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Properties of ground water in north part of Qatar, hydrological, hydro chemical studies, uses and issues, Qatar

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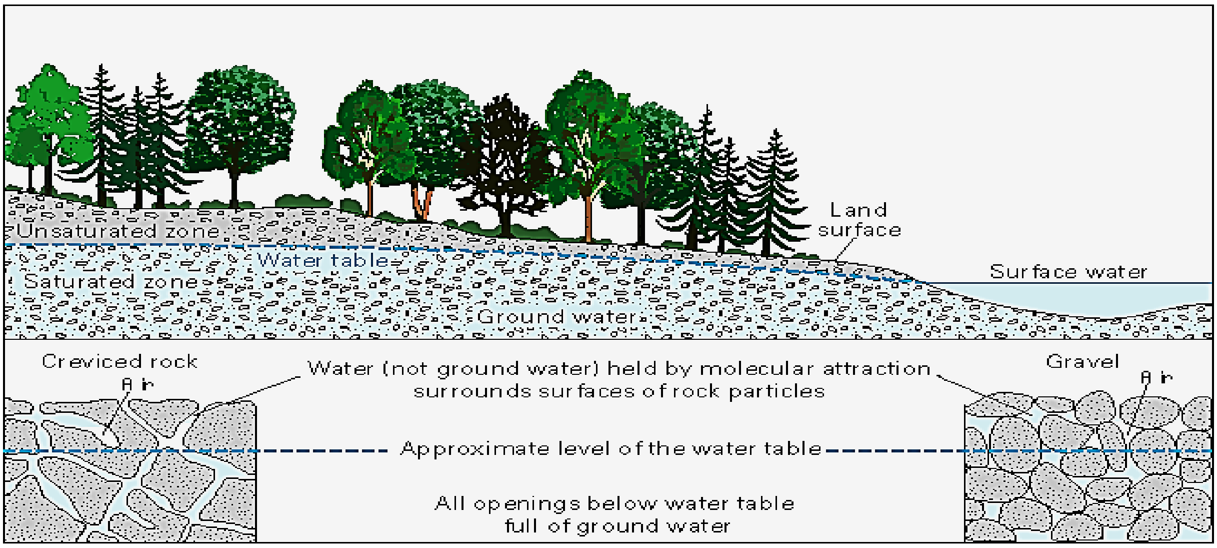
Abstract: As ground water is the only water source, then there is utmost need for exploring ground water aquifer besides importing water from neighboring countries and imposing serve strains on the available ground water resources .The present work deals with the hydrogeology, hydro geophysics, hydro chemistry, ground water management and planning in Qatar Peninsula.. For this purpose, field trips were carried out to measure geo-electrical properties of the rock units composing the geologic successions, and to measure the depth of water and deduction of ground water level for selected and test wells tapping the already proved aquifers (Dammam, Rus, Umm er Radhuma aquifers). In addition, ground water samples from the chosen wells have been collected for chemical analysis. A brief description of the geology of Qatar is included in this work with special attention to the lithology of water bearing formations, and the impact of structure on the hydrogeological conditions. The study of subsurface geological conditions of Qatar Peninsula has been made through the interpretation of geo electrical surveying data. 19 vertical electrical soundings (VESes) were conducted in the area of study. The interpreted geo electric measurements were correlated with the available information of some boreholes. The study of the hydro chemical conditions of the ground water aquifers of Qatar is mainly based on the chemical analysis of water samples collected by the present author. Total dissolved solids (TDS), major cations, major anions (Na+, Cl-, Ca+2, SO4-2, Mg+2, CO3-2, HCO3-) and PH were determined. In addition, hydro chemical coefficients were calculated to identify the origin of ground water and the suitability of ground water for irrigation purposes. The present study aims to: Identify the sub surface geological condition necessary for clarifying the hydrogeological conditions of Qatar Peninsula. And Studying the collective hydrogeological conditions of Qatar Peninsula in the light of new data and detailed information enabling the possibility of additional ground water resources and proposing hydrogeological map for Qatar. And Planning ground water resources with the aim of maximizing water utility in the light of ground water quantity and quality. The study of some area in north of Qatar state presents results of water geochemical analysis in aquifers, the change in water table and salinity in wells. Based on samples of water ranges between 1500-12000 ppm in salinity (TDS), water table ranges 35-200m in depth. This study makes the best useful way to use it for several fields according to many factors. Major anions and cations are useful indicators of geochemical and availability of water in aquifers, the suitable units for irrigation water and human uses range between 1000-5000 ppm, that problem effect on surface uses. Geological study shows the lithology, composition, thickness and structure of layers, which contain water. About three main aquifers in Qatar (Umm er Radahma aquifer Paleocene, Rus formation aquifer Eocene, Dammam formation aquifer Eocene). Geophysics methods support geological studies for detailed information about water table and extension of aquifer. Lithology and structure for aquifer in Qatar play important role in retention of water between layers. Main results for geochemical sample of water and mapping for water table between aquifers are important to consider in the interpretation data from aquifer, serving to remind us of the different uses underground water.

Keywords: properties of aquifers in north Qatar, hydrology in north Qatar.

Introduction

Ground water is the water that seeps through rocks and soil and is stored below the ground. The rocks in which groundwater is stored are called aquifers. Aquifers are typically made up of gravel, sand, sandstone or limestone **Waller, Roger M., Ground Water and the Rural Homeowner, Pamphlet, U.S. (1982): Geological Survey.** Water moves through these rocks because they have large connected spaces that make them permeable. The area where water fills the aquifer is called the saturated zone. The depth from the surface at which groundwater is found is called the water table. The water table can be as shallow as a foot below the ground or it can be a few hundred meters deep. Heavy rains can cause the water table to rise and conversely, continuous extraction of ground water can cause the level to fall **(Waller, Roger M.,**



Ground Water and the Rural Homeowner, Pamphlet, U.S. (1982): Geological Survey.

Figure 1 illustrates the major definitions used in the context of groundwater. (**Waller, Roger M., Ground Water and the Rural Homeowner, Pamphlet, U.S. (1982): Geological Survey.**

Over view ground water in Qatar:

The division of water resources in the State of Qatar into two parts: one of them is rainwater and groundwater resources of conventional and other unconventional resources are represented by the treatment of seawater processor water, purification of wastewater. It is found that the rain of the most recharge sources of underground water. Qatar have two groundwater aquifers north and south, and the different water quality and quantity in these aquifers. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers.).

The groundwater system in Qatar that is located in the east of the Arabian plate where water reservoirs are mainly located in the Triassic layers. There are no permanent rivers in Qatar and pose feeding the direct and indirect. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The present study concerns with the study of hydrological conditions of north part of Qatar state. The study area contains three locations Ash Shamal, Al Ghuwariyah, Umm Salal. The study area locates between longitudes 51° 11\ and 51° 0\ and latitudes 26° 0\ and 25°26\, and embraces on area of about 266 km^2. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The study is based on geological, geophysical, hydrological and hydro chemical data obtained from field observation and water analyses. (**Ministry of municipality and environment (MME) 2015**).

Geologically, the area consists of three main features, (Dammam, Rus, and Umm er-Radhuma), in which the limestone and dolomite are the principal rocks and the effect of fractures and minor faults is manifested. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994)**).

The subsurface investigation for ground water is discussed by constructing geologic and geo electric cross sections in different directions based on the electric logs and the available water wells. **(Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994)).**

Hydro geologically, the water level and depth to water are estimated in wells in this study area.

The hydrochemistry of analyzed water samples of study area is discussed. Salinity, different ions distribution and water quality are constructed and interpreted.

The problem is the rising of groundwater salinity under study area.

To illustrate rising of groundwater salinity under study area, three work sites Ash Shamal, Al Ghuwariyah, umm Salal were selected to be under detailed hydrological investigation.

