ppm).

	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
AL-Balad	18.4	23	74.19	1.35	121.13	3.50	33.6	1.24	59.78
Fares	28	3	80.44	0.70	134.15	2.60	23.4	1.29	53.68

Appendices 4.12 The chemical analysis of the Nahaleen springs during October 2008 in (ppm).

	Ca	Mg	Na	K	Cl	SO4	NO3	NH4	HCO3
AL-Balad	17.5	27.7	80.44	1.35	101.11	0.37	39	1.57	104.92
Fares	16	11	86.69	0.70	121.13	0.32	39.5	1.02	106.14

الملخص

جودة المياه الجوفية لمنطقة غربي بيت لحم

تعتبر منطقة الدراسة لهذا ا لبحث المنطقة الغربية لبيت لحم ، التي تبعد الى ما يقارب 12 كيلو متر من مدينة بيت لحم ، و 15 كيلو متر من مدينة القدس. و تقع كذلك 120- 130 شمالا و 160-170 شرقا.

تتكون منطقة الدراسة من أربعة أحواض هي حوسان ، وادي فوكين، بتير، نحالين. معدل الأمطار السنوية لهذه النطقة هو 570ملم سنويا. ويبداء موسم الامطار من منتصف الخريف حتى نهاية شهر ابريل ، 70% من مجموع الامطار السنوي يكون في شهري كانون أول وكانون ثاني . جيولوجية المنطقة تتكون من الصخور الرسوبية الجيرية، وصخورالخليل ويطا .

الملوث الرئيسي لينابيع المنطقة المياه العادمة ، الأنشطة الزراعية مثل استخدام الاسمدة والمبيدات، والانشطة الصناعية وتربية الحيونات ومخلفاتها.

تم جمع العينات للدراسة على مرحلتين، الأولى في شهر مايو ، أما الثانية فكانت في اكتوبر. حللت هذه العينات كيميائيا وبيولوجيا ، لدراسة جودة هذه الينابيع للشرب والزراعة والاستخدام المنزلي، كذلك تأثير التغير في الفصول على جودة هذه الينابيع.

غالبية الينابيع في منطقة الدراسة تعتبر غير صالحة للشرب بيولوجيا وذلك لتلوثها حيويا.

تمت دراسة جودة مياه الينابيع للزراعة وتبين مايلي: مياه جميع الينابيع مناسبة للري بالاعتماد على تصنيف (SAR) . أما بالاعتماد على(SSP) للتصنيف فقد تبين مايلي: أولا العينات المأخوذة في شهر مايو كانت كما يلي 15% جيدة، 65% مسموح الري بها و 20% تستخدم للري تحت ظروف معينة. أما عينات أكتوبر فقد كانت كما يلي 40 % جيدة للري، 50% مسموح الري بها ، 10 يسمح الري بها تحت ظروف معينة . ثانيا ، نتائج العينات بالنسبة للموصلية الكهربائية (EC) فقد كانت كما لأتي: عينات شهر مايو كانت كما يلي ، 5% ملوحة قليلة ، 90% ملوحة متوسطة ، 5% ملوحة عالية. أما عينات أكتوبر فكانت 5% ملوحة قليلة ، 85% ملوح متوسطة ، 10% ملوحة عالية. أما بالاعتماد على درجة الحموضة (pH) فجميع مياه الينابيع مناسبة في الفصلين.

اظهرت النتائج با لاعتماد على نموذج (Piper) أن مياه الينابيع في جميع العينات تقسم الى أربعة اقسام، وهي:

1) مياه قلوية أرضية مع زيادة البيكربانيت

2) مياه قلوية طبيعية مع زيادة البايكربانيت

3) مياه قلوية مع زيادة الكلور

4) مياه قلوية مع زيادة القلويات والكلور.

يوجد تأثيرفصلي على مياه الينابيع وثبت ذللك احصائيا باستخدام الوسط الحسابي والانحراف المعياري ، حيث تم تقسيم منطقة الدراسة الى أربع مناطق بحيث اعتبرت كل قرية منطقة وكانت النتائج كما يلي: كل مجموعة لها خصويتها ، لكن احصائيا وبشكل عام فان بعض التراكيز لم تظهر أي تغير مثل البوتاسيوم في ينابيع حوسان ، بعض التراكيز سجلت ارتفاع في عينات شهر اكتوبروذلك بسبب انخفاض مستو ى المياه الجوفية الناتج عن التدفق الدائم ، وبعض التراكيز أظهرت ارتفاع في عينة مايو وذلك للاختلاط بالمياه العادمة و مخلفات الزراعة .