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COLLEGE OF SCIENCE
DEPARTMENT OF GEOLOGY

Balneology and Mud Therapy of the Sulfate Springs along Abu-Jir Fault Zone

A Thesis
Submitted to the College of Science
University of Baghdad in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geology (Geochemistry)

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بسم الله الرحمن الرحيم

وَإِنَّ مِنَ الْحِجَارَةِ لَمَا يَتَفَجَّرُ مِنْهُ الأَنْهَارُ وَإِنَّ مِنْهَا لَمَا يَشَّقَّقُ فَيَخْرُجُ مِنْهُ الْمَاء وَإِنَّ مِنْهَا لَمَا يَهْبِطُ مِنْ خَشْيَةِ اللّهِ وَمَا اللّهُ بِغَافِلٍ عَمَّا تَعْمَلُونَ

صدق الله العظيم

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I certify that this thesis entitled Balneology and mud therapy of the sulfate springs along Abu- Jir Fault Zone has been prepared under my supervision in the Department of Geology, College of Science, University of Baghdad in partial fulfillment of the requirements for the Degree of Master of Science in Geology (Geochemistry).

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Sura Abdul Al-Ghani Al- Qaraghuli

DEDICATION

I would like to dedicate this work

My precious home ……………………….. Iraq
Supervisor ………… Dr. Salih M Awadh
My Father……………………… Mother
Brothers ………… Sister
And
My Best friends ………… All the geologists

Abstract

Sixteen springs existed along Abu-Jir Fault Zone as well as Sawa Lake are investigated for balneo-mud therapy assessment. Sampling for spring water was done during dry and wet periods, whereas sediment samples were collected during the dry period for the year 2011. Physico-chemical parameters including color, taste, odor, hydrogen number (pH), total dissolved solid (TDS), electrical conductivity (EC), temperature (T), total suspended solid (TSS), major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), major anions ($SO_4^{=}$, Cl^{-}, HCO_3^{-}, $CO_3^{=}$), secondary ions (NO_3^{-} ,PO_4^{3-}), H_2S, trace elements (Pb, Cd, Ni, Co, Zn, Fe, Mn, Cu)are made these are measured during two period while the elements (Cr, Hg, As, Mo, Se, Ag, Br, F, Li, Sr, Ba, B, Be, Th) are analyzed during dry period only in the ALS global Lab in Czech Republic. Some of biological tests such as dissolved oxygen (DO), biological oxygen demand (BOD) and microbiological analyses for bacteria and algae are measured.

The results of physico-chemical parameters are compared with the global famous guideline of the European Union, 2009 and US spas. Trace elements are compared with the guideline of Americans Spa and Iceland spa. The baneological assessment for the present spring water seems clearly almost fit for and valid for balneology as therapeutic uses.

Hydrochemically, the spring water is classified as brackish to salty water of weakly alkaline water belong to warm and hypothermal class. Genetically; it is originated from connate fossils water of marine origin mixed partially with water of meteoric origin. Haqlanya, Hit and Shithatha springs are characterized by Na- chloride and Na- sulfate. Kubaysa springs are characterized byNa- chloride during dry period, and were converted to Na- sulfate during wet and dry period. Najaf springs are characterized by Na,Mg- sulfate, whereas Sawa Lake is characterized by Na-chloride during both periods.

Chemistry of spring water reveals that water isimpermissible for drinking, permissible in minimum limit with risk for irrigation and some of it is permissible for aquacultural purpose, but others are impermissible.

Twelve samples of sediments collected from the spring bottom are mineralogically and geochemically studied. Clay mineral separationis made and both clay and non-caly are studied by XRD technique, also polarized microscope is used for testing salts that are floating on the surface of spring water.Chemical analyses (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, BaO, SrO and L.O.I) of sediments were carried out in theALS

Laboratory Group, Analytical Chemistry and Testing Services, Mineral Division-ALS Chemex at Seville, Spain.

The results of mineralogy and geochemistry of the spring sediments show that they are suitable for purpose of mudtherapy. Sawa Lake appears to be free of calcite, dolomite with little amount of halite (0.3%), but it's rich with gypsum (92%). Quartz and clay minerals in its sediments may be attributed to the dust participation. Al-Dwara spring in Hit area (11H-s) is characterized bypossessingthehighestamountof kaolinite (10%) and montmorillonite (27%), whilst Al-Marjspring (8H-s) contains a small amount of clay minerals and rich in calcite. Springs in kubaysa contain a good amount of kaolinite, palygorskit and montmorillonite {7K-s_2 (8%, 12%, 5%), 7K-s (5.5%, 5%, 6%), 6K-s (5%, 2%, 8%) and 4K-s (4%, 8.5%, 3%)} respectively. But 5K-s has low amount of clay minerals due to the high amount of calcite, dolomite and quartz. Palygorskite and montmorillonite are high in Shithatha spring 12Sh-s (17% and 10%) respectively. Najaf spring (14N-s) is characterized by high content of palygorskite (20%).

The mineralogical results of assessment of the spring sediments are compared with that of the sediments of Dead Sea which indicate that each spring has distinctive characteristics. This assessment reveals that the spring sediments arelessefficient thanDeadSea clays.

The geochemistry of sediments is compared with the chemical composition of the Dead Sea and the Hungarian sediments. It shows that Kubaysa springs(4K, 5K, 6K ,7K), Hit springs (8H,11H), Shathatha (12 Sh), Najaf spring (14N) and Sawa lake (17S), can be classified as mud-therapeutic springs which have sediments almost similar the Dead Sea sediments and Hungarian sediments with little differences.

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Chapter One

Introduction

1-1Preface

Balneology is the scientific study of naturally occurring mineral, water, which means all waters with a dissolved ingredient content of more than 1,000 g/l as well as natural waters with low mineralization if they contain one or several specific components that are therapeutic action on the human organism. Ground water to be classified as mineral waters must be contain specific components such as Li, Sr, Ba, Fe, Mn, Br, I, F, B, H_2S, CO_2 and Ra (Komatina, 2004). Water can be called mineral water if it erts pharmacological action on the human organisms which can be caused by presence of absence of any specific elements. (Komatina, 2004).

Balneology is the science that not very well known, and is even less seldom practiced. However, throughout Europe and Japan, balneology and hot springs therapy is very much a part of routine medical care. Medical prescriptions are given by licensed doctors for the treatment of a wide range of conditions, and utilizing mineral water as a part of preventative medicine is widely recognized and encouraged.

Balneotherapy is the practical study and application of the health benefits of water. Mud therapy is a spa treatment where the patient is placed in a pool or bath of warm mud that is used to relax joints and muscles. Mud baths are also proven to improve skin complexion and soothe away muscle aches and pains. Mud baths were used by the ancient Indians and incorporated volcanic ash and spring water into their treatments. They added the warm spring water to the mud mixture. These ingredients are still used in mud bath treatments today.

Historically, the mud bath treatment has been used for centuries in Eastern and Western European spas as a way to relieve arthritis. Mud baths have existed for thousands of years, and can be found now in high-end spas in many countries of the world.

Mud baths can be found at the Dead Sea in Jordan. Dead Sea mud, which is considered therapeutic, is applied to the face, hair and body. Spa is associated with water treatment which is also known as balneotherapy. Spa towns or spa resorts (including hot springs resorts) typically offer various health treatments.

The balneology and mud therapy have known since ancient times in word, but they still did not receive adequate attention it deserves in Iraq, they did not make the proper scientific guidance, where there are many sites have mineral water like Hammam Al-Aleel in Mosul. It was believed that the springs water in the study area are not less important and deserve focusing in term of balneology and mud therapy which one used widely in the world.

1-2 Location of the study area

The study area is located in the Western and Southern Desert of Iraq within the northern and eastern part of the Stable Shelf of the Arabian Platform, along the Abu-Jir Fault Zone (Figure 1-1) It extends from Al-Anbar governorate (Haqlanya, Kubaysa, Hit) passing through Karbala govrnorate (Shithatha) and Al-Najaf governorate (Baher Al-Najaf) ending in Samwa governorate (Sawa Lake).

The study area includes a series of springs extending parallel to the Euphrates River along the Abu-Jir Fault Zone. The traverse length of these series of springs is about 500 km (Al-Ani 1983). The general trend of these springs is NW-SE which fits with the general trend of the fault lineament in Iraq (Abu-Jir Fault zone) that is a border line between the Stable and Unstable Zone (Figure 1-1).

Sixteen springs as well as Sawa Lake are studied. These spring distributed in the study area as three springs in Haqlanya(1Hq,2Hq,3Hq), four in Kubaysa (4K,5K,6K,7K) four in Hit(8H,9H,10H,11H), two in Karbala (12Sh,13Sh), three in Najaf (14N,15N,16N) as well as the Sawa Lake (17S) in Samawa governorate (Figure 1-2).

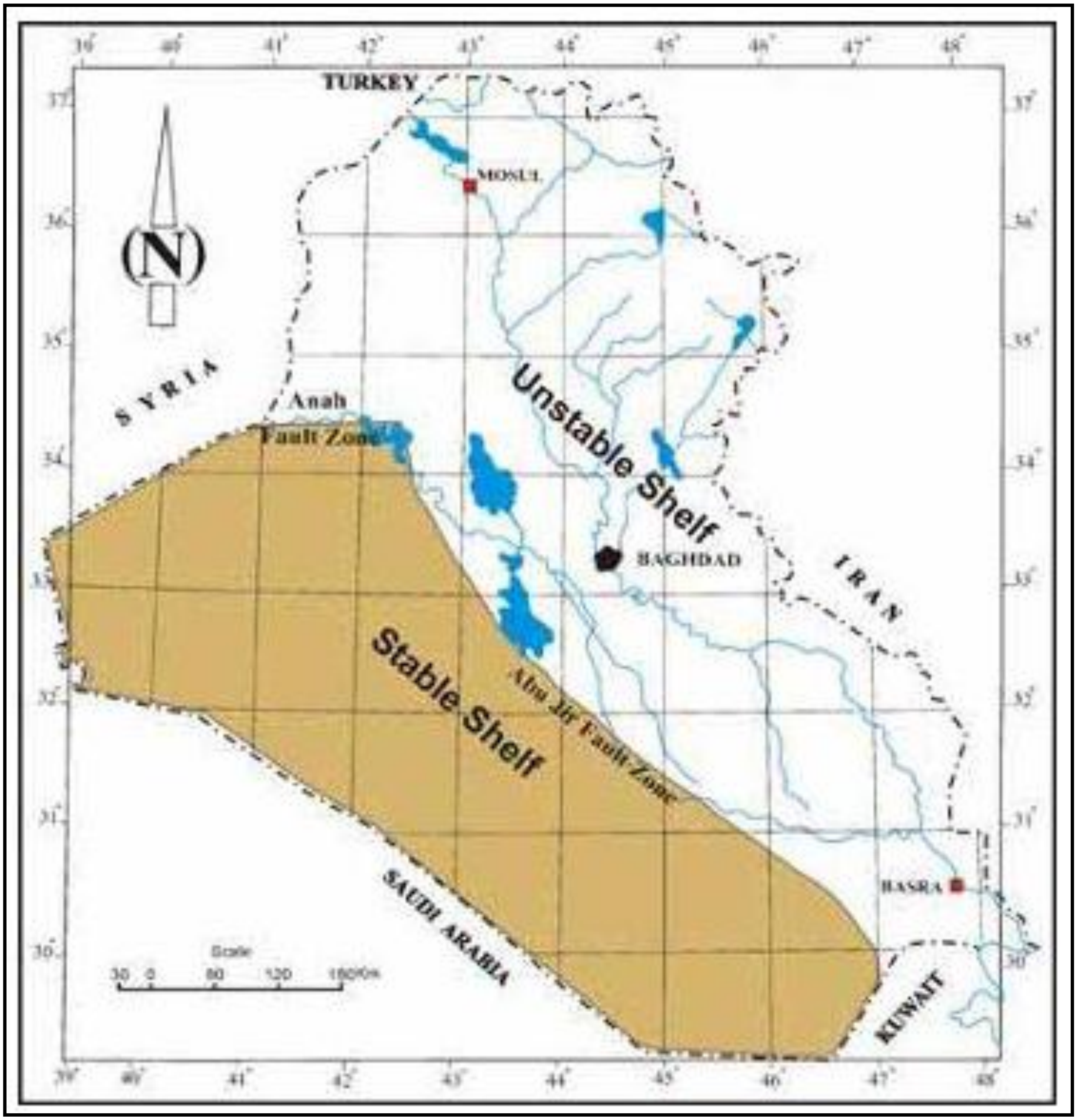

Figure 1-1: The proposed boundary between the Stable and Unstable Shelves of the Arabian platform (Fouad, 2007).

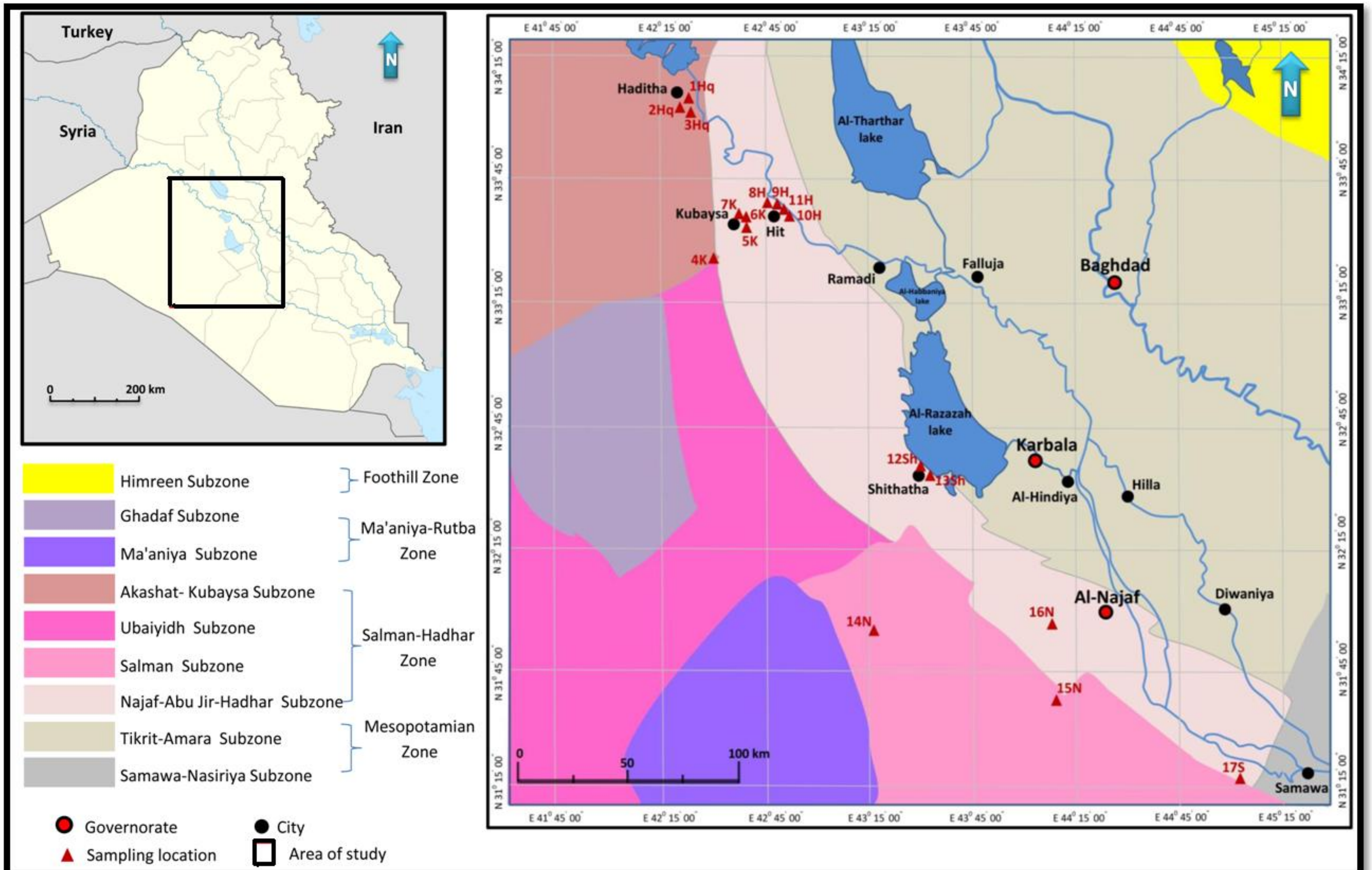

Figure 1-2: Location and simplified tectonic map of the study area.

Table 1-1: Name and location of springs

Spring No.	Local name	Area	Coordination		
			Longitude	Latitude	Elev. (m)
1Hq	Ain –Hajlan/1	Haqlanya	E 42˚21 59.8	N 34˚ 05 24.7	89
2Hq	Ain –Hajlan/2	Haqlanya	E 42˚21 59.8	N 34˚ 05 24.7	89
3Hq	Ain –Hajlan/3	Haqlanya	E 42˚ 21 59.8	N 34˚ 05 24.7	89
4K	Al-Arnab	Kubaysa	E 42˚ 27 53.7	N 33˚ 26 14.4	168
5K	Al-khudher	Kubaysa	E 42˚ 36 47.5	N 33˚ 34 6.7	120
6K	Al-Jarba	Kubaysa	E 42˚ 36 40.3	N 33˚ 34 3.9	115
7K	Kubaysa	Kubaysa	E 42˚ 35 36.7	N 33˚ 35 53.4	114
8H	Al-Marj	Hit	E 42˚ 44 18.3	N 33˚ 39 53.5	85
9H	Al-Qeer	Hit	E 42˚ 48 51.9	N 33˚ 38 20.9	60
10H	Al-Etfaa	Hit	E 42˚ 49 51.4	N 33˚ 37 48.8	56
11H	Al- Dwara	Hit	E 42˚ 50 10.3	N 33˚ 38 19.8	50
12Sh	Al- Khudher	Shithatha	E 43˚ 30 15.7	N 32˚ 35 2.2	35
13Sh	Ain-Altamer	Shithatha	E 43˚ 29 48.7	N 32˚ 35 19.7	56
14N	Alasawed	Najaf	E 43˚ 13 45.0	N 31˚ 55 37.3	13
15N	Kareem	Najaf	E 44˚ 05 45.0	N 31˚ 37 32.4	57
16N	Madhlum	Najaf	E 44˚ 05 26.7	N 31˚ 56 24.9	42
17S	Sawa Lake	Samawa	E 45˚ 01 44.5	N 31˚ 18 0.5	13

1-3 The previous studies

Balneology and mud therapy in Iraq did not receive contributions from previous studies, but persisted as old information exchanged among people as alternative medicine for the treatment of many diseases. A review of some previous works that have been done on spring water including those in the study area can be presented as follows.

Hamza (1975) studied the spring chemistry and classified water as sulfite, highly mineralized springs and other springs with lower mineralization (Kubaysa area).

Al-Ani (1983) described the hydrogeochemical criteria of the springs that extend from Hit to Al-Samawa; determine the hydrochemistry of these springs showed that are high salinity and very hard water.

Tariq and Karim (1986) studied Shithatha area (Abu-Jir Fault Zone) used Bouguer anomaly map of the area in attempt to detect the fault. They concluded two sets of faults, first sets are trending NS (Abu-Jir Fault Zone) and second set is trending EW (Immam Ahmad Fault).

Al-Marsoumi (2005) studied the spring water in Hit area, and classified those as thermal springs rich with H_2S of marine origin of sodium-chloride type mixed with meteroic water; also he determined the concentration of dissolved H_2S as 93 ppm.

Jassim and Goff (2006) discussed the Abu Jir Fault Zone, as being a boundary between stable and unstable platform and the effect of fault on the groundwater, hydrocarbons seepage and dissolved H_2S gases in the study area.

Mahmoud et al. (2006) recommends beneficiation of the mineralized water of some springs, and building modern sanatorium for medication purposes.

Abbas (2009) studied hydrochemistry of springs that extend along the southern sector of the Euphrates River within the Western Desert of Iraq. He found that the hydrocarbon accumulation is little due to the high hydrodynamic action.

Hussien and Gharbi (2010a) studied the physico-chemical parameters of spring water; then they indicated preferable factors that encourage the use of some of these springs in medical purpose.

Hussien and Gharbi (2010b) divided the spring water into tar sulfurous springs located in Hit and sulphurous springs in Kubaysa.

Al-Sa'di (2010) studied the effect of the Abu-Jir Fault Zone on the distribution and quality of groundwater in Iraq.

Awadh and Ahmed (2011**)** studied the chemistry of spring water in Hit city and found the dissolved H_2S gas concentration not exceed 650 ppm in the spring. This concentration decreases gradually through runoff in the dischrge channel, and then up a small amount into the river causing local pollution sites.

Al Dulaymie et al., (2011) study spring water in Hit and Kubaysa, and concluded that the spring waters are classified as brackish to salty, genetically, originated from connate fossil water of marine origin mixed by water of meteoric origin. Balneologically, they classified springs into two potential sites: the first one located in the region of Hit city (east of the Abu-Jir Fault Zone) and the second potential site representing the region of Kubaiysa city (west of the Abu-Jir Fault Zone).

Awadh et al., (2013) determined the width of Abu-Jir Fault Zone by using a new computational simulation modal to be 48 km in average. The study has conclusively demonstrated the validity of the use of geochemical anomalies along with the computational simulation to estimate the dimensions of the fault zone.

1-4 Objectives of the study

For the purpose of achieving the aims of the study, it must meet the following objectives:

1- Classification the spring water for Balneotherapy, drinking, irrigation and aquaculture purposes.
2- Determination the chemical and mineralogical composition of the spring sediments so as to assess it for the therapeutic purposes.

1-5 Geology of study area

The major geological formations exposed in the study area are described from the oldest to the youngest as follows; Baba, Anah, Euphrates, Fatha , Nfayil , Injana and Dibdibba Formations in addition to the presence of Recent Sediments. Rus Formation (Lower Eocene) consists predominantly of gypsum and anhydrite with minor amounts matter it extended from Sawa Lake to Basrah city. Dammam Formation also existed overlying Rus Formation in middle and south of Iraq.

1-5-1 Baba Formation

The Baba Formation comprises of porous massive chalky dolomitic limestone at the outcrop. The thickness of formation is more than 60m in Anah well-2. It unconformably overlies the lower Oligocene Shuran Formation in the type area. In Anah area, it lies unconformable over the Sheikh Alas Formation (Jassim and Goff, 2006). The formation is conformably overlain by the Bajawana Formation in the type locality. In Anah area, the Baba Formation is conformably overlain by Anah Formation. The Baba Formation was deposited in a fore reef environment along both the northeast and southwest margins of the Oligocene basin. The Formation extends along the Euphrates valley.

1-5-2 Anah Formation

Anah Formation was defined from the Euphrates valley about 15 Km west of Nahiyah Village near Anah. The type section in the Sara chug anticline comprises 40-60 m of white or gray dolomite and recrystallized limestone, massive in the Lower part and became thinner bedded upwards.

The formation also outcrops in the Euphrates Valley near Anah and near Shiranish in the high folded zone of north Iraq. The formation is mostly a reef deposits alternating with back reef, milioid facies (Jassim and Goff, 2006).

1-5-3 Euphrates Formation

This Formation is exposed in the Wadi Fuhaimi in the Anah Trough within the stable shelf and in the study area can be seen near Hit area. It has widespread exposure extending towards the south and southwest within the Mesopotamian Plain. It unconformably overlies Anah Formation. It mainly consists of limestone of Lower Miocene age. The thickness of this formation in its type locality near Wadi Fuhaimi is 8 m deposited under shallow marine, reef and lagoonal Environment with local coral reefs (Buday, 1980). This formation hosts the Euphrates River within the study area. It is an aquifer supplies partially the springs in the study area. Sometime appears as confined when covered by gypsum of Fatha, whilst unconfined when covered by Nfayil which characterized by dominant calcareous rather than gypsum particularly toward the south.

1-5-4 Fatha Formation

The age of this formation is Middle Miocene. The lower contact with Euphrates Formation is conformable. This formation in the study area appears to be on the top of the stratigraphic succession forming Mesa and Kuesta land scape near Hit area. The thickness of this formation is generally variable. In the central parts of the basin, the thickness is up to 900 m; whilst, in the study area (around Hit), it is less than 15m. Lithologically, it is evaporitic facies mainly consists of gypsum and anhydrite interbedded with limestone, marl and relatively fine grained clastics (Buday, 1980). It has wide distribution in Iraq. Its sediments cover the marginal areas of the Stable Shelf and almost all of the whole Unstable Shelf. Injana Formation overlies Fatha Formation near Karbala and Najaf areas. The formation has horizontal changes in lithology from gypsum to marly limestone toward the south direction. Due to this change the Nfayil Formation (Middle Miocene) is recommended. (Figure 1-3).

1-5-5 Nfayil Formation

The Nfayil Formation is recently added to the stratigraphic column of Iraq; previously the involved sequence was included with in Euphrates, Fatha and partly Injana Formations. This formation is composed of siltstone, green marlstone and sandstone. Their exposures appear from Hit to the Bahr Al-Najaf area in the north westerly of Tar Al- Najaf. The limit of upper contact conformable with the Injana Formation and it emplaces over. The depositional environment is shallow marine water (Sissakian, 1999), with normal to high saline water with clear oscillation in the sea level. The lithofacies indicates that the Nfayil is deeper than the Fatha Formation. Because the high permeability of the Nfayil Formation, the Euphrates aquifer in the study area (near Karbala and Najaf) is almost unconfined.

1-5-6 Injana Formation

The age of this formation is Upper Miocene. This formation is exposed along Tar Al-Sayyed and Tar Al-Najaf forming caves (Awadh et al, 2012). It composes in general of sequences of clay- stone, siltstone and sandstone with silt layers of chalky limestone. The source of this formation is the high land in the north and northeastern Iraq. The depositional environment of this formation is a changeable environment; it is a lagoon at the beginning, then it is changed to riverine and maritime (fluvio-lacustrine system) (Buday and Jassim, 1987).

1-5-7 Dibdibba Formation

This formation has age of pliocene-pleistocene. The type locality is represented by the section of Zubair oil field in South of Iraq. It comprises of sand and gravel contained pebbles of igneous rocks (in**c**luding pink granite) and white quartz. Rocks of this formation are exposed in the study area along Tar Al-Najaf in both Najaf and Karbala consisted of sandstone, claystone and siltstone. The formation was derived from multi-sources (felsic, mafic igneous rocks and metamorphic rocks) of passive continental margin, then transported by huge net of rivers with general direction of NE and deposited as fluviatile environment under semi humid to semi arid fluctuating climatic conditions covering wide area of Saudi Arabia, Kuwait and south and middle of Iraq (Al-Ankaz, 2012). It is often covered by sand sheets or by the alluvial fan sands of Wadi Al Batin (Jassim and Goff, 2006)

1-5-8 Quaternary deposits

A heterogeneous deposit of fine pebbles consisting of quartz, chert, carbonate and clay represent the Quaternary deposits. Cement materials are mainly silica and secondary gypsum.

The Holocene deposits in the study area comprise of valley sediments, flood plain deposits and eolian deposits. All these types of deposits form the flood plains such as Euphrates flood plain near Hit (Al-Habeeb, 1969) and secondary gypsum near Karbala-Najaf district.

Sabkha is well developed in hit area along Abu- Jir Fault Zone and Razaza and Habbaniyah lakes, along their banks the source of the brine in the former locality are springs water and in the latter is the lakes water.

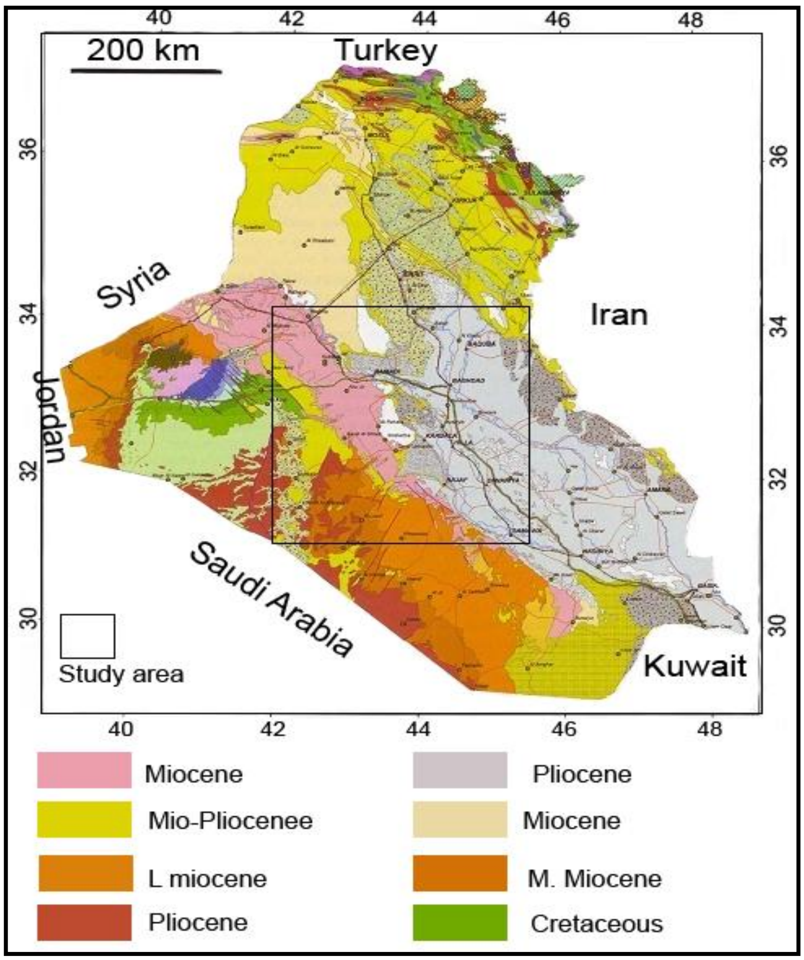

Figure 1-3: Geological map of the study area.

1-6 Structural features of Abu- Jir Fault Zone

The zone consists of several NW – SE trending faults that extend from Anah Graben, across the Euphrates River valley to Hit, Awasil, Abu- Jir, Shithatha, along the western side of the Euphrates River, continuouing through Kerbala, Najaf and Samawa to Basra. It meets Hafr Al-Batin lineament to the west of Basra and northwest Kuwait. It forms an expressive linear feature across the Iraqi territory for about 600 km that is clearly visible from satellite images (Fouad, 2007).

Fouad (2002 and 2004) based on seismic reflection sections covering the northern part of the zone, showed that the cross-sectional shape of the fault zone, which often resembles the longitudinal view of a cone, is not uniform with an abrupt variation in appearance and style along the zone. The zone consists of several steeply dipping normal faults that converge downwards.

It is generally wider at higher levels than lower ones. Some horizons were draped over the tip of the faults to define antiforms and/ or synforms with axes parallel to the zone. He concluded that these antiforms and synforms represent positive and negative flower structures and that the presence of such structures provides conclusive evidence to the occurrence of strike-slip movement along the fault zone imposed on the earlier normal one (Fouad, 2002 and 2004). The movement is thought to be right-lateral.

Seismic section across the Abu-Jir Fault Zone (Figure 1-4) that extends from Southwest to northeast shows the depth extent of fault which penetrating the Cenozoic, Mesozoic and Paleozoic(Aqrawi et al., 2010).

Furthermore, Abu-Jir Fault Zone exhibits some geomorphological features that are directly related to the lateral movement of the zone. The most expressive is Hit pressure ridge and the associated compressive mesoscopic structures, as well as Awasil, Al- Jabha, Al-Mudowar and Abu-Jir Depressions or sag ponds. Such features are distinctive to strike-slip faults, and their formation depends on the bending geometry of the fault surface relative to its slip vector and the magnitude of the movement (Harding 1985; Park, 1988 and Woodcock and Schubert, 1994).

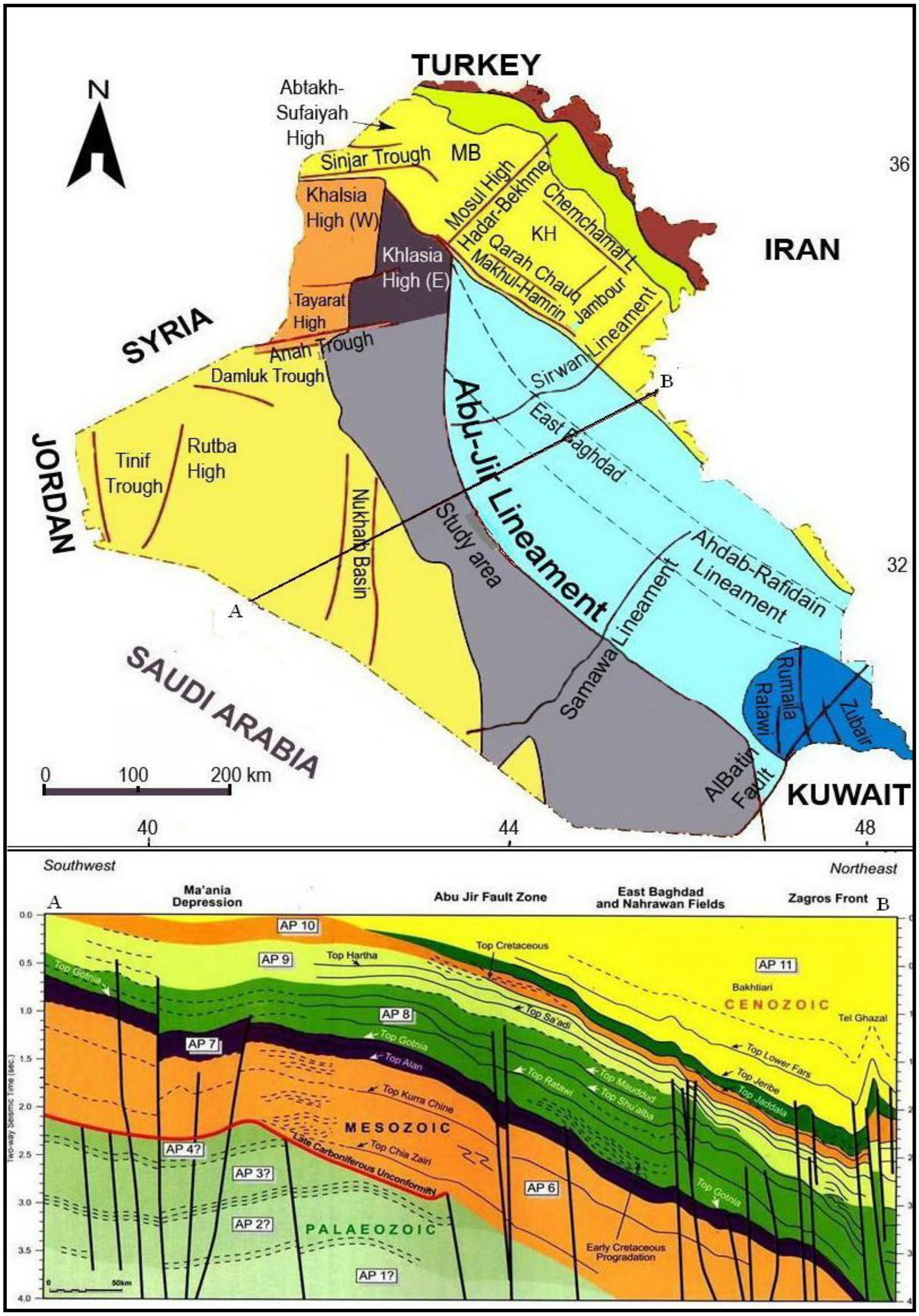

Figure 1-4: Seismic section across Abu-Jir Fault Zone extended from southwest and northeast (After Aqrawi et al., 2010)

1-7 Climate of the study area

Climate has a direct influence on water quality of spring water; and it is one of effective factors in hydrological cycle. The study area climate is characterized by a dry arid summer and cold with scarce rain in winter where the mean annual rainfall is 100-150 mm (Atlas of Iraqi Climate, 2000) Although it is considered a desert, considerable parts are characterized by very fertile soil in which different types of flowers and other kind of vegetation grow during rainy seasons.

The climatological data are obtained from the Iraqi Meteorological Organization for five climatic stations, Haditha , Hit , Shithatha, Najaf and Samawa stations for the period from 1999 to 2010 (Table 1-2).

Table 1-2: The mean of monthly data from Haditha , Hit, Karbala, Najaf and Samawa meteorological stations for the period from1999 to 2010.