To achieve the purpose of the study, the following steps have been conducted:

1. Collecting of surface and subsurface geological data including (lithology, stratigraphy and structure.
2. Collection of geo electric data to give more picture for subsurface geological conditions of the study area.
3. Collection hydrogeological records for the dugged wells in the study area. The records include depth to water and water level.
4. Collection of ground water samples and their analyses in water laboratory, water department, state of Qatar.
5. Tabulation of collected data and given data in the standard form.

The Purpose of the Study

1. Studying the geology of aquifers in Qatar.
2. Studying water table between wells of the study area.
3. Evaluate the concentration of elements and availability for irrigation and other uses, treatment methods of water.

4. Recommendations for overcoming the problem ground water salinity and decreasing water table in the north part of Qatar state.

The problem is the rising of groundwater salinity under study area and variation of water table.

Geological Study about Aquifers in Qatar:

1. **Umm er Radhuma aquifer (Paleocene):** this formation underlies the Rus formation, their contact is marked by abrupt lithological change from the cream or nearly chalky limestone of the Rus formation out above to grey brow, dolomitic limestone of Umm er Radhuma formation below consists mainly of thick sequences of white to gray to brownish vesicular dolomites, dolomitic limestone, and limestone. Range from 300 to 500 m in thickness. Contains mixed water (fresh and salt), fractures and solution cavities. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994)**).
2. **Rus formation aquifer (Eocene):** underlies the Dammam formation throughout Qatar but crops out in small area that are northwest of Doha and Dukhan anticline in western Qatar. Consists of white to brown, chalky dolomitic limestone, marl, clays, shale, gypsum and anhydrites. The beds of dolomitic limestone and evaporate tend to be massive and the clayey beds tend to be thin and occur intercalations. The occurrence of thick gypsum beds mainly confined to southern Qatar where they may comprise more than half the total thickness of formation. In northern Qatar evaporate, beds are generally absent and the Rus composed of carbonate facies. Range from 10 to 100 m in thickness contain fresh water, abundant fractures, vugs and solution channels. (**AL-Hajari, s., (1990):** The sedimentology of the lower Eocene Rus formation and its relationship of ground water of the state of Qatar.).
3. **Dammam formation aquifer (Eocene):** Location: crops out over most the Qatar peninsula. Five member are recognized with general lithology. Consists of Five member are described as:

<u>The Abarug member:</u> is composed of dolomitic limestone and marl. The Simsima member is composed of chalky limestone, some chert and clay. The Dukhan Alveodina limestone member is composed of massive whitish limestone abundant fossils and variable clay content. The Midra shale member is composed of yellow-brown to greenish attapulgite shale. More or less rich in carbonates. It composed to from 1 to 4 layers of shale whose individual thickness are several centimeters.it is thicker at the upper part of the lower Dammam sub formation and becomes thinner towards the lower part. The fhaihil velates limestone member is composed of whitish, compact, crystalline fossiliferous limestone). (**Cavalier, C., AL-Salatt, A. and Huuze, Y. (1970):** Geological description of the Qatar peninsula).

This formation range from one to 65 m in thickness contains old water (10000-17000) years and upper part tend to well-fractured, vugs, solution cavities. (**Environment Studies Center (ESC) 2014 -Professional Founder Geophysical consulting center (PFGC) (2016):** Geology of Qatar).

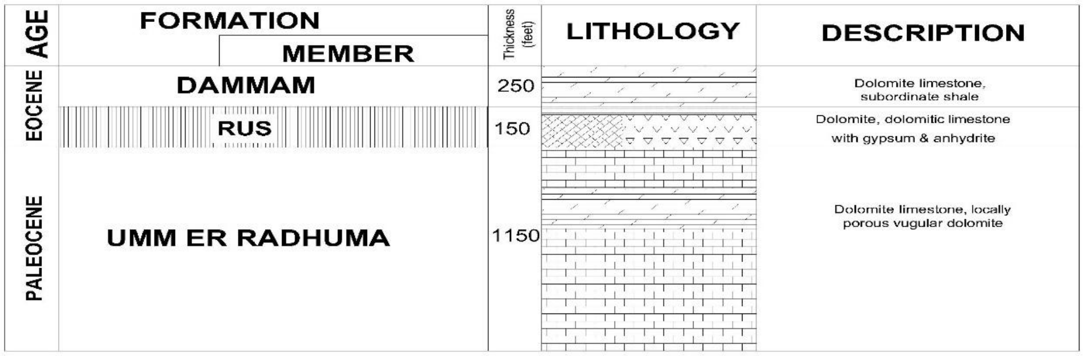


Figure (2): The lithology of three-formation aquifer.

Geo electric Study about Aquifers in Qatar:

Introduction

Different geophysics methods have been successfully applied for exploration of groundwater. These are the electric resistivity, the induced polarization, and the electromagnetic, magnetic and well logging methods. The electric resistivity methods have been widely used for ground water prospection due to the ability to provide useful information about subsurface structure at reasonable depths. Resistivity techniques are used in evaluation and development of ground water resources. It is important to obtain the maximum amount of information about geological formations and the ground water flow regime (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

Geo electric survey (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers):

1. **Basic resistivity concept:**
   - a- Rock resistivity: resistivity's of rock formations vary over a wide range, depending on the rock materials, density, porosity, pore size and shape, fluid type and content, temperature and pressure.
   - b- Theory of the electric resistivity: the principle of the electrical resistivity method is the measurement of the earth resistance by passing low frequency current into the ground through to stakes or electrodes (current electrodes) and measuring the potential difference resulting across another two stakes or electrodes (potential electrodes). If the distance between the four electrodes is known, then together with the current potential measurements, may be used to calculate resistivity of the earth. The type of this field survey is known as vertical electrical sounding (VES).

c- The basic multi-layer variable-parameter conditions were recognized and described as:

2. **Surface layer: dry sand, silt or clay with high resistivity and small depth.**
   a- Dry rock above water table: may be higher or lower resistivity than the surface layer depending on the condition of ground water surface.
   b- Rock below water table: the presence of water reduces the resistivity considerable and abruptly.
3. **In the north and central area of Qatar state following three layers:**
   a- Surface layer with high resistivity (200-1000 ohm.m) related to dry surface rock.
   b- Intermediate layer (30-100 ohm.m) related to limestone containing freshwater reserves.
   c- A conductive medium (0.3-30 ohm.m) related to limestone containing the underlying saline groundwater.
   d- Field measurements and interpretations: 19 of vertical electric soundings (VESes) were conducted in the area of study.

