THE FEASIBILITY OF USING GROUNDWATER IN UM-QASR AREA FOR DOMESTIC AND AGRICULTURAL PURPOSES

A THESIS SUBMITED TO
THE COLLEGE OF ENGINEERING-UNIVERSITY OF
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MASTER OF SCIENCE IN
CIVIL ENGINEERING

BY
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TO

SOUL OF MY BELOVED MOTHER

أمكانية استخدام
المياه الجوفية في منطقة أم قصر
للأغراض المنزلية و الزراعية

من قبل المهندس

حيدر عبد الرضا خنفر العضب

بِسْمِ ٱللَّهِ ٱلرَّحْمَـٰنِ ٱلرَّحِيمِ

۞ وَإِذِ ٱسْتَسْقَىٰ مُوسَىٰ لِقَوْمِهِۦ فَقُلْنَا ٱضْرِب بِّعَصَاكَ ٱلْحَجَرَ ۖ فَٱنفَجَرَتْ مِنْهُ ٱثْنَتَا عَشْرَةَ عَيْنًا ۖ قَدْ عَلِمَ كُلُّ أُنَاسٍ مَّشْرَبَهُمْ ۖ كُلُوا۟ وَٱشْرَبُوا۟ مِن رِّزْقِ ٱللَّهِ وَلَا تَعْثَوْا۟ فِى ٱلْأَرْضِ مُفْسِدِينَ ۝

صَدَقَ اللهُ العَلِيُّ العَظِيمُ

CERTIFICATION

We certify the thesis titled **"THE FEASIBILITY OF USING GROUNDWATER IN UM-QASR AREA FOR DOMESTIC AND AGRICULTURAL PURPOSES"** which is being submitted by **HAIDER ABDULRIDHA KHANFAR AL-ADHAB** was prepared under our supervision at the University of Basrah in a partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE** in civil Engineering.

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I

ABSTRACT

The present study is concerned with investigating the use of groundwater in Um-Qasr area for domestic and agricultural purposes. Um-Qasr area is located in the southeast of Iraq, in Basrah, with municipal area equal to (70 km^2). It is located within Dibdibba formation, which mainly composes of sand and gravel with some cementing material as silt and clay.

It was taken (11) groundwater samples from different wells for obtaining the quality, classification, and assessment of these samples. The chemical analysis results are as follow: potassium (12.01-18.4 mg/l), sodium (886.2-1821 mg/l), magnesium (60.76-140.96 mg/l), calcium (136.27-220.44 mg/l), chloride (709.1-1634 mg/l), nitrate (1.8-11.2 mg/l), sulfate (1238.4-2889.6 mg/l), and bicarbonate (96.41-219.66 mg/l). The TDS, pH, and temperature were ranged between (3580 ppm-9040 ppm), (6.4-7.1), and (25$^°$C - 28$^°$C) respectively.

The origin of groundwater is meteoric and its type is from (Na+K-sulfate) family as found in Sulin's method. It was found by using Schoeller's method that the groundwater were located in the second group of cations [r(Na+K)>rCa>rMg], (except for wells of numbers 8 and 9, which were located in the first group). In other side, the groundwater were located in the third group of anions [rSO$_4$>rCl>rHCO$_3$], (except well number 1, which was located in the second group). By using Schoeller–Sulin's method, It was found that the groundwater in all wells were classified at (Sulfate-Sodium group), except well number 1, which was classified at (Chloride-Sodium group). Also, the results were compared with WHO standards (1995) for drinking water and it was noted that the groundwater is not suitable for drinking. In other hand, it was noted that the groundwater was not suitable for agricultural purposes except dates and some crops as tomato, cucumbers, and potatoes.

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CHAPTER ONE
INTRODUCTION

1.1 General

Due to the decrease in rainfall quantity in the recent years and the increase in rates of water demand for the different purposes, the surface water sources does not satisfy the increasing water need. Thus, the groundwater sources become an important one in Iraq and in other countries in the world.

The physical and chemical characteristics of groundwater depends on many factors such as the geological formations, the source of the ground water (marine or meteoric water), etc.. In most cases, the quality of groundwater is unsuitable for drinking because it has several ions, metals, and bacteria with concentrations exceed the allowable averages of the international standards. Therefore it must be treated by several steps to reduce undesired concentrations to the suitable degree for drinking or used as water supply in domestic, irrigation of crops and industrial uses.

Um-Qasr area, which is located in the south east of Iraq in Basrah governorate is supplied with water by using a pipe line extended from the center of Basrah City (Maqal area). The transported water is withdrawn from Shatt Al-Arab River. The shortage in water quantity of this river become very clear which raise the need for reducing the dependence on the water of this river. Therefore the study of groundwater, especially in Um-Qasr area, as a water supply source become essential.