Station	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Elements Climate
Haditha	68.4	102.4	181.7	229.9	323	428	457.7	485.5	315.7	205.4	120.4	94	Monthly year evaporation total (mm)
Hit	75.6	107.6	204.1	248.6	377.4	501.5	513.1	479	377.6	320.5	132.7	87.3	
Shithatha	321.3	428.8	568	368.4	327.1	296.1	189.7	113.3	77.4	61.7	125.4	218.4	
Najaf	406.6	559.8	602.8	547.5	426.6	300.6	209.5	127	91.7	95.7	147.6	283.3	
Samawa	353.1	458.2	485.2	445.5	371.8	259.5	195.4	114.8	84.8	89.3	137.3	252	
Haditha	44.9	6.1	5.6	12	0.8	0	0	0	0	2	6.2	7	Monthly rain fall totals (mm)
Hit	11.2	9.6	7.4	12	3.7	0	0	0	0.7	18.1	4.8	3.7	
Shithatha	11.7	18.36	15.33	12.4	4.9	0.13	0	0	0.1	1.6	2.7	6.1	
Najaf	8.167	13.5	10.1	17.4	3.5	0	0	0	0	2.6	1.7	5.2	
Samawa	3.067	12.13	5.633	14.7	5.7	0	0	0	0	3	0.8	4.1	
Haditha	1.65	6.9	12.4	16.4	22.5	27.9	28.8	29	25.4	18.4	9.1	5	Mean min. Temp.(C)
Hit	4.15	7.35	11.25	15.05	21.9	26.3	28.1	27.1	23.05	18.3	9.75	6.5	
Shithatha	5.9	9.5	12.83	18.1	23.47	27.9	30.2	29.7	26	20.4	20.4	20.4	
Najaf	6	9.7	13.1	18.3	24.3	26.9	29.9	18.3	26.2	20.5	11.4	8.4667	
Samawa	5.8	7.1	11.3	17.3	22.9	25.8	27.7	26.8	23.4	18.6	12.1	7.4	
Haditha	13.15	16.5	25.3	30	36.1	41.3	44.3	45.9	39.9	33	25.9	18.9	Mean max. Temp.(C)
Hit	17.4	20.55	24.5	29.95	36.25	42.15	43.55	44.15	39.15	33.65	24.4	19.1	
Shithatha	5.9	9.5	12.83	18.1	23.47	27.9	30.2	43	40	20.4	20.4	20.4	
Najaf	18.7	21.8	26.633	31.4	38.5	42.27	45.57	40	40.8	31.7	24.96	20.43	
Samawa	17	20	24.8	32	38.2	42.5	44.5	44.2	41.3	34.7	25.6	19.1	
Haditha	1.5	1.6	1.9	1.8	1.9	2.3	3	1.1	1.8	1.1	1.9	1.9	Wind speed (m/s)
Hit	1.6	1.5	1.9	1.4	1.3	2.2	2.9	1.5	1.3	1.2	1.8	1.4	
Shithatha	1.7	2.2	2.9	2.6	2.4	2.7	2.6	2.3	1.8	1.6	1.5	1.6	
Najaf	1.7	2.4	2.9	2.9	2.3	2.2	2.1	1.8	1.3	1.2	1.3	1.5	
Samawa	2.8	3.4	3.7	3.7	3.5	3.5	3.4	3	2.5	2.4	2.3	2.5	

1-8 Hydrological conditions

Generally, the groundwater movement in the south part of the Western Desert is from SW to NE, but in the north part of the Western Desert it is from west to east towards the discharge zone along the Euphrates River,

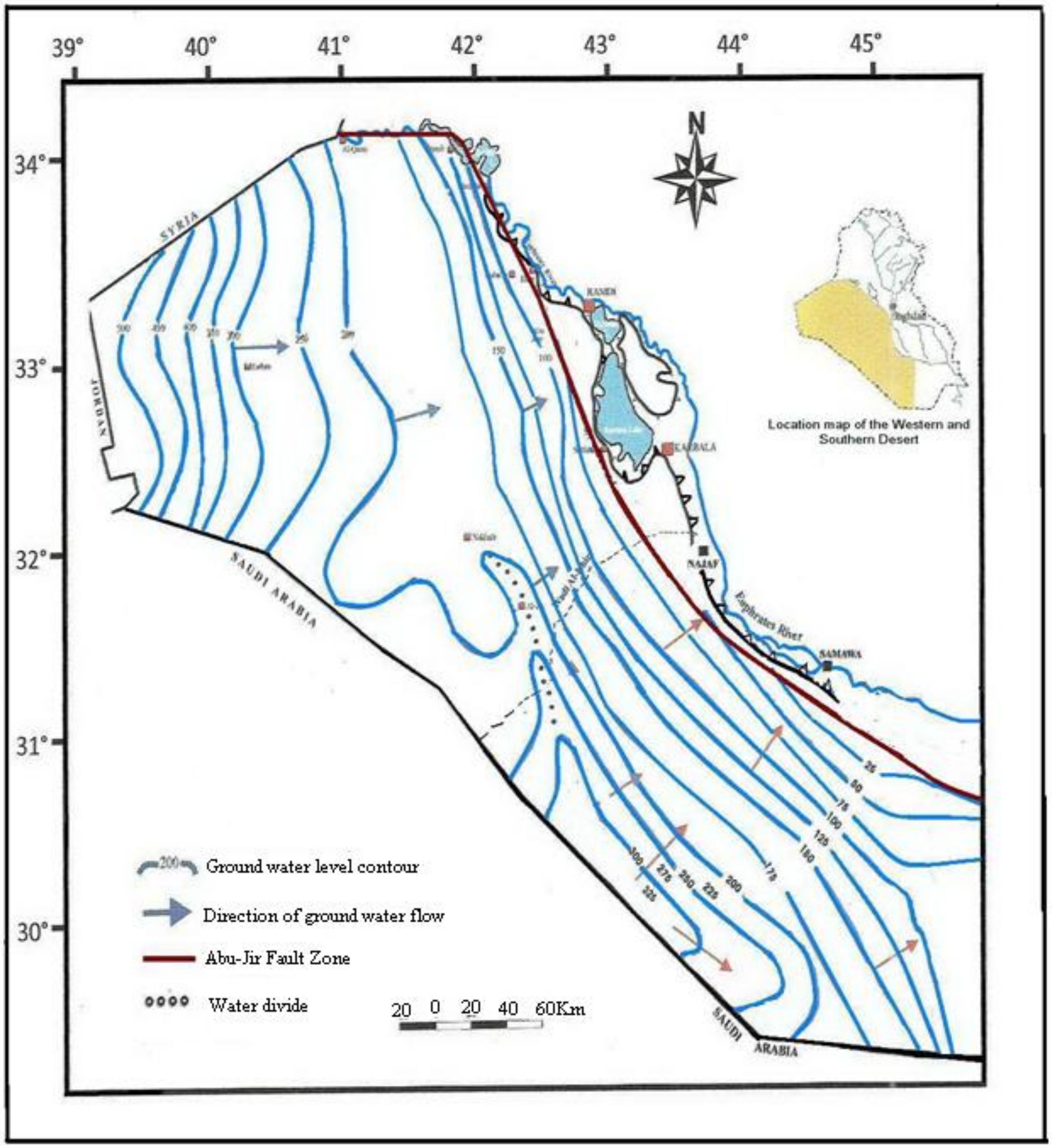

Figure 1-5: Hydrogeology contour map of Iraqi western and southern desert showing static water level and direction of groundwater flow, (Al-Jibury and Al-Basrawi, 2007).

Confined, unconfined and perched aquifers are known in the study area. The calcareous beds within the gypsum of Fatha represent the Perched aquifers of limited extend. Water Bearing Horizons of Euphrates Formation that may reach 50 m represent in most a confined aquifer in the north part of Abu-Jir Fault Zone. Also Baba and Anah Formations represent semi-confined aquifers. Toward the south part of the Abu-Jir Fault Zone. Aquifers of the Tayarat, Umm Er Radhuma, Dammam, Euphrates as well as Dibdibba are the major aquifers in Middle and south of Iraq and form a Varity hydrological system (Al-Jibury and Al-Basrawi, 2007).

1-8-1 Tayarat aquifer

The Tayarat aquifer is located in the western parts of the study area. It's about 200-330m deep. The Tayarat Formation is composed of limestone, clayey and dolomitic limestone and dolostone. It is characterized by the presence of cavities and Karstification in most areas (Jassim and Goff, 2006). This Formation is considered one of the most important aquifers in the study area. It represents a complex hydrogeological unit with Dammam, Umm Er Radhuma and Euphrates Formations, due to presence of hydraulic connection between these Formations (Al-Jiburi and Al-Basrawi, 2007). The results of pumping tests carried out in many wells provided the following data Electrical conductivity ranges from 2000-3000us/cm and total dissolved solids ranges from 648-5510 ppm with sulphatic water (Al-Jiburi and Al-Basrawi, 2007).

These hydrogeological parameters reflect the hydraulic characteristics of the aquifer within Tayarat Formation. High values of transmissivity coefficient indicate the presence of karstified canals and cavities within the rocks of the Formation, which represent good Passages for groundwater. The variations in the transmissivity values reflect the geological and structural properties in the area in addition to karstification phenomenon and the presence of joints, fissures and faults.

1-8-2 Umm Er Radhuma aquifer

Umm Er Radhuma Formation is composed mainly of dolomitic limestone and dolomite with thin beds of gypsum and anhydrite. It is characterized by the presence of fractures, fissures and cavities, which makes it a good water bearing formation within the Southern Desert. Hydrogeological investigations (Al-Jiburi and Al-Basrawi, 2007).

Reflected the presence of huge amounts of groundwater within the formation, which represents a part of complex hydrogeological system with other aquifers within other geological Formations .The recharged area extends widely inside and outside the Iraqi borders within the Saudi Arabia, which represents a good source of recharge.

The Electrical conductivity ranges less than 2000 µs/cm and the total dissolved solids ranges from 167-4500 ppm, with predominant sulphatic water and the presence of chloride and some bicarbonate water type (Al-Jiburi and Al-Basrawi, 2007).

1-8-3 Dammam aquifer

The Dammam Formation is one of the most important aquifers in Southwestern Iraq (Jassim and Gaff, 2006). It is composed of variable carbonate rocks mainly limestone, dolomatic limestone and dolomite, with marl and evaporates. It is characterized by the presence of cavities and karstified canals in addition to fractures, fissures and joints, which cause the formation to have highest transmissivity and permeability, in most area. The hydrogeological investigations in the Western and Southern Desert (Al-Jiburi and Al-Basrawi, 2007).
Reflected that the Dammam Formation contains huge amount of groundwater. This aquifer is part of a complex hydrogeological unit within different formations and is considered as the main regional groundwater aquifer within the Western and Southern Desert, due to its wide extension and its content huge amounts of groundwater.

The electrical conductivity ranges between 3000-4000µs/cm and the total dissolved solids ranges between 350-8530ppm, with predominate sulfate water type and presence of chloride and bicarbonate water types. The source of the sulfate is attributed to the presence of evaporates within, or gypsiferous soils (Al-Jawad et.al. 2002). In the discharge area huge groundwater issues from large springs, locally forming lakes (Sawa Lake)

1-8-4 Euphrates aquifer

The Euphrates Formation is composed mainly of limestone, with impermeable clay and marl. (Al-Jiburi & Al-Basrawi, 2007). Near the surface the limestone's are weathered, fractured and karstified, and have enhanced permeability. Karstification is usually restricted to the 10m thick basal conglomerate unit of the Formation.

The unit consists entirely of carbonate pebble and cobbles, which are prone to solution and due to their high original primary porosity it forms a very effective aquifer. Surface water infiltrates into cavities, fractures and flows towards the Euphrates or issues at the Euphrates boundary fault and the Abu-Jir Fault Zone as a long line of springs of variable discharge. Some of the largest springs are Haglan, Shithatha and Immam-Abdullah. Hit springs and some others are highly saline, sulphurated and rich in bitumen due to the mixing with heavy oil and brines from deep confined aquifers. The Haglan spring originates in fractured limestone's of the Euphrates Formation in 150 m wide front at the mouth of the Wadi Haglan, (Jassim and Goff, 2006).

The electric conductivity ranges between 5000-7000 µs/cm and the total dissolved solids ranges between 1966-64853ppm, with predominance of chloride water type. This aquifer is not considered as a main and important one, due to its bad water quality in most cases and its limited extension.

1-8-5 Dibdibba aquifer

The Dibdibba Formation is composed of pebbly sandstone and sandstone with some claystone, siltstone, and marl associated with secondary gypsum. It is 350 m thick (Buday and Jassim, 1987).

It is exposed at the southeastern part of the Southern Desert. This formation contains two water layers, in some places, lower and upper layers. The lower layer is characterized by salinity of 10000 mg/l in most areas, while the salinity in the upper layers does not exceed 10000mg/l (Al-Kubaisy, 1996). The electrical conductivity is more than 8000 µs/cm and the total dissolved solids ranges from 4790-35170ppm with chloride water type.

These aquifers are leaky except Tayarat aquifer which is believed to be confined, while Dammam- Um Erdhuma aquifers are hydraulically connected. They are also non homogeneous with variations in their hydraulic parameters both laterally and vertically, and a general increase in permeability with depth (AL-Ghazzi, 2004).

Chapter Two

Materials and methods

2-1 Preface

To meet the objectives of this study as much as possible, the reconnaissance trip and the detailed field work included sampling for both of spring water and its sediments. The spring water are analyzed for the physico-chemical parameters. Biological tests and trace elements are also studied for water and sediment samples. This chapter describes the field work, methods and techniques that are employed in this study. Anion, cations and biological tests are measured, and analyzed in the lab of the General Commission of Groundwater, whilst the biological tests are made in the Bacteriological laboratory of The Ministry of Science and Technology. trace elements of water samples (Al, As, Br, Ba, Cd, Cr, Co, Cu, Pb, Li, Ni, Mo, Zn, Hg, Fe, Mn, Sb, Be, Se, Th, V, and F) are analyzed in the Global ALS Laboratory Group in the Czech Republic-Prague Laboratory. The chemical analyses (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, BaO, SrO and L.O.I) of sediments are carried out in ALS Laboratory Group, Analytical Chemistry and Testing Services, Mineral Division-ALS Chemex at Seville, Spain.

2-2 Field work

Along Abu-Jir Faut Zone which extends partly for about 600 km, from Haqlaniya in the north to Samawa in the south. Sixteen springs as well as the Sawa Lake are sampled. Sampling includes both water and sediments.

Water samples were collected from the main springs during the dry period of October-2011, and wet period of April-2012, whilst the spring sediments are collected during the dry period.

All equipments such as bottles, syringes and beaker are rinsed twice with sample water before collection (Shafer et al. 1997). Each water sample is collected in two bottles at a depth of less than half meter using the procedure of Shelton (1994) and USEPA (2000). One bottle is polyethylene of 2.5L for hydrochemical analyses, and the second one is specific glass bottle (sterilized) of 1L capacity for biological analyses.

Sediments are collected from the spring bottom and kept in labeled nylon bags of 1 kg capacity.

During the field work, the geological feature such as formations, land topography, valleys, hydrological conditions, drainage and plant are clearly observed in order to help in data interpretation.

A total sample of water is taken from sixteen (16) springs; as well as samples from Sawa Lake. These springs are distributed in Al-Anbar, Karbala, Najaf and Samawa governorates. It could be described 3 springs in Haqlanya (1Hq,2Hq and 3Hq) , 4springs in Kubaysa (4K, 5K, 6K and 7K), 4springs in Hit (8H, 9H,10H and 11H), 2 springs in Shithatha (12Sh and 13Sh) and 3 springs in Najaf (14N, 15N and 16N) in addition to the Sawa Lake (17S) (Figure 1-2). In order to present a harmonic imagination with the objective; it is appropriate to display the view of springs (Plate 2-1, 2-2, 2-3, 2-4, 2-5) and Sawa Lake (Plate 2-6)

A total sediment samples collected from springs are 12. Five from Kubaysa, 4 from Hit (2 mud samples and 2 floated salts), 1 from Shithatha and 1 from Najaf the last one is from Sawa Lake.

Many parameters are measured locally in the field because the rapid and direct readings are recommended. These measurements included the hydrogen number (pH), electrical conductivity (EC), total dissolved solid (TDS) and temperature (T). The instrument used for these measurements is three in one of TDS-EC-pH meter. This instrument is calibrated by buffer solutions which are a standard solution for pH and TDS to obtain accurate reading. Temperature measured by thermometer. Also H_2S gas is fixed directly in the field by a chemical method; then H_2S is determined in the laboratory.

2-3 Laboratory and office works

Laboratory work included analyses of water and sediment samples. Water samples are prepared before analyses. It is filtrated with 0.45 mm cellulose acetate membrane filter (Hunt and Wilson, 1986), then residuals in filter paper are weighted for determining the total suspended solid (TSS). The filtrate water samples are sent to achieve different analyses such as physico-chemical analysis which there done in the Chemical Laboratory in the General Commission of Groundwater and the ALS Lab in Czech. Trace elements are analyzed at Ministry of Science and Technology and in the ALS Lab in Czech. Major oxides in the sediments are analyzed in the ALS lab Group in Seville, Spain. XRD are used for mineralogical identification, these analyses are done in Iraq Geological Survey.

Office work includes reviewing the references and previous studies and collecting geological information on the studied area. Climatic data of the studied area were collected from the Haditha, Hit, Shithatha, Najaf and

Samawa stations for the period from 1999 to 2010. Preparing the location map to the studied area. Using rock ware Aq.QA (V 1.1 /2006) to draw piper, Schoeller, Stiff diagrams, evaluate water type, calculate total hardness and evaluate for irrigation water such as salinity hazard, sodium adsorption ratio.

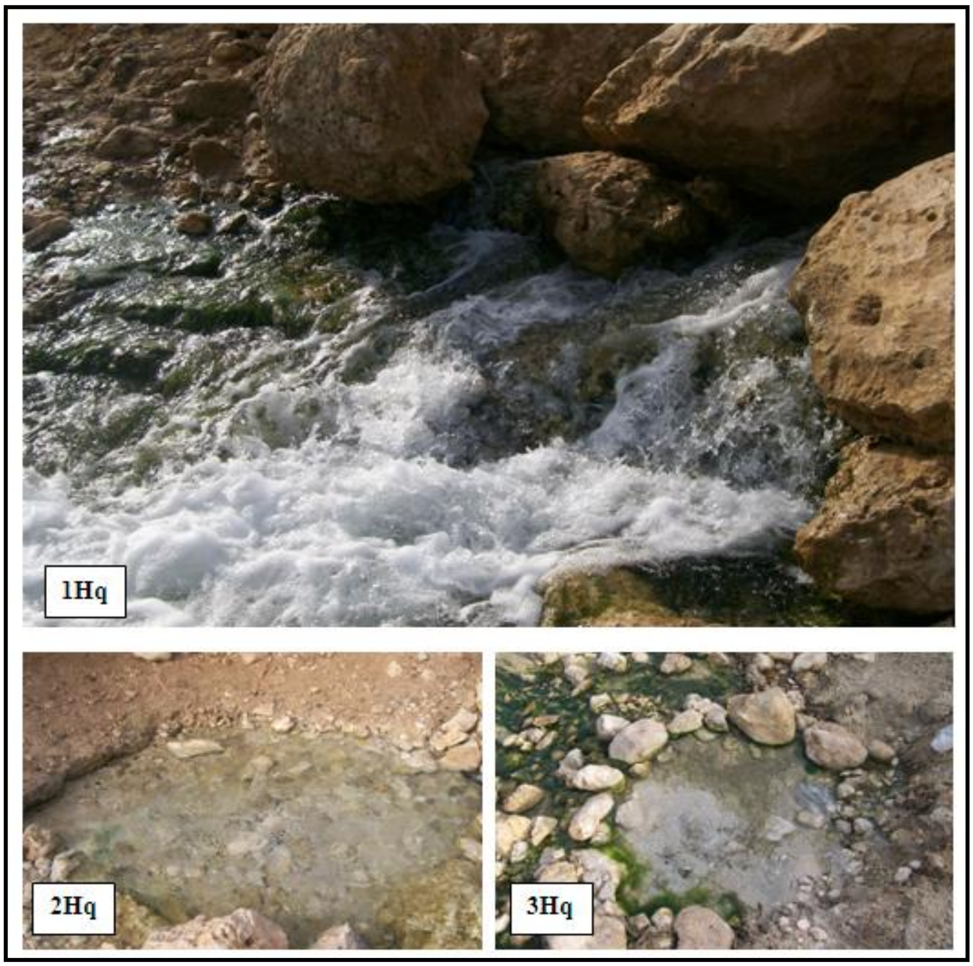

Plate 2-1: Springs in Haqlanya (Hajlan valley)

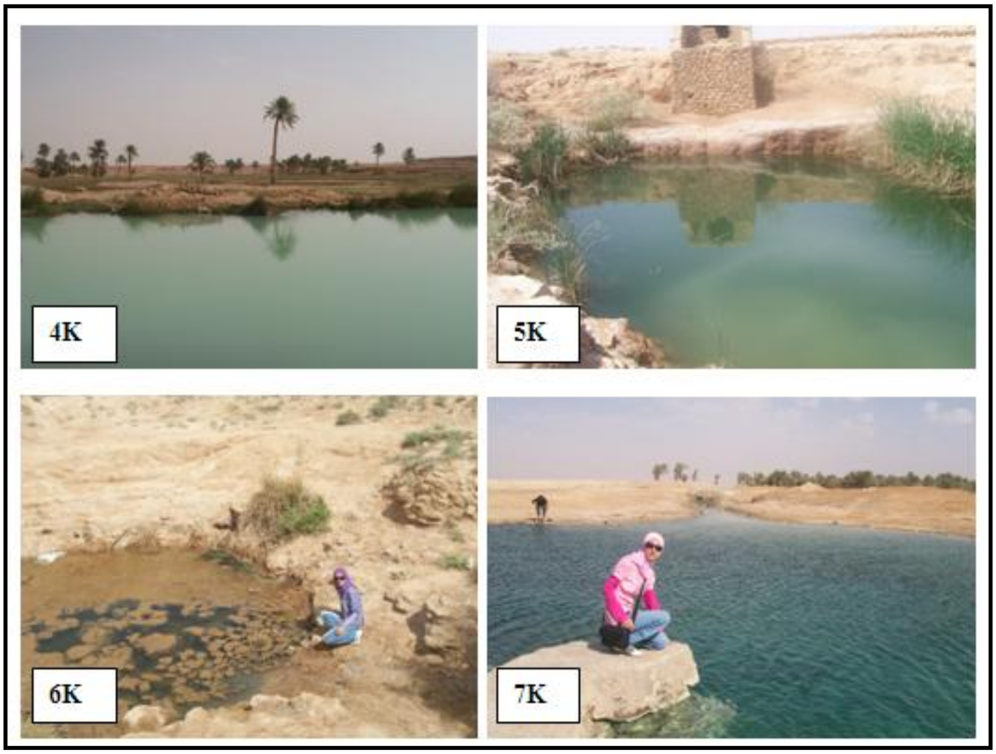

Plate2-2: Springs around Kubaysa

Plate 2-3: Springs in Hit.

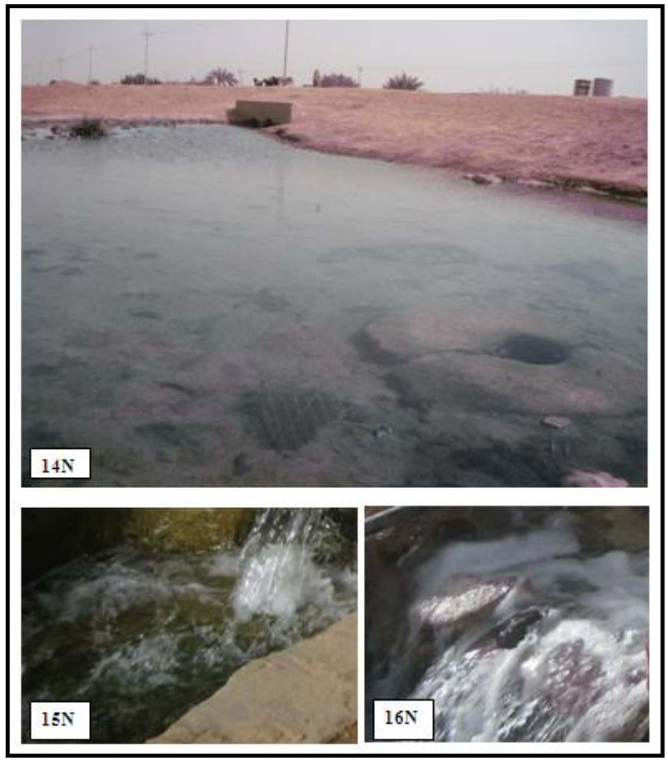

Plate 2-4: Springs in Shithatha.

Plate 2-5: Spring near Al-Najaf.

Plate 2- 6: View of the Sawa Lake shows the salty sediments on its rim

2-3-1 Spring water Samples

2-3-1-1 Physico-chemical analyses

Physical analyses include color, odor and taste can be detected by human senses, while pH, TDS, EC, Temperature are measured by instrument. Total suspended solid (TSS) is computed as the weight of the remnant on filter paper. Major cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and anions ($SO_4^{=}$, Cl^{-} , HCO_3^{-} and $CO_3^{=}$) during two periods (dry and wet) are done in the General Commission for Groundwater .and in the ALS global Lap in the Czech Republic-Prague Laboratory the method during dry period ,shown in Table 2-1, 2-2.

2-3-1-2 Trace elements

The trace element in water samples (Al, As, Br, Ba, Cd, Cr, Co, Cu, Pb, Li, Ni, Mo, Zn, Hg, Fe, Mn, Sb, Be, Se, Th, V, and F) are analyzed in the Global ALS Laboratory Group in the Czech Republic-Prague Laboratory. The analytical methods are summarized in Table 2-2.

Table 2-1: Analytical Methods used in General Commission for Groundwater.

Parameter	**Method**
Na^{+} and K^{+}	Flame photometer (APHA,1988)
Ca^{2+} and Mg^{2+}	Titration with EDTA (Ethylene Diamine Tetrcitic Acid)
Cl^{-}	Technecon in utonanlyze instrument (APHA,1988)
SO_4^{2-}	Technecon, Ultra violet spectro photometer (UV)
HCO_3^{-} and NO_3^{-}	Technecon, volumetric method
PH	PH-Meter
TDS	Drying in 105˚C (Boyd, 2000)
EC	Conductivity meter (Boyd, 2000)
Temperature	Thermometer (0-100˚C)

Table 2-2: the procedures of analysis elements in ALS global laboratory

Analytical methods and (Code)*	Methods Description
Chromatography (W-ANI-SCR)	Ions (F, Cl, Br, NO_3 and SO_4) in water matrix by are analyzed by liquid chromatography.
ICP-AES (W-METAXDG1)	Elements (K, Li, Na, Ca, Ag, Al, As, B, Ba, Be, Bi, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Ni, P, Pb, Sb, Se, Si, Sn,Te, V and Zn) are determined termination by inductively coupled plasma-atomic emission spectrometry. Samples is homogenized and mineralized by nitric acid in autoclave under high pressure and temperature prior to analysis
Spectrophotometry (W-PO40-SPC)	Orthophosphates is determined by spectrophotometry.

* The certification of results given by ASL Lab Group is shown in Appendex-1

2-3-1-3 Hydrogen sulfide gas (H_2S)

Hydrogen sulfide (H_2S) dissolved gas is fixed directly in the field by chemical method. The detail procedure used could be described as follows; 4 ml of 20% of $(CH3COO)_2$ Zn and 1 ml of 1 N from NaOH are transferred into volumetric flask of 100 ml (Al-Baity,1980). The flask is filled by the sample water and closed well.

In this case, white (fog) precipitate has been formed; it is ZnS. The following equation clearly explains this reaction;

$$\mathbf{(CH3COO)_2\,Zn + 2NaOH + H_2S \longrightarrow ZnS + 2CH_3COONa + 2H_2O}$$

Sulfur concentration is computed using the molecular weights of Zn, S and H.

2-3-2 Spring sediment samples

Major oxides, Mineralogical identification, salinity and hydrogen number sediment are measured.

2-3-2-1 Major oxides

Main oxides such as: SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, Cr_2O_3, TiO_2, MnO, P_2O_5 and SrO in whole package –XRF* as well as C, Cl and loss on ignition (LOI) are analyzed. Chloride is determine by samples are fused by Cl-KOH and measured by ionic chromatography (IC). Total Carbon (TC) is determined. Loss on ignition (LOI) is measured by these analyses are done in the ALS Laboratory Group, Analytical Chemistry and Testing Services, Mineral Division-ALS Chemex at Seville, Spain.

* The certification of results given by ASL Lab Group is shown in Appendex-2

2-3-2-2 Mineralogical identification

A total of 12 samples are selected to be analyzed using XRD technique in order to identify the mineralogical composition in both fraction (Clay and non clay minerals). X-ray diffraction is performed in Iraq Geological Survey.

The analyses conditions are listed below:

Target: Cu K-Alpha
Wave: 1.54060
Voltage: 40 KV
Current: 30 Ma

Slit:
Divergence: 1.0 deg
Scatter: 1.0 deg
Receiving: 0.15 mm

Measure:

Axis: Theta- 2 Theta
Scan mode: Continuous Scan
Range: 5.0- 50.0 deg
Step: 0.05 deg
Speed: 5.0 deg/min

2-3-2-3 Salinity-pH of sediments

These parameters are measured for sediment slurries (10 gm of sediments mixed with 50 ml of distilled water) using the TDS-EC-pH meter.

2-3-3 Biological parameters

These tests are done on both of the spring water and spring sediments. Biological tests for water include measured Dissolved Oxygen (DO), Biological Oxygen Demand (BOD) in addition to microbiological tests. All these measurements are done at Laboratory of Water Treatment Technology at the Ministry of Science and Technology. Biological tests for spring sediments are done in the Department of Biology, University of Baghdad using different techniques.

2-3-3-1 Dissolved Oxygen (DO)

Once the sampling process is finished, the water samples are transported to the laboratory soon. Starch is added too for the purpose to neutralize the acidity. To obtain initial oxygen (mg/l), titration with Sodium thiosulfate ($Na_2S_2O_3$) with volume 203 mls where processed (Makereth et al., 1978).

2-3-3-2 Biological Oxygen Demand (BOD_5)

Biological Oxygen Demand (BOD_5) is measured using sample in the opaque bottle after five days. Two mls of each $MnSO_4$ and Azide are added. Thereafter 2 mls of hydrochloric acid (HCl) are added and titrated with Sodium thiosulfate ($Na_2S_2O_3$).
BOD_5 can be found by using the equation of Makereth et al., (1978):

BOD_5 = initial dissolved oxygen - final dissolved oxygen

Where:

Initial dissolved oxygen (DO calculate in Transparent bottle).
Final dissolved oxygen (DO calculate after 5 days in opaque bottle).
BOD_5 is the deference between initial and final dissolved oxygen.

2-3-3-3 Microbial tests for water

Water samples are collected in specific stirred glass bottles of 1L size filled totally and closed tightly. Then samples are sent to the Bacteriological laboratory belong to The Ministry of Science and Technology. Volume 1-10 ml from each water sample is taken for each test. Sample is transferred into Petri dish, or gas positive tube according to the type isolation. (Benson, 2001 and Tortora et al., 2004) .The suitable Agar with sterilized conditions and special temperature is poured (Table 2-3).

Table 2-3: Methods of test samples for Microbial Identification

Microorganism types	Type of Agar	Incubation (hours)	T˚C
Total number of aerobic bacteria colony	Nutrient Agar	24	37
Pseudomonas, Staphylococcus, Bacillus, Lactobacillus	MacConky Agar Nutrient Agar	24	37
Probability of Colin form bacteria	MacConky Broth	24	37
Escherichia coil	MacConky Broth	24	44
Probability of streptococcus	Azide dextrose broth	72	37
Fecal coliform bacteria	Azide dextrose broth	72	44
Anaerobic bacteria Clostridium perfiringens	Iron sulfate Agar	72	37

2-3-3-4 Microbial tests for sediments

Springs sediments samples are dried naturally, then crushed to get powder and passed through 270 mesh to be ready for test.

Many steps and procedures are followed up for culturing and bacterial identification, these procedures could be briefly mentioned below:

2-3-3-4-1 Media preparation

14 gm of Nutrient agar***** and 27 gm of MacConkey agar****** are placed in two Flasks; 200 ml of distilled water to each are added. The two mediums are homogenized by heat, and then it dissolved autoclave under condition of 1bar and 121˚C for 15 minutes. Mediums are cooled slightly. The nutrient agar became yellow color, while macConkey agar became red.

*****Nutrient Agar Medium: This media is prepared according to the instructions of the manufacturer company and then used for isolating and preserving bacteria.

*MaCconkey Agar Medium: This media is prepared according to the instructions of the manufacturer company then used for identifying Gram-negative bacteria and detecting their ability to ferment lactose.

2-3-3-4-2 Microbial isolation

Ten samples are cultured on agar media nutrient agar, macConkey Agar under septic conditions at Department of Biology, University of Baghdad by applying the suitable microbiological procedures sediment sample diluted (1:10) agar media are previously mentioned. Samples are cultured depending on the poured Plate method. That is described by adding 0.1 ml of the sample on the center of the Petri dish, then pouring the prepared medium that are cooled to 37˚C over the samples. Thereafter, it will be homogenized together to give correct results. Nutrient agar medium is used in order to detect the general microorganisms that are found in the samples including bacteria (Gram +ve and Gram –ve, fungi and yeasts, while MaCconkey agar medium to detect Gram –ve bacteria. All the cultured Petri dishes are incubated at 37˚C for 24 hours (Benson, 2001; Tortora et al., 2004)

2-3-3-4-3 Microbial identification

After the end of the incubation period, the grown colonies are identified at Department of Biology /College of Science /university of Baghdad. Methods of identification included examining the macroscopic characteristics for each colony. Screening of the isolated microorganisms is done depending on the opportunistic and pathogenic characteristics of the isolates.

Plate 2-7: Preparation of sediment sample for bacterial test.

2-4 Accuracy and precision

Accuracy and precision of chemical results are computed for both of water and sediment samples to have high reliability and be sure that our results are in safe side and accepted. The accuracy and precision are explained such as following:

2-4-1 Accuracy of water samples

The analytical accuracy of the water samples is indicated from the results of reaction error test uncertainty (U) or relative difference (R.D) by calculating absolute difference between total cations and anions concentration on the total of these concentration in epm unit ,as percentage (Hem,1989,Mazor ,1990 and Kehew ,2001),and according to the following equation.

$$\mathbf{R.D\%} = \frac{r\sum Cations - r\sum Anions}{r\sum Cations + r\sum Anions}\ \mathbf{x100}$$

$$\mathbf{A\%=100\text{-}R.D}$$

Where R.D% relative difference

A is accuracy or certainty

When (R.D < 5%) the results could be accepted for interpretation, but if 5% < R.D < 10% then the results are accepted with risk. if the value (R.D%.10%) could not be depended on the results in hydrochemical interpretation (Hem, 1989).

In this study, R.D% value ranged between (0.3-5.8 %) for dry period and between (0.04-8 %) for wet period (Table 2-4). Accordingly, the results of the analyses appear to be acceptable and can be used in the hydrochemical interpretation.

Table 2-4: The analytical accuracy of the results of spring water samples.

Sample No.	dry	A%	Notes	wet	A%	Notes
	R.D%			R.D %		
1Hq	3.0	97	Accepted	1.9	98.1	Accepted
2Hq	0.3	99.7	Accepted	0.09	99.91	Accepted
3Hq	0.1	99.9	Accepted	2.6	97.4	Accepted
4K	5.8	94.2	Accepted with risk	2.4	97.6	Accepted
5K	1.1	98.9	Accepted	0.6	99.4	Accepted
6K	5.7	94.3	Accepted with risk	0.5	99.5	Accepted
7K	3.9	96.1	Accepted	0.04	99.96	Accepted
8H	0.3	99.7	Accepted	1.8	98.2	Accepted
9H	5.1	94.9	Accepted with risk	8	92	Accepted with risk
10H	1.4	98.6	Accepted	0.4	99.6	Accepted
11H	2.3	97.7	Accepted	0.1	99.9	Accepted
12Sh	1.0	99	Accepted	0.6	99.4	Accepted
13Sh	3.7	96.3	Accepted	0.49	99.51	Accepted
14N	0.3	99.7	Accepted	0.3	99.7	Accepted
15N	0.3	99.7	Accepted	0.5	99.5	Accepted
16N	1.7	98.3	Accepted	1.9	98.1	Accepted
17S	4.3	95.7	Accepted	4.4	95.6	Accepted

2-4-2 Precision of sediment samples

Precision is defined as the range of the compatibility and harmony among different results of the sample analyzed multiple times under the same conditions. In the present study sample number 12Sh-s is analyzed triplicates and the results are comparable (Table 2-5).

Standard deviation used for finding precision. The following equation shows the relative standard deviation (R.S.D) from the confidence level 63%, in this case, the precision will be acceptable to 5-15% (Stanton, 1966).

$$R.S.D\% = (\sigma/X)\ 100.$$

The following equation shows the relative standard deviation (R.S.D) from the confidence level 93%. Accordingly, the precision will be acceptable to the 25% (Maxwell, 1968).

$$R.S.D\% = (2\sigma/X)100$$

Where/ σ = Standard deviation; X= average

Precision of the analytical results of this study appears to be acceptable.

Table 2-5: Precision of triplicate results of 12Sh-s samples sediment.

Elements		Number of analyses			X	±σ	R.S.D %	
		1	2	3			(σ/X)100	(2σ/X)100
SiO_2	%	31.68	31.31	31.24	31.41	0.23	0.75	1.5
Al_2O_3		6.31	6.24	6.22	6.25	0.04	0.75	1.51
Fe_2O_3		3.08	3.05	2.99	3.04	0.04	1.50	3.01
CaO		27.08	26.76	26.94	26.92	0.16	0.59	1.19
MgO		2.52	2.49	2.48	2.496	0.02	0.83	1.6
Na_2O		0.66	0.66	0.661	0.66	0.0005	0.08	0.17
K_2O		1.28	1.27	1.25	1.26	0.01	1.20	2.41
Cr_2O_3		0.03	0.03	0.031	0.03	0.0005	1.90	3.80
TiO_2		0.41	0.41	0.411	0.41	0.0005	0.14	0.28
MnO		0.03	0.03	0.031	0.03	0.0005	1.90	3.80
P_2O_5		0.04	0.045	0.045	0.04	0.002	6.66	13.3
SrO		0.07	0.07	0.071	0.07	0.0005	0.82	1.64
BaO		0.05	0.05	0.04	0.04	0.005	12.37	24.7
LOI		26.01	25.7	25.8	25.83	0.15	0.61	1.22
Total		99.3	98.11	98.21	98.54	0.66	0.66	1.33

Table 2-6: Analytical accuracy of the standard (STSD-4) (For sediments).

Elements		Number of analyses			X	±σ	R.S.D %	
		STSD-4	1	2			(σ/X)100	(2σ/X)100
SiO_2	%	58.83	55.95	61.86	58.9	2.4	4	8.19
Al_2O_3	%	12.09	11.49	12.72	12.1	0.5	4.1	8.3
Fe_2O_3	%	5.73	5.41	6	5.7	0.2	4.2	8.4
CaO	%	4	3.79	4.21	4	0.1	4.2	8.5
MgO	%	2.13	2.01	2.25	2.13	0.09	4.5	9.1
Na_2O	%	2.66	2.56	2.85	2.4	0.1	7.8	15.6
K_2O	%	1.57	1.51	1.69	1.6	0.07	4.6	9.3
Cr_2O_3	%	0.01	0.01	0.03	0.02	0.009	47.8	95.7
TiO_2	%	0.78	0.71	0.81	0.76	0.04	5.5	11.0
MnO	%	0.19	0.17	0.21	0.19	0.01	8.5	17.1
P_2O_5	%	0.22	0.21	0.23	0.22	0.008	3.7	7.4
SrO	%	0.04	0.02	0.06	0.04	0.01	40.8	81.6
BaO	%	0.22	0.2	0.24	0.22	0.01	7.4	14.8
LOI	%	11.05	11.01	12.1	11.6	0.5	4.4	8.8
Total	%	99.53	95	101	99.88	2.6	2.6	5.2

Chapter Three
Balneology

3-1 Preface

Balneotherapy is the therapeutic use of mineral and thermal water most through immersion in a bath or body of water. Hydrotherapy is the external application of water in any form or temperature (hot, cold, steam, liquid, ice) for healing purposes.” The meaning can imply a type of exercise carried out in a pool – aquatic exercise – on the other hand it includes water jets, douches, body wraps (application of wet towels to the skin).

When water immersion (bathing, balneotherapy, hydrotherapy) is concerned, there are three types of effects; thermal, mechanical and chemical. Hot water immersion whether it is in mineral or tap water has factors such as temperature, hydrostatic pressure, buoyancy, and viscosity effects. Depending on the temperature of the bathing water, thermal effects are; analgesic, muscle relaxation, anti-inflammatory, etc. depending on the depth of the bathing medium hydrostatic pressure has effects mainly on cardiovascular and urinary systems; central blood redistribution. According to Archimedes Law buoyancy enables having easily lying position and ability to float and causes mechanical relaxation. Viscosity affects resistance of motion through water (during walking and exercising).

In most diseases you have pain – muscle spasms, increased metabolites, and in several ways this can be mitigated by hot water immersion.