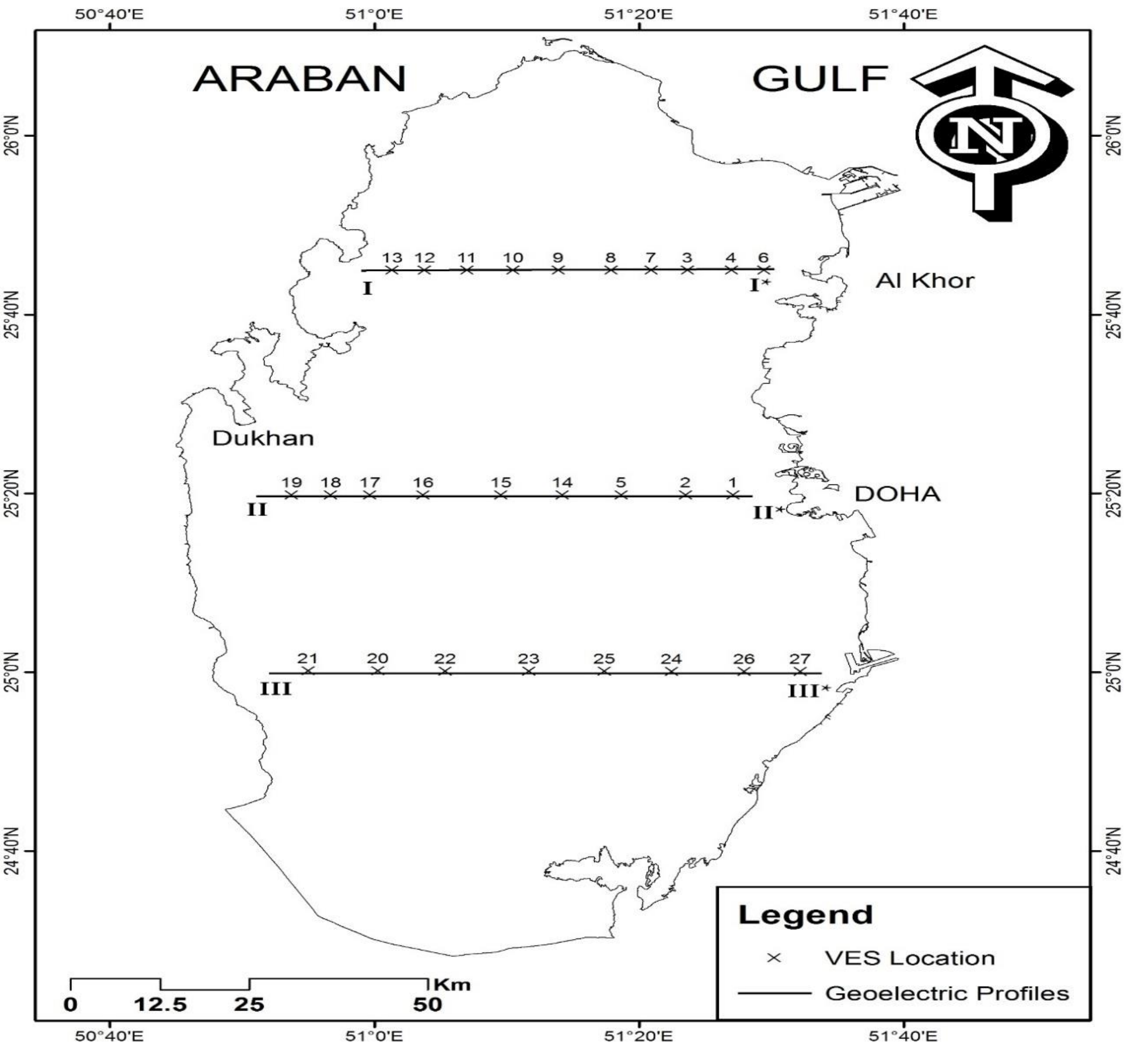


Figure (3) showing the geo electric study area.

(**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

Method of the present geoelectric study: Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994): Lithology and geophysical survey for aquifers).

The present fieldwork was carried out using direct measuring devices (digital) for both current intensity and potential difference through two individual circuits. A source of direct current is connected to the current circuit, into the ground using steel electrodes connected to cables on reels.

The resistivity meter model used in the present study is GSRHS/HV 350. This equipment can be used successfully with great precision to conduct the geoelectric survey under different geological and pedological conditions. However, for more details about its components, accessories and operation, reference is made to the catalogue and operation instructions of the instrument given by ing-buco f. geotecknik, roubold-torf Strasse-1, 2085 Quickborn b.hbg, Germany.

FIELD MEASUREMENTS: Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994): Lithology and geophysical survey for aquifers).

19 of vertical electric soundings (VESes) were conducted in the area of study. At the beginning of the surveying, some VESes are carried out near to the available boreholes in the study area. Thus, the geoelectric measurements were correlated with the available information of these wells, with assumption that the range of the layer resistivity's did not vary laterally. It is worthy to mention that the distribution pattern of VESes locations are governed by the accessibility of terrain in the study area.

For evaluating the field "VES" data, the apparent electric resistivity's are plotted against increasing values of electrode spacing, and a preliminary interpretation processes has been done in the site of survey for controlling the usage of the field data in the subsequent interpretation processes.

The "curve-matching, method" was used for processing and interpreting the field curves in terms of layer thickness (m) and resistivity's (ohm.m). However, some of the field curves are interpreted using automatic computer program of Zohdy (1989) for confirming the interpretation by the curve-matching technique. The results of interpretation using both techniques are of great similarity to each other.

As mentioned, the geo electric method is used in present work is the electric resistivity method in the form of vertical electrical soundings (VES). The well-known schlumberger configuration, **(Kunetz (1966): principles of direct current resistivity-prospecting.Gerbruder Borntraeger. Berlin, Nikolassee, 99p).** was chosen and applied. The natural self-potential (SP) is measured and subtracted from the gained potential difference Δv.

The measured field curve was usually smoothed before interpretation.

The value of resultant apparent resistivity (ρ_a) for such point is calculated using the following equation:

$\rho_a = \Delta v / I. K$ (ohm.m)

ρ_a is the resultant apparent resistivity in ohm.m.

Δv is the potential difference in millivolts.

I is the direct current intensity in milliamperes.

K is constant configuration geometric factor.

Each measured point was repeated by changing the value of the used power supply and ρa being calculated for each measurement. The mean value for both measurements was used to plot the apparent resistivity curve.

Geo electric sections:

1- Geo electric section I-I\:

The geo electric section I-I\ extends for about 40 km east-west crossing the northern part Qatar parallel to latitude 24°45\. it crosses some towns and villages as Al-Ghuwayriyah, Al Kharg, Umm Juwayid and sulokiyah and uses the data of (13,12,11,10,9,8,7,3,4,6). (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The first geo electric layer has a wedged shape with maximum thickness of about 40 m under the site of VES no.13 (near Al-sulokiya), with three distinct values of electric resistivity ranging from 23 to 238 Ohms.m equivalent limestone, marls and shales of Dammam formation. However, few lenses of very high sensitivity values 840, 1152 and 700 Ohms.m representing fresh water lenses within the limestone could be distinguished at depth of 25 m, 10 m and 1 m respectively under the sites of VESes 12, 10, and 9. These fresh ground water lenses may be the accumulation of runoff water with the depressions under these areas. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The second geologic layer is characterized by its medium values of resistivity. They range between 28 and 93 ohms.m correlated with dolomitic limestone facies related to Rus Formation. This layer is of about 70 m thickness and embedded two lenses of very high resistivity value under the sites of VESes 8 and 4. The resistivity values of these two lenses are 364 and 1400 ohm.m respectively. These two lenses represent the main aquifer in northern Qatar. The ground water is of saline nature. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers). The third geo electric layer has depth of about 65 m with resistivity ranges from 7 to 15 ohm.m. It is correlated with chalky limestone belongs to Rus Formation under VES 6 the resistivity reaches 294 ohm.m. This may be due to the facies change to crystalline limestone.