Um-Qasr located between longitude–line (47° 53' E - 47° 57' E) and latitude line (30° 00'N - 30° 05'N) with (278 km^2) as a total area. The municipal area equal to (70 km^2) and the design area equal to (23 km^2), see Figure (1-1).

Its borders Khur Al-Zubair from the east, Safwan area from the north and west, and Kuwait from the south. Its population is about 60700 person.

Figure (1-1) Locational map of wells in Um-Qasr area (The study area)

1.2 Sources of Water Supply

Several sources are used for supplying the water required for domestic, agriculture, and industrial purposes. These include; precipitation, surface water, and groundwater. In dry climate zones, the major source of water supply is groundwater as well as surface water, but in the wet climate zones, precipitation represents the most important one. In study area, the water supplies can be listed as following:

Precipitation is represented by rainfall, hail, sleet, and snow. In the study area (Um-Qasr), rainfall is the only kind of precipitation. Rarely, hail and sleet precipitated with low percentage at Um-Qasr area for long interval (5 years and above). There is no snow precipitated in this area because it has hot climate and the average of temperature in the winter is high.

Groundwater can be considered as an important type of the water sources, because it has several advantages, it may require no treatment, it has approximately constant temperature through out the year, its amounts are more certain, and it is more economical than the other sources (Todd, 1980).

Groundwater comes from (a) natural springs, (b) wells, (c) infiltration galleries, basins, or cribs, (d) wells, galleries, and possibly springs, and (e) wells or galleries with flows maintained by returning to the groundwater previously with drawn from the same aquifer for cooling or similar purposes (Fair, 1971).

1.3 The Hydrologic Cycle and Groundwater

In general, groundwater represents one part of the earth's water circulatory system (invisible subsurface part) known as the hydraulic cycle. Groundwater which occurs below the ground surface is called aquifers. Aquifer occurs in porous geological formations which have sufficient permeability. These formations allows water to move with in them, and allow this water discharge or be extracted. Department of land and water conservation, in Australia, shows that the groundwater categorized as occurring in:

 - **Unconsolidated Sediment:-** non cemented sands and gravels commonly found in alluvial valleys, coastal plains, and sand dune system. Groundwater contained within fractures and joints.

 - **Sedimentary Rocks:-** consolidated or semi consolidated formation such as sand stone, lime stone, and shale. Groundwater occurs both within the pore space in the rock matrix and also within fractures and joints.

 - **Fractured Rocks:-** Igneous rock volcanic and metamorphic rocks such as granite, basalt, slate, and gneiss. Groundwater in these rocks occurs mainly within fractures and joints.

   Water enters these porous formations from the ground surface either from rains or from bodies of surface water, this water often travels slowly for varying distances until it returns to the surface by action of natural flow, plants, or humans (Todd, 1980).

   Freeze and Cherry, 1979, divided the flow between the subsurface and the surface of the ground into two parts. The first one is "inflow" and includes precipitation in the form of rainfall or snow melt. It is delivered to streams both on the land surface as over land flow to tributaries channel; and by subsurface flow routs, as inter flow and base flow following infiltration into the soil, stream flow, lakes, and reservoirs. Sea water can be classified as the first one flow, if the hydraulic gradients slopes down ward in an inland direction. Under the action of gravity, the water with in the ground moves through the unsaturated zone, but in the saturated zone, it moves in direction determined by the surrounding hydraulic situation.

   And the second one is "out flow" and takes place as stream flow (or runoff) and as evapotranspiration, a combination of evaporation from open bodies of water, evaporation from soil surface, and transpiration for the soil by the plants, while, Todd 1980, described the out flow as water emerges from   under   ground. This discharge occurs as flow in to surface water bodies, such as a stream lakes and oceans, or emerges to the surface as a

spring water. The groundwater system in humid (wet) and arid (dry) regions differ from each other as shown in Figure (1-2).

In wet climates, there is high rainfall, large volume water seeps in to the groundwater, which gives actively to the water cycle feeding stream, springs, and wet land during periods when the rainfall is lower. In dry-semidry climates, there is no exchange between the ground surface water and groundwater regimes because the small volume of the seepage from the little rainfall penetrates the thick and dry soil (Struckmeier et. al. 2005).

The combination of the storage capacity of groundwater reservoirs and the small flow rates gives large distribution of source for water supply. The emerging of groundwater into surface stream channel helps the stream flow when there is lower runoff.