Spring water contains a wide variety and concentration of dissolved constituents that make it a very good prospect for different applications such as balneology, agriculture, aquaculture, industrial processes and district heating. Balneological applications require fluids at the lowest temperature. However, this water must satisfy the norms prescribed for different physicochemical and biological parameters.

This chapter deals with the hydrochemistry of the spring water as well as the Sawa Lake. It can be presented as follows:

3-2 Hydrochemistry

Hydrochemistry is concentrated on the study of physico-chemical parameters including color, taste, odor, hydrogen number (pH), total dissolved solid (TDS), electrical conductivity (EC), temperature (T), total suspended solid (TSS), major cations (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), major anions ($SO_4^{=}$, Cl^{-}, HCO_3^{-}, $CO_3^{=}$), secondary ions (NO_3^{-} ,PO_4^{3-}), H_2S, trace elements such as Al, As, Br, Ba, Cd, Cr, Co, Cu, Pb, Li, Ni, Mo, Zn, Hg, Fe, Mn, Sb, Be, Se, Th, V, and F. Some of biological tests like dissolved oxygen (DO), biological oxygen demand (BOD) and microbiological analysis.

All these parameters are required for the purpose of balneological evaluation, so these factors in the spring water will be presented clearly in this chapter. Then will be compared with the famous global concentration to indicate whether these springs suitable for Balneology or not.

3-2-1 Phyisco-chemical parameters

3-2-1-1Color

It is an aesthetic property of water that are judged subjectively and are caused by dissolved impurities either from natural sources, like the peaty water from upland moors, or from the discharge of noxious substances into the water course by peoples (Shaw, 2002). Dissolved organic material from decaying vegetation and certain inorganic matter causes color in water. Color can also be caused by inorganic metal such as iron or magnesium, or by humic substances, which have form the degradation of leaves and other organic debris. Color itself is not usually objection from the stand point of health (Davis and Masten, 2004).

Generally, the water color varies in the different springs. Excessive blooms of algae were clearly notice at Jarba spring in Kubaysa or growth of aquatic micro-organisms may also form color. Water of springs Haqlanya, Shithatha, Najaf and Sawa Lake are colorless, while all water spring of Hit with light yellow color due to presence hydrocarbons. Kubaysa spring presents a wide range of color resulted from the reflection of sunlight that is a nice spectra for visitors.

3-2-1-2 Taste and odor

The taste and odor do not have a scale, but depends primarily on the receptivity of the human (Todd, 1980). It results from the presence of residual organic material decomposed or fungi (Hem, 1985) or the presence of minerals in the water (Hamil and Bill, 1986). Clean water doesn't contain any taste or odor resulting from the effectiveness pollutants (Abawi and Hassan, 1990).

The presence of odor in some spring water are due to the presence of sulfur compounds dissolved or Hydrocarbons accumulated in the water as in some springs in the Hit (Al-Marsoumi, 1989). Humic compounds, algae and fishes, and dissolved gases in water have clearly affected on springs. Pierce et, al., (1998) suggested that the humic, algae are factors affected taste and odor. Generally Most of spring water along the Abu-Jir Fault Zone containing dissolved H_2S gas with varies amounts, which liberates into the atmosphere, causing unpleasant odors. Haqlanya springs are characterized by odorless, whilst Kubaysa and Hit springs have bad odor. Odor especially attributed to the effect of hydrogen sulfide gas. The other springs of Karbala, Najaf and Sawa Lake odorless or less odor.

3-2-1-3 Hydrogen number (pH)

The pH is a measure of the hydrogen ion concentration in water. The pH value of water indicates whether the water is acidic or alkaline. Drinking water with a pH ranges from 6.5 to 8.5 (WHO, 2008) is generally considered satisfactory.

The pH value in the spring water samples during dry period ranges between 7.1 and 7.5 with average 7.3, while in Sawa Lake was 8.5. During wet period, it ranges between 7.1 and 7.6 with average 7.3 and in Sawa Lake was 8.4 (Tables 3-1 and 3-2). Komatina (2004) Classified water according to the pH value as follows:

pH<3.5 Strongly acid
pH =3.5-5.5 Acidic
pH =5.5-6.8 Weakly acidic
pH =6.8-7.2 Netural
pH= 7.2-8.5 Weakly alkaline
pH>8.5 Alkaline

Accordingly the spring waters are classified as weakly alkaline water.

The slight seasonal variation in pH value (Figure 3-1) can mainly attribute to the temperature, and human activity (farmland) (Kahraman, 2004). It was found a homogeneity pH values during the dry period, whist heterogeneous during the wet period. This may be attributed to the heterogeneity of rainfall falling on the different study sites.

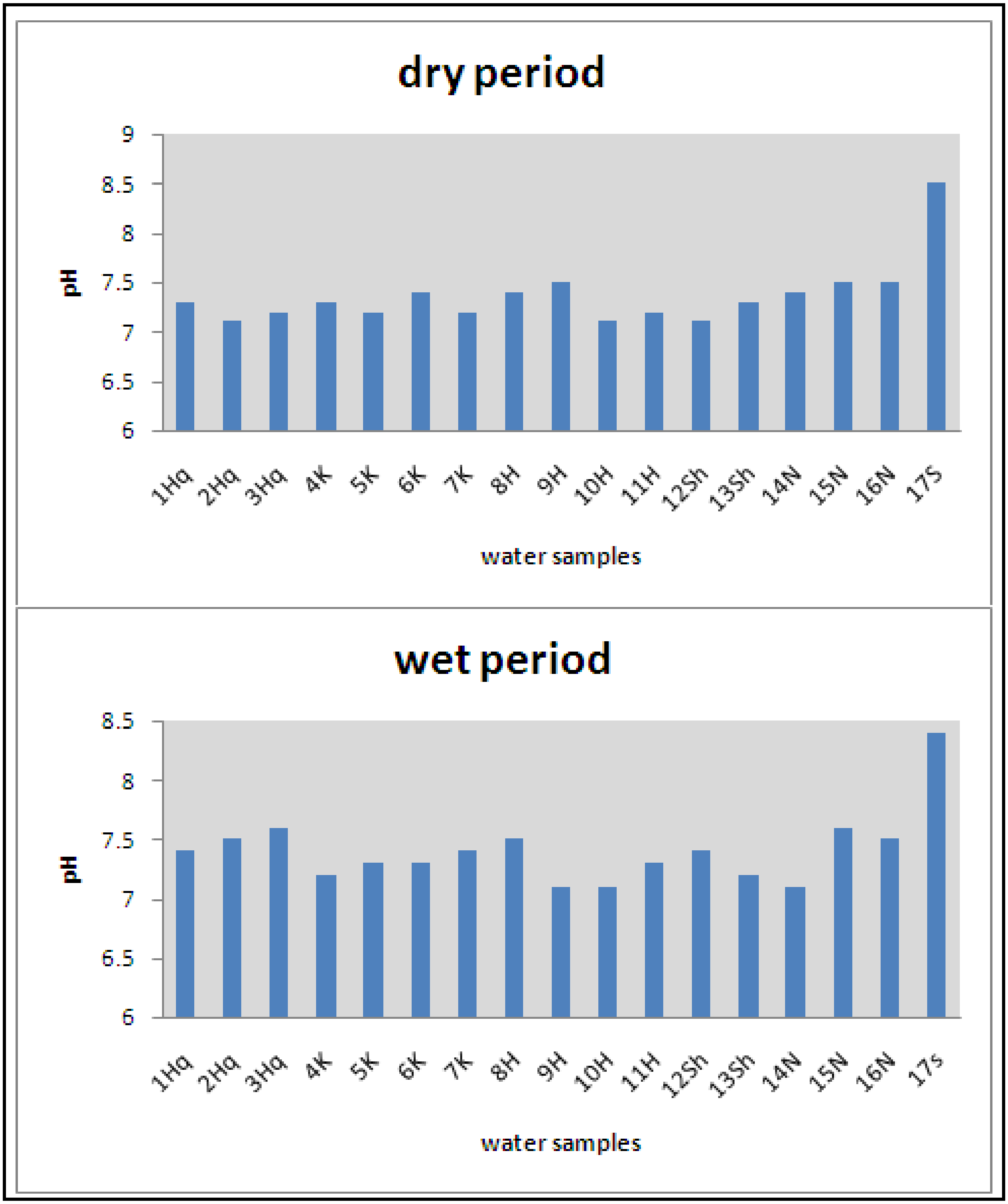

Figure 3-1: The values of pH for water samples during dry and wet period.

Table 3-1: Physico-chemical and trace elements (ppm) of the spring water during the dry period.

parameter	Unit	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
pH	----	7.3	7.1	7.2	7.3	7.2	7.4	7.2	7.4	7.5	7.1	7.2	7.1	7.3	7.4	7.5	7.5	8.5
***T w**	˚C	22	22	22	29	27	28	29	30	31	29	28	29	27	28	27	28	27
****T a**	˚C	24	24	24	39	39	39	39	40	36	36	36	35	32	32	30	30	32
TSS	mg/l	120	120	200	780	140	360	100	300	840	320	340	40	60	80	80	80	380
EC	µS/cm	5523	5068	5038	3553	5703	12028	6102	11867	35417	12767	14152	3658	3315	3453	2067	4559	48022
TDS	ppm	3452	3148	3110	2180	3477	7290	3667	7106	21082	7555	8325	2139	1927	1996	1188	2605	27441
H_2S		139	123	134.5	104	314	349	34	733	1082	663	523	733	1710	104	104	104	590
CO_2		8.4	.8.3	8.1	9.8	10	10	9.9	40	44.8	30	25	3.6	3.7	3.3	3.1	3.2	0
Ca^{2+}	ppm	288	320	312	225	300	712	262	780	1010	711	925	160	177	180	122	382	781
Mg^{2+}		134	146	144	94	125	378	129	400	367	410	375	110	85.2	80	81	127	1610
TH		1270	1399	1371	948	1263	3333	1185	3593	4032	362	3852	852	792	778	637	1476	8575
Na^{+}		709	480	472	396	688	1294	854	900	6690	1145	1385	380	319	320	135	251	6240
K^{+}		94.1	22	21	8.1	4.9	70	102	16	479	145	65	2.3	56.7	4	11	37.7	389
SO_4^{2-}		674	1260	1253	389	1080	1236	226	2300	326	2730	1420	852	145	675	530	1200	8970
Cl^{-}		1330	650	643	565	888	2220	1640	1670	11800	1934	2930	524	594	301	248	424	9320
HCO_3^{-}		223	270	265	503	392	1380	463	1040	410	480	1225	111	551	436	61	184	104
CO_3^{2-}		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	27.2
NO_3^{-}		3	2	3	5	4	10	2	9	9.5	7	6.2	2	2.3	6	3	3	13.2
PO_4^{3-}		<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04
Pb	ppm	0.1	0.1	0.1	0.09	0.1	0.27	0.06	0.16	0.26	0.17	0.17	0.1	0.1	0.14	0.15	0.17	0.37
Zn		0..03	0.07	0.07	0.13	0.08	0.22	0.12	BDL	BDL	BDL	BDL	0.07	0.01	0.06	0.56	0.4	0.1

element	unit	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
Cd	ppm	0.02	0.02	0.02	BDL	BDL	0.01	BDL	BDL	0.04	0.004	0.005	0.02	0.01	BDL	BDL	BDL	0.04
Ni		0.04	0.04	0.04	0.1	0.08	0.22	0.07	0.18	0.21	0.13	0.13	0.04	0.05	0.1	0.1	0.1	0.4
Co		0.07	0.09	0.08	0.07	0.1	0.2	0.08	0.18	0.31	0.2	0.2	0.08	0.07	0.15	0.1	0.11	0.1
Fe		0.01	0.01	0.01	0.04	0.05	0.08	0.03	0.08	0.26	0.1	0.09	BDL	BDL	0.07	0.07	0.08	0.4
Mn		0.0009	0.0009	0.0009	0.01	0.01	0.01	0.01	0.03	0.03	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cu		0.0026	0.0025	0.0025	0.003	0.003	0.003	<0.0020	0.002	0.0036	0.002	0.002	0.0021	0.0022	0.0020	0.0020	0.0021	0.0045
Br		10.4	10.2	10.3	11.1	13.2	14	12.7	80	89.2	66	60	4.1	4.73	2.4	2.3	2.5	33.2
F		1.1	1.2	1.1	0.6	0.8	0.7	0.9	1	2	1.5	1.9	1.0	1.0	1.2	1.4	1.3	9.25
Ba		0.0177	0.061	0.016	0.01	0.025	0.019	0.0296	0.01	0.186	0.1	0.09	0.01	0.011	0.003	0.004	0.00451	0.0185
B		1.34	1.32	1.3	1.5	1.6	1.6	1.5	6	7	5	5.4	0.9	0.9	0.6	0.56	0.66	12.4
Li		0.17	0.16	0.15	0.18	0.2	0.2	0.19	1.2	1.29	1.9	1.8	0.07	0.08	0.05	0.04	0.06	2.20
Sr		4.27	4.44	4.55	7.07	9.59	20.2	7.07	38.84	48.58	26.76	30.3	5.55	4.54	10.6	10.10	11.11	39.5
Al		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sb		<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
As		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Be		$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$	$<2*10^{-4}$
Cr		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Hg		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mo		<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.0058	0.0476
Se		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Th		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
V		<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

*****Tw =temperature of water; ******Ta=temperature of air; BDL=below detected limited

Table 3-2: Physico -chemical and trace elements of the spring water during the wet period.

Parameter	unit	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
pH	---	7.6	7.5	7.4	7.2	7.3	7.3	7.4	7.5	7.1	7.1	7.3	7.4	7.2	7.1	7.6	7.5	8.4
***T w**	˚C	20	20	20	28	26	26	25	30	28	28	27	27	23	24	25	24	24
****T a**	˚C	22	22	22	30	28	29	30	35	30	30	29	29	25	28	28	28	26
TSS	mg/l	100	100	100	1400	1000	2900	1900	3100	4000	2900	2800	100	100	200	100	100	280
EC	µS/cm	4616	5897	5457	4378	6909	13916	4481	10749	24694	6918	15697	2058	2894	3167	2970	2983	44143
TDS	ppm	2885	3663	3369	2686.5	4213	8434	2699.5	6437	14699	4094	9234	1204	1683	1831	1707	1705	25225
H_2S		586	516	481	111	279	705	356	726	1989	1158	502	237	307	488	97	125	570
Ca^{2+}	ppm	210	332	315	257	370	802	262	523	1202	369	814	125	71	159	150	155	750
Mg^{2+}		121	158	144	188	188	373	163	300	828	185	582	84	36	78	88	85	1500
TH		1022.3	1479	1379	1415	1697	3537	1324	2540	6408	1682	4427	657	325	717	736	736	8045
Na^+		530	534	438	370	609	1384	376	1042	2815	603	1051	130	428	321	260	240	5200
K^+		100	116	106	8.5	112	75	9.5	63	237	109	391	10	13	2	3	4	250
SO_4^{2-}		781	1300	1208	951	1632	2256	964	2071	3312	1600	3121	545	512	662	500	510	8500
Cl^-		782	715	658	650	731	2202	658	1530	3865	719	2182	242	361	367	319	330	8900
HCO_3^-		361	508	500	262	571	1342	267	908	2440	509	1093	68	262	242	387	387	100
CO_3^{2-}		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25
NO_3^+		3	4	7.8	6	2	9	6	2.3	11.7	2	0.2	3	3	7.5	4	4	12
Pb	ppm	0.2	0.2	0.2	0.95	0.8	1.3	2.3	0.01	0.08	1.4	1.6	0.2	0.3	0.2	0.2	0.3	0.26
Zn		BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cd		0.07	0.08	0.09	BDL	BDL	0.02	BDL	BDL	BDL	0.12	0.12	BDL	BDL	0.04	0.04	0.04	0.05
Ni		0.03	0.03	0.03	0.2	0.09	0.1	0.08	0.2	0.3	0.2	0.2	0.03	0.03	0.2	0.2	0.2	0.3
Co		BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Fe		0.01	0.01	0.01	BDL	BDL	BDL	0.04	BDL	0.04	0.04	0.03	BDL	BDL	BDL	BDL	BDL	0.1
Mn		BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cu		BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

3-2-1-4 Temperature

It is an important factor in the geochemical reactions and increases with depth by 2.9˚C for each 100 m depth (Todd, 1980). Temperatures are measured in the field by thermometer.

In this study, both of the water and air temperature was measured. The temperature of water range between 22 – 31˚C with average 27˚C during dry period (Tables 3-1 and 3-2) and ranges between 20-30˚C with average 25˚C during wet period are evidence of warm water suitable for bathing.

The mean of air temperature for the springs is 33˚C and ranges between 24 – 40˚C during dry period, whilst the mean of air temperature is 27˚C, and ranges between 22-35 ˚C in wet period. The correlation between the springs water temperature and air temperature shows good relation (Figure 3-2). It indicates that there is direct effect of the climatic factors on the water of the springs, and may be slight source of heat flow in Hit area due to the highest temperature. Tepid to warm baths are utilized (20- 37.8˚C) are useful for balneology and hydrotherapy. It was recorded that the temperature of the air higher than of water. The fluctuation of temperature is mainly due to the measuring time. Komatina (2004) Classified of water to cold with temperature below 20˚C, warm 20-30˚C, thermal 37-42˚C, highly thermal 42-100˚C and super saturated above 100˚C. Accordingly the spring water is warm. On this basis, the springs appear to be warm spring according to classification of Komatina (2004).

Aquaculture, spa and pool applications require geothermal fluids of the lowest temperature 25-95˚C (Tylor, 2005). Water temperature is described as being cold (<20°C), hypothermal (20-30°C), thermal (>30-40°C); or hyperthermal (>40°C) (Matz et al., 2003). Accordingly, spring water are classifies to be hypotheraml springs.

3-2-1-5 Total dissolved solids (TDS)

The total dissolved solids (TDS) give a measure of the amount of chemical salts dissolved in the water (Wright, 1991). High concentration of total dissolved solid may cause adverse taste effects. Highly mineralized water may also deteriorate domestic plumbing and appliances (Walton 1971) and effect on human health but it is very useful for balneology.

TDS of spring water vary between 1188- 21082ppm with average 5016.1 ppm and Sawa Lake TDS is 27441 ppm during dry period while TDS range between 1204- 14699 ppm with average 4409 ppm and Sawa Lake is

25225ppm (Tables 3-1 and 3-2) that mean all water samples exceed 1000ppm therefore unsuitable for drinking but it may be permissible to use for balneology application because it considered as mineral water.

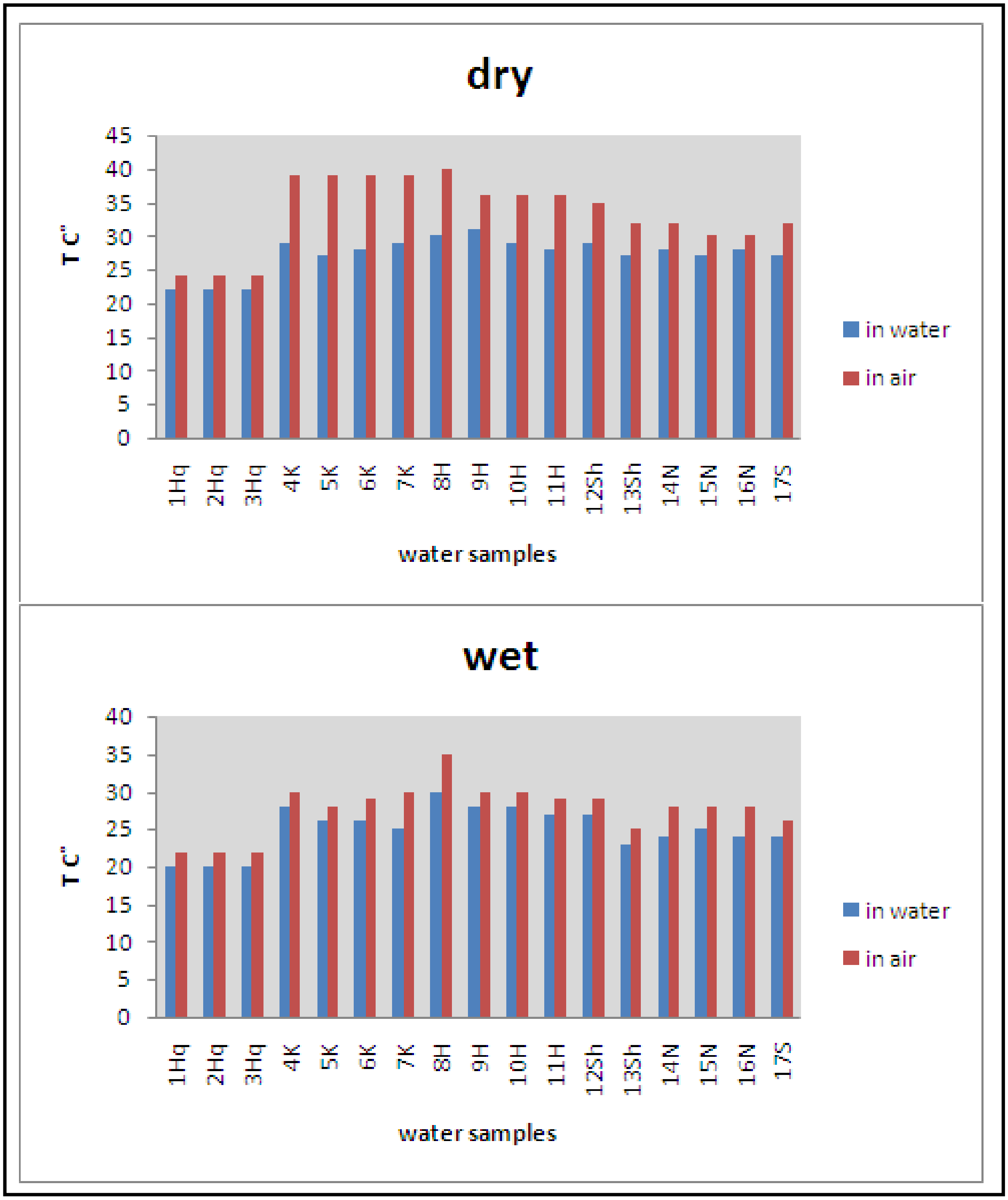

Figure 3-2: The temperature of water and air for springs during dry period and wet period.

3-2-1-6 Electrical conductivity (EC)

Electrical conductivity is an indirect measurement of salinity (Hem, 1991; APHA, 1998; and Mazor, 1990). It is the ability of ($1cm^3$) of water to conduct an electric current at a standard temperature of 25°C and is measured in micro-siemens per centimeter (µS/cm) depending on the total amount of soluble salts (Todd, 2005). The response of the conductance value to temperature changes is somewhat different for different salts and different concentrations, but in diluted solutions for most ions increase of 1°C increases conductance by about 2%. The variation of conductivity gives important information on the evolution of water quality. The average of EC for spring water is range between 2067-35417 µS/cm with average 8392 µS/cm and Sawa Lake EC is 48022at dry period; while at wet period; EC ranges between 2058-24694 µS/cm with averages 7362 µS/cm and Sawa Lake EC is 44143 µS/cm (Table3-1, 3-2). According to the classification of Detay, 1997, the type of spring water is excessively mineralized water as shown in Table 3-3. TDS showed a linear relationship with EC (Figure 3-3).

Table 3-3: Relationship between EC and TDS (After Detay, 1997).

EC (µS/cm)	Mineralization
<100	Very weakly mineralized water
100-200	Weakly mineralized water
200-400	Slightly mineralized water
400-600	Moderately mineralized water
600-1000	Highly mineralized water
>1000	Excessively mineralized water

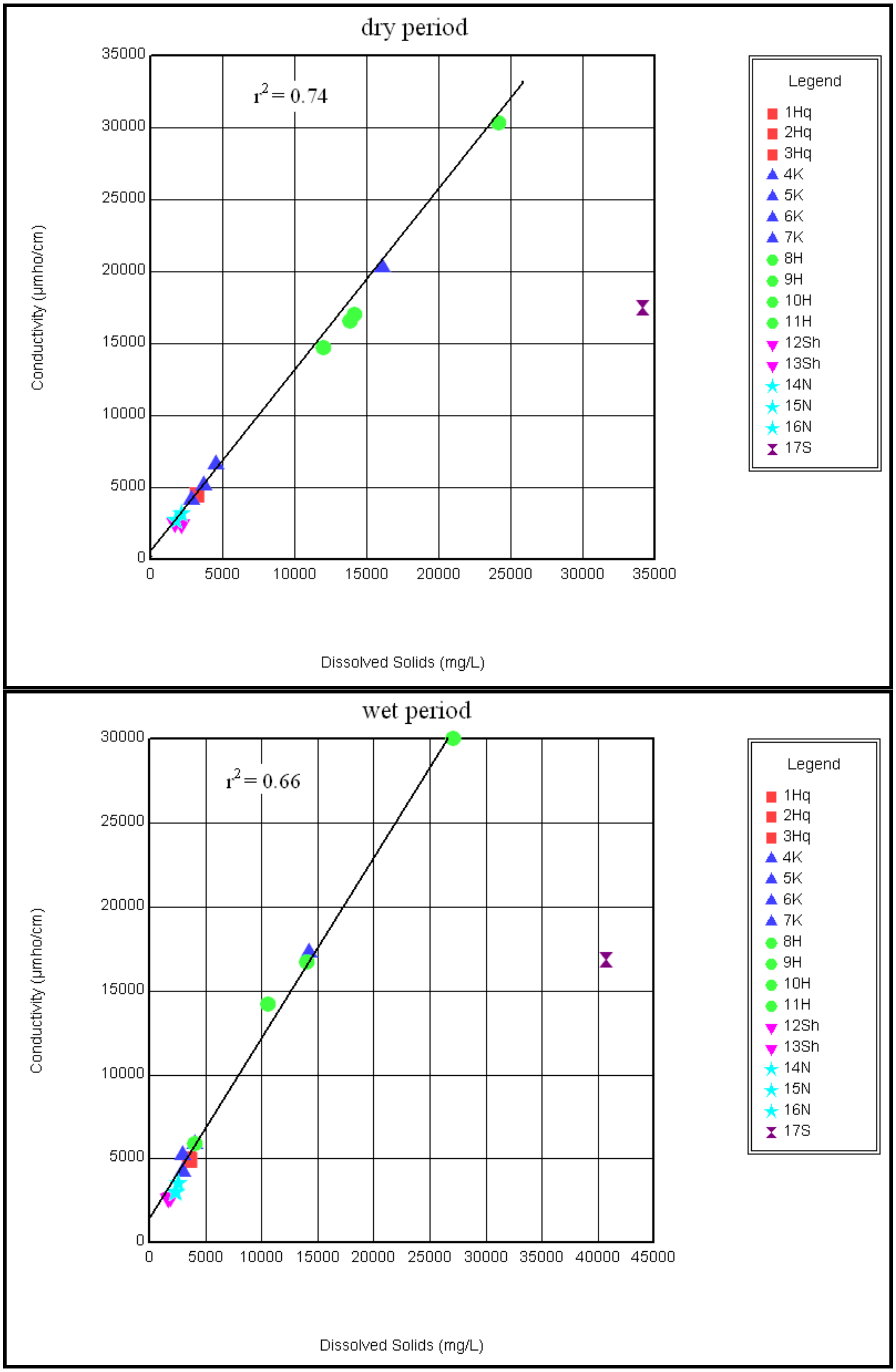

Figure 3-3: Relationship between EC and TDS in the spring water during two periods.

3-2-1-7 Total suspended solids (TSS)

Total suspended solids (TSS) apply to the dry weight of the material that is removed from a measured volume of water sample by filtration through a standard filter (Bartram and Ballance, 1996). It composed of clay, algae, bacteria, and decomposed organic particles (Casey, 1997). Total suspended solid of the spring water are listed in Table 3-1 and 3-2.

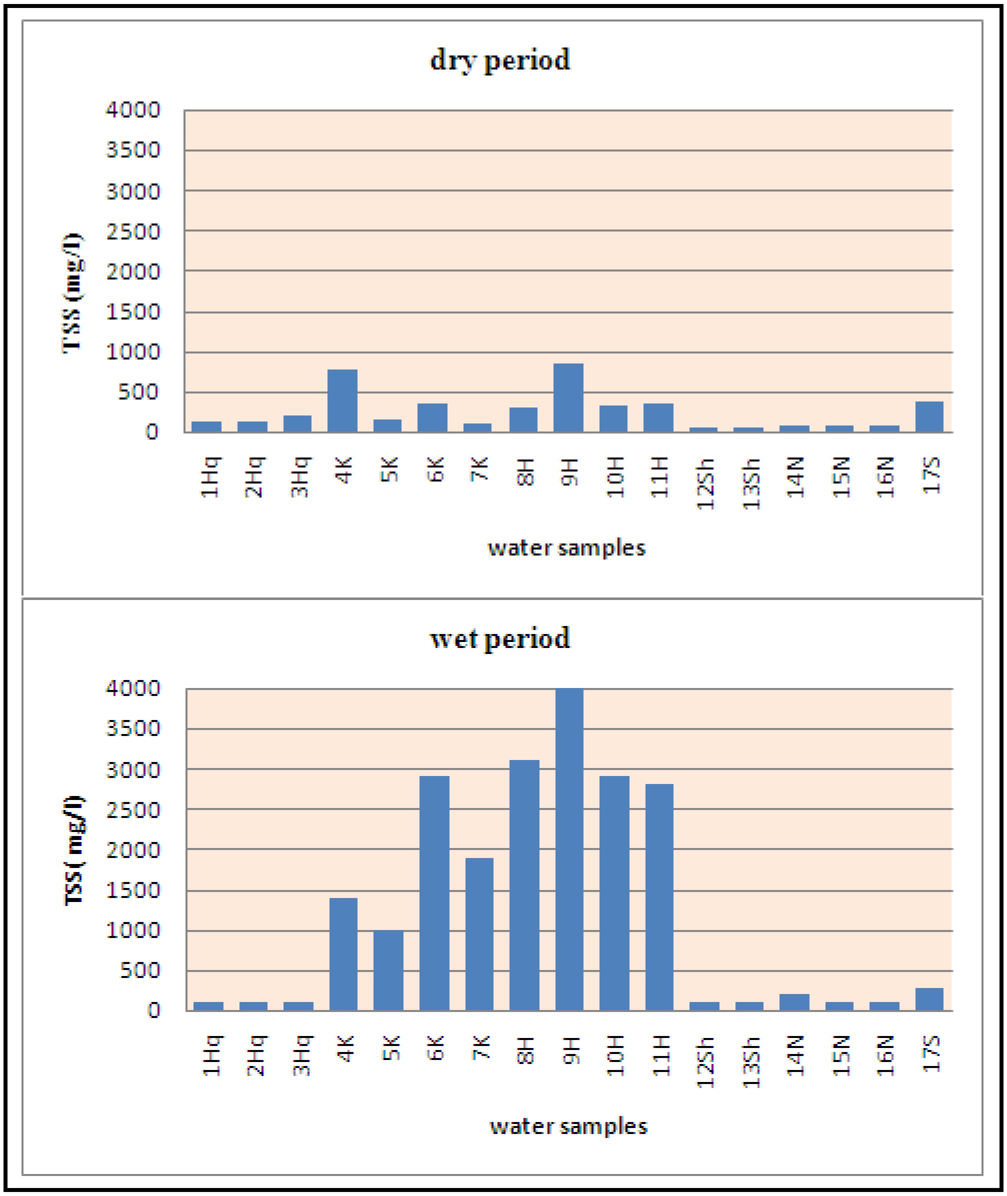

Figure 3-4: The TSS value for water samples during dry and wet period.

Generally, the TSS appears to be increased during the wet periods indicating rapid flow water from springs.

3-2-2 Chemical parameters

Naturally, groundwater contains ions. These ions slowly dissolve from soil particles and rocks as the water moves along mineral surface in the pores or fractures of the unsaturated zone and the aquifer. A list of the dissolved solids in any water is long, but it can be divided into 3 groups: major constituents, minor constituents and trace elements.

3-2-2-1 Cations

Four major cations ($Ca^{2+,}$ Mg^{2+}, Na^{+} and K^{+}) are studied as follows:

3-2-2-1-1 Calcium (Ca^{2+}), magnesium (Mg^{2+}) and total hardness (TH)

Calcium regarded an important major cation in water. Main source of Ca^{2+}derived from chemical weathering of rocks and mineral containing this ion such as limestone, dolomite, gypsum, aragonite, mineral of igneous rock such as feldspar ,amphibole, and pyroxene (Hem, 1985). Ca^{2+}concentrations in sedimentary rock reach 23 – 30% (Faure, 1998). Generally, water in Iraq rich by Ca^{2+}, which can attributed to sedimentary rock, Ca liberated during weathering goes into solution as bicarbonate, $Ca(HCO_3)_2$ from this $CaCO_3$ is precipitated nearly quantitatively in the carbonate sediments (Hem, 1985). Results of Ca are listed in Table (3-1 and 3-2).

During dry period, Ca in Haqlanya ranges between 288-320 ppm with an average of 306 ppm (Table 3-1); in Kubaysa ranges between 225-700 ppm with an average 374.7 ppm. In Hit, it ranges between 711-1010 with average 856.5 ppm; In Shithatha and Najaf the range is 160-177, 122-382 with average168.5 and 228 ppm respectively, finally, Ca in Sawa Lake is 781ppm.

At wet period, Ca ranges between 210-332 with average 285.6 ppm in Haqlanya, while in Kubaysa and Hit 257-802, 369-1202 with average 422.7 and 727 ppm respectively, as for Shithatha and Najaf it ranges between 71-125, 150-159 with average 98 and154 ppm respectively. In Sawa lake Ca concentration is up to 750 ppm .

Magnesium (3.4%) comes after Ca (20.39%) in lake and river water but in sea water it is more abundant (Mg 3.69%, Ca 1.15%). It is alkaline felsic earth element necessary for growth, nutrient of plant and animals (Hem, 1985). The common sources of Mg^{2+} in natural water are dolomite and ferromagnesian mineral.

Mg in Haqlanya , Kubaysa ,Hit ,Shithatha and Najaf range 134-146 94-378 , 367-410, 85.2-110 ,80-127 with average141.3,181.5,388,97.6 and 9.0 respectively, while in Sawa Lake is 282 ppm at dry period.(Table 3-1)

During the wet period, Mg concentration in Haqlanya, Kubaysa, Hit, Shithatha and Najaf range 121-158,163-373,185-828,36-84,78-88 with average 141,288,473.7,60, 83.6, while in Sawa lake was 1500 ppm. (Table 3-2).

Medically, Mg converts blood sugar to energy and promotes healthy skin. Balneology and hydrotherapy require high Mg concentration. Helps maintain water balance, colitis, brittle nails, muscle cramps, rheumatoid arthritis.

Total hardness presents the concentration of calcium and magnesium in water samples which is able to precipitate when it is heated and it is usually expressed as the equivalent of $CaCO_3$ (Faure, 1998). It can be calculated by the following equation:

TH = 2.497 Ca + 4.115 Mg

All are measured in (ppm).TH is an important criteria for determining the usability of water for domestic, drinking and many industrial uses (Karanth, 2008). Total Hardness concentration range between 637- 8575 with average 2283 ppm at dry period (Table 3-1), while 657-8045 with average 2243 ppm in wet period (Table 3-2). The value of total hardness over 300 therefore considered over very high (Todd , 1980).

3-2-2-1-2 Sodium (Na^+)

Sodium ion is one of the most reactive metals present in nature. Alkali feldspar is the main source of this element, and is also found in evaporation minerals such as halite and rock salt. The rain water is believed to be enriched in sodium ions, as resultant particles from the evaporation of seawater (Langmuir, 1997).

All natural water, cations have a measurable amount of sodium. Actual concentrations range from about 0.2 mg/L in some rain and snow to more than 100 000 mg/L in brine which are in contact with salt bed (Hamil and Bell, 1986). At dry period, Na concentration varies between 472-709 with average 553 in Haqlanya ; in Kubaysa ranges between 396-1294 with average 808ppm. In Hit ranges between 900-6690 with average 2530, as for

Shithatha and Najaf, Na range between 319-380, 135-320 with average 349.5, 235.3 ppm respectively. In Sawa Lake, Na concentration is 6240 ppm.

During wet period, Na in Haqlanya is 438-534 with average 500.6 ppm. In Kubaysa ranges 370-1384 with average 684.7ppm; in Hit it ranges 603-2815 with average 1378 ppm, while in Shithatha and Najaf range 130-428 with average 279 and 240-321with average 274 ppm respectively. In Sawa Lake Na concentration is 5200 ppm. Medically, sodium and natural salts assist with the alleviation of arthritic symptoms, and may stimulate the body's lymphatic system when used in baths as balneology use.

3-2-2-1-3 Potassium (K^+)

Although the abundance of potassium in the earth's crust is about the same as that of sodium, potassium is commonly less than one tenth the concentration of sodium in natural water like sodium, potassium is high soluble and therefore is not easily removed from water except by ion exchange (Hamil and Bell, 1986).

The concentration of K ion in rain water is about 312 µg/L, and in surface water is 2.3ppm, and it may reach 3ppm in the groundwater.

During Dry period, K in Haqlanya ranges between 100-116 ppm with average 107.3 ppm (Table 3-1); in Kubaysa, K ranges between 8.5-112 ppm with average 51.25ppm. In Hit, it ranges between 63-391with average 200 ppm; In Shithatha and Najaf range 10-13, 2-4 with average 11.5and 3 ppm respectively. In Sawa Lake, K concentration is 250 ppm.

At wet period, K ranges between 21-94.1,with average 45.7ppm in Haqlanya, while in Kubaysa and Hit, it ranges between 4.9-102, 16-479 with average 46.2, 176.2 ppm respectively. For Shithatha and Najaf, K ranges 2.3-56.7, 4-37.7 with average 29.5, 17.5 ppm respectively, whilst in Sawa Lake; K concentration is 389 ppm (Table 3-2).

Medically Potassium is assists in the normalization of heart rhythms, assists in reducing high blood pressure, helps to eliminate body toxins and promotes healthy skin.

3-2-2-2 Anions

In this study, the major anions ($SO_4^{=}$, Cl and HCO_3^-) as well as the minor anaions (NO3- and PO_4^{3-}) are discussed such as follows:

3-2-2-2-1 Sulfate ($SO_4^{=}$)

Sulfate occurs naturally in groundwater. It occurs in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4.7H_2O$), and gypsum ($CaSO_4.2H_2O$). Naturally comes from dissolution of sulfate mineral in evaporate (gypsum and anhydrite) (Todd, 1980). It also occurs as by product of oxidation of pyrite and marcasite in clay mineral (shale). Chemical fertilizers, soap, pesticide, SO_2 in air, are also the source of SO_4^{2-} (WHO, 1996).

During dry period, $SO_4^{=}$ in Haqlanya ranges between 674-1260with average 1062.3; in Kubaysa ,It ranges between 226-1236 with average 732.7 while in Hit ,It ranges between 326-2730 with average 1694. In Shithatha and Najaf, the range appears to be as 145-852,530-1200 with average 498and 802 ppm respectively. In Sawa Lake $SO_4^{=}$concentration is 8970 ppm . (Table 3-1).