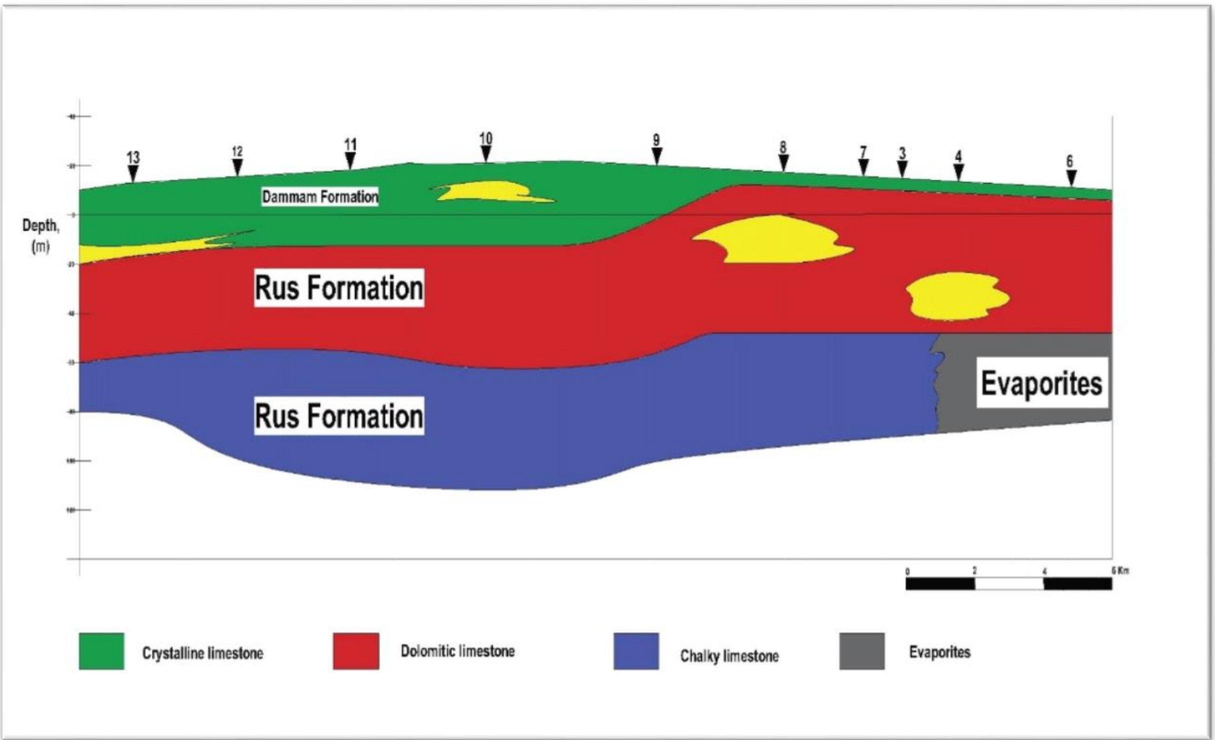


Figure (4) subsurface geological cross section in the direction I-I′ based on geoelectrical cross section I-I′ (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers.).

2- Geologic Section II-II′:

The geologic section II-II′ depends on the data of VESes 19, 18, 17, 16, 15, 5, 2 and 1 and extends for about 46km in east-west direction in the middle part of Qatar.

The sections exhibit three geo electric layers with three distinct values of electric resistivity.

The first geoelectric layer is a thin layer occurring under the site of VESes 1, 2, 5, 18 and 19 with relatively high resistivity values range from 140 to 26000 ohm.m. The maximum-recorded thickness is under the site of VES No. 1. This geoelectric layer can be correlated with the Dammam limestone and dolomite. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The second geoelectric layer has relatively low electric resistivity values (40-47 ohm.m under the sites of VESes 14 and 5. The layer also exhibits lateral resistivity changes, which may indicate lateral facies change. The low resistivity values under VES's 14 and 15 may indicate residual evaporate facies. Resistivity values increases to the west where they amount 135 to 220 ohm.m, and can be correlated with evaporate facies from 170 to 308 ohm.m, towards east and a similarly be correlated with evaporate facies. (**Ph.D. degree in**

science geology on Qatar peninsula for Latifa Shaheen (1994): Lithology and geophysical survey for aquifers).

The resistivity values under the sites of VES No. 19 changed to be 1140 ohm.m to the extreme west of the profile and could be correlated with crystalline limestone. The thickness of this geoelectric layer varies from 30 to 75 m. (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

The third geoelectric layer has a considerable thickness ranging from 100 to 170 m with resistivity values varying from 63 to 100 ohm.m. These values change to very low resistivity values (3 to 9 ohm.m) under the sites of VES's 18 and 19 which may be correlated with sediments of clayey nature assigned to Umm er Radhuma Formation with high resistivity lense (520 ohm.m) under the site of VES No. 15 (**Ph.D. degree in science geology on Qatar peninsula for Latifa Shaheen (1994):** Lithology and geophysical survey for aquifers).

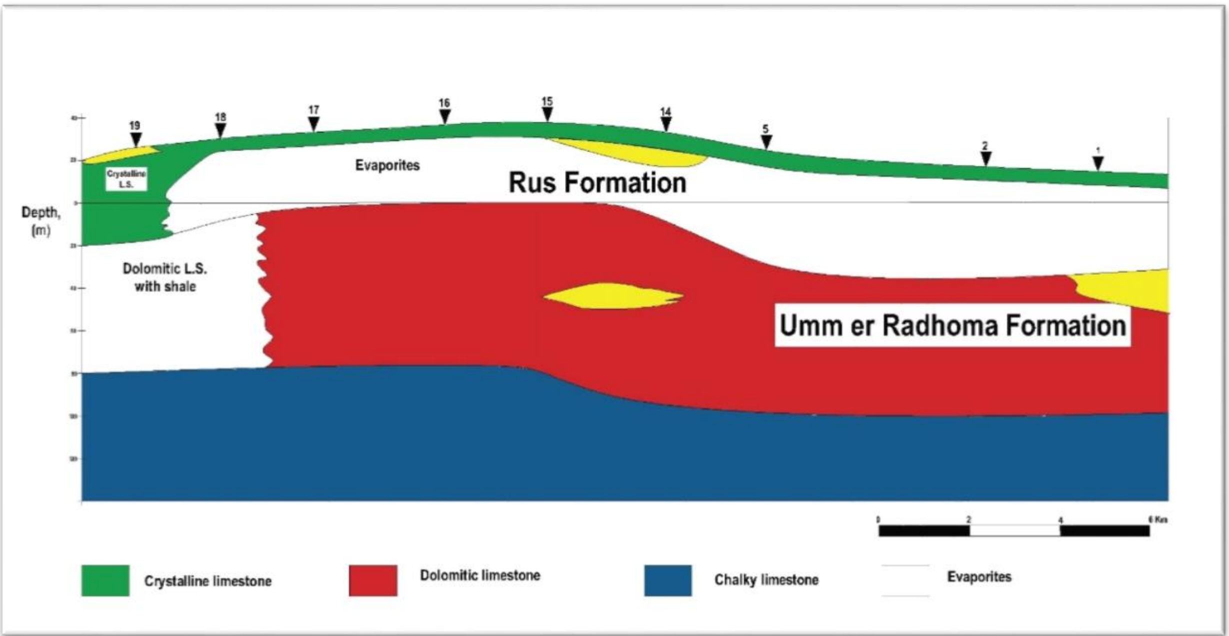


Figure (5) subsurface geological cross section in the direction I-I' based on geoelectrical cross section

Hydrological Study about Aquifers in Qatar:

Site description: The study hyrology and chemical analysis of collcet samples in four sites:

1. **Ash shamal (shamal site)** (**Professional Founder Geophysical consulting center (PFGC) (2016):** Geology of Qatar)**:**
    1. (Three Wells) were made the geophysical survey.
    2. Location(Farm is located in the northern part of the State of Qatar, about 102 km north of Doha).
    3. Water table is ranged between 15 to 20 m but drilling pipe is ranged between 30 to 40 m.

Table (1): Results of observation water table in wells of Ash Shamal area: (Professional Founder Geophysical consulting center (PFGC) (2016): Geology of Qatar).