At the wet period, $SO_4^{=}$ concentration in Haqlanya ranges 781-1300 with average 1096.3; in Kubaysa 951-2256 with average 1450.7, while in Hit it ranges 1600-3312 with average 1940.8 as for Shithatha and Najaf range 512-545 and 500-662 with average 528 and 557 ppm respectively and finally in Sawa Lake it up to 8500 ppm (Table 3-2).

Medically, sulfur and sulfates, mineralized sulfur-rich spring, in France, Spain, and Japan S and SO_4 are used to address a wide variety of conditions, including skin infections, respiratory problems, and skin inflammations. Mineralized springs rich in sulfates (i.e. sulfur compounds) have a far reduced "sulfur" effect as compared to Sulfur-rich springs. Such water are often prescribed internally for liver and gastrointestinal conditions, as well as for some respiratory conditions with inhalation therapy in European spas.

The source of SO_4^{2-} in the studied springs is mainly from gypsum and anhydrite dissolved from Fatha and Nfayil Formations, while the expected source of SO_4^{2-} in the Sawa Lake is the Rus Formation. Sulfate is partially reduced to form H_2S.

3-2-2-2-2 Chloride (Cl^-)

A major ion that present in all natural water, however, chloride also can be derived from human sources. It is not effectively removed by the septic systems and therefore, remains in their effluent high concentration of chloride in water is known to cause no health hazard. Hence, it is readily available in almost all potable water (Canter and Knox, 1985).

During the dry period, Cl^- concentration in Haqlanya ranges 643-1330with average 874.3; in Kubaysa 565-2220 with average 1328.2, while in Hit it ranges 1670-11800 with average 4584. In Shithatha and Najaf, it ranges 524-594 and 248-424 with average 559 and 324.3 ppm respectively. In Sawa Lake, Cl concentration is 9320 ppm (Table 3-1).

At wet period, Cl concentration in Haqlanya ranges 658-782 with average 718;in Kubaysa 650-2202 with average 1062.2 while in Hit ranges 719-3865 with average 2074 as for Shithatha and Najaf range 242-361 and 319-367 with average 301and 337 ppm respectively. In Sawa Lake, chloride concentration reaches to 8900 ppm (Table 3-2).

Saline hot springs are rich in sodium chloride. Mineral springs naturally rich in chlorides, in amounts between 3-5%, are considered by some researchers to be beneficial for rheumatic conditions, arthritis, central nervous system conditions, posttraumatic and postoperative disorders, as well as orthopedic and gynecological disease. These concentrations encourage establishing the therapeutic resorts**.**

3-2-2-2-3 Bicarbonate (HCO_3^-)

Bicarbonate combines with calcium and magnesium carbonate. The source of bicarbonate ions in ground water is from the dissolution of carbonate rocks and from carbonate species present with pH usually between 5 and 7 (Taylor, 1958). It was observed that below pH of 6, especially all dissolved carbonate species are in the form of H_2CO_3. Above pH=7, the ratio of $CO_3^=$ to H_2CO_3 increases (Drever, 1988).

The concentration HCO_3 during dry period in Haqlanya range 223-270with average252.6; in Kubaysa ranges 392-1380with average 684.5
In Hit it ranges between 410-1225 with average 788.7 while Shithatha and Najaf range111-551,61-436 with average 331,227 respectively at last Sawa Lake 104 ppm ,as for CO_3 27.5ppm (Table 3-1).

The concentration HCO_3 during wet period in Haqlanya ranges 361-508 with average 456.3; in Kubaysa ranges 262-1342 with average 610.5 In Hit it ranges 509-2440 with range 1237.5 while Shithatha and Najaf range 68-262,242-387,with average 165,336.6 respectively . Sawa Lake CO_3 concentration is 100 ppm (Table 3-2).

In Spain, bicarbonate water is classified as such if the water contains more than 250 ppm of free carbon gas. However, springs that contain bicarbonate (sodium bicarbonate, calcium bicarbonate, carbon dioxide, etc.) may also be utilized for the observed benefits commonly associated with bicarbonate hot springs.

Bathing in bicarbonate water, the balneologists believe, it assists opening peripheral blood vessels and helps to improve circulation to the body's extremities. European balneotherapists also utilize bicarbonate water for bathing to address hypertension and mild atherosclerosis. For these conditions, tepid to warm baths are utilized (20- 37.8˚C).

3-2-2-3 Secondary anions

3-2-2-3-1 Nitrate (NO_3^-)

Nitrate ion (NO_3^-) is the stable form of combined nitrogen for oxygenated system. Although chemically it is un-reactive, it can be reduced by microbial action (WHO, 1996). The sources of NO_3^- are waste water, oxidation of organic, nitrogen in soil, industrial waste, NO_2 gasses present in air (fuel burning) and fertilizer (Hudak, 2000). Distinguishing between NO_3^- which comes from geological source (sedimentary rock with high organic matter content, nitrogen convert to ammonia then to NO_3^-), and NO_3^- which comes from industrial source. NO_3^- which comes from geologic source associated with high concentration of chloride and absence of tritium (Radovan and Simpkin, 2001).

Nitrate range between 0.2-10 with average 4.41 ppm during dry period, while Nitrate varies between 0.2-11.4 with average 4.43ppm in wet period (Tables 3-1 and 3-2).

3-2-2-3-2 Phosphate (PO_4^{3-})

There is Phosphorus like Phosphate in the earth crust. The Apatite mineral groups are the main source that contains phosphorus in the earth crust forming a ratio 0.12%. They are abundant in shale, sandstone and carbonate rocks with a concentration (ppm) of 400, 170 and 700 respectively (Collins, 1975). Sediments contain a quantity of phosphate more than its presence in surface water and ground water (Boyd, 2000). Phosphorus is notable for strength in the sediment and is capable of forming ionic pairs with various metals, especially with Iron (Fe), Aluminum (Al), Magnesium (Mg) and calcium (Ca), making minerals more stable in aquatic environment with low temperature, there is a high concentration of phosphate ion in oxidizing conditions and those of semi equivalence conditions.

All springs water and Sawa lake during dry period, concentration of PO_4 is less than <0.04 ppm (Table 3-1).

3-2-3 Hydrogen sulfide (H_2S) and Carbon dioxide (CO_2)

a. Hydrogen sulfide

The rotten-egg odor of hydrogen sulfide can be detected by most people in water that have only a few tenths of a milligram per liter of this material in solution. (H_2S) is generated in natural water by sulfate reduction, all plants, animals, and bacteria metabolize sulfur in order to synthesize amino acids such as cysteine and methionine. The bacteria involved are of the genus *Desulfovibrio desulfuricans* or genus *Desulfotomaculum* and are heterotrophs, that is, they require organic matter for energy transfers (Langmuir, 1997) such as equation:

$$C + CaSO_4^{\,2-} \xrightarrow{\text{Anaerobic Bacteria}} CaS + 2CO_2$$
$$CaS + CO_2 + H_2O \longrightarrow CaCO_3 + H_2S\uparrow$$

When the concentration of H_2S exceeds 0.05 mg/l in drinking water it irritates mucous and cause nausea, vomiting, and epigastric pain following ingestion, and when inhaled, hydrogen sulfide is highly acutely toxic to human. It formed a complex with the Fe^{3+} of the mitochondrial, herby blocking oxidative metabolism (WHO, 2006).

During dry period, it ranges between 105-1082, whilst it ranges between 97-1989 ppm in wet period (Tables 3-1 and 3-2).

The public health guidelines for the concentration of H_2S (WHO 1981) are:

– The odor threshold for H_2S is in concentration range between 0.0005 and 0.13 ppm.

– Eye irritation may occur after exposure to concentrations of 10.5–21.0 ppm.

– Keratoconjunctivitis and pulmonary edema may occur after exposure to H_2S concentrations of 100–1,000 ppm.

– Concentration of H_2S more than 1,000 ppm causes acute intoxication.

b. Carbon dioxide

The average concentration of CO_2 in the water samples of the springs range between 3.1-44.8 with average 14.6 mg/l (Table 3-1).

The presence of CO_2 in the water of springs is hydrogeochemically attributed to the following dissolution reaction between the groundwater and their bearing horizons composed of limestone and dolomite

$$H^+ + CO_3^{2-} \longrightarrow HCO_3^-$$
$$H^+ + HCO_3^- \longrightarrow H_2CO_3^-$$
$$H_2CO_3^- \longrightarrow CO_2 + H_2O$$

The variation in the concentration of CO_2 is controlled by the escapement degree of CO_2 bubbles from the water solution, which increased in the shallow aquifer causing lowering in the CO_2 concentration.

According to Laboutka (1974), the water of all springs are not classified as carbon dioxide water because their concentrations are less than the recommended limit (500 mg/L) which is used for classification. Also, these aspects indicate that the spring water cannot be used for CO_2 therapeutic purposes, which need a CO_2 concentration more than 250 mg/l, in accordance with the Japanese balneotherapeutic definition (Agishi and Ohatsuka 1998).

3-2-4 Trace elements

Trace constituent s mostly occur in range 0.0001- 0.1mg/l. It includes light and heavy elements. All trace elements are essential for life, but increase and decrease their concentration in body causes physiological damage. There is no doubt that the increased use of metals and their dispersal in the environment will affect the soil and groundwater. Agricultural pollution in the form of fertilizers is expected to contribute to metal dispersal in the subsoil (Vissers et al., 2007). Also diffuse atmospheric trace element pollution will most probably influence groundwater background concentrations (Nriagu, 1989). Furthermore, the changes in pH, redox potential (Eh), and salinity associate with many forms of pollution are known to indirectly affect heavy element concentrations in groundwater (Kjoller et.al. 2004). To reinstate homeostasis, the body requires the supplementation of the missing element. Balneology may help in restore the element balance in cells by absorbing trace elements via the skin from water. The mineral water and trace elements detoxifies and regenerates the body and refreshes mind.

Trace elements are very important in Balneological and hydrotherapy studies, For this reason, trace elements (Pb, Cd, Ni, Co, Zn, Fe, Mn, Cu) which measured during two period while these elements (Cr, Hg, As, Mo, Se, Ag, Br, F, Li, Sr, Ba, B, Be, Th) are analyzed just during dry period in (ALS global Lab in Czech Republic).

3-2-4-1 Lead (Pb)

Lead is a naturally occurring element found in bedrock ore, but rarely in source water. The amount of lead dissolved into water depends on factors such as pH, Alkalinity, water temperature and hardness, flow length and time, within a reduction environment the deposited lead sulfide will increase its concentration in sediments (Drever, 1997).

During dry period, the concentration of Pb in three springs of Haqlanya is 0.01ppm; in Kubaysa varies between 0.06-0.27 with average 0.13, while in Hit it ranges between 0.16-0.26 with average 0.19 ppm. In Shithatha the concentration of Pb is 0.1 for two springs, while in Najaf, it varies between 0.14-0.17 with average 0.15ppm. In Sawa Lake Pb concentration is 0.37 ppm (Table 3-1).

At wet period, the concentration of Pb in three springs of Haqlanya is 0.02 ppm; in Kubaysa ranges between 0. 8-2.3 with average of 1.3 while in Hit, it ranges 0.01-2.3 with average of 1.09ppm, as for Shithatha and Najaf range between 1.4-1.6, 0.2-0.3 with average 1.5, 0.23 respectively. Lead concentration in Sawa Lake is 0.26 ppm (Table 3-2).

3-2-4-2 Cadmium (Cd)

Cadmium is found in very low concentrations in most rocks, as well as in coal and petroleum. It can be present in groundwater through contact with dissolved rocks and minerals. There are other sources of cadmium in groundwater such as mining, smelting and industrial operation and also the burning of fossil fuels, fertilizers, sewages, leaching of landfills in addition to corrosion of galvanized pipe. In water, cadmium has no taste, odor or color and it can only be detected through a chemical test. The cadmium ion has a tendency to link with Sulfur, where the later represent its main host (Fairbridge, 1972).

The concentration of Cd in the dry period in all spring study of Haqlanya is 0.02 ppm ,in Kubaysa is below detected limited except 6K concentration is 0.01ppm while Hit it ranges between 0.004-0.04 with average 0.01except 8H recorded BDL .As for Shithatha ranges 0.01-0.02 with average 0.015ppm whilst all Najaf springs in study area are BDL ,finally Sawa Lake cadmium concentration is 0.04 ppm (Table 3-1).

During wet period in Haqlanya the concentration of Cd ranges between 0.07-0.09 with average 0.08 .While Kubaysa is below detected limited except 6K concentration is 0.02ppm .As for Hit concentration of Cd is 0.12 for 10H, 11H and other spring are BDL ,Shithatha BDL for two springs and Najaf concentration is 0.04 ppm .finally Sawa Lake Cd concentration is 0.05 ppm (Table 3-2) .

3-2-4-3 Nickel (Ni)

A large number of Nickel compounds have been identified and characterized; many of them, such as Nickel Sulfate, Nickel Nitrate, Nickel Chloride and Nickel Acetate are relatively soluble in water. Other Nickel such as Nickel Hydroxide, Nickel Oxide, and Nickel Sulfide occur virtually soluble in water (Fan et. al., 2000). It inters groundwater and surface water by dissolution of rocks and soils, from atmospheric fallout, from biological decays and from waste disposal. Many Nickel compounds are relatively soluble in water, especially at pH value less than 6.5. This pH is available in the spring water. Generally exists as Nickel ions in aqueous systems. The Nickel content of groundwater is normally below 20 µg/l. Nickel ions are characterized by the ability of moving and migrating for long distances. It has tendency to adsorb with Iron Oxides and Manganese. A relationship also between (SO_4^{-2}) and Nickel in the water of alkaline and reducing environments, because (SO_4^{-2}) is reduced to (H_2S) and the resultant compound will dissolve (Gassama, 1994).

The concentration of Ni at dry period in Haqlanya is0.04ppm; Kubaysa, it ranges between 0.07-0.22 with average of 0.11ppm; for Hit, it ranges between 0.13-0.21with average of 0.16 ppm , for Shithatha it ranges between 0.04 -0.05 with average 0.045 ,Najaf Nickel concentration is 0.1ppm ,finally Sawa Lake is 0.42 ppm .(Table 3-1).

During wet period Nickel concentration in Haqlanya springs is 0.03 ppm .Kubaysa, Hit are range between 0.08-0.2, 0.2-0.3 with average of 0.11, 0.22 ppm respectively. For Shithatha springs Nickel concentration is 0.03 while Najaf is 0. 2 ppm finally Sawa Lake is 0.3ppm (Table 3-2).

3-2-4-4 Zinc (Zn)

Concentration of free Zinc ion usually is low because the controlling minerals have low solubility within the pH range of most natural water (Boyd, 2000). The Zinc ion precipitates when pH value is in between 7-9 from of Zinc Sulfide (ZnS), when the Sulfur deposits were found (Drever, 1997). Zinc is available in the earth crust in ratio of 75 ppm, in limestone of 20ppm and Shale of 120ppm. Zn concentration in freshwater ranges between 0.2-100 ppb and in the sea water ranges between 0.2-48 ppb (Alloway and Ayers, 1997), in river water reaches 20ppb, in surface water ranges between 10-250ppb and in groundwater reaches 8.9 ppb (Crompton, 1997).

The concentration of Zn in dry period at Haqlanya range between 0.03-0.07 with average 0.05 ppm ,In Kubaysa range between 0.08-0.22 with average 0.13 ppm as for Hit all study springs Nickel is BDL ,while in Shithatha and Najaf range 0.01-0.07, 0.06-0.5 with average 0.04, 0.34 ppm Respectively .finally Sawa Lake is 0.1(Table 3-1)

During wet period all study spring the concentration of Zn are below detected limited (BDL). Medically, zinc element is useful for skin, hair, and nail conditions.

3-2-4-5 Copper (Cu)

Copper is found naturally in rock, soil, plants, animals and water. Copper often occurs in nature as a metal in minerals. The principal copper ores are Sulfates, Oxides and Carbonates (Drever, 1997). Copper is frequently found naturally in groundwater; but with levels that are generally very low. Common Synthetic sources of Copper are fertilizers, animal Feedlots, industrial waste, septic system and food processing waste may cause increase Cu concentration in water.

The concentration of Cu in dry period in Haqlanya is BDL while in Kubaysa and Hit range between 0.01-0.06,0.03-0.07 with average 0.03,0.04ppm respectively Except 7K is BDL.as for Shithatha the concentration of Cu is BDL , while Najaf concentration is 0.02 ppm ,finally Sawa Lake is 0.04 ppm (Table 3-1)

During wet period all study spring Cu concentration are below detected limited. Medically cupper is useful for Infections and viral illnesses, rheumatoid arthritis, influenza, pigmentation disorder.

3-2-4-6 Iron (Fe) and manganese (Mn)

Iron and manganese are metallic elements present in many types of rocks. Iron and manganese ions both are commonly found in water and are essential elements required in small amounts by all living organisms. Concentrations of iron and manganese in groundwater are often higher than those measured in surface water. The most common sources of iron and manganese in ground water are naturally occurring, for example from weathering of iron and manganese bearing minerals and rocks. Iron ions are formed as dissolved ferrous ion (Fe^{2+}) in natural water and hot springs under reductive conditions where it transforms to ferric Ions (Fe^{+3}) under oxidizing conditions (Boyd, 2000).

The concentration of Fe in dry period in Haqlanya is 0.01 while in Kubaysa it ranges between 0.03-0.08 with average 0.05 as for Hit it ranges 0.08-0.26 with average 0.13 ppm ,Shithatha is BDL whilst Najaf ranges 0.07-0.08 with average 0.073 .finally Sawa Lake concentrations of Fe is 0.4ppm (Table 3-1).

During wet period Fe in Haqlanya concentration is 0.01, Kubaysa is BDL except 7K concentration is 0.04 while Hit it ranges 0.03-0.04 with average of 0.036 ppm except 8H is BDL, for Shithatha and Najaf are also BDL and finally Sawa Lake is 0.1 ppm (Table 3-2).

The concentration of manganese during dry period in Haqlanya is 0.0009 while in Kubaysa and Hit are 0.01, 0.03 ppm respectively. For Shithaha,Najaf and Sawa Lake less than 0.0005 ppm . During wet period all study spring Mn concentration are below detected limited

3-2-4-7 Arsenic (As)

Arsenic is one of the most toxic elements in our environment and is listed as the third most toxic substance, after lead and mercury in the US Toxic Substances and Disease Registry (Naidu et al. 2006). Arsenic is present in both inorganic and organic forms (Smedley and Kinniburgh 2002). Generally, inorganic arsenic species are more toxic than organic forms to living organisms (Goessler and Kuehnett 2002; Meharg and Hartley-Whitaker 2002; Ng 2005). Inorganic arsenic was regarded as the number one toxin in the USEPA list of prioritized pollutants (Ahmad, 2001). Exposure to As may come from both natural sources and anthropogenic activities, including industrial sources and food and beverages. However, natural sources of As have led to the largest incidence of poisoning (Naidu et al., 2006). Natural groundwater As contamination has been reported from more than 70 countries in the world (Sharma and Sohn ,2009).

The concentration of As for all samples in dry period is less than 0.01ppm. Medically despite Arsenic in larger doses is toxic in the human body, minute amounts may assist the body with plasma and tissue growth. Foot bathing in mineral water with a high content of arsenic is used to address fungal conditions of the feet.

3-2-4-8 Strontium

The Sr like calcium ion is chemically and replaces it in the installation of some minerals. Strontium ion concentration in the water depends on the ion exchange process with limestone. Oilfield water contains a high concentration of this ion. The average concentration of this ion in the groundwater ranges between 2-10 ppm (Hem, 1989).

The spring water in the study area are rich with this ion reflecting the mixing of deep-water.

The concentration of Sr in dry period in Haqlanya it is ranges between 4.2-4.5 with average 4.36 ppm, in Kubaysa ranges 7.07-20.2 with average10.9 as for Hit it is ranges between 26.76-48.58 with average 36.12 ppm.

3-2-4-9 Boron (B) and fluoride (F^-)

Boron is considered one of the elements represents minor group found in ground water effects human health. The permissible concentration is 1.0 ppm, whereas F^- ranges between 1.5-2.4 ppm. Boron mostly existed as borate salts BO_3. Boron builds muscle mass, increases brain activity and strengthens bones. Fluoride deficiency affects Dental caries, bone growth difficulties, tendon and ligament problems, loss of elasticity in the veins, osteoarthritis.

The concentration of B and F in dry period in Haqlanya it is ranges between 1.3-4 and 1.1-1.9 with average 1.32 ,1.6 ppm respectively, In Kubaysa ranges between 1.5-1.6 and 0.6-0.9 with average 1.55 and 0.75

respectively. In Hit they range 5-7, 1.8-2 with average 5.85 and 1.92 ppm respectively. In Shithath B concentration 0.9 while F 1.0 ppm and in Najaf they range between 0.56-0.66 and 1.2-1.4 with average 0.6 and 1.32ppm. In Sawa Lake the concentration of B and F are 12.4 and 9.25 ppm respectively.

In addition to the elements mentioned above are also other elements of no less importance were analyzed, these are Co, Cr, Hg, Mo, Se, Ag, Br, Li, Ba, Be where necessary for therapeutic uses.

3-2-5 Biological tests

Bacterial tests in spring water are carried out on the spring samples. All tests are done in Department of Biology and Laboratory of Water Treatment Technology at the Ministry of Science and Technology. The identified species of bacteria as well as algae and fungi are explained below. BOD5 and DO are done in Laboratory of Water Treatment Technology at the Ministry of Science and Technology.

3-2-5-1 Total number of coliform

The coliform group of bacteria is defined as aerobic and facultative an aerobic non spore forming Gram's – stain negative that ferment lactose with gas production within 48hr of incubation. The basic coliform analysis is a fermentation of bacteria in makonky bronth media based on gas production which is an evidence that coliforms have converted the lactose sugar into lactic. If no gases appear in the vial test the result is negative (Hammer & Viessman, 2005).

Table 3-4: Water class and water type based on coliform counting (after Abdul Redah, 1984)

Account per 100 ml Of coliform	Water class	Water type
< 1	one	normal
1 – 2	two	acceptable
3 – 10	three	doubtful
>10	four	non-acceptable

This group of bacteria is to recur in human & animal gastro in sestina. Several factors affect the rate at which bacteria grow, including temperature, pH, and oxygen levels. The warmer the environment, the faster the rate of growth. Generally, for each increase of 10°C, the growth rate doubles (Spellman, 2003), also they are influenced by water discharge, dust deposition, organic matter and incidence of human and animal pollution (Mutlak et.al., 1980).

3-2-5-2 Total number of fecal coliform

Escherichia coli are non-spore-forming, Gram-negative bacteria, usually motile by peritrichous flagella. They are facultative anaerobic with gas usually produce from fermentable carbohydrates (Hunter et al., 2004). The common test for fecal coliform is a second phase confirmatory test following growth of coli forms in the presumptive total coliform test (Hammer & Viessman, 2005). Presence of coliform is better indicator of fecal coliform concentration, (Davis & Mastin 2004). Is a potential hazard of exposure of water consumer to other pathogenic, principle indicator of suitability of particular water for domestic (APHA, 1975). Coliform group was chosen as indicator for pollution; because it was found in human gastrointestinal tract at very high levels, because coliform have been shows to have resistance similar to most pathogens (Tat & Trussel, 1977).

Table 3-5 present the result of bacterial analyses in the spring wateer. The total number of bacteria in the waters of the springs was calculated. All identified types of bacteria were isolated from each other. The largest number of bacteria found in Kubaysa (spring 5K), but the lowest number was found in Hit (spring 11H). All the spring water contain bacteria except Shithathah Najaf and Sawa Lake. All springs appear to be free of bacteria Streptococcus, clostridium, Yeast and modules, while all the springs contain bacteria *Bacilli*, *Lactobacillus*, *pseudomonas* as well as Algae and fungi.

A variety of nonpathogenic filamentous fungi have recently been isolated from the Dead Sea water. Some species may survive in the hypersaline brine for extended time periods (Ma’or et al., 2006). In the present study, Fungi were identified in the spring water (Table 3-5).

Table 3-5: Result of microbiological tests of springs water, N= negative that mean pathogen doesn't found it in the samples, P= positive that mean pathogen found in the samples.

pathogen	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
Total number of bacteria	600	650	610	840	900	300	150	380	N	300	85	N	N	N	N	N	N
coli bacteria	9	4	7	43	15	23	23	N	N	24	15	N	N	N	N	N	N
Fecal coil	N	N	N	P	P	P	P	N	N	P	P	N	N	N	N	N	N
Escherichia coli	N	N	N	P	P	P	P	N	N	P	P	N	N	N	N	N	N
Streptococcus	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Aclostridium	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Bacilli	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Lactobacillus	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Staphylococcus	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
pseudomonas	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Yeast and moduls	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
Alga and fungi	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P

3-2-5 -3 Dissolved Oxygen and Biological Oxygen Demand

Dissolved oxygen (DO) is defined as the measure of water quality indicating free oxygen dissolved in water. The quantity of dissolved oxygen in water is typically expressed in ppm or mg/l. Since oxygen is soluble in water, the amount of dissolved oxygen in water is in the state of dynamic equilibrium. The solubility of the dissolved oxygen is proportional to the temperature and pressure of the water, therefore the concentration of dissolved oxygen in water is affected by many factors including ambient temperature, atmospheric pressure, and ion activity.

Biological oxygen demand (BOD_5) is a measure of the amount of oxygen required by aerobic micro-organism to break down the organic compound to less harmful substances such as carbon dioxide it is the quantity of oxygen used by micro-organisms in the aerobic stabilization of waste water and polluted water. The standard 5-days at 20°C BOD_5 value is commonly used to define the strength of polluted municipal waste water (Hammer and Viessman, 2005). Pollution index of aquatic body is good index of water quality are shown in Table 3-6. It is preferable to correlate the result of this study with this index. Results are listed in Table 3-7 presenting the quality of spring water ranges between clean to critical. Each spring has independent and distinct properties, therefore positive correlation between DO and BOD was found (Figure 3-5).

Table 3-6: Pollution Index of water quality (Pandey, et al, 2005).

Water Type	**BOD_5(ppm)**
Very clean	**<1**
Clean	**2**
May be clean	**3**
Critical	**5**
Polluted	**>10**

Table 3-7: Dissolved oxygen (DO) and Biological oxygen demand (BOD_5) during wet period.

Sample no	ppm		Quality
	DO	BOD_5	
1Hq	4.9	2.1	Clean
2Hq	5.0	2.1	Clean
3Hq	5.0	2.1	Clean
4K	4.2	3.0	May be clean
5K	4.9	3.0	May be clean
6K	9.2	5.6	Critical
7K	7.1	5.5	Critical
8H	7.6	6.0	Critical
9H	8.7	7.0	Critical
10H	8.2	6.5	Critical
11H	8.9	7.3	Critical
12Sh	5.1	2.9	Clean
13Sh	3.7	2.2	Clean
14N	3.5	2.4	Clean
15N	3.2	2.2	Clean
16N	3.6	2.2	Clean
17S	6.5	5.0	Critical
Range	3.2-9.2	2.1-7.3	Clean-Critical

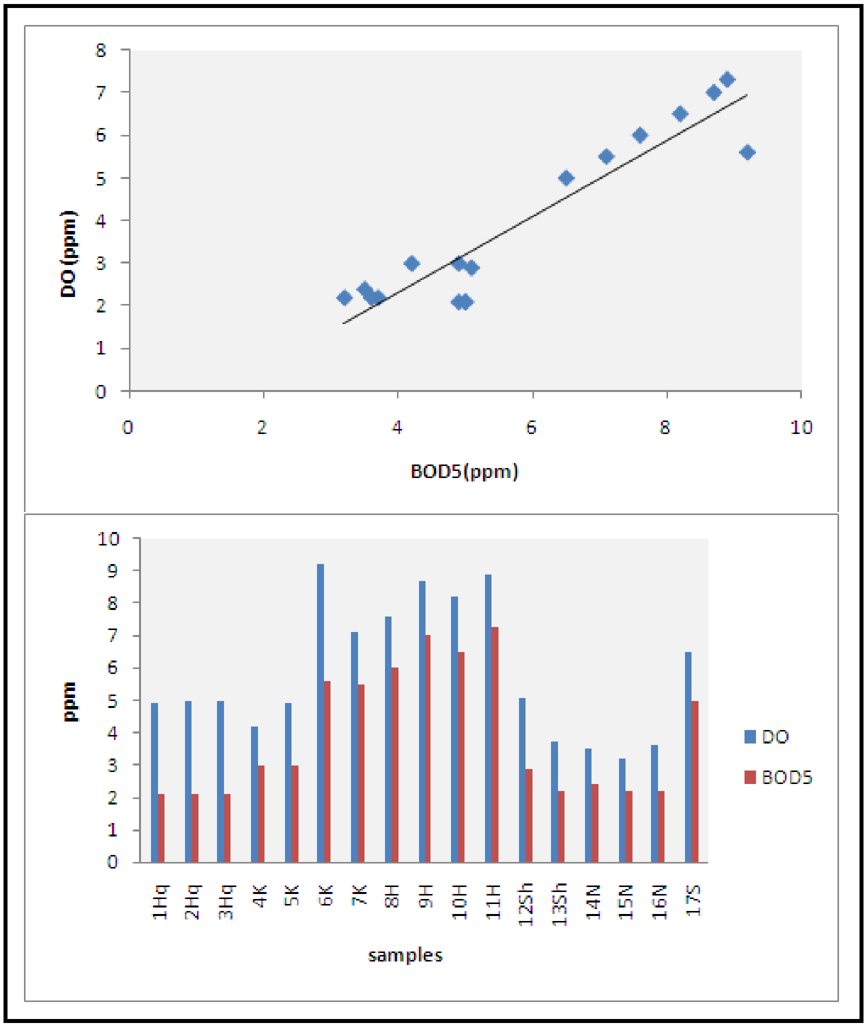

Figure 3-5: the relationship between DO and BOD and distribution during wet period.

3-3 Water quality

For the purpose for finding the water quality, hydrochemical formula and water classification will be presented below.

3-3-1 Hydrochemical formula

Hydrochemical formula can be determined according to Ivanov (1968) by the formula below:

$$\text{TDS gm/l} \; \frac{\text{Anion epm\% decreasing order}}{\text{Cation epm\% decreasing order}} \; \text{pH}$$

Cation and anion unit is epm % decreasing in order, TDS in gm/l. Values (epm%) less than 15% should be ignored from the formula.

According to the chemical formula, it is simple to classify the spring water type. Tables 3-8 and 3-9 describe water type during dry and wet periods. Haqlanya, Hit and Shithatha springs are characterized by Na-chloride and Na- sulfate. Kubaysa springs are characterized by Na- chloride during dry period, whilst it converts to Na- sulfate during wet dry. Najaf springs are characterized by Na,Mg- sulfate, whereas Sawa Lake is characterized by Na-chloride during the both periods.

Table 3-8: Hydrochemical formula of the spring water during dry period, TDS in gm/l.

Sample No.	Chemical formula	Water type
1Hq	$TDS_{(3.340)} \frac{Cl(67.84)SO4(25.42)HCO3(6.73)}{Na(52.54)Ca(24.54)Mg(18.79)K(4.11)} pH_{(7.3)}$	Na-Ca-Mg-SO_4 -chloride
2Hq	$TDS_{(3.324)} \frac{SO4(53.50)Cl(37.32)HCO3(9.17)}{Na(42.20)Ca(32.35)Mg(24.30)K(1.14)} pH_{(7.1)}$	Na-Ca-Mg-Cl -sulfate
3Hq	$TDS_{(3.311)} \frac{SO4(53.67)Cl(37.24)HCO3(9.08)}{Na(42.30)Ca(32.15)Mg(24.43)K(1.10)} pH_{(7.2)}$	Na-Ca-Mg-Cl- sulfate
4K	$TDS_{(2.931)} \frac{Cl(49.11)HCO3(25.87)SO4(25.01)}{Na(47.28)Ca(30.89)Mg(21.24)K(0.57)} pH_{(7.3)}$	Na-Ca-Mg- HCO_3-SO_4- chloride
5K	$TDS_{(4.568)} \frac{Cl(46.28)SO4(41.63)HCO3(12.08)}{Na(54.06)Ca(27.11)Mg(18.59)K(0.22)} pH_{(7.2)}$	Na-Ca-Mg-SO_4- chloride
6K	$TDS_{(15.990)} \frac{Cl(56.19)SO4(23.13)HCO3(5.01)}{Na(45.95)Ca(28.53)Mg(24.93)K(1.43)} pH_{(7.4)}$	Na-Ca-Mg-SO_4 -chloride
7K	$TDS_{(3.758)} \frac{Cl(78.80)HCO3(13.16)SO4(8.03)}{Na(58.50)Ca(20.64)Mg(16.72)K(4.12)} pH_{(7.2)}$	Na-Ca-Mg -chloride
8H	$TDS_{(11.960)} \frac{SO4(42.67)Cl(41.89)HCO3(15.43)}{Na(35.10)Ca(34.98)Mg(29.53)K(0.36)} pH_{(7.4)}$	Na-Ca-Mg-Cl-HCO_3-sulfate
9H	$TDS_{(23.890)} \frac{Cl(96.06)HCO3(1.97)SO4(1.96)}{Na(75.77)Ca(13.15)Mg(7.86)K(3.19)} pH_{(7.5)}$	Na-Ca-Mg -chloride
10H	$TDS_{(13.800)} \frac{SO4(47.65)Cl(45.64)HCO3(6.70)}{Na(40.54)Ca(28.95)Mg(27.48)K(3.02)} pH_{(7.1)}$	Na-Ca-Mg-Cl- sulfate
11H	$TDS_{(17.020)} \frac{Cl(62.7)SO4(22.32)HCO3(15.40)}{Na(43.12)Ca(33.27)Mg(22.20)K(1.19)} pH_{(7.2)}$	Na-Ca-Mg-SO_4-HCO_3-chloride
12Sh	$TDS_{(2.223)} \frac{SO4(51.65)Cl(42.95)HCO3(5.38)}{Na(49.12)Mg(26.91)Ca(23.78)K(0.17)} pH_{(7.1)}$	Na- Mg-Ca-Cl- sulfate
13Sh	$TDS_{(1.724)} \frac{Cl(57.82)HCO3(31.73)SO4(10.4)}{Na(44.47)Ca(28.37)Mg(22.48)K(4.66)} pH_{(7.3)}$	Na-Ca-Mg- HCO_3-chloride
14N	$TDS_{(2.204)} \frac{SO4(47.17)Cl(28.44)HCO3(24.37)}{Na(47.12)Ca(30.40)Mg(22.24)K(0.34)} pH_{(7.4)}$	Na-Ca-Mg-Cl-HCO_3- sulfate
15N	$TDS_{(1.819)} \frac{SO4(57.97)Cl(36.68)HCO3(5.33)}{Mg(35.23)Ca(32.24)Na(31.02)K(1.49)} pH_{(7.5)}$	Mg-Ca -Na- Cl- sulfate
16N	$TDS_{(1.803)} \frac{SO4(62.48)Cl(29.85)HCO3(7.66)}{Ca(46.09)Na(26.33)Mg(25.22)K(2.33)} pH_{(7.5)}$	Ca-Na- Mg-Cl- sulfate
17S	$TDS_{(33.506)} \frac{Cl(63.24)HCO3(36.01)CO3(0.21)SO4(0.52)}{Na(59.91)Mg(29.26)Ca(8.62)K(2.20)} pH_{(8.5)}$	Na- Mg-Ca- HCO_3-chloride

Table 3-9: Hydrochemical formula of the spring water during wet period, TDS in gm/l.

Sample No.	Chemical formula	Water type
1Hq	$TDS_{(4.930)} \frac{Cl(49.70)SO4(36.71)HCO3(13.57)}{Na(50.02)\ Ca(22.79)Mg(21.61)K(5.56)} pH_{(7.4)}$	Na-Ca-Mg-SO4-HCO3-chloride
2Hq	$TDS_{(4.900)} \frac{SO4(48.63)Cl(36.16)\ HCO3(15.20)}{Na(42.20)Ca(32.35)Mg(23.30)K\ (5.33)} pH_{(7.5)}$	Na-Ca-Mg-Cl-HCO3-sulfate
3Hq	$TDS_{(4.940)} \frac{SO4(48.36)Cl(35.62)HCO3(16.01)}{Na(38.57)Ca(31.90)Mg(24)K(5.50)} pH_{(7.6)}$	Na-Ca-Mg-Cl-HCO3-sulfate
4K	$TDS_{(4.\ 240)} \frac{SO4(46.62)\ Cl\ (43.09)\ HCO3\ (10.27)}{Na\ (36.04)\ Mg\ (34.67)Ca(28.47)K(0.48)} pH_{(7.2)}$	Na- Mg-Ca-Cl- sulfate
5K	$TDS_{(5.900)} \frac{SO4\ (53.03)\ Cl(32.19)HCO3\ (14.48)}{Na\ (41.81)Ca(29.21)Mg\ (24.43)K\ (4.53)} pH_{(7.3)}$	Na-Ca-Mg-Cl-HCO_3- sulfate
6K	$TDS_{(17.270)} \frac{Cl\ (47.20)SO4(35.77)HCO3\ (17.02)}{Na\ (45.27)Ca(30.17)Mg\ (23.10)K(1.44)} pH_{(7.3)}$	Na-Ca-Mg-SO_4-HCO_3-chloride
7K	$TDS_{(5.260)} \frac{SO4(46.63)\ Cl\ (43.03)HCO3(10.33)}{Na\ (37.92)Mg\ (31.12)Ca(30.38)\ K(0.56)} pH_{(7.4)}$	Na- Mg-Ca- Cl- sulfate
8H	$TDS_{(14.190)} \frac{SO4\ (42.55)\ Cl(42.51)HCO3(14.92)}{Na(46.34)\ Ca(26.74)Mg(25.25)K\ (1.65)} pH_{(7.5)}$	Na-Ca-Mg-Cl- sulfate
9H	$TDS_{(30.000)} \frac{Cl\ (49.81)SO4(31.57)HCO3(18.60)}{Na\ (47.67)Mg\ (26.54)Ca\ (23.41)K(2.36)} pH_{(7.1)}$	Na- Mg-Ca- SO_4-HCO_3-chloride
10H	$TDS_{(5.860)} \frac{SO4\ (53.70)Cl(32.63)HCO3\ (13.66)}{Na(41.82)\ Ca(29.43)Mg(24.28)K(4.45)} pH_{(7.1)}$	Na-Ca-Mg-Cl -sulfate
11H	$TDS_{(16.690)} \frac{SO4\ (44.93)Cl\ (42.47)\ HCO3\ (12.58)}{Mg\ (33.19)Na\ (31.66)\ Ca(28.20)K(6.94)} pH_{(7.3)}$	Mg-Na-Ca- Cl- sulfate
12Sh	$TDS_{(2.680)} \frac{SO4(58.81)\ Cl(35.31)HCO3(5.87)}{Mg(36.24)Ca(32.77)Na(29.63)\ K(1.34)} pH_{(7.2)}$	Mg -Ca-Na-Cl -sulfate
13Sh	$TDS_{(2.680)} \frac{SO4(42.32)\ Cl\ (40.34)HCO3(17.32)}{Na\ (73.10)Ca(13.94)\ Mg(11.64)\ K(1.39)} pH_{(7.2)}$	Na-Ca-Mg-Cl-HCO_3- sulfate
14N	$TDS_{(1.819)} \frac{SO4\ (48.97)\ Cl(36.70)\ HCO3(14.32)}{Na(49.18)\ Ca(28.01)Mg\ (22.62)K(0.18)} pH_{(7.1)}$	Na-Ca-Mg-Cl-HCO_3- sulfate
15N	$TDS_{(2.970)} \frac{SO4\ (40.29)Cl\ (34.75)\ HCO3(24.94)}{Na(43.27)\ Ca(28.70)Mg\ (27.72)K(0.29)} pH_{(7.6)}$	Na-Ca-Mg-Cl-HCO_3-sulfate
16N	$TDS_{(2.970)} \frac{SO4\ (40.44)Cl\ (35.38)\ HCO3(24.17)}{Na41.27\ \ Ca(30.65)Mg\ (27.67)K\ (0.40)} pH_{(7.5)}$	Na-Ca-Mg-SO4-Cl-HCO_3- sulfate
17S	$TDS_{(16.865)} \frac{Cl(58.26)SO4(41.15)HCO3\ (0.38)CO3(0.19)}{Na\ (57.46)Mg(31.37)Ca(9.53)\ K(1.62)} pH_{(8.4)}$	Na- Mg- Ca -SO_4 -chloride

3-3-2 Piper diagram

Piper diagram (Figure 3-6) can show the percentage composition of the three ions by grouping Na^+ and K^+ together, the major cations can be displayed on one trilinear diagram, as well as the three groups of the major anions. Analyses are plotted on the basis of the percent of each calculated cation and anion. Each apex of triangle represents a 100% concentration of one of the three constituents. The diamond-shaped field between the two triangles is used to represent the composition of water with respect to both cations and anions. As groundwater flows through the aquifer it assumes a diagnostic chemical composition as a result of interaction with the lithologic framework. The term hydrochemical facies is used to describe the bodies of groundwater. The facies are function of the lithology, solution kinetics, and flow patterns of the aquifer. Hydrochemical facies can be classified on the basis of the dominant ions in the facies by means of the trilinear diagram (Fetter, 2001).