No. of Well	Water Table	Depth of Drilling pipe
Well 1	15 m	30 m
Well 2	17 m	34 m
Well 3	20 m	40 m

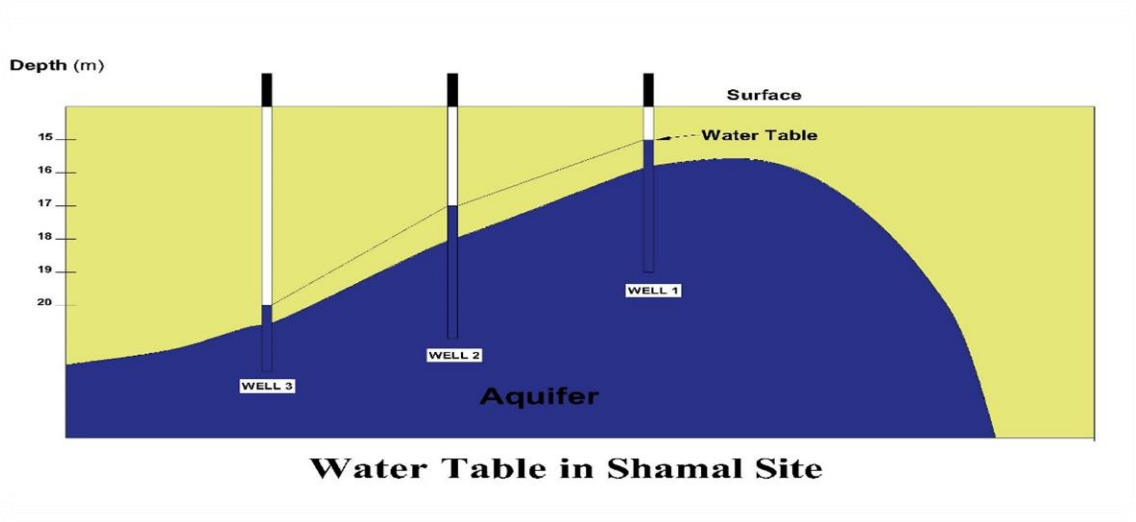


Figure (6): Water table in Shamal site (three wells)

2. **Al Ghuwariyah (Azba site): (Professional Founder Geophysical consulting center (PFGC) (2016):** Geology of Qatar).
    1. (Three Wells) were made the geophysical survey.
    2. Location (Farm is located in the northern part of the State of Qatar, about 88 km north of Doha).
    3. Water table is ranged between 32 to 40 m but drilling pipe is ranged between 48 to 60 m.

Table (2): Results of observation water table in wells of Al Ghuwariyah area.

No.of well	Water table	Depth of drilling pipe
Well 4	32 m	48 m
Well 5	35 m	53 m
Well 6	40 m	60 m

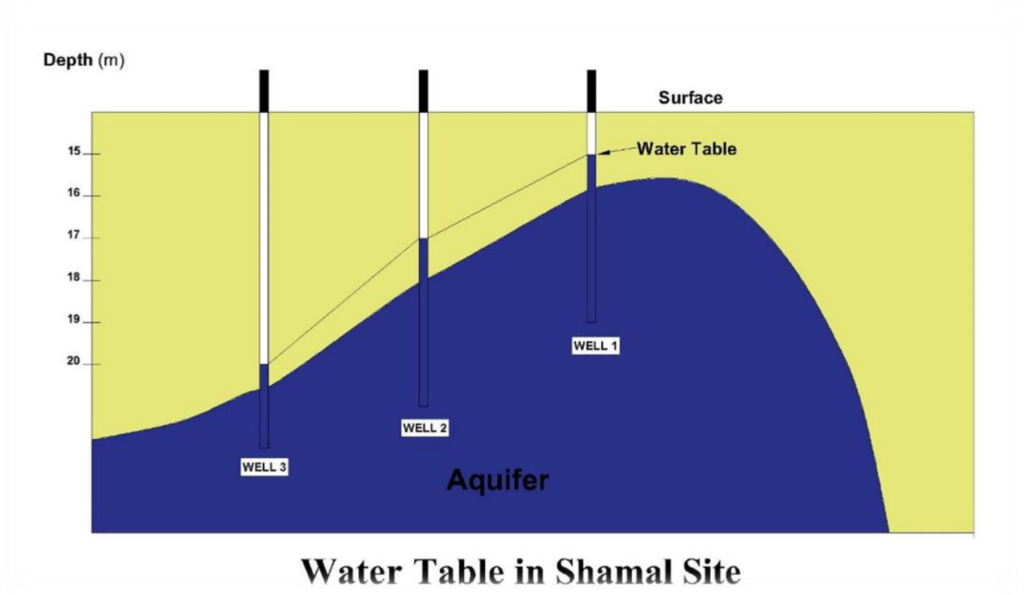


Figure (7): Water table in Azba site (three wells)

3. **Umm Salal (Rawdat al Ajuz site): (Professional Founder Geophysical consulting center (PFGC) (2016):** Geology of Qatar).
    1. (Six Wells) were made the geophysical survey.
    2. Location (Farm is located in the northern part of the State of Qatar, about 48 km north of Doha).
    3. Water table is ranged between 28 to 42 m but drilling pipe is ranged between 40 to 60 m.

Results of observation water table in wells of the area study (**Professional Founder Geophysical consulting center (PFGC) (2016):** Geology of Qatar).

Table (3): Results of observation water table in wells of Umm Salal

No.of well	Water table	Depth of drilling pipe
Well 7	28 m	40 m
Well 8	32 m	50 m
Well 9	35 m	50 m
Well 10	38 m	50 m
Well 11	40 m	50 m
Well 12	42 m	60 m

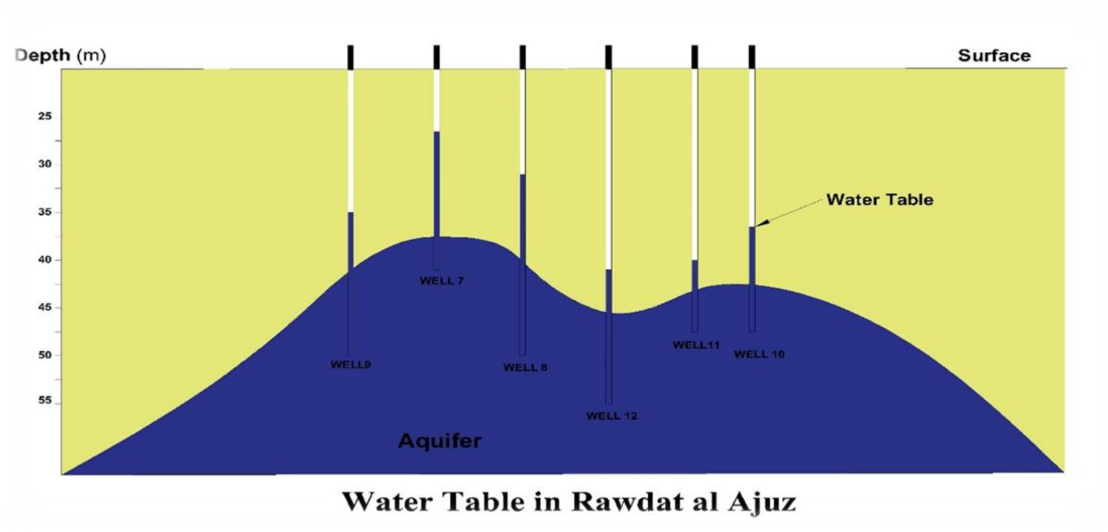


Figure (8): water table in Rawdat al Ajuz site (six wells):

Hydro chemical study about aquifers in Qatar:

The water hydro chemical study represents the chemical water relationship and interaction with rocks Bearing her where there is no natural salt-free water, it is a study details Chemical and natural water of great importance in the evaluation of the quality of water for use in a variety of purposes Which relied on the results of the chemical analysis of the water samples of the study area (**Laboratory department in (MME) soil &water unit (2016**).

Fieldwork and laboratory

Fieldwork included identifying the wells sites scattered in the area

of study, (where they were collecting water models (12wells), As with respect to laboratory work has the water models in geochemistry laboratory analysis, included chemical analyzes of both cations and negative ions (CO_3, HCO_3, SO_4, Cl, Ca, Na, and Mg), Electrical conductivity (EC, pH in addition, total dissolved salts TDS). (**Laboratory department in (MME) soil &water unit (2016)**).

Table (4): illustrates the results of chemical analyzes for each of the models wells of the study area

Results and discussion:

Sample ID	p^H	EC (MS/cm)	T.D.S ppm	CO_3	HCO_3	Cl	Ca	Mg	Na	So_4	Temp
Well 1	6.84	15.83	9500	0.00	3.65	123.47	42.45	17.38	46.62	47	25ºc
Well 2	7.01	11.46	6870	0.00	4.13	77.59	31.96	31.96	35.12	26	25ºc
Well 3	6.73	20.10	12010	0.00	4.21	164.50	45.12	29.49	98.34	70	25ºc
Well 4	6.84	20.70	12410	0.00	4.63	179.82	40.75	38.05	20.14	35	25ºc
Well 5	7.71	21.50	12880	0.00	2.49	190.38	40.19	29.34	21.02	60	25ºc
Well 6	7.03	20.20	12110	0.00	4.49	177.59	38.03	26.91	18.80	47	25ºc

Well 7	7.39	4.41	2640	0.00	4.55	12.49	21.52	12.09	10.22	25	25ºc
Well 8	7.37	3.55	2130	0.00	3.84	9.38	18.07	8.96	8.33	32	25ºc
Well 9	7.59	2.45	1468	0.00	3.39	6.66	11.16	6.04	9.88	21	25ºc
Well 10	7.79	2.62	1569	0.00	3.22	7.02	12.60	6.47	5.66	34	25ºc
Well 11	7.74	2.56	3940	0.00	2.45	30.24	18.46	9.73	6.44	42	25ºc
Well 12	7.93	3.36	2020	0.00	2.99	11.38	13.18	8.12	7.65	20	25ºc

Hydro chemical analyzes showed the extent of the hydro chemical situation correlation and situation Geological study area, shows the variation in the concentration of salinity and major elements in the study area source.

The basis of nutrition and subsurface geological formations and outstanding origins Maritime and high salinity in the water. For the high salt concentration in the ground water, whether Composition attributable to deposits geological eras on the general area of the study area indicating a high level of total concentrations of the major elements is affected by the salt concentration of the area the study in geological conditions, and agricultural and climatic, and it operates the rain water falling to wash the soil and the delivery of their salts into groundwater sources and ultimately elevate the concentration of salinity the main ions, which are used for the purposes of the wells in summer watering some plants leading to wash the soil and irrigation water filtered to the configuration to yield deposits geological ages, which are loaded concentrations of salt dissolved high and this leads to raise the concentration of salt in general. By the results of the chemical analysis of the waters of the deep and shallow wells can be counted invalid to drink because of the high proportion of dissolved salts in it. In terms of the validity of the groundwater, the search area for the purposes of irrigation water could count all the wells in the area unsuitable for irrigation.

Must groundwater be used to optimal use in the rationalization of consumption in the agricultural field by calculating the discharge-and-charge volumes and assess the effects of salinity resulting from the indiscriminate withdrawal and monitoring analyzes of chemical water inside the wells monthly to avoid R.O System and crops and agricultural problems and soil salinization. Increasing the salinity of the wells after specific periods ranging from one year to three years, according to a random rate of withdrawals from wells estimated 2000-5000 PPM. (**Water science and technology association (2014-2015):** Classification of water type and water quality).

We take three samples from three different areas, that indicator for difference in salts concentration because of difference in discharge for each well and other many factors as (rain-sea water if that near-contamination by elements in surrounded rocks). According to water, availability to irrigation uses that good from 1000 to 5000 ppm after this percent need treatment system to remove salts that influence the growth and the soil. (**Water science and technology association (2014-2015):** Classification of water type and water quality).

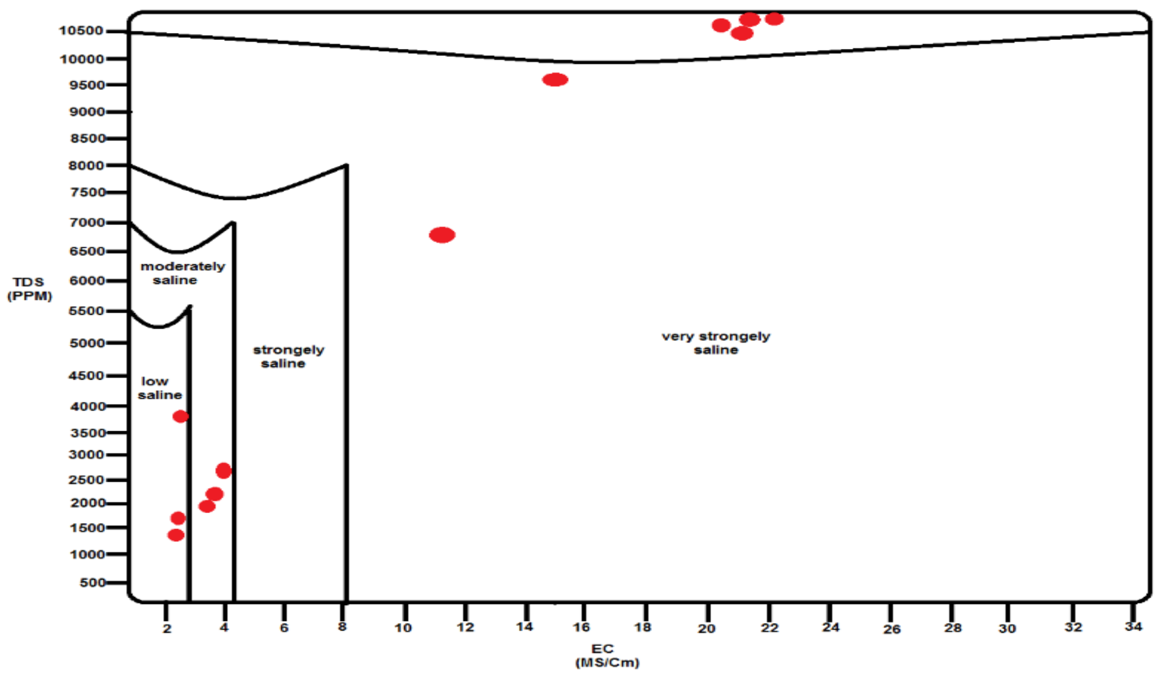
Variation in the height of the water level inside the wells based on layered pressure zones on the layer water bearing and repair of wells to avoid the escape of water in the surrounding strata

Table (5) shows the validity of water to use in irrigation purpose according the research in Laboratory department in (MME) soil &water unit (2016) (Laboratory department in (MME) soil &water unit (2016)).

Sample ID	Quality of water	EC (MS/cm)	Suitable Crops
Well 1	permissible	15.83	Animal Feed and palm
Well 2	permissible	11.46	Animal Feed and palm
Well 3	unsuitable	20.10	Agriculture cannot be before the water treatment
Well 4	unsuitable	20.70	Agriculture cannot be before the water treatment
Well 5	unsuitable	21.50	Agriculture cannot be before the water treatment
Well 6	unsuitable	20.20	Agriculture cannot be before the water treatment
Well 7	semi suitable	4.41	All crops in Qatar
Well 8	semi suitable	3.55	All crops in Qatar
Well 9	suitable	2.45	All crops in Qatar
Well 10	suitable	2.62	All crops in Qatar
Well 11	suitable	2.56	All crops in Qatar
Well 12	semi suitable	3.36	All crops in Qatar

Figure (9): Water validity in agricultural purposes and other uses

Water use and issues:



65 percent for agricultural purposes, 33 percent for municipal purposes and 2 percent for industrial use. All water used for irrigation is pumped from wells and from the sewage treatment plants to the farms and Doha. There is no pricing system and water is given free to the farmers.