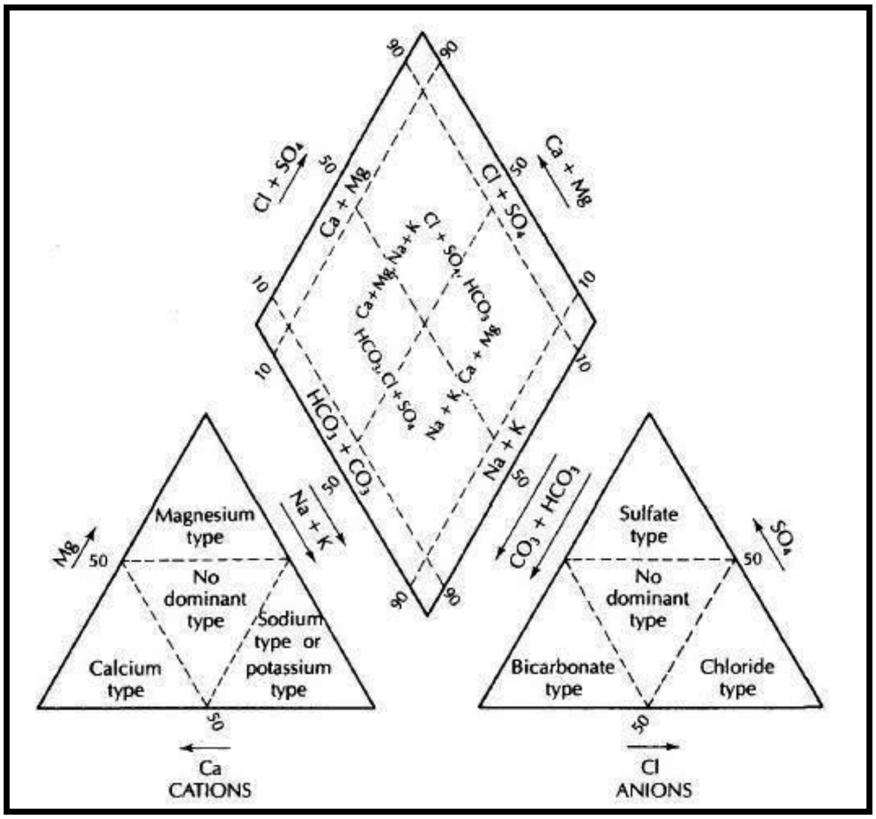

Figure 3-6: Hydrochemical classification system for natural water using Piper diagram (Fetter, 2001).

When comparing the values of cations and anions of the water samples for two periods (Figures 3-7), with the hydrochemical classification diagram in figure 3-6. It can be concluded that the general facies of spring water are (Cl^-- SO_4^{2-}) water for the two periods (dry and wet). The reasons behind these different chemical springs types can be referred to the active ion exchange between the spring water and the Euphrates and Fatha formation. Moreover, by the application of the ionic concentration percentage frequency relationship method, it was found that cations and anions are the classified as (Cl^-- SO_4^{2-}) and (Na^+) in most.

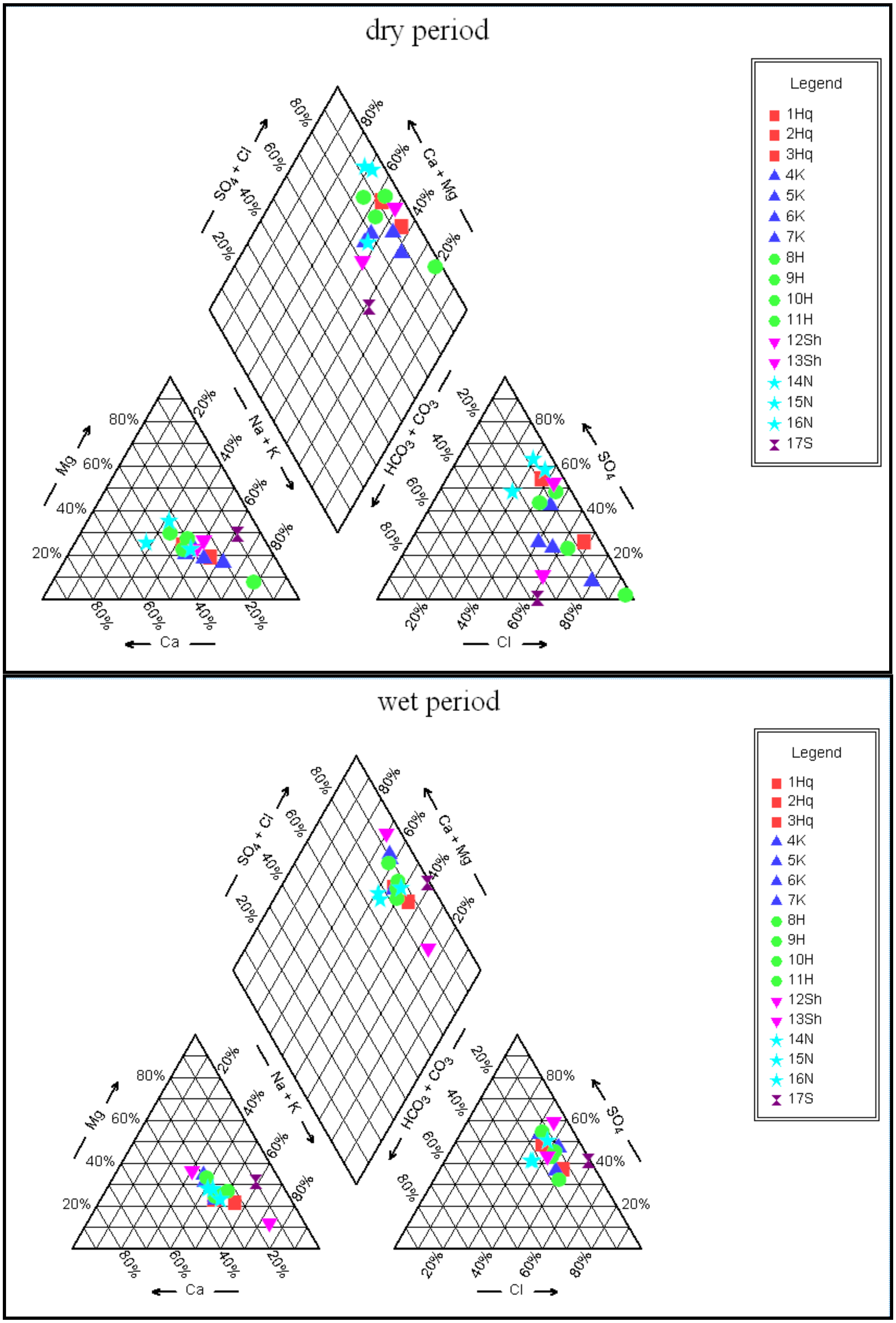

Figure 3-7: Piper diagram of the spring water for two periods.

3-3-3 Schoeller Classification

The classification uses semi logarithmic graph to plot the concentrations of the anions and cations. The concentrations are plotted in meq/l (Shoeller, 1972) this type of diagram allows us to make a visual comparison of the compositions of different water in descending order (Fetter, 1994).

According to this classification, parallel relationship in the hydrochemical composition for the water reflect the effect of dissolution processes or weathering of rocks by the water, otherwise the water composition is from another source (Al-Jalell, 2000). Figure 3-8 illustrates the application of Schoeller classification on spring water during the low and wet period. It appears to be almost fit with the hydrochemical formula results. Table 3-10 lists the type, family and group of water.

3-3-4 Stiff diagram

This diagram is used for presenting cations and anions data (epm) graphically. Cations are represented on the left side, whereas the anions on the right side of the diagram (Figure 3-9). It illustrates the spring water in addition to Sawa Lake samples for two periods (dry and wet) that appears to be fit with the hydrochemical formula Chloride (Cl^-) and sulfate ($SO_4^=$) appear to be prevailing as anions and Sodium (Na^+)and Ca^{2+} as cations.

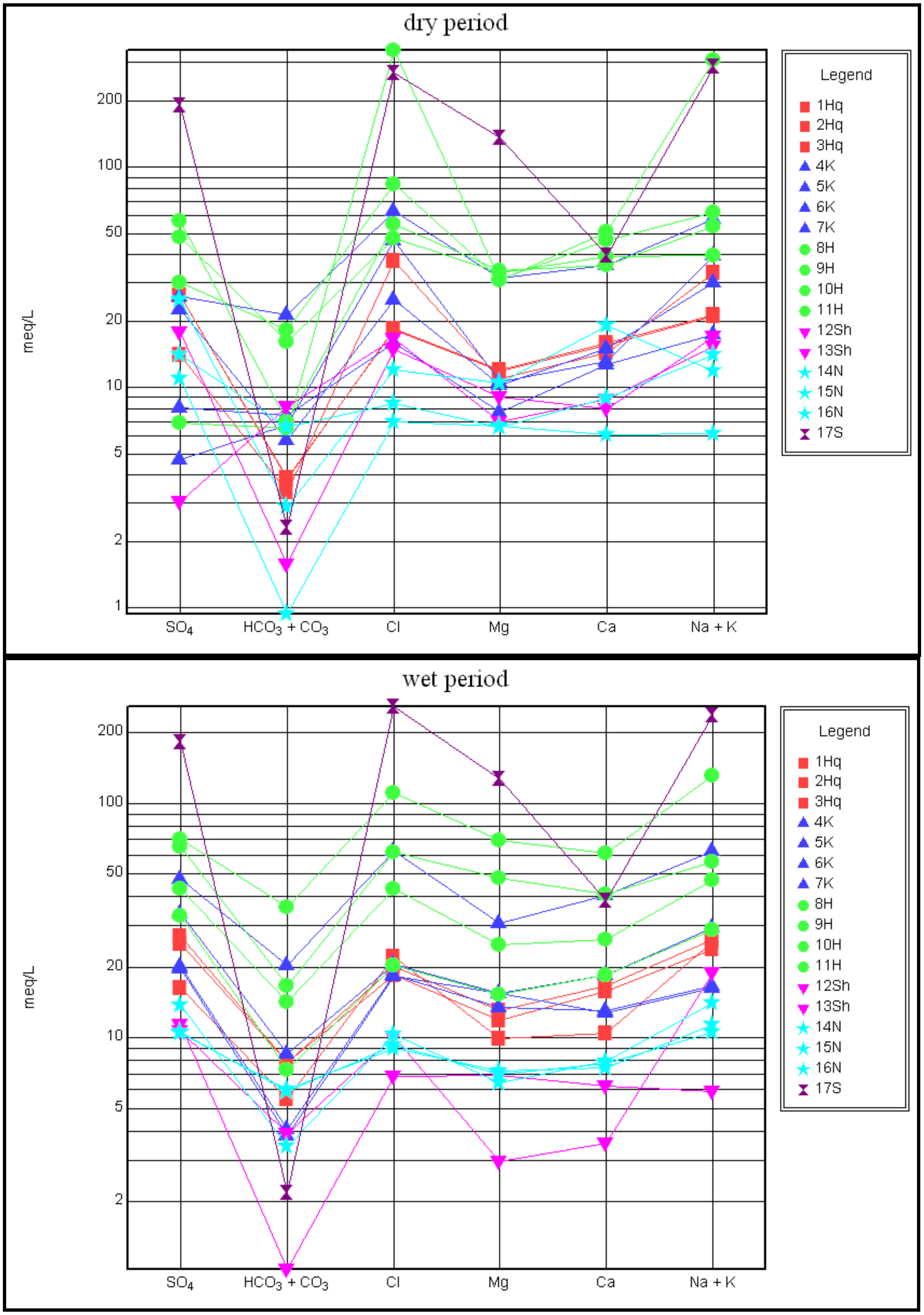

Figure 3-8: Schoeller diagram of the spring water for dry and wet periods.

Table 3-10: The dominant cations and anions in the spring water for two periods.

Sample no	Type		Family	Group	
	anions	Cations			
1Hq	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na -Cl	Cl	**dry period**
2Hq	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na-SO_4	SO_4	
3Hq	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
4K	rCl>HCO3>SO_4	rNa>Ca>Mg>K	Na- Cl	Cl	
5K	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
6K	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
7K	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
8H	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
9H	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
10H	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
11H	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
12Sh	rSO_4>Cl>HCO_3	rNa>Mg>Ca>K	Na- SO_4	SO_4	
13Sh	rCl>HCO3>SO_4	rNa>Ca>Mg>K	Na- Cl	Cl	
14N	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
15N	rSO_4>Cl>HCO_3	rMg>Ca>Na>K	Mg-SO_4	SO_4	
16N	rSO_4>Cl>HCO_3	rCa>Na>Mg>K	Ca- SO_4	SO_4	
17S	rCl>HCO_3>SO_4	rNa>Mg>Ca>K	Na- Cl	Cl	
1Hq	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl_4	Cl	**wet period**
2Hq	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na-SO_4	SO_4	
3Hq	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na-SO_4	SO_4	
4K	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
5K	rSO_4>Cl>HCO_3	rNa>Mg>Ca>K	Na- SO_4	SO_4	
6K	rCl>SO_4>HCO_3	rNa>Ca>Mg>K	Na- Cl	Cl	
7K	rSO_4>Cl>HCO_3	rNa>Mg>Ca>K	Na- SO_4	SO_4	
8H	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
9H	rCl>SO_4>HCO_3	rNa>Ma>Ca>K	Na- Cl	Cl	
10H	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
11H	rSO_4>Cl>HCO_3	rMg>Ca>Na>K	Mg- SO_4	SO_4	
12Sh	rSO_4>Cl>HCO_3	rNa>Mg>Ca>K	Na- SO_4	SO_4	
13Sh	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
14N	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
15N	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na-SO_4	SO_4	
16N	rSO_4>Cl>HCO_3	rNa>Ca>Mg>K	Na- SO_4	SO_4	
17S	rCl>HCO_3>SO_4	rNa>Mg>Ca>K	Na- Cl	Cl	

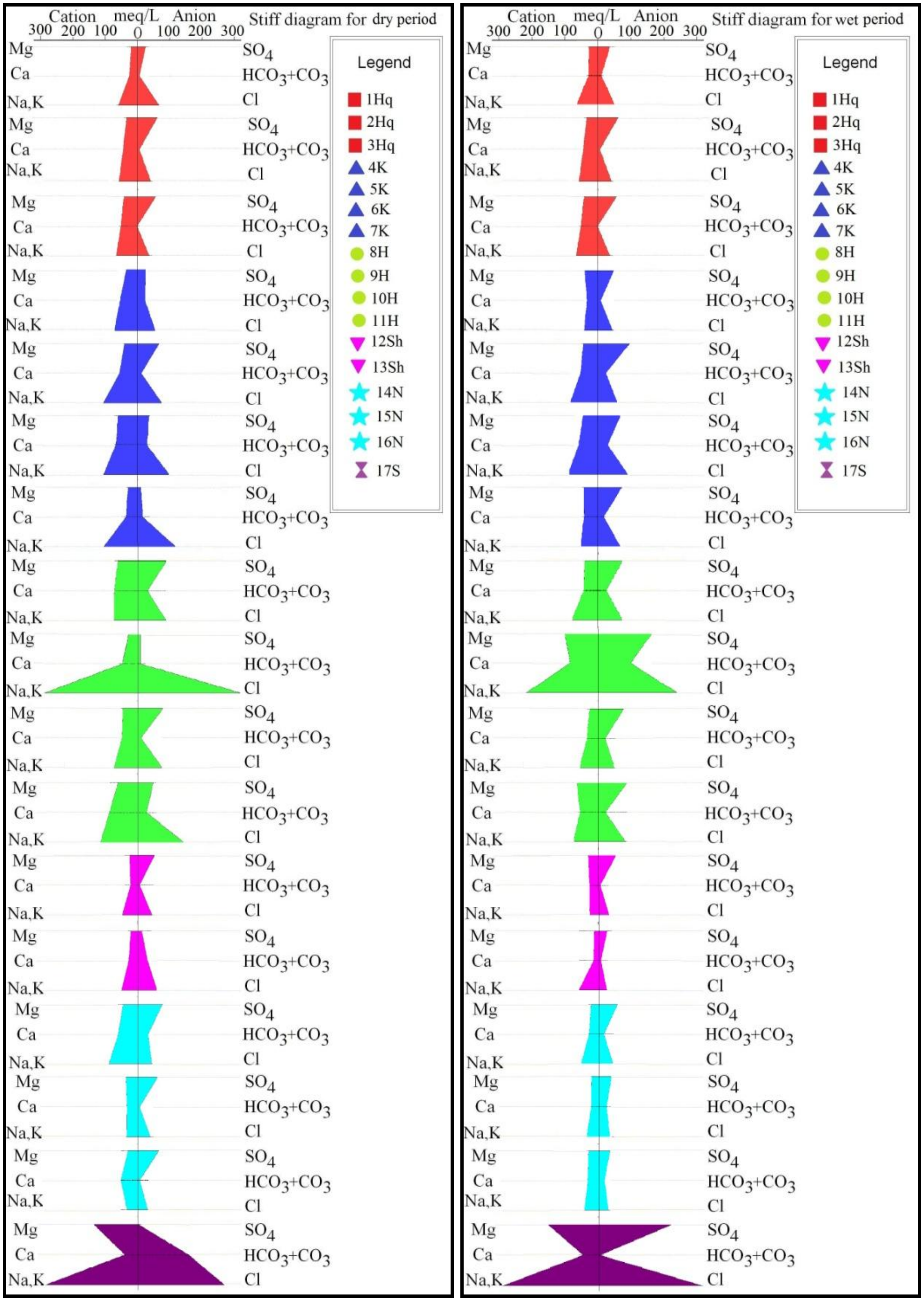

Figure 3-9: Stiff diagram for spring water during the two periods.

3-4 Genetic classification

The hydrochemical function ratios rNa/rCl and rNa-rCl/rSO_4 are calculated from the chemical constituents for the water samples of the springs, where r represents the concentration in meq. The hydrochemical ratios of the spring water are listed in Table 3-11.

According to Ivanov,et al.,1986 if the function ratios rNa/rCl more than one, it represents meteoric origin, while if less than one that meant marine origin. As for rNa-rCl/rSO4 if value more than zero that mean meteoric origin, whilst if less than zero that represent marine origin.

Springs of Haqlanya (1Hq, aHq and 3Hq) are meteoric to marine origin. Kubaysa springs (4K and 5K) are meteoric, while (6K and 7K) are marine origin. Hit springs (8H, 9H, 10H and 11H) are marine origin. Shithatha springs (12Sh, 13Sh) and Najaf springs (14N, 15N and 16N) are distributed as marine and meteoric origin. Sawa Lake (17S) is of meteoric to marine origin (Table 3-11).

According to the genetic classification of the groundwater established by Sulin and Ivanov in Collins (1975); the water of the springs is originated from connate fossil water of marine origin; mixed by the water of meteoric origin. The connate water exists in hydrostatic condition of deeper high pressure zone; mixed with hydrodynamic groundwater influenced by meteoric water infiltration.

The mixing of spring waters with the meteoric water was in different quantities some time was high mixing, but other some was low mixing.
Consequently, the origin of some springs waters appeared as meteoric origin.

Table 3-11: Hydrochemical function ratios of the spring water and Sawa Lake.

Samples	rNa/rCl	rNa-Cl/rSO$_4$	origin	Periods
1Hq	0.82	-0.47	Marine	**Dry period**
2Hq	1.13	0.09	Meteoric (may be marine of highly meteoric mix)	
3Hq	1.13	0.09	Meteoric (may be marine of highly meteoric mix)	
4K	1.08	0.16	Meteoric (may be marine of highly meteoric mix)	
5K	1.19	0.21	Meteoric (may be marine of highly meteoric mix)	
6K	0.89	-0.24	Marine	
7K	0.80	-1.9	Marine	
8H	0.83	-0.1	Marine	
9H	0.87	-6.1	Marine	
10H	0.91	-0.08	Marine	
11H	0.72	-0.75	Marine	
12Sh	1.11	0.09	Marine (partially mixed with meteoric)	
13Sh	0.82	-0.94	Marine	
14N	1.64	0.38	Meteoric (may be marine of highly meteoric mix)	
15N	0.84	-0.1	Marine	
16N	0.91	-0.04	Marine	
17S	1.03	4.04	Marine (partially mixed with meteoric)	
1Hq	1.04	-0.06	Marine (partially mixed with meteoric)	**Wet period**
2Hq	1.15	0.11	Meteoric (may be marine of highly meteoric mix)	
3Hq	1.02	0.02	Meteoric (may be marine of highly meteoric mix)	
4K	0.87	-0.11	Marine (partially mixed with meteoric)	
5K	1.28	0.17	Meteoric	
6K	0.97	-0.03	Marine	
7K	0.88	-0.1	Marine	
8H	1.05	0.05	Marine (partially mixed with meteoric)	
9H	1.12	0.1	Marine (partially mixed with meteoric)	
10H	1.29	0.1	Marine (partially mixed with meteoric)	
11H	0.74	-0.2	Marine	
12Sh	0.82	-0.1	Marine	
13Sh	1.82	0.7	Marine (partially mixed with meteoric)	
14N	1.35	0.2	Meteoric(may be marine of highly meteoric mix)	
15N	1.25	0.2	Marine (partially mixed with meteoric)	
16N	1.12	0.1	Marine (partially mixed with meteoric)	
17S	0.90	-0.1	Marine	

3-5 Assessment of spring water

Spring water is assessed for Spa therapy (balneology), drinking, agricultural and aquacultural purposes. These assessments are explained below:

3-5-1 Balneological assessment

Water quality plays an important role in balneology, since the chemical properties of the water determine possible adverse effects on human health; water chemical properties also determine the curative properties of water for skin diseases and other kinds of therapeutic uses. According to Komatina (2004), mineral (medicinal) water can be classified on the basis of a number of criteria such as total mineralization, ion and gas composition, content of active therapeutic components, radioactivity, acidity or alkalinity, and temperature.

According to ASHRAE (1999), the desirable temperature for swimming pools is 27^{o}C. For typical condition spa therapy, the air temperature ranges 27-29^{o}C, water temperature ranges 29-35 ^{o}C suitable, relative humidity 50-60%. Drinking and bathing in geothermal water, and using the mud precipitates on the skin are thought to give certain health benefits.

Temperature, bacterial (coliform) and pH is very important factor need to be assessed for balneological purposes.

For the purposes of swimming have been relying on the limited proposed by Nelson (1978) (Table 3-12).

Table 3-12: Swimming limits proposed by Nelson, 1978.

pollutants	Concentrations
Temperature	Less than 29.5C$^{\circ}$
Coliform	Up to 2000/100 ml
pH	5-9

When comparing the spring water with the swimming guideline, the spring water appears safe for swimming, depending on temperature, harmful Bacteria and pH. This study recommends avoiding swimming in springs that Have asphalting floated on its water because it is very dangerous. Asphaltine is existed in some springs in Hit area

The assessment for balneology, the physico-chemical parameters must be compared with the global famous guideline. For this reason, the physico-chemical parameters are compared with the European Union, 2009 and US spas (Lund, 1996 and Eaton, 2004) as shown in Table 3-13. The balneological assessment is illustrated in Table 3-14. Trace elements were compared with the guideline of Americans Spa and Iceland spa (Tables 3-15 and 3-16). The full banelogical assessment for the spring water seems clearly fit and valid for balneology as therapeutic uses.

Here, one should take in consideration, that the Cations and anions are suitable for balenotherapy. All spring contain F within acceptable limit except 4K, 5K, 6K, and 7K in which F was less than 1.0. Sr acceptable just in three springs (1Hq, 2Hq and 3Hq). All springs characterized by high concentration of Cd, Cu, B, and Br. Bromine is another important element for balneotherapy, the high concentration of Br prevents bacteria or algae growth in the spa. Sulfate tends to be dominant beside chloride in all springs. The sulfur that penetrates the skin is oxidized and evokes various physiologic responses in the skin, such as vasodilatation in the microcirculation, an analgesic influence on the pain receptors, and inhibition of the immune response. It also interacts with oxygen radicals in the deeper layers of the epidermis, producing sulfur and disulfur hydrogen, which may be transformed into pentathionic acid; this may be the source of the antibactericidal and antifungal activity of sulfur water (Matz et al., 2003). Sulfur baths (2000 mg/l) recommended for patient with Fibromyalgia (Buskila et al. 2001). Magnesium-rich in spring water is used in the treatment of inflammatory skin diseases (Schempp et al., 2000). Therapeutic uses of spring include Arthritis, and central circulation troubles. Peripheral circulation troubles, chronic constipation, muscle cramp and construction, general health recovery, respiratory System troubles rheumatism, inflammation of respiratory apparatus and some skin disease (Saman, 2000). In Iraq, Local people used the spring water to treat a variety of diseases. Attempts and experiences have proved the effectiveness of this water springs on healing, where treated dermatological and allergies diseases and ulcers, nervous diseases, muscle contraction, rheumatism, arthritis, central and peripheral circulation troubles, urinary lithaiasis, chronic constipation and intestinal troubles, general health improvement sedative, diuretic and regulation of gland secretions.

3-5-2 Assessment for drinking water

Water coming from different natural sources contains many chemical species which are undesirable for drinking. Sometimes these constituents have direct adverse impacts on the human health; others are responsible for an unpleasant taste and odor. Water with a dirty appearance or with an unpleasant taste or odor and color could be rejected by consumers. This means that it is important to assess not only the safety measures but also the appearance of drinking water.

The Iraqi standard (2009) and WHO (2008) standards have been used as guides for the water quality evaluation for drinking purpose (Table 3-17).

On this basis, pH parameter appear to be within the guideline of Iraqi standard, 2009 in addition to WHO, 2008, whilst other parameters like cations, anions concentrations are out of the standards. Accordingly, the spring water are impermissible for drinking, because the most essential parameters are out of the standard range in spite of acceptable limit of trace elements. The results of assessment can be seen clearly for each parameter in Table 3-19.

Table 3-13: Physico-chemical parameters of the spring water compared with guideline (EU Mineral) and (US spas) during two periods.

Indications		Unit	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	period
TDS*	>1500	ppm	3452	3148	3110	2180	3478	7290	3667	7106	21082	7555	8325	2139.3	1927.9	1996	1188	2606	27441	Dry period
EC*	>2310	µS/cm	5523	5068	5038	3553	5704	12029	6102	11867	35418	12768	14152	3658	3316	3453	2067	4560	48022	
Ca^{2+}*	>150	ppm	288	320	312	225	300	712	262	780	1010	711	925	160	177	180	122	382	781	
Mg^{2+}*	>50		134	146	144	94	125	378	129	400	367	410	375	110	85.2	80	81	127	1610	
Na^{+}*	>200		709	480	472	396	688	1294	854	900	6690	1145	1385	380	319	320	135	251	6240	
K^{+}**	0-90		94.1	22	21	8.1	4.9	70	102	16	479	145	65	2.3	56.7	4	11	37.7	389	
$SO_4^{=}$*	>200		674	1260	1253	389	1080	1236	226	2300	326	2730	1420	852	145	675	530	1200	104	
Cl^{-}**	0-1300		1330	650	643	565	888	2220	1640	1670	11800	1934	2930	524	594	301	248	424	9320	
HCO_3**	0-700		223	270	265	503	392	1380	463	1040	410	480	1225	111	551	436	61	184	8970	
F*	>1		1.1	1.2	1.1	0.6	0.8	0.7	0.9	1	2	1.5	1.9	1.0	1.0	1.2	1.4	1.3	9.25	
CO_2*	>250		8.4	.8.3	8.1	9.8	10	10	9.9	40	44.8	30	25	3.6	3.7	3.3	3.1	3.2	0	
TDS*	>1500	ppm	2885	3663	3369	2686.5	4213	8434	2700	6437	14699	4094	9234	1204	1683	1831	1707	1705	25225	Wet period
EC*	>2310	µS/cm	4616	5897	5458	4379	6909	13916	4481	10750	24694	6919	15698	2059	2895	3168	2970	2984	44144	
Ca^{2+} *	>150	ppm	210	332	315	257	370	802	262	523	1202	369	814	125	71	159	150	155	750	
Mg^{2+}*	>50		121	158	144	188	188	373	163	300	828	185	582	84	36	78	88	85	1500	
Na^{+}*	>200		530	534	438	370	609	1384	376	1042	2815	603	1051	130	428	321	260	240	5200	
K^{+}**	0-90		100	116	106	8.5	112	75	9.5	63	237	109	391	10	13	2	3	4	250	
$SO_4^{=}$*	>200		781	1300	1208	951	1632	2256	964	2071	3312	1600	3121	545	512	662	500	510	8500	
Cl^{-}**	0-1300		782	715	658	650	731	2202	658	1530	3865	719	2182	242	361	367	319	330	8900	
HCO_3**	0-700		361	508	500	262	571	1342	267	908	2440	509	1093	68	262	242	387	387	100	

*EU spa = European Union, 2009; **US spas= Lund 1996 and Eaton 2004.

Table 3-14: Assessment of the spring water with EU and Us spas during two periods.

Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	Period
TDS	>1500	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	dry period
EC	>2310	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	
Ca^{2+}	>150	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	
Mg^{2+}	>50	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Na^{+}	>200	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	
K^{+}	0-90	S	S	S	S	S	S	S	S	X	X	S	S	S	S	S	S	X	
SO_4^{2-}	>200	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S	S	
Cl^{-}	0-1300	S	S	S	S	S	X	X	X	X	X	X	S	S	S	S	S	S	
HCO_3^{-}	0-700	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
F	>1	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	
CO_2	>250	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
TDS	>1500	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S	S	S	wet period
EC	>2310	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Ca^{2+}	>150	S	S	S	S	S	S	S	S	S	S	S	X	X	S	S	S	S	
Mg^{2+}	>50	S	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S	S	
Na^{+}	>200	S	S	S	S	S	S	S	S	S	S	S	X	S	S	S	S	S	
K^{+}	0-90	S	S	S	S	S	S	S	S	S	S	X	S	S	S	S	S	X	
SO_4^{2-}	>200	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cl^{-}	0-1300	S	S	S	S	S	S	S	X	X	S	X	S	S	S	S	S	X	
HCO_3^{-}	0-700	S	S	S	S	S	X	S	S	X	S	X	S	S	S	S	S	S	

S=suitable for Balneology; X=exceed limited

Table 3-15: Trace element compared with guideline of (Americans Spa and Iceland spa).

Indications			1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	
Pb*	ppm	<4	0.1	0.1	0.1	0.09	0.1	0.27	0.06	0.16	0.26	0.17	0.17	0.1	0.1	0.14	0.15	0.17	0.37	**dry period**
Zn*		<5	0..03	0.07	0.07	0.13	0.08	0.22	0.12	BDL	BDL	BDL	BDL	0.07	0.01	0.06	0.56	0.4	0.1	
Cd**		$3x10^{-6}$	0.02	0.02	0.02	BDL	BDL	0.01	BDL	BDL	0.04	0.004	0.005	0.02	0.01	BDL	BDL	BDL	0.04	
Fe**		0.023	0.01	0.01	0.01	0.04	0.05	0.08	0.03	0.08	0.26	0.1	0.09	BDL	BDL	0.07	0.07	0.08	0.4	
Mn**		0.023	0.0009	0.0009	0.0009	0.01	0.01	0.01	0.01	0.03	0.03	BDL	BDL	BDL	<0.0005	BDL	BDL	<0.0005	<0.0005	
Cu**		$5x10^{-6}$	0.0026	0.0025	0.0025	0.003	0.003	0.003	<0.0020	0.002	0.0036	0.002	0.002	0.0021	0.0022	0.0020	0.0020	0.0021	0.0045	
Br**		9.7	10.4	10.2	10.3	11.1	13.2	14	12.7	80	89.2	66	60	4.1	4.73	2.4	2.3	2.5	33.2	
F*		>1	1.1	1.2	1.1	0.6	0.8	0.7	0.9	1	2	1.5	1.9	1.0	1.0	1.2	1.4	1.3	9.25	
B*		0.08	1.34	1.32	1.3	1.5	1.6	1.6	1.5	6	7	5	5.4	0.9	0.9	0.6	0.56	0.66	12.4	
Sr**		5.3	4.27	4.44	4.55	7.07	9.59	20.2	7.07	38.84	48.58	26.76	30.3	5.55	4.54	10.6	10.10	11.11	39.5	
Al**		0.02	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
As**		$6x10^{3}$	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
Cr**		$35x10^{-5}$	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	
Hg**		$7x10^{-6}$	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Se*		$3x10^{-5}$	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	
Pb*	ppm	<4	0.2	0.2	0.2	0.95	0.8	1.3	2.3	0.01	0.08	1.4	1.6	0.2	0.3	0.2	0.2	0.3	0.26	**wet period**
Zn*		<5	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Cd**		$3x10^{-6}$	0.07	0.08	0.09	BDL	BDL	0.02	BDL	BDL	BDL	0.12	0.12	BDL	BDL	0.04	0.04	0.04	0.05	
Fe**		0.023	0.01	0.01	0.01	BDL	BDL	BDL	0.04	BDL	0.04	0.04	0.03	BDL	BDL	BDL	BDL	BDL	0.1	
Mn**		0.023	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Cu**		$5x10^{-6}$	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	

*American spa=Agishi and Ohatsuka (1998) and Parish and Lotti(1996); **Iceland spa = Kristmannsdóttir et al, (2005).

Table 3-16: Assessment trace elements for balenological (therapeutic uses).

Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	Period
Pb	<4	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	**dry period**
Zn	<5	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cd	$3x10^{-6}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Fe	0.023	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	
Mn	0.023	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cu	$5x10^{-6}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Br	9.7	S	S	S	S	X	X	X	X	X	X	X	S	S	S	S	S	X	
F	>1	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
B	0.08	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Sr	5.3	S	S	S	S	S	S	S	X	X	X	X	S	S	X	X	X	X	
Al	0.02	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
As	$6x10^{3}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cr	$35x10^{-5}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Hg	$7x10^{-6}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Se	$3x10^{-5}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Pb	<4	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	**wet period**
Zn	<5	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cd	$3x10^{-6}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Fe*	0.023	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Mn	0.023	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cu	$5x10^{-6}$	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	

S=suitable for Balneology; X=exceed limited

Table 3-17: Physico-chemical parameters of the spring water compared with guideline of Iraqi standard, 2009 and WHO, 2008 during dry period. (For drinking).