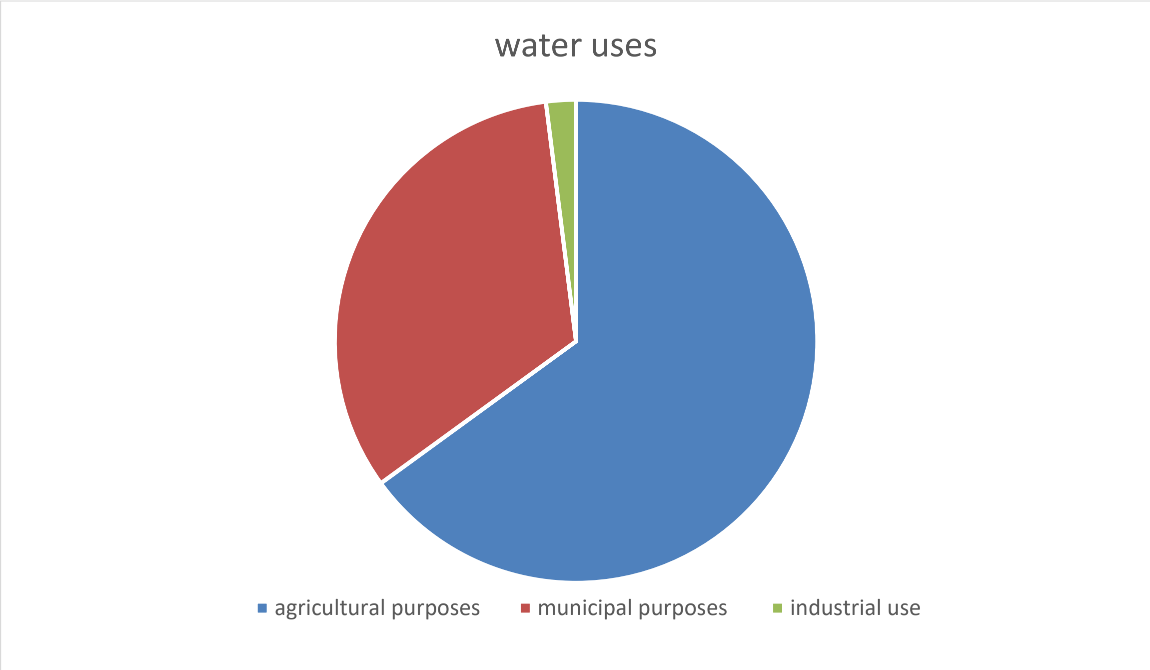


Figure (10): Water uses in Qatar state.

Water Management

Qatar has carried out a number of programs and studies, issued water laws, and established committees for the consolidation of integrated water resources management, the most important of which are the following:

1. Increasing natural recharge: The drilling of wells (with a special design including a perforated casing and graded gravels) in depressions to depths that reach the water bearing formations will accelerate the natural recharge of floodwater. The project started in 1986 and 341 recharge wells have been drilled since then (DAWR, Irrigation and Drainage Unit, 2006). Continuation of this project will make rapid recharge possible from the occasional storm runoff that accumulates in depressions before its loss through evaporation. Experiments reveal that drilling wells in depressions could accelerate the recharge of floodwater by up to 30 percent.
2. Development of water monitoring and irrigation scheduling: The water monitoring development program has been promoted through a telemetry system at 3 automatic agro meteorological stations, 25 hydro meteorological stations and 48 hydrogeological stations. These automatic stations provide reliable data for irrigation scheduling and designing irrigation systems. **(FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008) and (Water and Electricity Company program, 2007).**

Artificial recharge of groundwater: The Rus and upper Umm er Radhuma aquifers in northern Qatar have been heavily exploited for agricultural purposes. The total abstraction is far in excess of the average natural recharge. To solve this problem, a study concerning the artificial recharge of freshwater in the aquifer system was conducted in the period from 1992 to 1994. The objective of the study was to determine the feasibility of a large-scale artificial recharge project to augment the depleting northern groundwater aquifer and improve the water quality. The study indicates that the artificial recharge freshwater recovery efficiency, called 'the user specific recovery efficiency' (water salinity range 1000–3600 mg/l) could reach 100 percent in Rus and transition Rus/Umm er Radhuma. (**Joel 0. Kimrey (1985): PROPOSED ARTIFICIAL RECHARGE STUDIES IN NORTHERN QATAR, OPEN-FILE REPORT 85-343, Prepared in cooperation with the DEPARTMENT OF AGRICULTURAL AND WATER RESEARCH, QATAR MINISTRY OF INDUSTRY AND AGRICULTURE**).

1. Development of deep aquifers: A recent study indicates that the development of the aquifer is constrained by several factors. These factors include depth of occurrence (450-650 m), low well production levels of up to 15 l/s at a drawdown of more than 100 m and salinity within the range of 4 000 to 6 000 mg/l.
2. Increasing treatment and reuse of wastewater: The Drainage Affairs increased the volume of treated sewage effluent (TSE) through the connection of more residential areas to the public sewer and extension to Doha South and Doha West Treatment Plants. The amount of TSE increased from 46 million m^3 in 2004 to 58 million m^3 in 2006 and the amount reused in forage production and irrigation of landscape increased from 39 million m^3 to 44 million m^3 during the same period. (**Hashim, M.A. and A. Abdul Malik. 2005. Water-related ecological hazards and their mitigation in Qatar. In: Proceedings. WSTA Seventh Gulf Water Conference. 19–23 November 2005, Kuwait. Vol. II, pp 917-932.**) **In addition, Drainage Affairs. 2005. Treated sewage effluent.**
3. Irrigation research and studies: Irrigation research and studies over the last ten years have included crop water requirements of the major crops in Qatar, irrigation with saline water, optimizing the use of TSE for forage production, the economics of protected agriculture when using desalinated water, optimum use of water resources in agriculture and modernizing irrigation in the Qatari farms. (**Ministry of municipality and environment (MME) 2015**).

Environment and Health:

Practical problems are associated with using saline water on the Qatari farms. The most serious ones are groundwater pollution, degradation of soils and consequent abandonment of farms. Groundwater pollution is caused by several factors, the main one being uncontrolled and excessive pumping from wells. The present extraction rate is estimated to be about four times the average recharge from rainfall, which leads to a lowering of the water table and the consequent up-flow of brackish water from the underlying aquifer, thus increasing the water salinity. The average annual rate of increase in water salinity in the wells during the period 1982–2004 was estimated at 2.2, 1.6 and 1.7 percent for representative farms in northern, central and southern regions of the country respectively. Seawater intrusion is a common worldwide problem along sea coasts, peninsulas and islands ((**FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008**). In Qatar, the problem is more severe, because the high permeability of the fractured limestone aquifer containing freshwater permits the rapid intrusion of seawater. The return flow from irrigation to groundwater reservoirs is estimated at an average of 25 percent of the gross water application. This has been determined from lysimetric observations. Although this irrigation return flow increases the recharge to groundwater, it deteriorates the water quality because the percolating poor quality water dissolves salts from the soil and underlying strata and carries them to those aquifers bearing relatively fresh water. Moreover, farmers sometimes use large quantities of low quality water to wash the salts away, avoid plants wilting, and apply heavy chemical fertilizers to increase the yield. This practice is not necessarily beneficial, because it may contribute to groundwater pollution. On the Government, Experimental Farm, drainage water analysis shows a significant increase in nitrate derived from nitrogenous fertilizers. ((**FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008**).

Table (6): Average rate of increase in wells water salinity (%) at representative farms of different regions in Qatar during the period 1983/83-2003/04.

Region	Farm No.	1982/83 average E.C. (ds/m)	2003/04 average E.C. (ds/m)	Average annual rate of increase in the farms (%)	Average annual rate of increase in the region (%)
North	110	3.2	3.7	0.74	2.19
	143	1.6	2	1.19	
	199	1.6	2.5	2.68	
	690	1.6	2.8	4.13	
Center	248	3.3	3.9	0.87	1.65
	260	2.70	4	2.29	
	741	0.8	1.1	1.79	
South	561	4.6	6.5	1.97	1.70
	516	4	5.6	1.90	
	746	3.5	4.4	1.22	

Scarcity of water resources, severe climatic conditions, pollution of groundwater, unsuitable cropping patterns, incorrect cultural practices, overgrazing and socioeconomic development all lead to soil degradation and cause desertification. In addition to these factors, improper farm layouts and erroneous irrigation designs together with poor water management intensify the problem of desertification. The accumulation of salts year after year degrades the soils and renders them unproductive and is considered the main reason for abandonment of farms. Most of the degraded soils are found in farms located near the coasts because of the effect of the high saline irrigation water or in inland farms where heavy textured soils become saline. Of a total number of 434 farms during the 1975/76 season, 259 were in operation and 175 abandoned. During the 2004/05 season the total number of farms increased to 1 285 and abandoned farms numbered 293 (DAWR, Irrigation and Drainage Unit, 2006). There is no irrigation induced waterlogging in the farms because the water table is very deep. However, waterlogging occurs in the non-irrigated areas of the Sabkha soils and covers an area of 61 000 ha approximately) **FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008).**

Prospects for agricultural water management:

The national strategy and policy for the development of water resources and irrigation consists of a short-term strategy and a long-term strategy.

The short-term strategy aims at improving the present water use situation. To prevent further depletion and pollution of groundwater the following measures will be implemented in the near future:

1. Water meters will be installed in all wells;
2. After the installation of water meters, it should be ensured that the water allocated for each farm shall not be exceeded;
3. The farm owner shall not irrigate more than the area specified and shall not install any water conveyance and irrigation systems in contravention of the instructions issued by the DAWR;
4. The owner of the farm shall be required to take all necessary steps for the protection and maintenance of wells, pumps, conveyance and distribution pipelines, irrigation systems and all control devices.

Notwithstanding the implementation of groundwater laws, the DAWR has taken several steps to improve irrigation efficiency and increase crop production:

1. Adoption of cropping patterns for each farm in accordance with the salinity of irrigation water and characteristics of the soil.
2. A ban on the drilling of new boreholes in the areas most affected where there is excessive abstraction or where the water salinity of wells exceeds 12000 μmhos/cm;
3. Stop awarding permits for establishing new farms or extending existing farms until the aquifer has returned to its equilibrium state.
4. Encourage the shift to protected agriculture.

5. Make full use of non-conventional water resources for crops irrigation. This includes the use of treated sewage effluent and the possible use of desalinated groundwater for irrigation and cooling greenhouses;
6. Study the possibility of introducing a pricing system for water consumption with penalties for extravagant water use and incentives for water saving.
7. Provide interest-free loans to farmers to promote modern irrigation systems with a repayable period of several years.

The MMAA is planning to implement a technical study and survey for the development of groundwater resources over the next two years. This study includes the mechanism of natural and artificial recharge, monitoring the new wells network, monitoring the groundwater rate of recharge and abstraction and water quality, preparation of a 3-D groundwater flow model and establishment of groundwater geographic information system (**DAWR, Agricultural and Statistics Section.** 2006. The annual book of agricultural statistics 2004. MMAA. Doha, Qatar).

The Permanent Water Resources Committee (PWRC) has launched a long-term program for integrated water resource management in Qatar. The general objective of the program is to formulate a comprehensive National Water Resources Management and Development Strategy (NWRMDS) with a planning vision up to the year 2050 (**Ministry of municipality and environment (MME)**.

The future demand to meet the municipal and industrial requirements can be achieved by increasing the capacity of the existing desalination plants and from building new desalination plants. Food self-sufficiency is not a practical policy and taking into account land availability and climate factors, the amount of food capable of being produced will be based on the following water resources for irrigation:

1. The safe yield of groundwater, which is 58 million m^3/year (DAWR, Groundwater Unit, 2006); Availability of TSE, which is expected to be 129 million m^3 in 2013, 193 million m^3 in 2020 and 255 million m^3 in 2050 **FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008).**
2. Availability of Gas-to-Liquid treated industrial wastewater, which is expected to reach a ceiling of 50 million m^3/year after several years.
3. Other water resources could be investigated for technical and economic feasibility including:
4. Reuse of drainage water under Doha city (20 million m^3/year of TDS in the range of 7000 mg/l) for irrigating salt-tolerant crops (**FAO, Irrigation in the Middle East region in figures – AQUASTAT Survey 2008**).
5. Seeding of clouds for enhancement of water resources.
6. Using desalinated water for irrigation and cooling greenhouses.

Conclusions:

The present study indicates the importance of the systematic hydrogeological studies for each aquifer as a separate hydro geologic unit has its own hydro geological characteristics. This principle will lead to valuable results concerning the real hydro geologic conditions of Qatar will enable forecasting amount of annual recharge, the storage, the safe yield and finally will help in proposing more precise water policy for Qatar state.

The present study considered the achieved results by other authors, especially the hydro geological connection between Dammam aquifer and Rus aquifer of northern Qatar from one side and the connection between Dammam and or Rus aquifer and Umm er Radhuma aquifer of confined nature.

The hydrogeologic data obtained from detailed geologic studies based on the previous authors, and the present author, especially the results of geoelectrical prospecting, field observations and monitoring of water wells. Also, the data collected from the maps, profiles and hydrogeological cross sections constructed by the author.

1. **Ash shamal (shamal site):** the Depth of drilling pipe ranges from 30 to 40 m and salinity ranges 9500 to 12010 ppm.
2. **Al Ghuwariyah (Azba site):** the Depth of drilling pipe ranges from 48 to 60 m and salinity ranges 12110 to 12880 ppm.
3. **Umm Salal (Rawdat al Ajuz site):** Depth of drilling pipe ranges from 40 to 60 m and salinity ranges 2020 to 3940 ppm.

Recommendations

In the author's opinion, the water resources of Qatar should be reconsidered in the light of the following recommendations:

1. Priorities must be paid to the middle and southern parts of Qatar in addition to the northern exhausted part of the country. Attention must be paid to Umm er Radhuma and Aruma aquifers.
2. Re-estimation of recharge and ground water possibilities of the different aquifers by reconsidering the former data and estimation.
3. Additional ground water programs and test for the different aquifers by drilling new wells especially designed and executing pumping and chemical tests.
4. Attention must be paid to offshore drilling programs for ground water exploration near shore of Qatar state. This needs new techniques and methodology.
5. The proposed project for injecting imported water from outside Qatar may continue to the water storage. However, this high technology process needs more extensive and detailed hydrogeological and hydro chemical studies, including in addition to the techniques and costs, studying the impact of mixing of imported fresh water supplies on the original brackish and/or saline water embedded

within the injected aquifers. The proposed impact can be predicted using suitable hydrologic mathematical model based on checked data.

6. The regulation of the present land use project is necessary. Redistribution of the present cultivated areas especially in north Qatar is urgently needed, using geo technology and modern techniques for irrigation, genetic techniques, tissue culture to adopt low water consuming crops, and cultivations suitable for saline water, alkaline soil and hot, humid climate is necessary.

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