Parameters	unit	Iraqi 2009	WHO 2008	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
pH	---	--	6.5-8*	7.3	7.1	7.2	7.3	7.2	7.4	7.2	7.4	7.5	7.1	7.2	7.1	7.3	7.4	7.5	7.5	8.5
EC	µS/cm	--	2500**	5523.3	5068	5038	3553	5703	12028	6102	11867	35417	12767	14152	3658	3315	3453	2067	4559	48022
TDS	ppm	1000	600*	3452.1	3148	3110	2180	3477	7290	3667	7106	21082	7555	8325	2139	1927	1996	1188	2605	27441
Ca^{2+}		150	--	288	320	312	225	300	712	262	780	1010	711	925	160	177	180	122	382	781
Mg^{2+}		100	--	134	146	144	94	125	378	129	400	367	410	375	110	85.2	80	81	127	1610
Na^{+}		200	200*	709	480	472	396	688	1294	854	900	6690	1145	1385	380	319	320	135	251	6240
SO_4^{2-}		400	250*	674	1260	1253	389	1080	1236	226	2300	326	2730	1420	852	145	675	530	1200	8970
Cl^{-}	ppm	350	250	1330	650	643	565	888	2220	1640	1670	11800	1934	2930	524	594	301	248	424	9320
NO_3^{-}		50	50	3	2	3	5	4	10	2	9	9.5	7	6.2	2	2.3	6	3	3	13.2
Pb		0.01	0.01	0.1	0.1	0.1	0.09	0.1	0.27	0.06	0.16	0.26	0.17	0.17	0.1	0.1	0.14	0.15	0.17	0.37
Zn		3	4*	0..03	0.07	0.07	0.13	0.08	0.22	0.12	BDL	BDL	BDL	BDL	0.07	0.01	0.06	0.56	0.4	0.1
Cd		0.003	0.003	0.02	0.02	0.02	BDL	BDL	0.01	BDL	BDL	0.04	0.004	0.005	0.02	0.01	BDL	BDL	BDL	0.04
Ni		0.02	0.07	0.04	0.04	0.04	0.1	0.08	0.22	0.07	0.18	0.21	0.13	0.13	0.04	0.05	0.1	0.1	0.1	0.4
Fe		0.3	0.3	0.01	0.01	0.01	0.04	0.05	0.08	0.03	0.08	0.26	0.1	0.09	BDL	BDL	0.07	0.07	0.08	0.4
Mn		0.1	0.4	0.0009	0.0009	0.0009	0.01	0.01	0.01	0.01	0.03	0.03	BDL	BDL	BDL	<0.0005	BDL	BDL	<0.0005	<0.0005
Cu		1	2	0.0026	0.0025	0.0025	0.003	0.003	0.003	<0.002	0.002	0.0036	0.002	0.002	0.0021	0.0022	0.002	0.0020	0.0021	0.0045
F		1	1.5	1.1	1.2	1.1	0.6	0.8	0.7	0.9	1	2	1.5	1.9	1.0	1.0	1.2	1.4	1.3	9.25
Ba	ppm	0.7	0.7	0.0177	0.061	0.016	0.01	0.025	0.019	0.0296	0.01	0.186	0.1	0.09	0.01	0.011	0.003	0.004	0.0045	0.0185
B		0.5	0.5	1.34	1.32	1.3	1.5	1.6	1.6	1.5	6	7	5	5.4	0.9	0.9	0.6	0.56	0.66	12.4
Al		0.2	0.2	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Sb			0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
As		0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cr		0.005	0.05	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Hg		0.001	0.006	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mo		0.01	0.07	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.0058	0.0476
Se		0.01	0.01	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30

Table 3-18: Physico-chemical parameters of the spring water compared with guideline of Iraqi standard, 2009 and WHO, 2008 during wet period. (For drinking).

parameter	**Unit**	**Iraqi 2009**	**WHO 2008**	**1Hq**	**2Hq**	**3Hq**	**4K**	**5K**	**6K**	**7K**	**8H**	**9H**	**10H**	**11H**	**12Sh**	**13Sh**	**14N**	**15N**	**16N**	**17S**
pH	---	6.5-8	6.5-8*	7.6	7.5	7.4	7.2	7.3	7.3	7.4	7.5	7.1	7.1	7.3	7.4	7.2	7.1	7.6	7.5	8.4
EC	µS/cm	2500	2500**	4616	5897	5457	4378	6909	13916	4481	10749	24694	6918	15697	2058	2894	3167	2970	2983	4414.
TDS	ppm	600	600*	2885	3663	3369	2686	4213	8434	2699.5	6437	14699	4094	9234	1204	1683	1831	1707	1705	25225
Ca^{2+}	ppm	150	--	210	332	315	257	370	802	262	523	1202	369	814	125	71	159	150	155	750
Mg^{2+}		100	--	121	158	144	188	188	373	163	300	828	185	582	84	36	78	88	85	1500
Na^{+}		200	200*	530	534	438	370	609	1384	376	1042	2815	603	1051	130	428	321	260	240	5200
$SO_4^{=}$		250	250*	781	1300	1208	951	1632	2256	964	2071	3312	1600	3121	545	512	662	500	510	8500
Cl^{-}		350	--	782	715	658	650	731	2202	658	1530	3865	719	2182	242	361	367	319	330	8900
NO_3^{-}		50	50	3	4	7.8	6	2	9	6	2.3	11.7	2	0.2	3	3	7.5	4	4	12
Pb	ppm	0.01	0.01	0.2	0.2	0.2	0.95	0.8	1.3	2.3	0.01	0.08	1.4	1.6	0.2	0.3	0.2	0.2	0.3	0.26
Zn		4	4*	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cd		0.003	0.003	0.07	0.08	0.09	BDL	BDL	0.02	BDL	BDL	BDL	0.12	0.12	BDL	BDL	0.04	0.04	0.04	0.05
Ni		0.02	0.07	0.03	0.03	0.03	0.2	0.09	0.1	0.08	0.2	0.3	0.2	0.2	0.03	0.03	0.2	0.2	0.2	0.3
Fe		0.3	0.3	0.01	0.01	0.01	BDL	BDL	BDL	0.04	BDL	0.04	0.04	0.03	BDL	BDL	BDL	BDL	BDL	0.1
Mn		0.4	0.4	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Cu		2	2	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL

Iraqi 2009= Iraqi standard (2009); WHO, 2008=World health organization (2008).
*No health-based, but for taste, odor and appearance, **European commission, 2007.

Table 3-19: Assessments chemical parameters of all samples compared with Iraqi standard, 2009 and WHO, 2008 (for drinking).

Element	Iraqi 2009	WHO 2008	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S
pH	6.5-6.8	6.5-8.0	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
EC	--	2500	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	X
TDS	1000	600	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ca^{2+}	150	--	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	X
Mg^{2+}	100	--	X	X	X	S	X	X	X	X	X	X	X	X	S	S	S	X	X
Na	200	200	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	X	X
$SO4^{2-}$	400	250	X	X	X	X	X	X	S	X	X	X	X	X	S	X	X	X	X
Cl-	350	250	X	X	X	X	X	X	X	X	X	X	X	X	X	S	S	X	X
NO_3^{+}	50	50	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Pb	0.01	0.01	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Zn	3	4	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Cd	0.003	0.003	X	X	X	S	S	X	S	S	X	X	X	X	X	S	S	S	X
Ni	0.02	0.07	S	S	S	X	X	X	S	X	X	X	X	S	S	X	X	X	X
Fe	0.3	0.3	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X
Mn	0.1	0.4	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Cu	1	2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
F	1	1.5	S	S	S	S	S	S	S	S	X	S	X	S	S	S	S	S	X
Ba	0.7	0.7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
B	0.5	0.5	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Al	0.2	0.2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Sb	--	0.2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
As	0.01	0.7	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Cr	0.005	0.05	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Hg	0.001	0.006	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Mo	--	0.07	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Se	0.01	0.01	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S

S=suitable for drinking; X=exceed limited

3-5-3 **Assessment for irrigation purposes**

The chemical composition of the water is diverse with regard to water quality for irrigation purposes. Depending on its origin, water derived from springs, streams, and wells contain considerable quantities of chemical substances which reduce crop yields and deteriorate soil fertility (Phocaides, 2007). Different kinds of salts are normally found in irrigation water; the amounts and combinations of these substances define the suitability of water for irrigation and the likelihood of plant toxicity. Two types of salt problems exist which are very different: those associated with total salinity and those associated with sodium. Soils may be affected only by salinity or by a combination of salinity and sodium (Texas A&M University, 2003).

3-5-3-1 **Salinity and sodium assessment**

A preliminary step for assessing the irrigation water quality is to classify these prospects according to salinity. Salinity on its own does not define the suitability of irrigation water; it represents only a general guide and other factors must be considered (ANZECC, 2000). Table 3-20 summarizes the different classes of irrigation water based on electrical conductivity and TDS. The sodium hazard is the effect that irrigation water containing large amounts of sodium could cause on soil; it is usually expressed as SAR (sodium adsorption ratio). SAR is related to infiltration problems and it is calculated from the ratio of sodium to calcium and magnesium according to Hem (1985) by the formula below:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

The soil structure is changed by the reaction of the sodium cation, which is the major cation dominant in water with high salinity. The sodium cation replaces the calcium and magnesium in the soil. This cation exchange causes the deterioration of the soil structure making the soil impermeable to water and air. High concentrations of exchangeable sodium shift the pH to alkaline values, reducing the availability of micronutrients such as Fe and P (Phocaides, 2007). The sodium hazard of water based on the SAR values is shown in Table 3-21.

Table 3- 20: Water classification based on salinity (Texas A&M University, 2003).

Class of water	**Electrical conductivity (µS/cm)**	**TDS (mg/l)**
Class 1, Excellent	250	175
Class 2, Good	250-750	175-525
Class 3, Permissible	750-2000	525-1400
Class 4, Doubtful	2000-3000	1400-2100
Class 5, Unsuitable	3000	2100

Table 3-21: Sodium hazard of water based on SAR (Wilcox ,1948).

SAR class	Range of value	Sodium hazard	Comments
S1	<10	Low	Use on sodium sensitive crops
S2	10-18	Medium	Amendments and leaching are needed
S3	18-26	High	Generally unsuitable for continuous use
S4	>26	Very high	Generally unsuitable for use

The result of SAR for the spring water and sodium hazard with comment for each SAR vales are listed in Table 3-22

The classification of water samples based on salinity and SAR can be seen in Table 3-23.

3-5-3-2 Richard classification

Richard classification depends on electrical conductivity (EC) and sodium adsorption ratio (SAR). Accordingly, the relation between EC and SAR give 16 types of water. According Richard, 1954, the classification of irrigation water is displayed in Table 3-24.

Table 3-22: SAR values with sodium hazard for study samples.

Samples	SAR ppm	Sodium hazard	Comments	Period
1Hq	8.65	Low	Use on sodium sensitive crops must be cautioned	Dry period
2Hq	5.58	Low	Use on sodium sensitive crops must be cautioned	
3Hq	5.54	Low	Use on sodium sensitive crops must be cautioned	
4K	5.38	Low	Use on sodium sensitive crops must be cautioned	
5K	8.42	Low	Use on sodium sensitive crops must be cautioned	
6K	9.8	Low	Use on sodium sensitive crops must be cautioned	
7K	10.78	Medium	Amendments (such as gypsum) and leaching needed.	
8H	6.52	Low	Use on sodium sensitive crops must be cautioned	
9H	8.892	Low	Use on sodium sensitive crops must be cautioned	
10H	8.45	Low	Use on sodium sensitive crops must be cautioned	
11H	9.69	Low	Use on sodium sensitive crops must be cautioned	
12Sh	5.65	Low	Use on sodium sensitive crops must be cautioned	
13Sh	4.92	Low	Use on sodium sensitive crops must be cautioned	
14N	4.98	Low	Use on sodium sensitive crops must be cautioned	
15N	2.32	Low	Use on sodium sensitive crops must be cautioned	
16N	2.83	Low	Use on sodium sensitive crops must be cautioned	
17S	29.29	Very high	Generally unsuitable for use	
1Hq	7.21	Low	Use on sodium sensitive crops must be cautioned	Wet period
2Hq	6.04	Low	Use on sodium sensitive crops must be cautioned	
3Hq	5.68	Low	Use on sodium sensitive crops must be cautioned	
4K	4.28	Low	Use on sodium sensitive crops must be cautioned	
5K	6.43	Low	Use on sodium sensitive crops must be cautioned	
6K	10.2	Medium	Amendments (such as gypsum) and leaching needed	
7K	4.48	Low	Use on sodium sensitive crops must be cautioned	
8H	8.98	Low	Use on sodium sensitive crops must be cautioned	
9H	15.2	Medium	Amendments (such as gypsum) and leaching needed	
10H	6.38	Low	Use on sodium sensitive crops must be cautioned	
11H	6.86	Low	Use on sodium sensitive crops must be cautioned	
12Sh	2.2	Low	Use on sodium sensitive crops must be cautioned	
13Sh	2.862	Low	Use on sodium sensitive crops must be cautioned	
14N	5.2	Low	Use on sodium sensitive crops must be cautioned	
15N	4.16	Low	Use on sodium sensitive crops must be cautioned	
16N	3.84	Low	Use on sodium sensitive crops must be cautioned	
17S	25.2	Very high	Generally unsuitable for use	

Table 3-23: Classification of water based on salinity and SAR

code	1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	period
Class water ,basis on salinity (TDS or EC)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	dry period
Sodium Hazard of water ,based on SAR	A	A	A	A	A	A	B	A	A	A	A	A	A	A	A	A	D	
Class water ,basis on salinity (TDS or EC)	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5	wet period
Sodium Hazard of water ,based on SAR	A	A	A	A	A	B	A	A	B	A	A	A	A	A	A	A	D	

1: Excellent, 2: Good, 3: Permissible, 4: Doubtful, 5: Unsuitable, A: Low, B: Medium, C: High, D: Very High.

Table 3-24: Classification of irrigation water (Richard, 1954).

Ec (µmhos/cm)	Index	SAR	Index	Water class	Group
100-250	C_1	0-10	S_1	Excellent	Low
250-750	C_2	10-18	S_2	Good	Medium
750-2250	C_3	18-26	S_3	Fair	High
> 2250	C_4	26	S_4	Poor	Very high

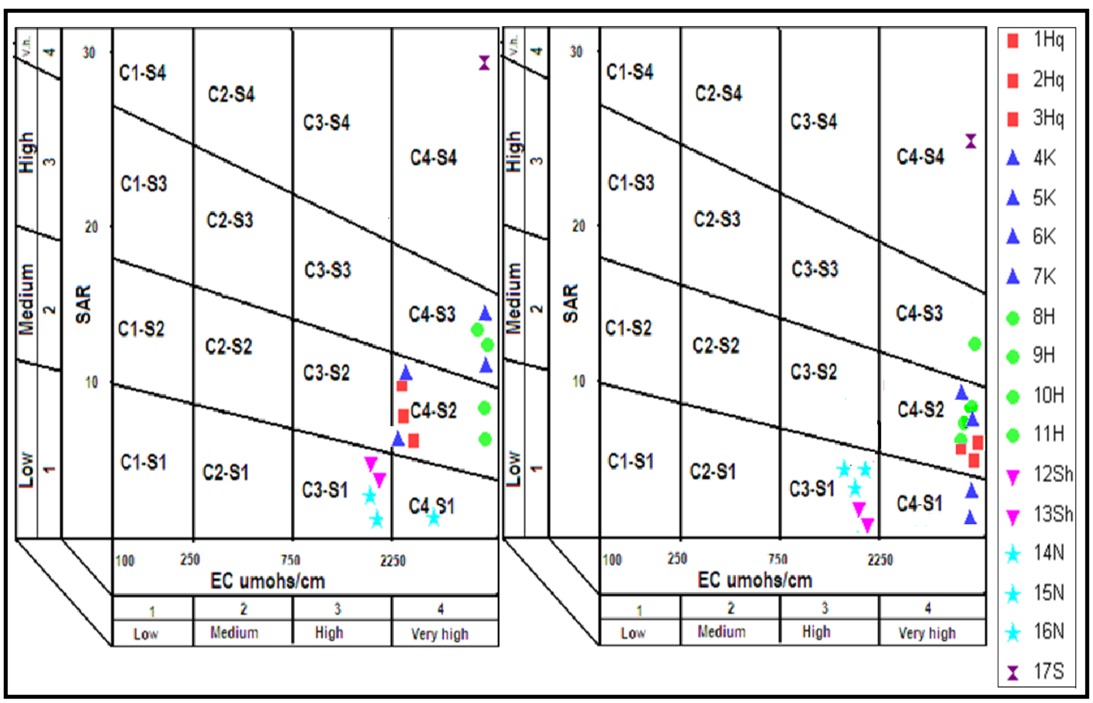

Figure 3-10: Classification of irrigation water: Richard classification (1954) plotted the study samples; left dry period, right wet period.

According to the Richard diagram, water samples of Haqlanya (1Hq, 2Hq and 3Hq) occupy class C_4S_2 during the both periods (Figure 3-11). Springs of Kubaysa and Hit are fall in C_4S_2 and C_4S_3. Springs of Shithatha (12Sh and 13Sh) and Najaf (14N, 15N and16N) are occupied within C_3S_1 field during wet period, while they occupied the field of C_3S_1 and C_4S_1 during the dry period. The Sawa Lake was occupied in C_4S_4 field.

3-5-3 Assessment of aquaculture

Aquaculture is defined as "the farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants" (FAO, 2002). But this study is going to discuss in simplified way the fish farming. Svobodova et al., (1993) described the limits of chemicals that effect on fish health such as follows:

Nitrate content varies from 2-10 mg/l in the springs (Table 3-25); it is lower than the guideline. The toxicity of nitrates to fish is very low, and mortalities have only been recorded when concentrations have exceeded 1000 mg/l; 80 mg /l is considered to be the maximum admissible nitrate concentration for carp and 20 /l for rainbow trout Svobodova et al., (1993). Hydrogen sulfide in the springs was higher that the guideline (0.002). It appears impermissible for fish farming.

A concentration as low as 0.52 mg/l of Al was found to markedly reduces the growth of these fish. In the spring, Al is very low (0.01 mg/l) and lower that the guideline (0.52 mg/l). The lethal content of Fe for fish depends on the physico-chemical properties of the water. In cyprinid culture, it is generally accepted the concentration of not exceed 0.2 mg /l; for salmonids this limit is 0.1 mg/l. Consequently, Fe is admissible in all springs, with exceptional that spring (9H) which has 0.26 mg/l Fe. Nickel compounds are of medium toxicity to fish. With short periods of exposure, the lethal concentration is between 30 and 75 mg /l. However, it is lower than in spring water.

The maximum admissible copper concentration in water for the protection of fish is in the range of 0.001 to 0.01 mg /l, depending on the physical and chemical properties of water and on the species of the fish (Svobodova et al., 1993). All springs contained Cu concentration higher than the guideline. Zinc poisoning of fish is most frequently encountered in trout culture (Svobodova et al., 1993). The lethal concentrations are around 0.1 mg/l for salmonids. The low content of Zn in the spring water make all springs are admissible, except two springs (6K and 7K). Zinc can precipitate at high pH and co-precipitate with calcium carbonate (ANZECC, 2000). The simplest method for removing zinc is to retain water for one or two days in a holding pond (Zweig et al., 1999).

In term of As, all spring water have low concentration (<0.01 mg/l), whereas the lethal concentrations are between 3 and 30 mg /l (Svobodova et al., 1993). Accordingly, springs are admissible for fish farming. The maximum admissible Cd concentration in water is 0.0002 mm/l, and for cyprinids 0.001 mg/l. Cadmium in the spring water recorded value higher than the guideline. For fish in general, the maximum admissible concentration of mercury in organic compounds has been suggested to be as low as 0.0003 mg/l. The maximum admissible Pb concentration in water is 0.004 to 0.008 mg/l for salmonids and 0.07 mg/l for cyprinids. The content of Pb in the springs permits to cyprinids for living.

Table 3-25: General guidelines of water quality for fish farming (Svobodova et al., 1993).

parameters	**Limit (mg/l)**	**Comments**
pH	6.5-8.5	
H_2S	0.002	
NO^{3-}	80	Maximum admissible for Carb
	20	Maximum admissible for Rainbow
Al	0.52	At pH 7.0
Fe	0.2	General acceptable limit
	0.1	For Salmonids
Ni	30-75	With short period of exposure, depending of species of fish
Cu	0.001-0.01	Depending on physical and chemical properties of water and species of fish
Zn	0.1	For Salmonids
As	3-30	depending of species of fish
Cd	0.0002	Maximum admissible concentration
	0.001	For Cyprinids
Hg	0.0003	Maximum admissible concentration
Pb	0.008	For Salmonids
	0.07	For Cyprinids

Table 3-26: Chemical components of the spring water compared with the general guideline of water quality for aquaculture (fish farming).

Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	
pH	6.5-8.5	7.3	7.1	7.2	7.3	7.2	7.4	7.2	7.4	7.5	7.1	7.2	7.1	7.3	7.4	7.5	7.5	8.5	Dry
H_2S	0.002	139	123	134	104	314	349	34	733	1082	663	523	733	1710	104	104	104	590	
NO_3	80	3	2	3	5	4	10	2	9	9.5	7	6.2	2	2.3	6	3	3	13.2	
CO_2	1	8.4	.8.3	8.1	9.8	10	10	9.9	40	44.8	30	25	3.6	3.7	3.3	3.1	3.2	0	
Pb	0.008-0.004	0.1	0.1	0.1	0.09	0.1	0.27	0.06	0.16	0.26	0.17	0.17	0.1	0.1	0.14	0.15	0.17	0.37	
Zn	0.1	0..03	0.07	0.07	0.13	0.08	0.22	0.12	BDL	BDL	BDL	BDL	0.07	0.01	0.06	0.56	0.4	0.1	
Cd	0.0002	0.02	0.02	0.02	BDL	BDL	0.01	BDL	BDL	0.04	0.004	0.005	0.02	0.01	BDL	BDL	BDL	0.04	
Ni	30-75	0.04	0.04	0.04	0.1	0.08	0.22	0.07	0.18	0.21	0.13	0.13	0.04	0.05	0.1	0.1	0.1	0.4	
Cu	0.001-0.01	0.0026	0.0025	0.0025	0.003	0.003	0.003	<0.0020	0.002	0.0036	0.002	0.002	0.0021	0.0022	0.0020	0.0020	0.0021	0.0045	
Fe	0.2	0.01	0.01	0.01	0.04	0.05	0.08	0.03	0.08	0.26	0.1	0.09	BDL	BDL	0.07	0.07	0.08	0.4	
Al	0.52	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
As	3	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	
Hg	0.0003	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	
pH	6.5-8.5	7.6	7.5	7.4	7.2	7.3	7.3	7.4	7.5	7.1	7.1	7.3	7.4	7.2	7.1	7.6	7.5	8.4	Wet
H_2S	0.002	586	516	481	111	279	705	356	726	1989	1158	502	237	307	488	97	125	570	
NO3	80	3	4	7.8	6	2	9	6	2.3	11.7	2	0.2	3	3	7.5	4	4	12	
Pb	0.008-0.004	0.2	0.2	0.2	0.95	0.8	1.3	2.3	0.01	0.08	1.4	1.6	0.2	0.3	0.2	0.2	0.3	0.26	
Zn	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Cd	0.0002	0.07	0.08	0.09	BDL	BDL	0.02	BDL	BDL	BDL	0.12	0.12	BDL	BDL	0.04	0.04	0.04	0.05	
Ni	30-75	0.03	0.03	0.03	0.2	0.09	0.1	0.08	0.2	0.3	0.2	0.2	0.03	0.03	0.2	0.2	0.2	0.3	
Cu	0.001-0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	
Fe	0.2	0.01	0.01	0.01	BDL	BDL	BDL	0.04	BDL	0.04	0.04	0.03	BDL	BDL	BDL	BDL	BDL	0.1	

Table 3-27: Assessment spring water for aquaculture (fish farming)

Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	
pH	6.5-8.5	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	Dry period
H_2S	0.002	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NO_3	80	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
CO_2	1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	S	
Pb	0.008-0.004	X	X	X	X	X	X	S	X	X	X	X	X	X	X	X	X	X	
Zn	0.1	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	X	S	
Cd	0.0002	X	X	X	S	S	X	S	S	X	X	X	X	X	S	S	S	X	
Ni	30-75	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cu	0.001-0.01	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Fe	0.2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	X	
Al	0.52	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
As	3	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Hg	0.0003	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Indications		1Hq	2Hq	3Hq	4K	5K	6K	7K	8H	9H	10H	11H	12Sh	13Sh	14N	15N	16N	17S	Wet period
pH	6.5-8.5	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
H_2S	0.002	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
NO3	80	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Pb	0.008-0.004	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Zn	0.1	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cd	0.0002	X	X	X	S	S	X	S	S	S	X	X	S	S	X	X	X	X	
Ni	30-75	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Cu	0.001-0.01	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	
Fe	0.2	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	

S=suitable for aquaculture; X=exceed limited

4-Discussion

The balneologists believe, bathing in bicarbonate water has many benefits. It assists opening peripheral blood vessels and helps to improve circulation to the body's extremities. European balneotherapists also utilize bicarbonate water for bathing to address hypertension and mild atherosclerosis. For these conditions, tepid to warm baths are utilized (20-37.8˚C). Each of spring water in this study has temperature within this range during the both periods of dry and wet. Also, spring has high concentration of bicarbonate. Accordingly, this study recommends swimming in springs for treating some diseases by improving the blood circulation, such as heart disease and arteries hardening. According the HCO_3^- basis, Sawa Lake is the best due the high concentration of this radical.

Hot baths (30-36˚C) generally increase the efficiency of the sweat glands. When heat is applied to the skin, nearby arteries dilate and the blood slows, while at the same time more blood is pushed into the charged arteries, causing redness and congestion. The skin's opened pores effectively absorb the active constituents of essential elements from water. Hydrotherapy treatments initiates increase in blood and lymph circulation, strengthens your immune system, improves your metabolism and detoxifies your body (Burr et al., 1999).

pH range during dry and wet periods is suitable for balneology and hydrotherapy. pH as well as the total count of bacteria are recommended factors needed to be assessed. All springs appear to be free of bacteria Streptococcus, clostridium, Yeast and modules, while all the springs contain bacteria *Bacilli*, *Lactobacillus*, *pseudomonas* as well as Algae and fungi. The largest number of bacteria found in Kubaysa (spring 5K), but the lowest number was found in Hit (spring 11H). All the spring waters contain bacteria except Shithathah Najaf and Sawa Lake. The count of total bacteria is less than of 2000/100 ml. The presence of useful bacterial types feed on harmful bacteria expressed as useful case in the therapeutic evaluation.

Assessment of the spring water in comparison with EU and Us spas during the two periods confirm that the spring waters are useful and suitable for balneological therapy, taking into consideration, that there are some springs containing asphaltine with water causing problem. The study advises against swimming directly, but pumping water and collected in private pools to avoid asphaltine. All spring water is not acceptable for drinking, but can be used in minimum limit and with risk for irrigation specifically. For aquaculture purposes, spring water tends to be almost unsuitable for fish agriculture, especially those of high H_2S, other springs are suitable.

Chapter Four

Mud therapy

4 Mud therapy

4-1 Preface

Despite of the uses of clay minerals for patient orally in the form of pills, powders, suspensions, and emulsions as interior uses (oral intake) as gastrointestinal protectors, antacids, and anti diarrhoeaics, clay minerals are also applied topically (to the body's exterior, or on a limited portion of the body) as dermatological protectors or for cosmetic reasons.

Clays can be used mixed with water (geotherapy), mixed with sea or salt lake water or minero-medicinal water, and then matured (pelotherapy), or mixed with paraffin (paramuds). These three methods are used in spas and in beauty therapy. In geotherapy and pelotherapy the application form can be as face masks, cataplasms, or mud baths, depending on the body area to be treated, although in some spas they are also used for corporal massages. Application temperature (hot or cold) depends on the therapeutic aims. The paramuds are applied only as cataplasms, and always hot.

Clay minerals can be beneficial to human health by serving as active principles in pharmaceutical preparations, in spas, and in beauty therapy medicine. The use of clay minerals as therapeutic purposes and dermatological protectors should be preceded by a mineralogical study of the corresponding raw materials.

In some cases, however, these minerals can be harmful to human health. Both the beneficial and harmful effects of clay minerals are described in this chapter. Mud is an important element of nature. It contains important minerals which have positive effects on human health and can absorb toxins from human body, therefore is very useful in preventing many diseases. It is also known for its healing properties. It also helps in cooling and relaxing body as it can hold moisture for a long time.

Twelve (12) samples of sediments collected from spring bottom are studied. Clay mineral separation, chemical analyses (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, BaO, SrO and L.O.I) of sediments are carried out in the ALS Laboratory Group, Analytical Chemistry and Testing Services, Mineral Division-ALS Chemex at Seville, Spain. XRD are done on clay and non-clay fraction. Polarized microscope is used for testing salts that are floating on the surface of spring water.

4-2 Benefits of mud therapy

Many benefits are obtained from mudtherapy; from these, the followings are some available benefits:

- It relaxes muscles and improves blood circulation. It maintains metabolism rendering positive impact on digestion
- It is useful in conditions of inflammation, swelling and relieves pain
- It is a good hair conditioner and is good for skin treatment.
- It is useful in condition of stiff joints

4-3 Types of mud

Mud found in different parts of the world has different properties. Mud composition varies with the place of origin. Firstly, mineral constituents of mud vary with the kind of rocks found in the region and the process of soil formation. Secondly, mud property is influenced by kind of flora and fauna of the region. Therefore, it is essential to learn about properties of mud before utilizing its benefits. For commercial purposes, it is important to note that before using any type of mud, it should be dried, powdered and sieved to remove any type of impurities such as stones and grass; but for natural uses in balneology, it directly uses without any treatment.

4-3-1 Black mud

Dark cotton soil having some greasiness is suitable for mud therapy as it is rich in minerals and also retains water for long time. It should always be free from contamination and any kind of pollution. This type of mud existed in spring sediment of Al-Dwara spring in Hit area (11H).

4-3-2 Mud from Dead Sea

Cleopatra and Queen Sheeba used it for enhancing beauty; black mud of Dead Sea has beauty and therapeutic powers. It contains more than 20 types of salts and minerals including magnesium, calcium, potassium, and bromide, silicates, natural tar and organic elements. This type of mud exists in the sediment of Al-Marj spring in Hit area (8H). This kind of mud could be used for healing and treatment any kind of skin disorders, the presence of silicates minerals masks very beneficial effect of softening and cleansing skin. The mud enhances blood circulation and leaves the skin with a glow. It is a famous mud in the world, and so it is chosen to compare with the spring sediments.

4-3-3 Moor mud

It is mud produced over thousands of years from organic residue of flowers, grasses and herbs. This residue is transformed over several years to fine paste which contains fulvic acids, vitamins, amino acids, plant hormones, humic acids in a form which could be easily absorbed by human body. This mud has therapeutic properties and is useful in detoxification, healing, beautification, nourishing human body. The mud has anti-inflammatory and anti-aging effects. It is also useful in conditions such as Arthritis and recovery from injury in sports. Two spring sediments rich by this type of mud, these are Al-khudher spring (5K) and Al-Jarba spring (6K) in Kubaysa.

4-4 Mineralogy

In this study, twelve samples of sediments (from the bottom of the springs) included 2 salt samples (floating on the water surface) have been studied. Samples are taken from 0-20 cm depth approximately. These are dried naturally by sunlight; then powdered using wood mortar to avoid contamination. Thereafter, they are passed through 270 mesh sieve. Then transferred to plastic bag and sealed to be ready for XRD and chemical analyses for oxides such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, $Cr_2O_3TiO_2$, MnO, P_2O_5, BaO, SrO and L.O.I) in addition to Cl and total carbon (C). Analyses are done in the in the ALS Laboratory Group, Analytical Chemistry and Testing Services, Mineral Division-ALS Chemex at Seville, Spain.

4-4-1 Mineralogy of clay and non-clay minerals

Clay minerals can rarely be identified with the petrological microscope because of their very fine crystal size, thus identification of clay minerals is normally undertaken through XRD of less than 2 μm fraction of the sediment (Tucker, 2001). For this reason, clay fraction is separated from the whole sample.

X-ray diffraction technique is used in identification the both of clay and non clay minerals.

Palygorskite, Kaolinite and montmorellonite are the dominated clay minerals in the spring sediments, whereas calcite, dolomite, quartz, gypsum and halite are the total constituents of the non clay minerals. The percentage of mineralogical composition of clay and non clay minerals are tabulated in Table 4-1.Sawa Lake appears to be free of calcite, dolomite with little amount of halite (0.3%), but its rich with gypsum (92%). Quartz and clay minerals in its sediments may be attributed to the dust participation. Al-Dwara spring in Hit area (11H-s) characterized by possessing the highest amount of kaolinite (10) and montmorillonite (27), whilst Al-Marj spring (8H-s) contain a small amount of clay minerals and rich by calcite. Springs in Kubaysa contain a good amount of kaolinite, palygorskit and montmorillonite {7K-s_2 (8%, 12%, 5%), 7K-s (5.5%, 5%, 6%), 6K-s (5%, 2%, 8%) and 4K-s (4%, 8.5%, 3%)} respectively. But 5K-s has low amount of clay minerals due to the high amount of calcite, dolomite and quartz. Palygorskite and montmorillonite are high in Shithatha spring- 12Sh-s (17% and 10%) respectively. Najaf spring- 14N-s is characterized by high content of palygorskite (20%).

Results of minerals identification using XRD technique for nine springs sediments, in addition to the sample collected from Sawa Lake are presented in Figures 4-1, 4-2, 4-3, 4-4, 4-5, 4-6, 4-7, 4-8, 4-9 and 4-10.

Table 4-1: Mineralogical composition (%) of the springs and Sawa Lake sediment; C=calcite, D=dolomite, Q=quartz, G=gypsum, H=halite, K=kaolinite, P=palygorskite, M=montmorillonite

Sample No.	Non clay minerals (%)					Clay minerals (%)			Total (%)
	C	D	Q	G	H	K	P	M	
4K-s	37	19	21	6.0	1.5	4.0	8.5	3.0	100
5K-s	40	30	17.5	5.0	0.0	2.5	3.0	2.0	100
6K-s	37	29	19	0.0	0.0	5.0	2.0	8.0	100
7K-s	35.5	28	20	0.0	0.0	5.5	5.0	6.0	100
7K-s_2	0.0	45	30	0.0	0.0	8.0	12	5.0	100
8H-s	75	8.0	6.0	4.0	0.0	2.0	3.0	2.0	100
11H-s	21	9.5	23	3.0	3.0	10	3.5	27	100
12Sh-s	48	0.0	21	0.0	1.0	3.0	17	10	100
14N-s	34	10	30	0.0	1.0	2.0	20	3.0	100
17S-s	0.0	0.0	4.0	91.7	0.3	4.0			100
Ranges	0.0-75	0.0-45	4-30	0.0-91.7	0.0-3	2.0-10	2.0-20	2.0-27	100

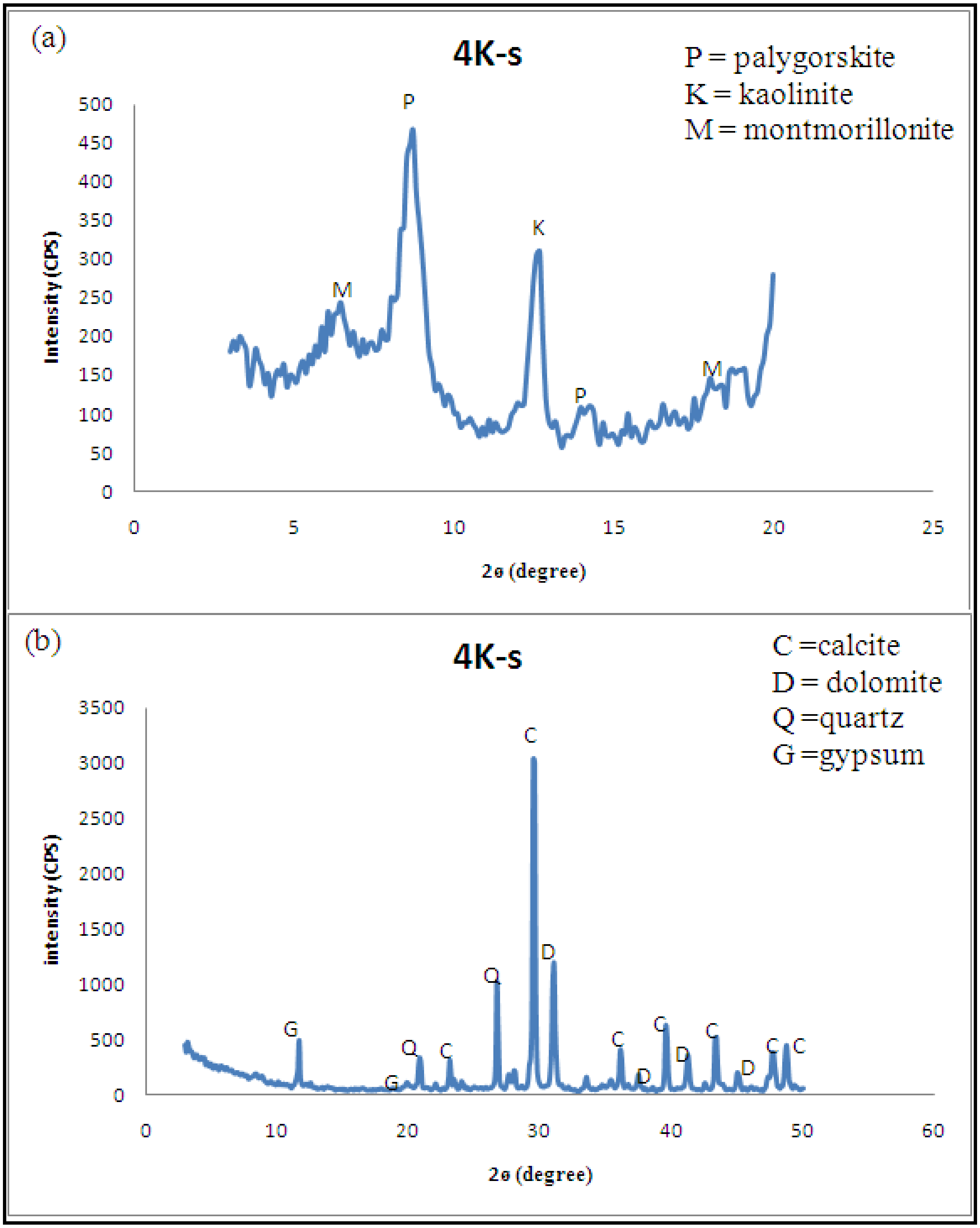

Figure 4-1: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Al-Arnab spring).

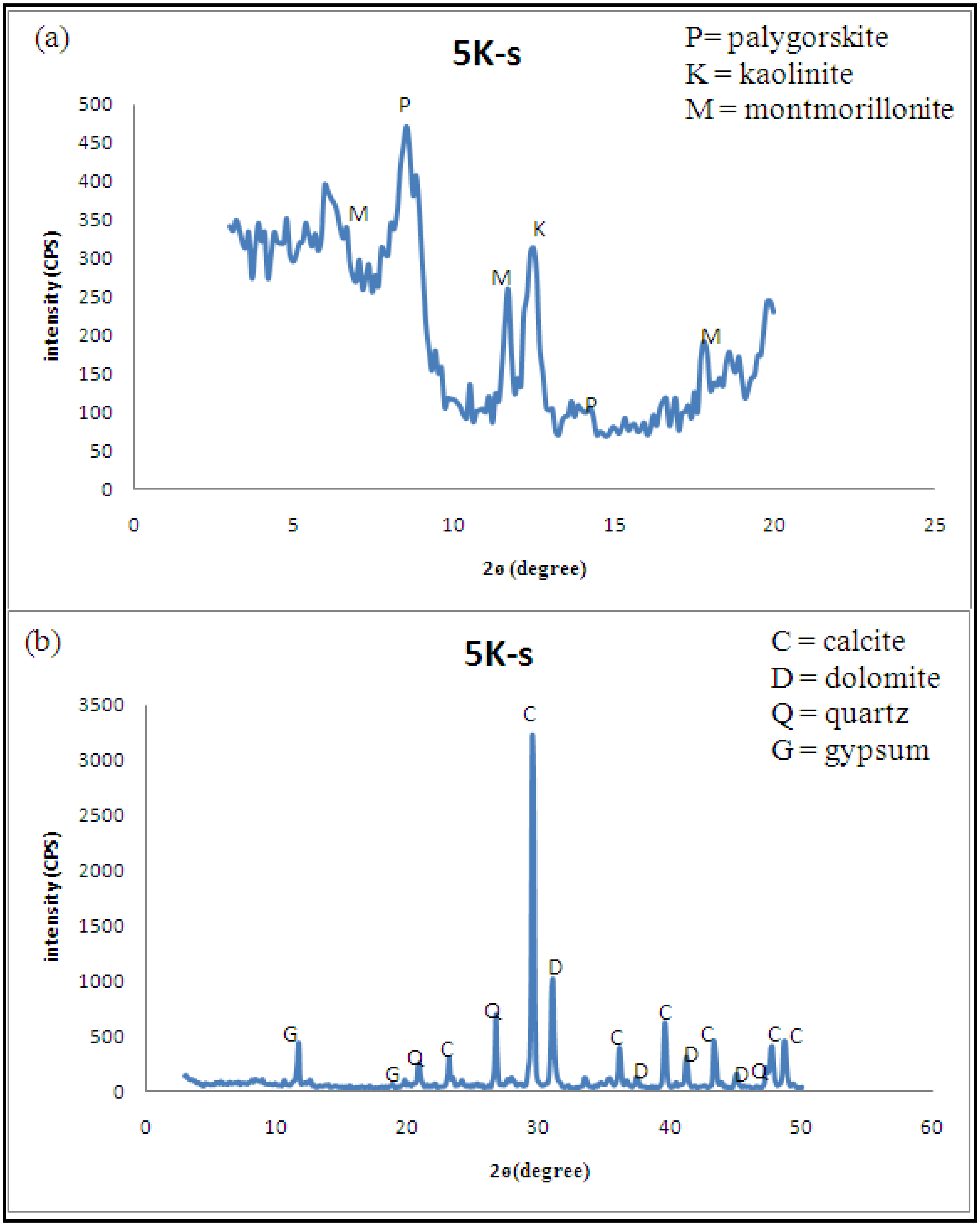

Figure 4-2: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Al-Khudher spring)

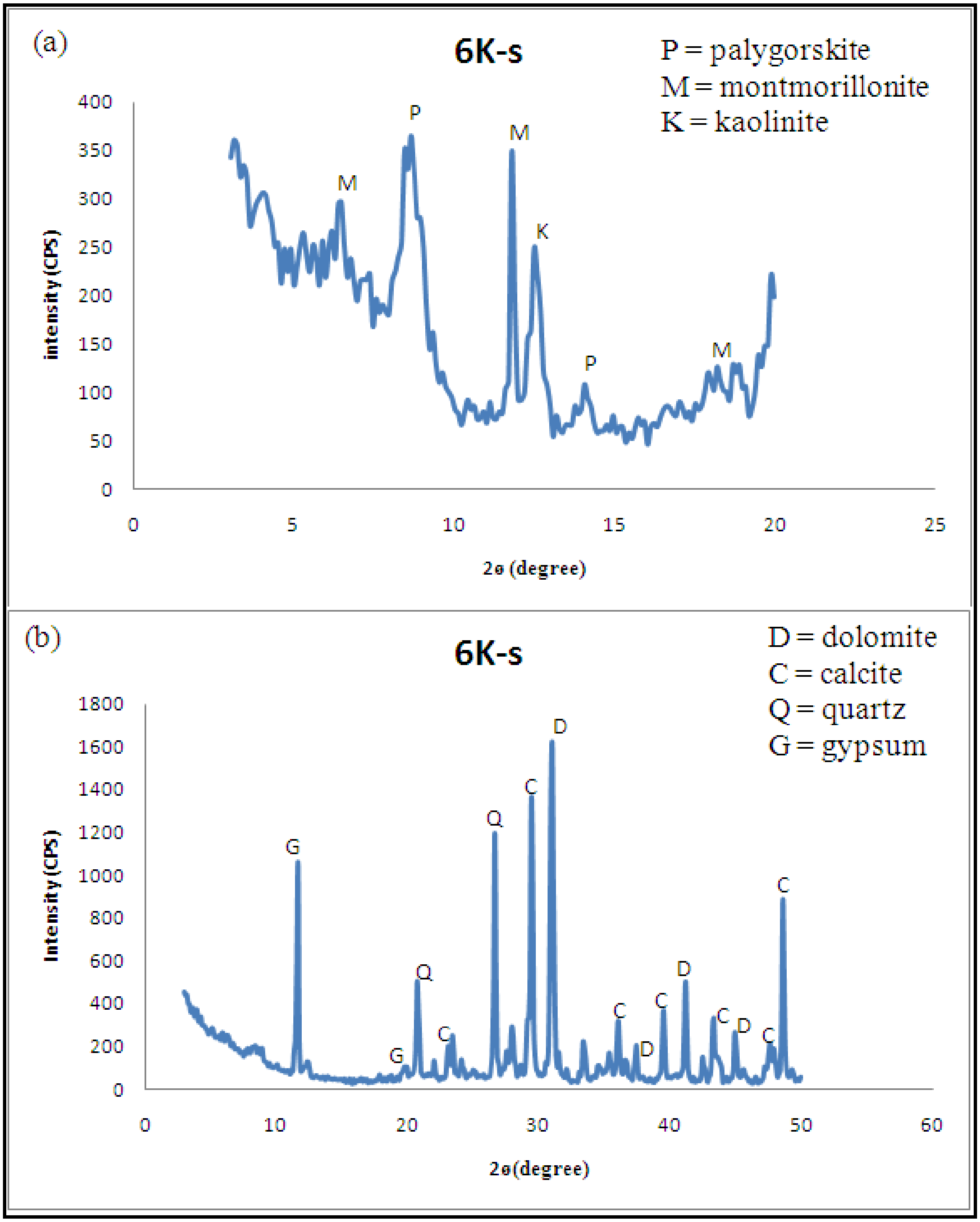

Figure 4-3: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Al-Jarba spring).

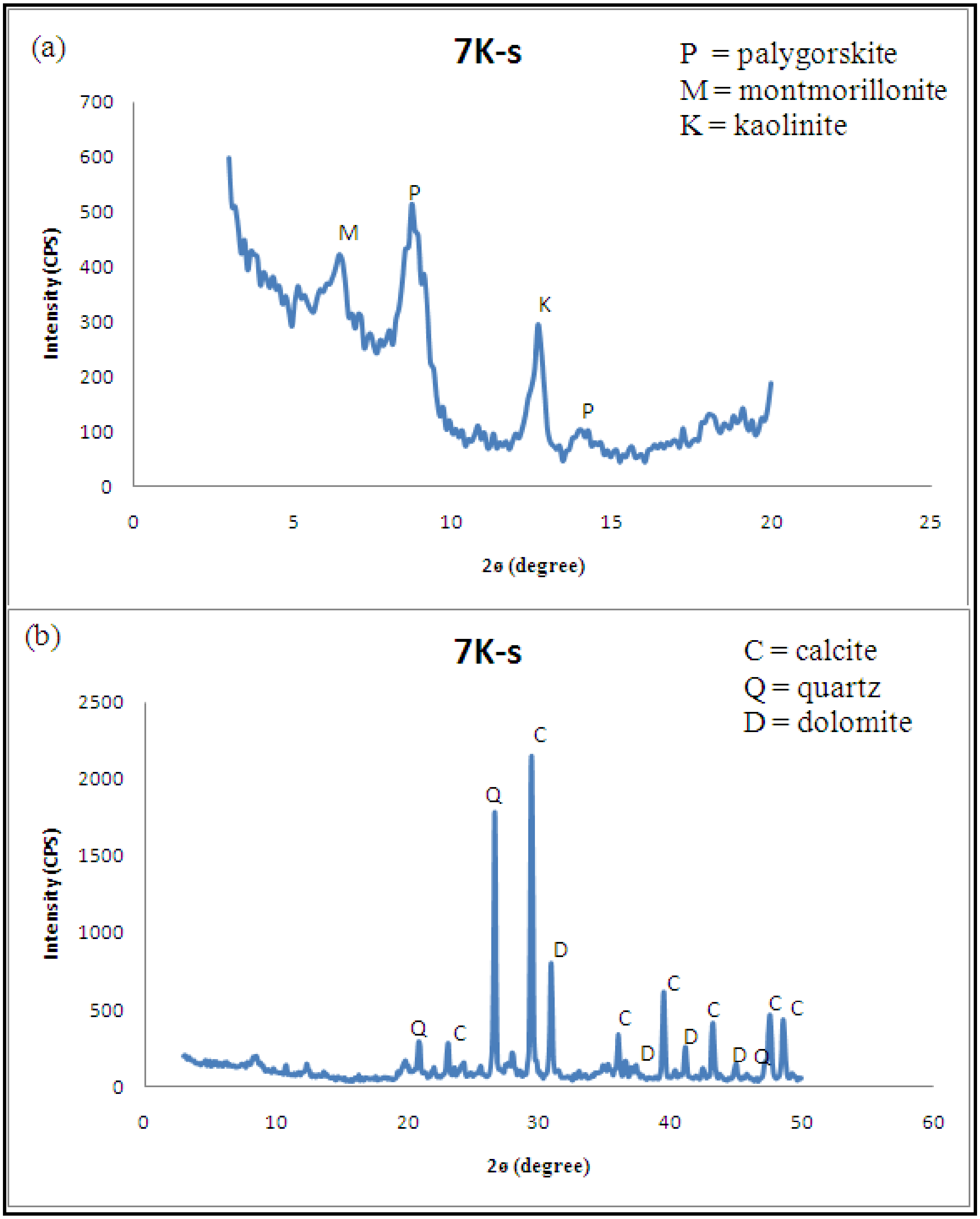

Figure 4-4: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Kubaysa spring).

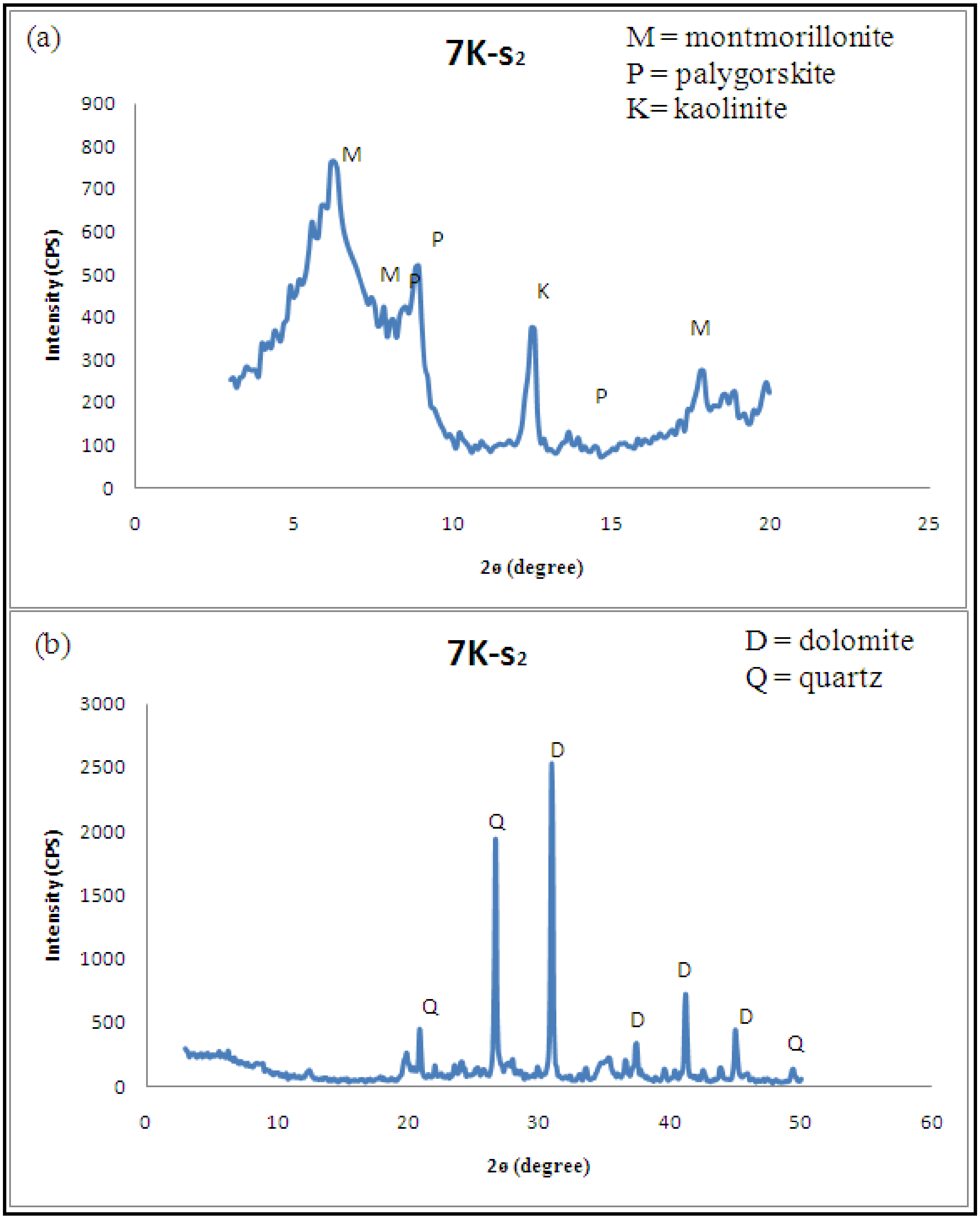

Figure 4-5: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Kubaysa spring).

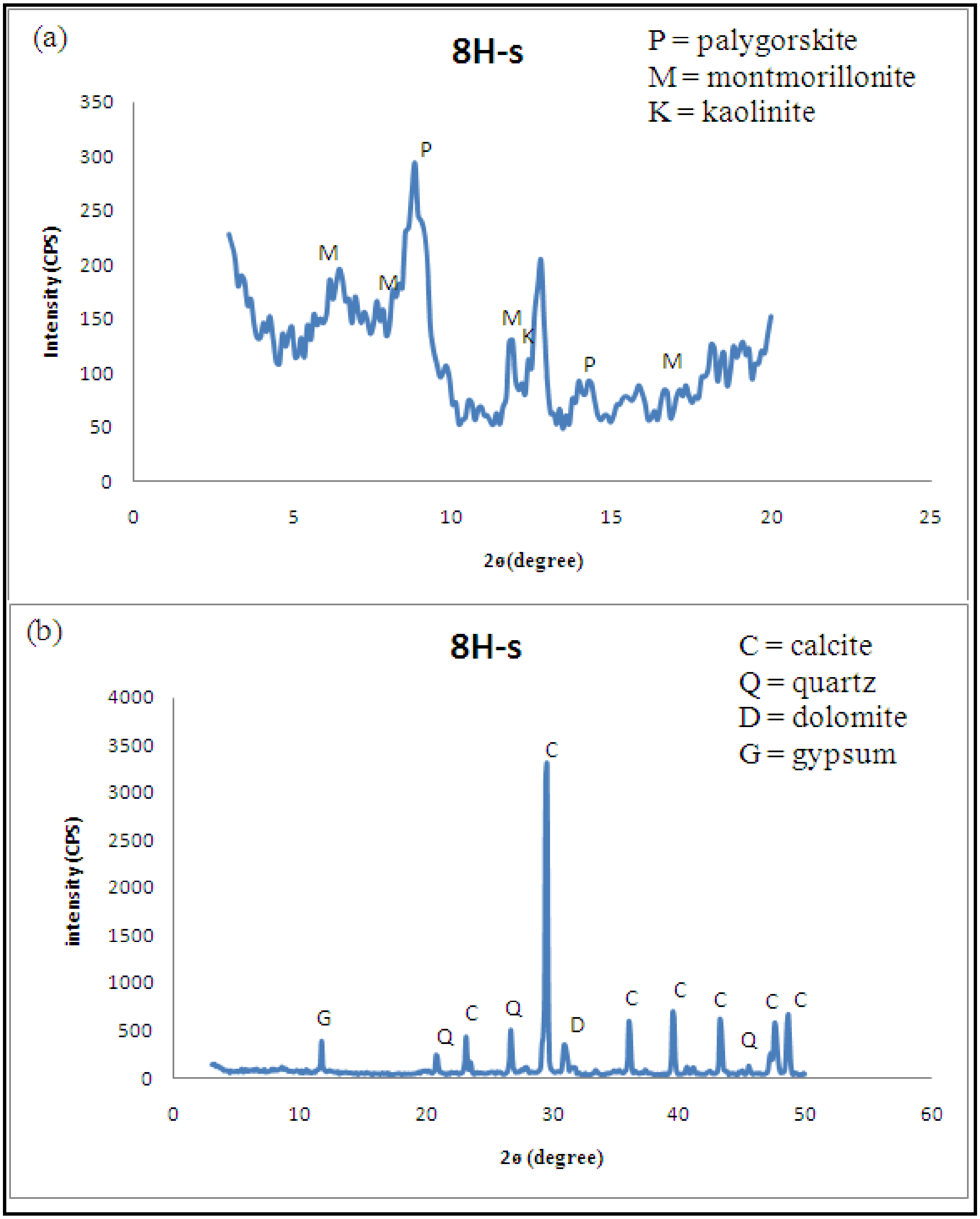

Figure 4-6: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (AL-Marj spring).

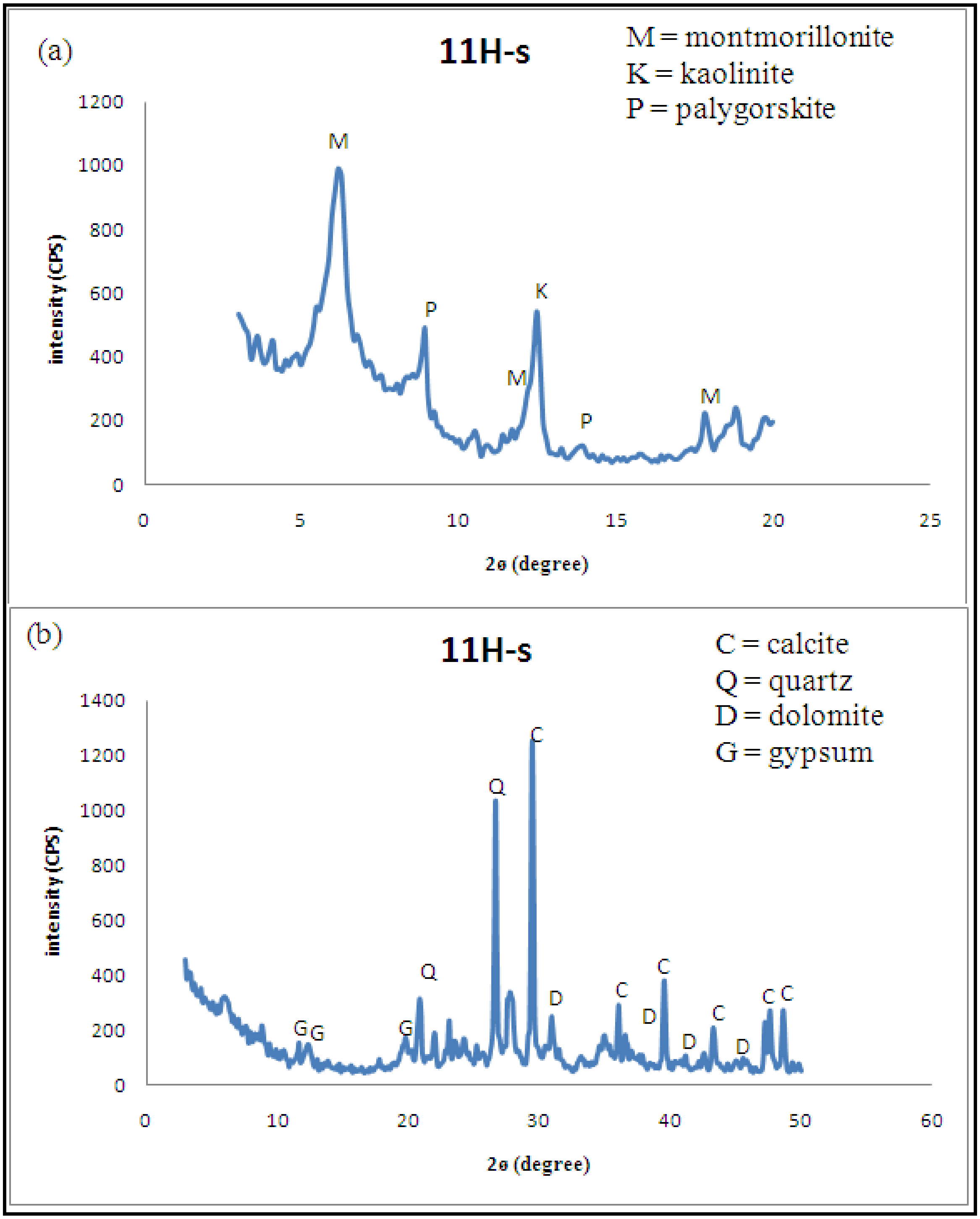

Figure 4-7: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (AL-Dawara spring).

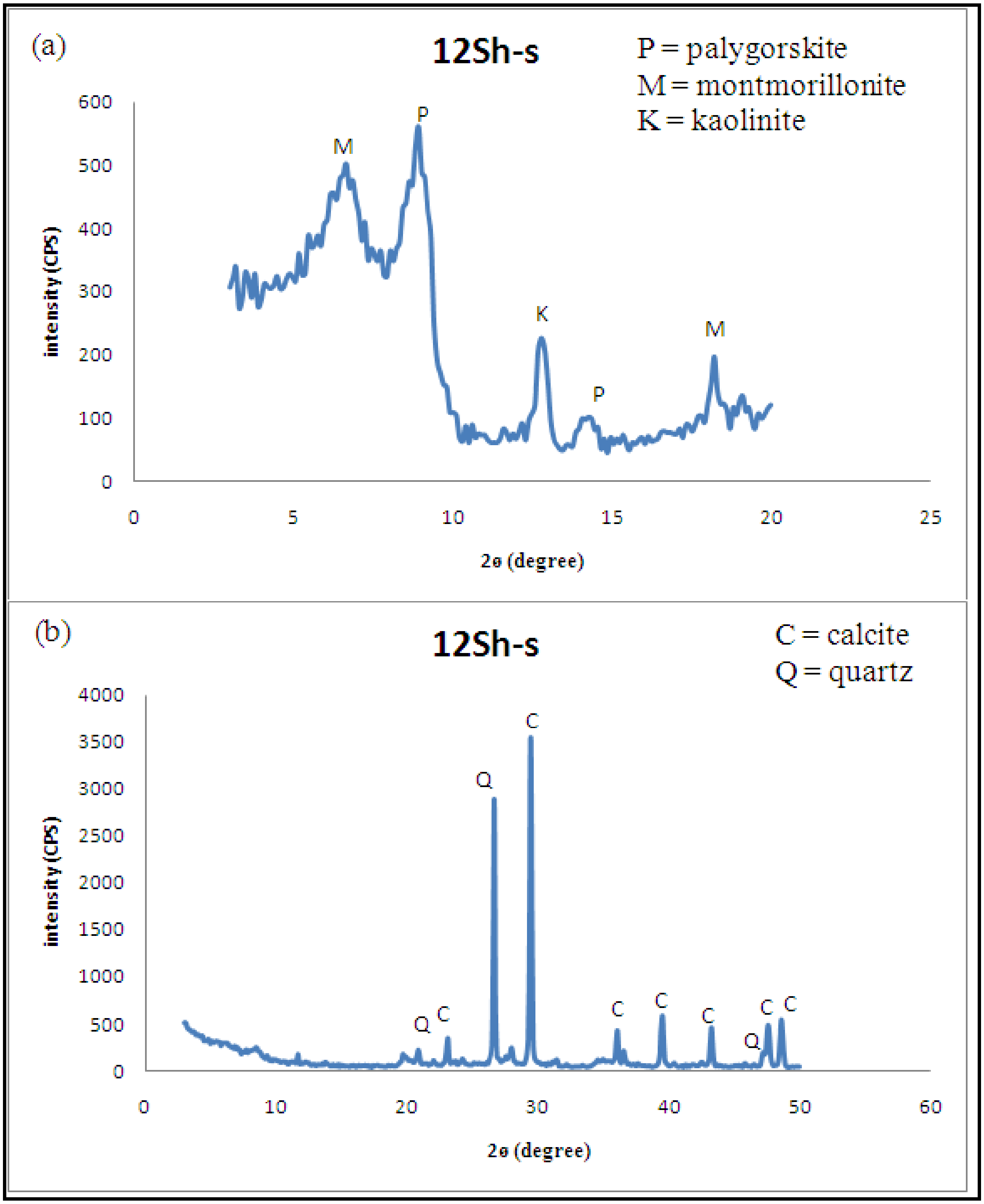

Figure 4-8: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment, (Shithatha spring)

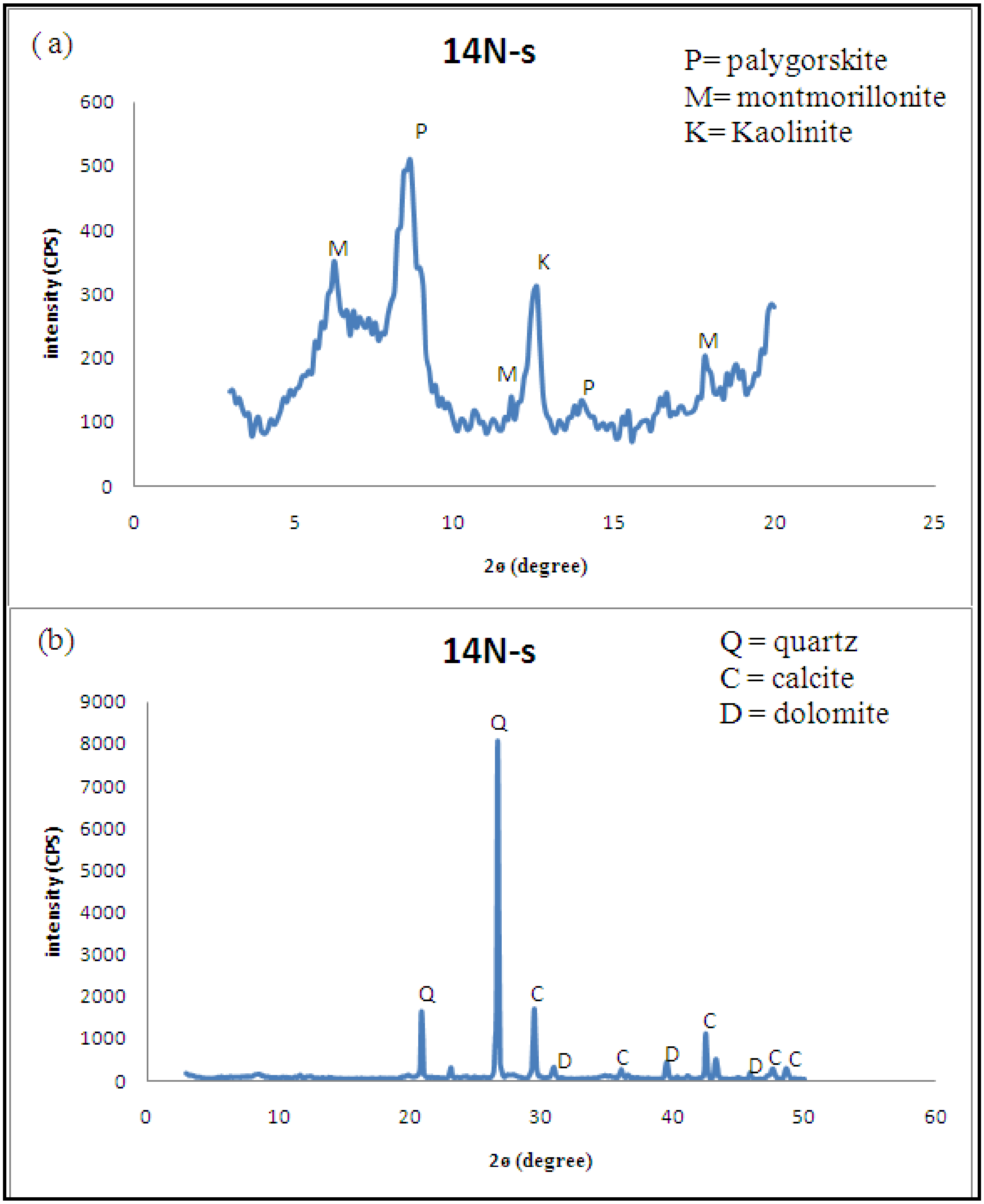

Figure 4-9: X- ray diffractograph of clay fraction (a) and non clay fraction (b) of spring sediment1, (Al - Asawed spring).

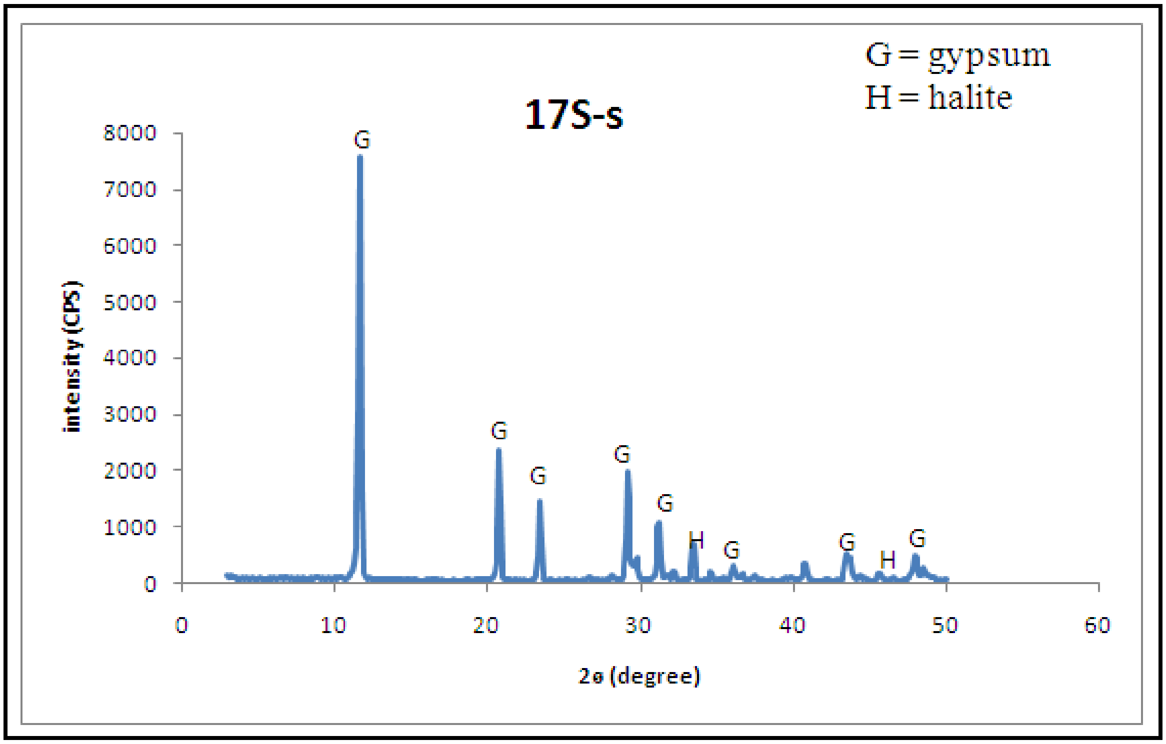

Figure 4-10: X- ray diffractograph of the Sawa Lake sediment.

4-4-2 Mineralogy of spring salts floated on water

High concentration of ions in spring water appears to be yielded saturation solutions. The state of saturation with intensity of evaporation caused formation a thin layer of salt, floating above the spring water. Salts take a variety of colors possible diagnosis for light gray, white and pink color. We did not recognize the reasons for the pink color. It needs more scrutiny and study. Two springs only have floated salts; these are Al-Marj spring (8H-t) that formed a thin layer of light gray salts (Plate 4-1), and Al-Dawara spring (11H-t) in Hit that formed a thin layer of pink salts (Plate 4-2). Salt floating on the surface of the spring water collected manually using fine openings sieve. Thereafter, salts are dried, prepared as thin sections and examined under polarized microscope. Plate 4-3 shows a cubic crystal of halite indicating that spring has saturation with Na and Cl ions.

Plate: 4-1: Light gray color salt floating on water, Al-Marj spring (8H-t).

Plate4-2: Pink salts color floating on spring water, Al-Dawara spring(11H- t)

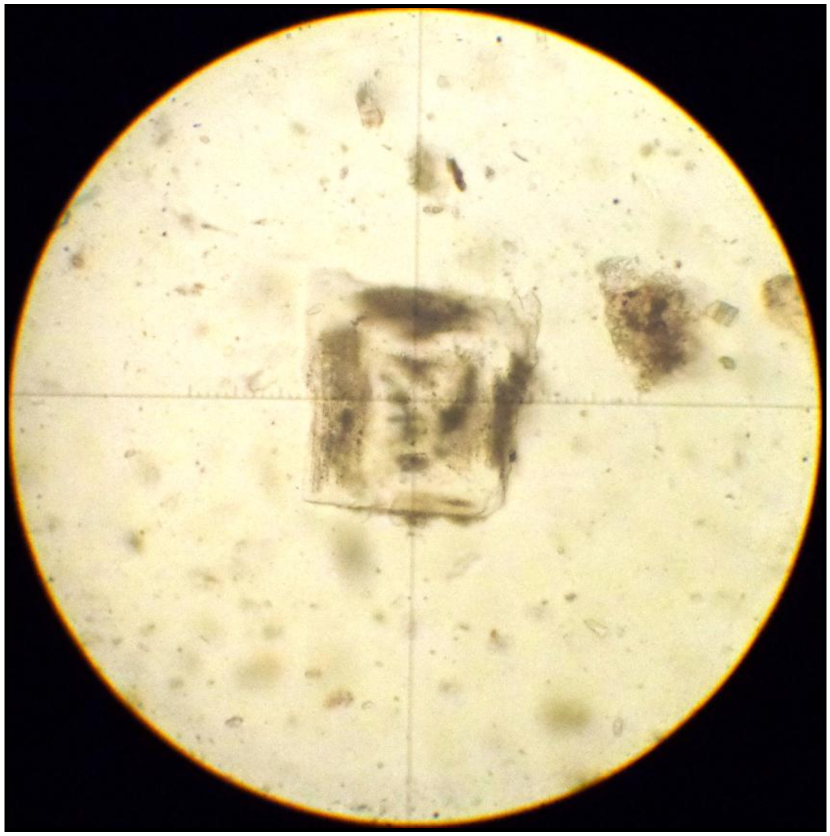

Plate 4-3: Halite crystal from Al-Marj spring (8H-t) under microscope, (+); (5X).

The floated salts are tested using XRD. This technique revealed that the thin crust of light gray salts of Al-Marj spring (8H-t) consists of calcite, gypsum and halite (Figure 4-11), while it is formed from calcite and gypsum in Al-Dawara spring (11H-t) in Hit (Figure 4-12).

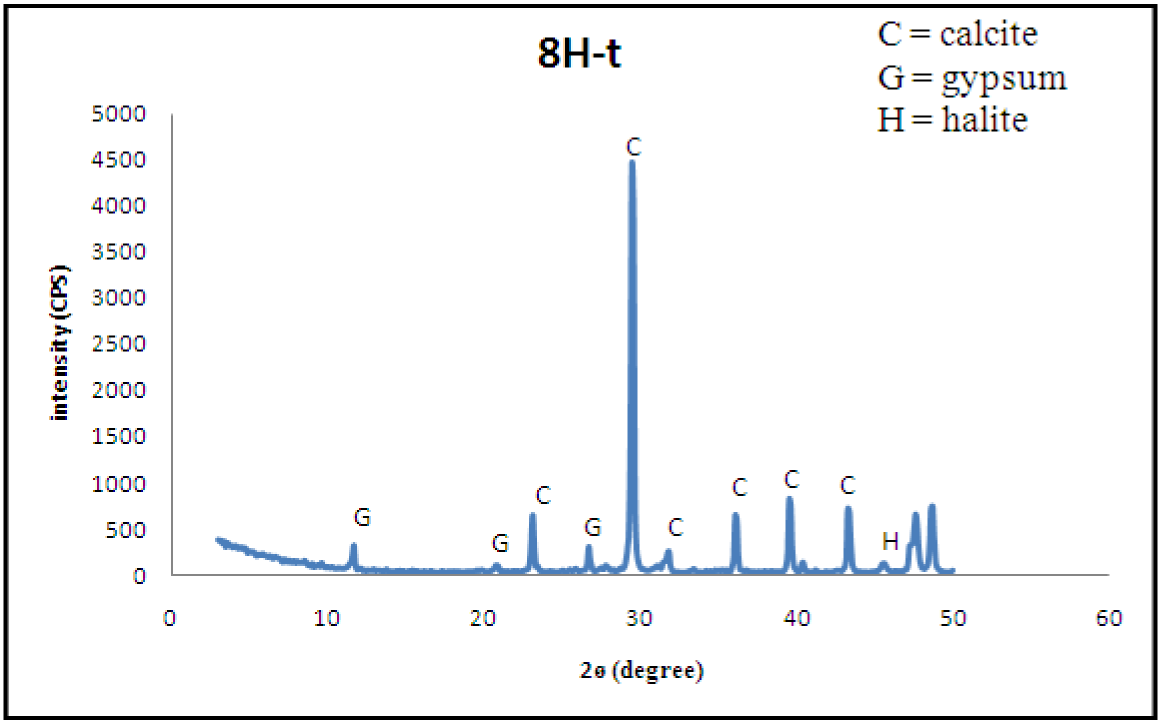

Figure 4-11: X- ray diffractograph of salt sample, Al-Marj spring, t=salt

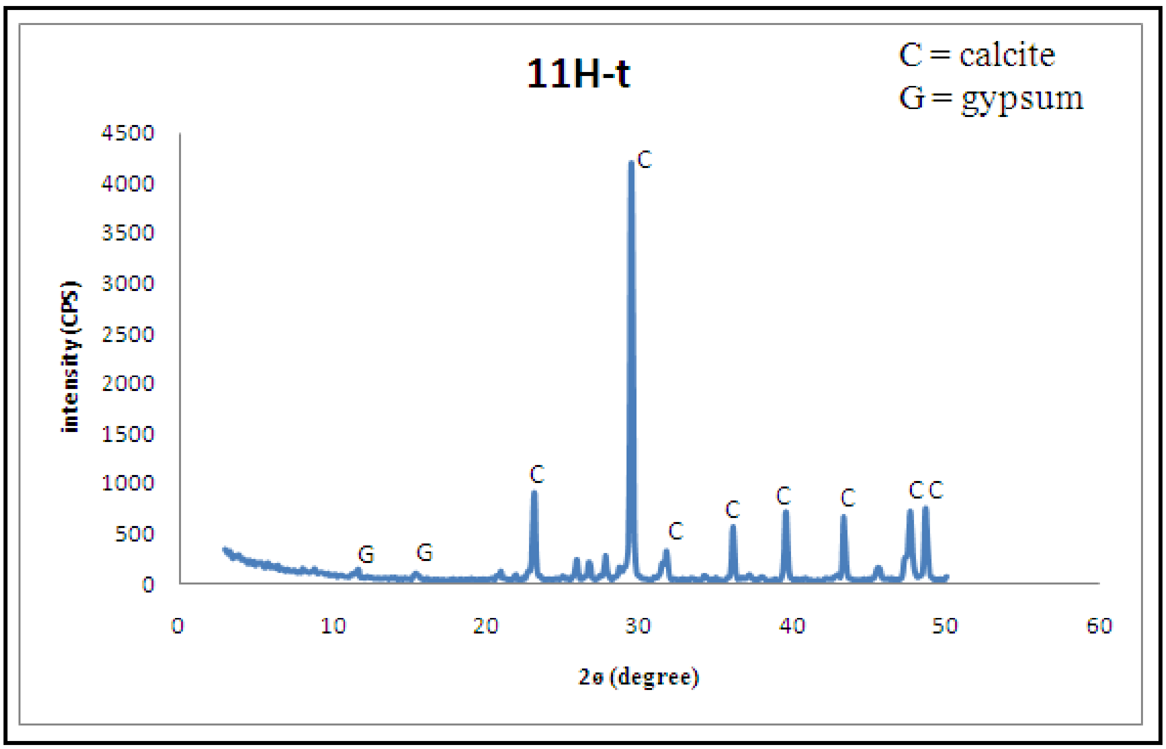

Figure 4-12: X- ray diffractograph of salt sample, Al-Dwara, spring, t=salt.

4-5 Therapeutic assessment based on mineralogy

The sediments collected from the bottom of spring sediments in the studied area are predominantly composed of calcite, dolomite, gypsum, quartz and halite, as well as clay minerals comprised montmorillonite, palygorskite and kaolinite. Little amount of organic and bituminous materials with asphaltine can be seen clearly in one spring in Hit (9H) and Al-Marj spring (8H).

Calcite and dolomite are originated from the limestone and dolomitic limestone of different formations in the studied area such as Euphrates Formation. Gypsum and halite are precipitated from spring waters by evaporation. Some quantity of gypsum comes from Fatha Formation.

Clay and quartz are originated from the claystone, marl, marly limestone of Fatha, Euphrates formations and Quaternary sediments. Organic matter and bituminous materials in addition to H_2S gas are originated from the depth in association with the groundwater.

There are a chemical processes led to formation sediments. Evaporation is action and dominant. The chemical composition of the spring sediments is compared with the sediments of Dead Sea (Table 4-2).

Result reveals that the spring sediments are lower quality than the Dead Sea sediments due to high content of calcite, dolomite and quartz with little amount of clay minerals. The results of assessment of the spring sediments in comparison with the sediments of Dead Sea are presented in Table 4-3 which shows that each spring has distinctive characteristics. This assessment does not mean that muds are unsuitable for treatment and cannot be use as therapeutic mud, but it means it's less efficient than Dead Sea clays.

Table 4-2: Mineralogical composition of spring sediments compared with the Dead Sea sediments.

Minerals		Dead* Sea	4K-s	5K-s	6K-s	7K-s	7K-s_2	8H-s	11H-s	12 Sh-s	14N-s	17S-s
Non clay minerals	Quartz	1-5	20.0	17.5	19	21	30.0	6	23	21	30.0	4
	Calcite	5-15	35.5	40.0	37	37	0.0	75	21	48	34	0.0
	Dolomite	0.0	28	30.0	29	19	45	8	9.5	0.0	10.0	0.0
	Gypsum	0.0	0.0	5	0.0	6	0.0	4	3	0.0	0.0	91.7
	Halite	0.0	0.0	0.0	0.0	1.5	0.0	0.0	3	1.0	1.0	0.3
Clay minerals	Montomorillonite	50-70	6	2	8	3	5	2	27	10.0	3	4%
	Kaolinate	10-20	5.5	2.5	5	4	8	2	10.0	3	2	
	Illite	10-15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Palygorskite	<5	5	3	2	8.5	12	3	3.5	17	20.0	
	Chlorite	<5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Total	100	100	100	100	100	100	100	100	100	100	100

*****= After Ma'or et al., 2006

Table 4-3: Therapeutic assessment of the spring sediments in comparison with the Dead Sea. (X= exceed limited, S= suitable for therapeutic) based on mineralogical composition.

minerals	D.Sea	4K-s	5K-s	6K-s	7K-s	7K-s_2	8H-s	11H-s	12 Sh-s	14N-s	17s-s
Quartz	1-5	X	X	X	X	X	S	X	X	X	S
Calcite	5-15	X	X	X	S	X	X	X	X	X	S
Dolomite	0.0	X	X	X	X	X	X	X	S	S	S
Gypsum	0.0	S	S	S	S	S	S	S	S	S	S
Illite	0.0	X	X	X	X	X	X	X	X	X	X
Montomorilonite	50-70	X	X	X	X	X	X	X	X	X	X
Kaolinite	10-20	X	X	X	X	X	X	S	X	X	X
Palgorskite	<5	X	S	S	X	X	S	S	X	X	X
Chlorite	<5	S	S	S	S	S	S	S	S	S	S

4-6 Therapeutic mud classification

Based on acidity, salinity, color and organic matters, the three classes of mud are:

1. Pure mineral (fango, mud) - neutral
2. Mainly mineral (sea mud or liman) - alkaline
3. Mainly vegetable peloid (moor, peat) – acid

Black mud is unique, black, hypersaline mud mined from the Dead Sea shores is extensively used in mud packs, masks, and topical body and facial treatments in spas surrounding the lake; and in cosmetic preparations marketed worldwide, but little is known about its anti-microbiological properties. It uses in dermatological and cosmetic preparations.

Red mud, yellow mud and light gray mud are also used for therapeutic and beauty purposes. There are many type of mud depended on its color. Black, red and light gray muds are existed in the studied springs.

The spring sediments could be classified as mainly mineral (sea mud or liman)-alkaline based on the acidity, minerals and color, where the pH tends to be alkaline (Table 4-4). Sediments contain TDS (40 mg/l) and EC (80 µs/cm) as lowest values in Najaf (14N-s), whilst 1650 mg/l and 2795 µs/cm in Hit (11H-s) respectively (Table 4-4). This variation in TDS and EC reflects the salinity of spring sediments.

Temperature of spring sediments reached 40°C in summer. This temperature is very useful for human body. The skin effects of mud are:

1. Increase the body temperature
2. Lowering of blood pressure
3. Influence on mineral metabolism and blood chemistry

The gray or black mud are used widely in dermatological and cosmetic preparations, there is a paucity of information concerning its chemical composition, microbial colonies, and effect on pathogenic and nonpathogenic microorganisms. Accordingly, such these factors are performed via this study to gain a better understanding of the spring sediments, and how could to invest this benefit for therapeutic purposes. The black mud existed in the study areas especially in spring sediment of Al-Dwara spring in Hit area (11H). Moor mud are existed in Al-khudher spring (5K) and Al-Jarba spring (6K) in Kubaysa.

Table 4-4: Salinity and acidity of spring sediments.

Sample No.	pH	TDS mg/l	EC μs/cm
4K-s	7.8	180	500
5K-s	7.7	800	1780
6K-s	7.3	810	1790
7K-s	7.9	190	400
7K-s_2	8.0	120	250
8H-s	6.9	1640	2788
11H-s	6.8	1650	2795
12Sh-s	8.8	130	240
14N-s	8.3	40	80
17S-s	n.d	n.d	n.d
Range	6.9-8.8	40-1650	80-2795

n.d= not determined

4-7 Health effects of clay

Many local trials for patients who took mud baths took place a long time ago and continue until now. Many medical cases for patients in particularly dermatological cases got healing after taking a mud bath for several times.

Black mud, gray mud and moor mud are three classes of mud that are used in mud therapy. These types of spring sediments have health effect. They are to recover from a lot of pain and diseases. Generally, the health effects of clay can summarized as below:

1. Chronic arthritis
2. Fibrositis
3. Neuritis, sciatic syndrome
4. after treatment of fractures
5. Sport and industrial injuries in spring

All These types found in the springs under study, making it useful for therapeutic uses.

4-8 Geochemistry

Geochemistry can be applied for assessing mud for therapeutic purposes.

4-8-1 Geochemistry of sediments and therapeutic assessment

The results of chemical composition of the spring sediments are listed in Table 4-5. Mineralogy appears to be fit with chemical analyses. Quartz participate the most of silica. Clay minerals added silica, Alumina, some of CaO, MgO, and Fe_2O_3 and little of LOI. Calcite participated in CaO and LOI. Dolomite added MgO as well as CaO and LOI. Gypsum added CaO, SO_4 and LOI. Na and Cl origianted from halit. P_2O_5, Cr, Ba, Mn and Sr are traces.

The Dead Sea and Hungarian sediments are famous sediments used for treatment as mud therapy. Tourists visit theses sites from all over the world for treatment purposes. For this reason it considered as guideline standard for the purpose of comparison. The variation in the results of chemical composition between Dead Sea and Hungarian sediments are used as range of comparison. Accordingly, Kubaysa spring (4K, 5K, 6K ,7K), Hit springs (8H,11H), Shithatha (12 Sh) ,Najaf spring (14N) and Sawa Lake (17S) , could be classified as springs that have sediments almost similar to the Dead Sea sediments and Hungarian sediments with little differences (Table 4-5). CaO appears to be high due to the abundant calcite, Na_2O and K_2O tend to be low due to scarcity of halite and illite respectively. Haqlanya springs have no fine sediments; they flow with coarse sand and pebbles. Here, focus attention to the springs contained asphaltine and tar (8H and 9H) floated on water surface is recommended to avoid summing, but Al-Marj spring (8H) useful for mud path. Silica and Alumina come from clay minerals. The excess silica forms quartz. Calcite, dolomite and gypsum give CaO and Loss on ignition. The source of magnesia (MgO) is dolomite and palygorskite. Halite is a source of Na_2O and Cl. The chemical analyses of spring sediments show few prominent features. First, the sediment is hypersaline, with the salt concentration of interstitial waters approaching that spring water (see Cl concentration). However, the ionic composition of sediment differs somewhat from that of spring brines. Table 4-6 present geochemical assessment for each spring.

Table 4-5: Results of chemical composition of spring sediments and Sawa Lake compared with the Dead Sea (D.S) and Hungarian Spa (H.S).

Oxides %	D.S*	H.S**	4K-s	K-s_2	6K-s	7K-s	7K-s_2	8H-s	11H-s	12 Sh-s	14N-s	17S-s
SiO_2	20	60.05	32.77	20.65	24.34	29.06	36.20	11.63	37.69	31.68	37.38	5.64
Al_2O_3	4.8	17.91	6.88	3.87	5.02	6.83	9.62	2.85	10.11	6.31	5.74	0.8
Fe_2O_3	2.8	4.34	3.34	2.0	2.56	3.42	3.12	1.46	5.86	3.08	2.90	0.43
CaO	15.5	1.54	23	31.39	26.74	23.72	12.73	40.16	15.84	27.08	21.45	36.89
MgO	4.5	2.10	4.37	6.99	7.97	5.86	10.17	2.91	4.82	2.52	4.39	2.2
Na_2O	1.7	0.89	0.55	0.37	0.69	0.61	0.45	0.56	1.81	0.66	0.63	0.67
K_2O	1.3	2.39	1.19	0.69	0.75	1.16	2. 65	0.31	1.25	1.28	1.11	0.05
TiO_2	0.5	0.54	0.45	0.28	0.38	0.44	0.63	0.18	0.62	0.41	0.40	-
MnO	--	0.05	0.04	0.03	0.03	0.04	0.02	0.021	0.09	0.034	0.04	-
P_2O_5	0.3	0.14	0.21	0.18	0.21	0.16	0.18	0.07	0.17	0.04	0.14	-
Cr_2O_3	-	-	0.02	0.01	0.01	0.02	0.03	0.01	0.04	0.03	0.02	-
LOI	-	1.72	25.59	32.8	30.74	27.66	22. 72	38.55	20.38	26.01	24.35	15.9
Total %	-	-	98.51	99.48	99.60	99.10	98.61	99.0	98.8	99.30	98.65	100
C (ppm)	-	-	6.19	7.55	6.07	6.68	4.75	9.71	4.6	5.53	6.37	-
Cl (ppm)	67000	-	720	780	3490	1610	440	6770	6750	490	750	8200
Sr (ppm)	550	-	425	680	766	425	170	1786	2807	595	766	-
Mn (ppm)	250	-	309	232	232	400	155	155	155	232	400	-
Ba (ppm)	200	-	179	89	90	90	179	179	179	448	89	-

*= Ma'or et al. (2006)

**= Hungarian Spa (Website)

Table 4-6: Therapeutic assessment of the spring sediment based on geochemistry compared with the Dead Sea (D.S) and Hungarian spa (H.S).

Oxides		D.S	H.S	4K-s	4K-s_2	6K-s	7K-s	7K-s_2	8H-s	11H-s	12 Sh-s	14N-s	17S-s
SiO_2		20	60.05	S	S	S	S	S	X	S	S	S	X
Al_2O_3		4.8	17.91	S	S	S	S	S	X	S	S	S	X
Fe_2O_3		2.8	4.34	S	S	S	S	S	X	S	S	S	X
CaO		15.5	1.54	X	X	X	X	S	X	S	X	X	X
MgO		4.5	2.10	S	S	X	X	X	S	S	S	S	X
Na_2O	%	1.7	0.89	X	X	X	X	X	X	X	X	X	X
K_2O		1.3	2.39	X	X	X	X	X	X	X	X	X	X
TiO_2		0.5	0.54	S	S	S	S	S	S	S	S	S	X
MnO		-	0.05	S	S	S	S	S	S	S	S	S	X
P_2O_5		0.3	0.14	S	S	S	S	S	X	S	S	S	X
Cl		67000	---	S	S	S	S	S	S	S	S	S	X
Sr	ppm	550	---	S	X	X	S	S	X	X	X	X	X
Mn		250	---	S	X	X	S	S	S	S	S	X	X
Ba		200	---	S	S	S	S	S	S	S	X	S	X

S= suitable for therapeutic, X = exceed the limited

4-8-2 Geochemistry of salt

Mineralogy reflects well the chemical composition of the spring salts. The results of chemical composition (%) of the spring salts are listed in Table 4-7. The light gray salt and pink salt float on the water surface of the Al-Marj spring (8H) and Al-Dwara spring (11H). The XRD diffractograph shows the results of salts (Figure 4-11 and 4-12), It is clear that the calcite is the predominant mineral with little amounts of gypsum and halite. The slightly alkalic pH and high Ca ions in the spring water participate in the precipitation of calcite. Some of the Ca ions are linked with SO_4 ions are forming gypsum, but this mineral appear to be unstable under the prevailing pH. Halite is formed from Na ion liked with Cl ion. Sodium is an alkali metal element, has small ionic radius with high ionic potential; therefore, it remains dissolved in the solution. For this reason the quantity of halite is very rare. But, it may be increased when the amount of water decreases due to evaporation within super saturation solution. This solution is noticed in an isolated area near Al-Marj spring is forming the white salt of halite. CaO, SO_3 L.O.I values are fit with the mole proportion of calcite and gypsum. Alumina and silica, iron, magnesium and potassium are rare and reflect the trace of clay and quartz that originated from atmospheric dust on the salt crust. Chromium, titanium and manganese are traces that linked as substituted elements with crystal lattice of calcite.

Table 4-7: Results of chemical analysis of the springs salts

Sample No	SiO_2	Al2O_3	Fe_2O_3	CaO	MgO	Na_2O	K_2O	Cr_2O	TiO	MnO	P_2O_5	SrO	BaO	LOI	Total
8H-t	5.07	1.31	0.73	45.48	1.56	0.63	0.09	0.01	0.074	0.02	0.04	0.34	0.02	43.89	99.3
11H-t	3.15	0.74	0.43	37.42	1.04	0.61	0.08	0.01	0.04	0.02	0.09	0.24	0.01	55.18	99.1

4-9 Bacteriology

Bacterial analyses are carried out on the spring sediments. Spring sediment samples are examined in terms of bacterial species. These are cultured in specific media to help bacteria growth. After testing the cultured media, a numbers of colony-forming microorganisms in the spring mud are observed. Lab test revealed the presence of the following bacteria: *pseudomonas*, *Bacillus subtilis*, *Staphylococcus and Lactobacillus.*

4-9-1 *Pseudomonas*

Pseudomonas is found in the spring sediments (Plate 4-4). These are aerobic oxidizing bacteria which have the ability to use organic materials such as hydrogen (H) and carbon monoxide (CO) as a source of energy. They have the ability to oxidize H_2S to produce SO_4^{2-} . Thus, they are enhancing the formation of sulfate mineral which characterizes springs sediment. They also have ability to use nitrite as source of energy, just like oxygen, in the presence of glaycole and phosphor. It converts nitrate compounds to nitrogen when the bacteria are found in poor aerated sediments rich in organic compounds. This properly explains the low concentration of nitrite in springs (Cruickshank et al, 1975). These are pathogenic bacteria to human and animals. For human, they causes many disease like wound infection and noscomial infection, otitismedia, meningitis, pneumonia, urinary track infenction, ostemylitits and septicemia in new born babies. Some strain of *pseudomans aerugenosa* have the ability to produce pyocin which is bacteriocin composed of protein have the ability to kill other bacteria of this species, or result species so it is considered abectria cidial agent (Sneach et al ,1986).

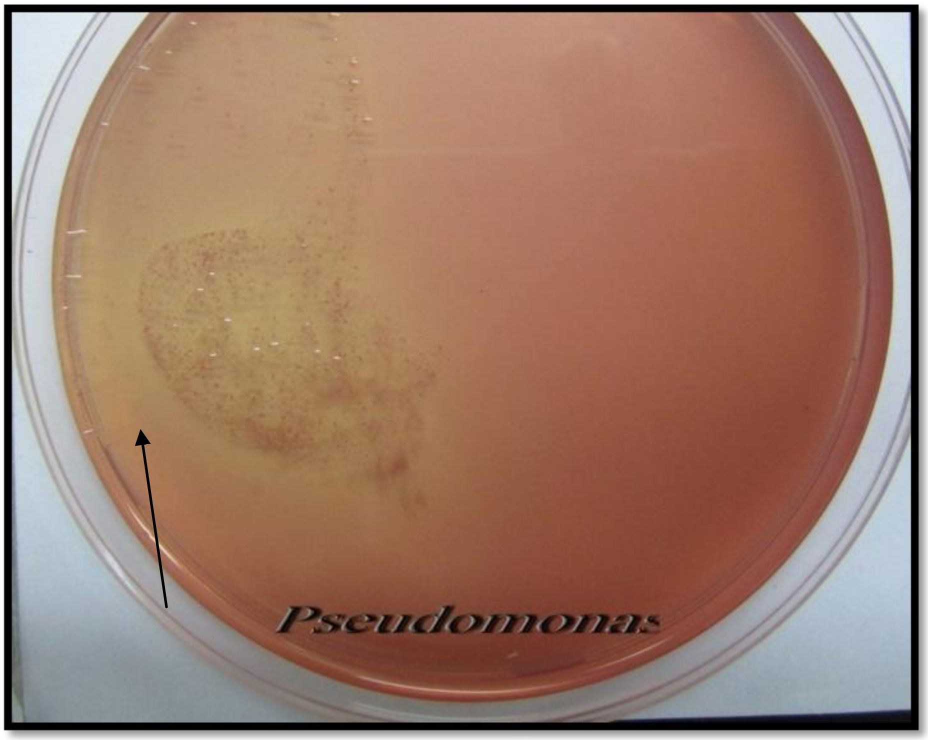

Plate 4-4: *Pseudomonas* growth on specific media in spring sediment, sample (5K-s).

4-9-2 *Bacillus subtilis*

These are free living aerobic bacteria in different kinds of soil and may be found in quantities of as much $1x10^7$ cells in one gram of soil or more they reduce nitrate compounds to nitrarte (incomplete reduction) or to nitrogen (complete reduction). Until quite recently, there have been indications that bacterial sulfate reduction also takes place in the bottom sediments of the Dead Sea (Nissenbaum, 1976), but currently there is little if any sulfate reduction activity in Dead Sea water. *Bacillus subtilis* is found in the spring sediments (Plate 4-5).

4-9-3 *Staphylococcus*

These are aerobic or facultative anaerobic bacteria; they are generally highly resistant to salt and have the ability to decompose organic materials. They are free living non pathogenic species, but may be pathogenic where a suitable portal of entry is provided this species is associated with urinary Track infections. ***Staphylococcus*** is found in the spring sediments (Plate 4-5).

4-9-4 *Lactobacillus*

Lactobacillus (Plate 4-5) is a genus of Gram-positive facultative anaerobic or microaerophilic rod-shaped bacteria (Makarova, 2006). They are a major part of the lactic acid bacteria group, named as such because most of its members convert lactose and other sugars to lactic acid.

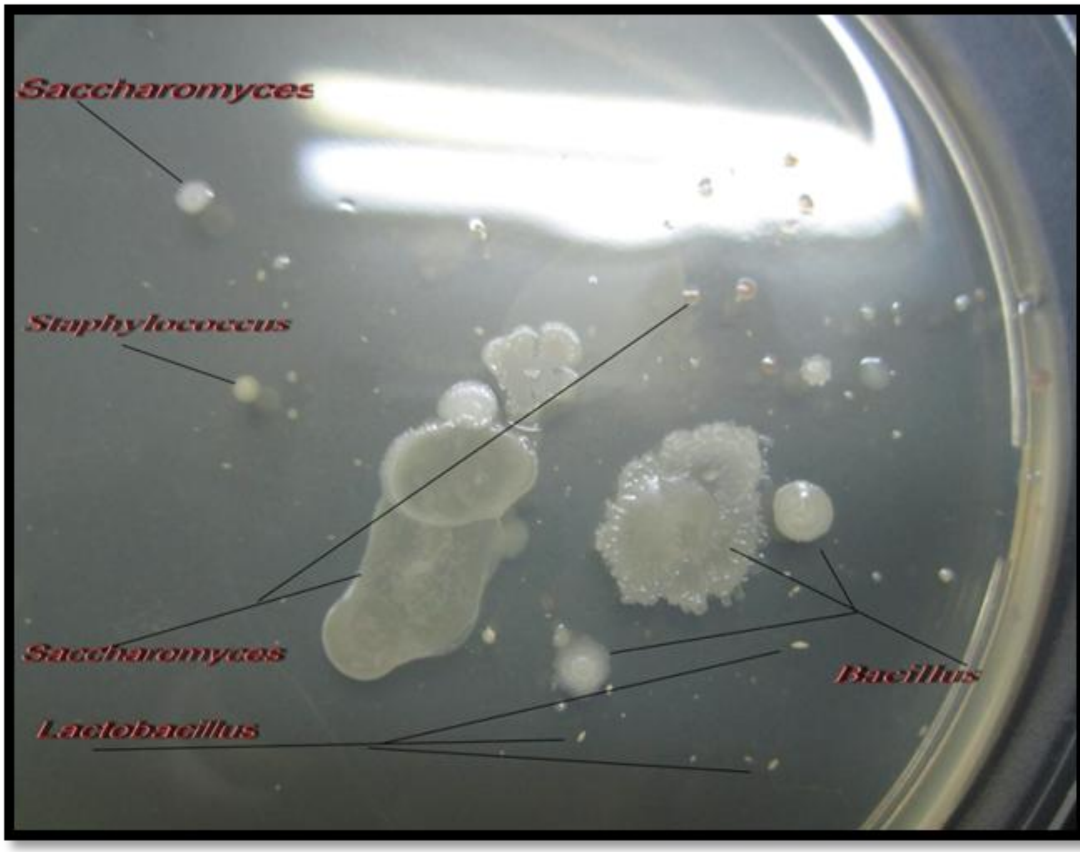

Plate 4-5: *Bacillus subtilis, Staphylococcus* and *Lactobacillus* growth in the specific media cultured on spring sediment; sample (11H-s).

It defined as live microbial food supplements which improve the health of the host, have obtained increasing medical importance. In the intestine they may prevent the overgrowth of pathogenic bacteria, increase the resistance of the gut to invasion by pathogens and ameliorate disease processes by inducting the secretion of soluble factors such as cytokines and antimicrobial beta-peptides.

Discussion

Kaolinite , montmorillonite, palygorskite, sepiolite and illite, as well as calcite, quartz, and feldspars are used in spa and beauty therapy. The presence of these phases should be controlled, because the final product applied to the patient should have only the required and appropriate mineral properties for their use. According to Carretero et al, 2006 the main properties of clay minerals determining their usefulness in spa and aesthetic medicine are softness, particularly as face mask, good plastic properties for easy application, and adherence to the skin during treatment, similarity in pH to that of the skin so as to avoid irritation or other dermatological problems, high sorption capacity. Clays can eliminate excess grease and toxins from skin, and hence are very effective against dermatological diseases. The high CEC, enabling an exchange of nutrients (K^+ or Na^+) to take place while the clay mineral is in contact with the skin.

The Bacterial species such as *pseudomonas, Bacillus subtilis*, *Staphylococcus and Lactobacillus (*Lactobacillus is beneficial bacteria added to food to improve the flavor). It lives in the human body, especially in the colon, as well as it has ability to secrete some enzymes to inhibit the effectiveness of the other bacterial species that are harmful. This action kills the harmful bacteria. This is a good specification in sediment of springs. In addition to this, caution should be taken against harmful bacteria, particularly *Pseudomonas*. The antibacterial properties of spring sediments are probably owing to chemical and/or physical properties. The differences observed in bacteria survival between crude sediments and water may be attributed to the difference in salinity, H_2S gas and pH.

The classification of spring sediments as a sea mud or liman-alkaline made them suitable for the mud therapy. Sediments contain TDS (40 mg/l) and EC (80 µs/cm) as lowest values in Najaf (14N-s), whilst 1650 mg/l and 2795 µs/cm in Hit (11H-s) respectively. This variation in TDS and EC reflect the salinity of spring sediments.

The black mud exists in the study area especially in the spring sediment of Al-Dwara spring in Hit area (11H). Moor mud exists in Al-khudher spring (5K) and Al-Jarba spring (6K) in Kubaysa.

Calcite and dolomite are originated from the limestone and dolomitic limestone of different formations in the studied area such as Euphrates Formation. Gypsum and halite are precipitated from spring waters by evaporation. Some quantity of gypsum comes from Fatha Formation. Clay and quartz are originated from the claystone, marl, marly limestone of Fatha, Euphrates formations and Quaternary sediments. Al-Dwara spring in Hit area (11H-s) is characterized by possessing the highest amount of kaolinite (10%) and montmorillonite (27%). Al-Marj spring (8H-s) contains a small amount of clay minerals and rich with calcite. This makes it not useful for mud therapy. Springs in Kubaysa contain a good amount of kaolinite, palygorskit and montmorillonite {7K-s2 (8%, 12%, 5%), 7K-s (5.5%, 5%, 6%), 6K-s (5%, 2%, 8%) and 4K-s (4%, 8.5%, 3%)} respectively. But 5K-s has low amount of clay minerals due to the high amount of calcite, dolomite and quartz. Palygorskite and montmorillonite are high in Shithatha spring-12Sh-s (17% and 10%) respectively. Najaf spring- 14N-s is characterized by high content of palygorskite (20%). Little amount of organic and bituminous materials with asphaltine can be seen clearly in one spring in Hit (9H) and Al-Marj spring (8H). Organic matter and bituminous materials in addition to H_2S gas are originated from the depth in association with the groundwater. These constituents expressed as undesirable factors for mud therapy and balneology as well.

The Sawa Lake appears to be free of calcite, dolomite with little amount of halite (0.3%), but its rich with gypsum (92%). Quartz and little clay minerals in its sediments may be attributed to the dust and air-borne suspended participation. Its sediment doesn’t encourage swimming for mud therapy, but is suitable for many chemical factors for balneology.

The spring sediments could be used in therapeutics, but lower quality of the Dead Sea mud in terms of mineralogical composition and chemical composition. Some springs contain mud that belong to black mud and moor mud which is very good in therapeutic purpose. In term of mud therapy, the best springs are Al-Dwara in Hit and Al-Jarba, and al-Khudher in Kubaysa. There are so many cases and local experiences known in healing people from dermatological disease.

Chapter Five

Conclusions and recommendations

5-1 Conclusions

Springs in the study area can be considered as spas that have many forms and some of them emphasize certain treatments. The following conclusions deduced by this study:

1-The spring waters are weakly alkaline water belong to warm and hypothermal class, pH doesn't out of range 7.2-8.5 in both of dry and wet periods. Temperature of water and weather, especially during summer season appears very suitable for balneology.

2- In term of balneology, the physico-chemical parameters of Haqlanya, Kubaysa, Hit springs and Sawa Lake for therapeutic purposes, are suitable, except Shithatha (12 Sh and 13Sh springs), where Na and Ca tend to be less than the standard respectively. 12Sh where Na and Ca lower than the standard. Najaf springs are suitable for the same purpose, except 15N spring where Ca less than the standard. Trace element concentrations almost are acceptable. Springs rich in salt and mud that has the effect of absorbing the sunlight, moisturizing the skin and activates the blood circulation of the joint.

3- The water is rich in the natural tar and bitumen, which works as anti-inflammatory agent against skin allergies but causes problem during swimming.

4- In term of mudtherapy, Kubaysa springs (5K and 7K), Hit spring (11H), Shithatha spring (12 Sh) and Najaf spring (14N) are good for healing from many diseases. A pathogenic bacteria (*Pseudomonas*) was found in the sediments of 5K spring. Species such as *pseudomonas*, *Bacillus subtilis*, *Staphylococcus and Lactobacillus* have ability to secrete some enzymes to inhibit the effectiveness of the other bacterial species that are harmful. This action leads to kill the harmful bacteria.

5- The specific characters of water that make it potable water are unavailable in the spring and Sawa Lake water. Accordingly, their waters are impermissible for drinking.

6- TDS in all springs and Sawa Lake tend to be high. The lowest TDS is found between 1204-1683 ppm in Shithatha during wet period, whilst in Hit area varies between 4094- 14699 ppm during wet period, but the highest TDS was recorded in Sawa Lake to be ranged between 25225-27441 ppm. All springs have low sodium hazard, except 7K that has medium sodium hazard and 17S has very high sodium hazard during two

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Web site: http://www.hungarianwellnessmud.com.

Appendices

ALS Group

CERTIFICATE OF ANALYSIS

Work Order	: **PR1207895**	Issue Date	: 12-MAR-2012
Client	: **Sura Abdul Al-Ghani**	Laboratory	: ALS Czech Republic, s.r.o.
Contact	: Sura Abdul Al-Ghani	Contact	: Client Service
Address	: University of Baghdad, College of Scinece Earth Department Baghdad Iraq	Address	: Na Harfe 336/9 Prague 9 - Vysocany Czech Republic 190 00
E-mail	: syrean_2008@yahoo.com	E-mail	: customer.support@alsglobal.com
Telephone	: ----	Telephone	: +420 226 226 228
Facsimile	: ----	Facsimile	: +420 284 081 635
Project	: M Sc student project	Page	: 1 of 4
Order number	: ----	Date Samples Received	: 02-MAR-2012
C-O-C number	: ----	Quote number	: PR2012SURAB-IQ0001
Site	: iraqi springs	Date of test	: 07-MAR-2012 - 12-MAR-2012
Sampled by	: Client - Sura	QC Level	: ALS CR Standard Quality Control Schedule

General Comments

This report shall not be reproduced except in full, without prior written approval from the laboratory.
The laboratory declares that the test results relate only to the listed samples.

Signatories

This document has been electronically signed by those names that appear on this report and are the authorized signatories specified in the Appendix to Certificate of Accreditation No. 521/2008 to Testing Laboratory No. 1163, which has been issued by Czech Accreditation Institute.

Signatories	Position
Zdenek Jirak	Prague Laboratory Manager

Testing Laboratory Accredited by CAI

ilac-MRA

L 1163

ALS Czech Republic, s.r.o.
ALS Laboratory Group

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ALS Minerals

To: UNIVERSITY OF BAGHDAD
UNIVERSITY POST OFFICE, P.O. BOX 47182
BAGHDAD, AL-JADERIYA
IRAQ

Page: 1
Finalized Date: 6-APR-2012
Account: UNIBAG

CERTIFICATE SV12057152

Project: GEOLOGICAL SAMPLES (SEDIMENTS)
P.O. No.: SV12-0344
This report is for 11 Soil samples submitted to our lab in Seville, Spain on 16-MAR-2012.
The following have access to data associated with this certificate:

SURA ABDUL AL-GHANI	SALIH MUHAMMAD AWADH	

SAMPLE PREPARATION

ALS CODE	DESCRIPTION
WEI-21	Received Sample Weight
LOG-22	Sample login - Rcd w/o BarCode
SCR-41	Screen to -180um and save both

ANALYTICAL PROCEDURES

ALS CODE	DESCRIPTION	
Cl-IC881	Cl - KOH fusion and IC	
ME-XRF06	Whole Rock Package - XRF	XRF
OA-GRA06	LOI for ME-XRF06	WST-SIM
C-IR07	Total Carbon (Leco)	LECO

To: UNIVERSITY OF BAGHDAD
ATTN: SURA ABDUL AL-GHANI
UNIVERSITY POST OFFICE, P.O. BOX 47182
BAGHDAD, AL-JADERIYA
IRAQ

This is the Final Report and supersedes any preliminary report with this certificate number. Results apply to samples as submitted. All pages of this report have been checked and approved for release.

Signature:
Colin Ramshaw, Vancouver Laboratory Manager

Comments: ME-XRF06: Samples with low total were rechecked and confirmed.

المستخلص :

تمت دراسة 16 ينبوع ممتدة على طول فالق أبو جير، بالاضافة الى بحيرة ساوة لغرض تقييم مياهها وأطيانها للاغراض العلاجية. جمعت عينات المياه خلال الفترتين الجافة والرطبة، بينما جمعت عينات الرسوبيات خلال الفترة الجافة للعام 2011. تم قياس العوامل الكيموفيزيائية المتضمنة اللون والطعم والرائحة، والدالة الحامضية والمواد الصلبة الذائبة الكلية ، والإيصالية الكهربائية ودرجة الحرارة ، والأيونات الموجبة الرئيسة (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) والأيونات السالبة الرئيسة ($CO_3^{=}$, HCO_3^{-}, Cl^{-}, $SO_4^{=}$) والأيونات السالبة الثانوية (NO_3^{-}, PO_4^{3-}, H_2S) والعناصر النادرة (Pb, Cd, Ni, Co, Zn Fe, Mn, Cu) التي حللت خلال الفترتين (الجافة والرطبة)، بينما العناصر النادرة الاتية Th, Cr, Se Hg, Mo, Ag, As, Br, F, Li, Sr, Ba, B, Be فقد تم تحليلها في الفترة الجافة فقط. انجزت التحاليل الكيميائية في المختبرات العالمية ALS في جمهورية الجيك. كما تم اجراء بعض التحاليل الأحيائية مثل كمية الاوكسجين المذاب (DO) والمتطلب الحيوي للأوكسجين (BOD) والاحياء المجهرية للبكتريا والطحالب.

تمت مقارنة نتائج العوامل الكيموفيريائية مع المحددات العالمية للأتحاد الاوربي ،2009 والمنتجعات الأمريكية. أما نتائج العناصر النادرة، فقد قورنت مع محددات المنتجعات الامريكية والمنتجعات الأيسلندية. أظهر التقييم العلاجي لمياه الينابيع مطابقتها العالمية لمعظم الايونات والعناصر، وصلاحيتها للاستخدامات العلاجية.

صنفت مياه الينابيع من الناحية الهيدروكيميائية الى انها ينابيع ساخنة ذات مياه مالحة الى شديدة الملوحة، ضعيفة القلوية، ناشئة من مياه حبيسة ذات اصل بحري، ممتزجة جزئيا بمياه جوية. تميزت ينابيع الحقلانية وهيت وشثاثة بنوعية مياه صوديوم- كلورايد و صوديوم- كبريتات . ينابيع كبيسة من نوع صوديوم- كلورايد خلال الفترة الجافة، تغير ت خلال الفترة الرطبة الى صوديوم- كبريتات. ينابيع النجف تميزت بمياه صوديوم، مغنيسيوم- كبريتات، اما بحيرة ساوة فقد كانت ذات مياه صوديوم- كلورايد خلال الفترتين. كشف كيمياء مياه الينابيع أن هذه المياه غير صالحة للشرب، لكنها تصلح للزراعة مع محاذير، وان بعضها يصلح لتربية الاسماك كأحواض طبيعية فيما لا يسمح البعض الأخر.

تم دراسة 12 عينة رسوبية جمعت من قيعان الينابيع من الناحية المعدنية والجيوكيميائية. تم فصل المعادن الطينية ودراسة كل من المعادن الطينية وغير الطينية بوساطة الأشعة السينية، كما استخدم المجهر المستقطب في دراسة معدنية الاملاح الطافية على سطح الماء. أجريت التحاليل الكيميائية للرواسب ، حيث تم تحليل الاكاسيد:

SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, TiO_2, MnO, P_2O_5, BaO, SrO and L.O.I في مجموعة المختبرات العالمية (ALS) في أسبانيا. بينت الدراسة المعدنية والجيوكيميائية لرسوبيات الينابيع أمكانية تقييمها لأغراض العلاج بالاطيان . تبين ان رسوبيات بحيرة ساوة خالية من الكلسايت والدولومايت، وتحوي كمية قليلة من الهالايت (0.3%)، لكنها غنية بالجبس (92%) ، الكوارتز والمعادن الطينية تشكل النسبة المتبقية والتي يعزى جزء منها الى التساقط الغباري. أعلى نسبة للكاؤلينايت (10%)،

والمونتموريلونايت (27%) وجدت في ينبوع الدوارة في هيت ، بينما احتوى ينبوع المرج في هيت على كمية قليلة من المعادن الطينية مع زيادة نسبة الكلسايت. ينابيع كبيسة تحتوي على نسب جيدة من المعادن الطينية مثل الكاؤلينايت والباليغورسكايت والمونتموريلونايت وكما يأتي:

{7K-s_2 (8%, 12%, 5%), 7K-s (5.5%, 5%, 6%), 6K-s (5%, 2%, 8%) and 4K-s (4%, 8.5%, 3%)} على التوالي. أما الينبوع 5K-s فتميز بقلة المعادن الطينية وزيادة الكلسايت والدولومايت والكوارتز. في ينبوع شثاثة 12Sh-s ، فان الباليغورسكايت شكل نسبة (17%) فيما شكل المونتموريلونايت (10%). تميز ينبوع النجف (14N-s) بوفرة الباليغورسكايت (20%).

تمت مقارنة نتائج الدراسة المعدنية مع محددات رسوبيات البحر الميت ورسوبيات هنكارية والتي تعتبر محددات عالمية. تبين بعد المقارنة بأن ينابيع كبيسة (4K, 5K, 6K ,7K) ، وهيت (8H,11H) و شثاثة (12Sh) و النجف (14N) وبحيرة ساوة (17S) يمكن تصنيفها كينابيع ذات اطيان علاجية، كونها تمتلك رسوبيات ذات صفات مشابهه للمحددات العالمية مع وجود بعض الاختلافات.

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العلاجية بمياه وأطيان الينابيع الكبريتية الممتدة على طول فالق أبو جير

رسالة مقدمة الى
كلية العلوم، جامعة بغداد
وهي جزء من متطلبات نيل درجة ماجستير علوم
في علم الأرض- جيوكيمياء

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