It is important to notice the difference between the quantity of groundwater and other components of the hydraulic cycle as shown in Table (1-1).
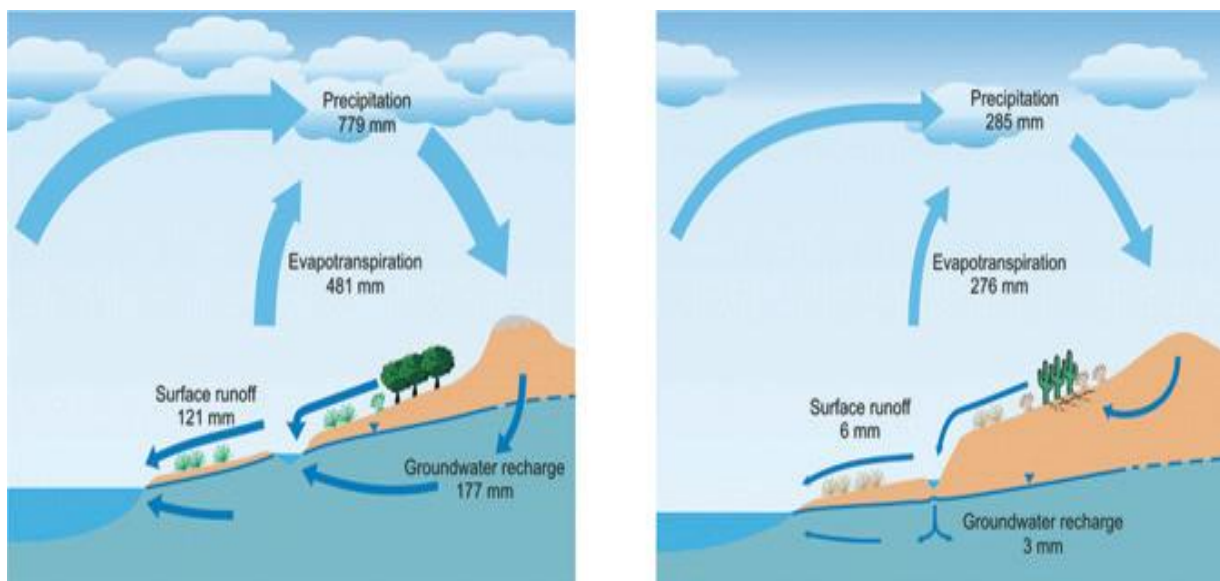
Figure (1-2) The water cycle in different climatic zones of the world, humid regin (left) and arid regin (right)

Table (1-1) Estimate of the water balance of the world ,after Freeze and Cherry ,1979

Parameter	Surface area (km^2)×10^6	Volume (km^3)×10^6	Volume (%)	Equivalent depth (m)	Residence time
Oceans and seas	361	1370	94	2500	4000 years~
Lakes and reservoirs	1.55	0.13	< 0.01	0.25	10 years~
Swamps	< 0.1	< 0.1	< 0.01	0.007	1-10 years
River channels	< 0.1	< 0.1	< 0.01	0.003	2 weeks~
Soil moisture	130	0.07	< 0.01	0.13	2 weeks -1 year
Ground water	130	60	4	120	2 weeks-10,000yrs
Icecaps and glaciers	17.8	30	2	60	10-1000 years
Atmospheric water	504	0.1	< 0.01	0.025	~ 10 days
Biosphere water	< 0.1	< 0.1	< 0.01	0.001	~ 1 weeks

With reference to Table (1-1) if we remove from consideration, the 94% of the earth water that rests in the oceans and seas at high levels of salinity, then groundwater accounts for about two - third of the fresh water resources of the world (Freeze and Cherry, 1979).

1.4 Groundwater Pollution

Groundwater pollution may be defined as an undesirable changing in water properties (chemical, physical, and biological properties) caused by artificial (human activities) or naturally occurring pollution. If the pollution of groundwater is compared with that of surface water, it is can be seen that the surface water is polluted faster than the groundwater, but the last one is difficult to control and detected. With the growing recognition of the importance of groundwater resources, the works are increasing to reduce, prevent, and eliminate ground water pollution (Todd, 1980).

The major pollutants in the groundwater is the total dissolved solids in water (TDS) and (TDS) include cations, anions, organic mater, etc.. The University of California–Division of Agriculture and Natural Resources, in partnership with Natural Resources Conservation Service (NRCS) presented reference sheet, which is part of the Farm Water Quality Planning (FWQP) series, to teach the basic concepts of water shed, non point source pollution

(NPS) , self–assessment techniques, and evaluation techniques. In this sheet, they classified the (TDS) in to three groups, major, secondary, and trace constituents in natural ground water. Table (1-2) described these groups. In Turkey, Sagnak, 2007, presented two sources of pollution:

1- Naturally Occurring Groundwater Pollution:

    Its reasons of pollution are;

a- Sea water intrusion: Sea water moves to the aquifer if groundwater is over exploited and its quality starts to impair, which is the concentration of salt increases.

b- Lake–river–aquifer relations: They are polluted each one on the others because they are connected under the hydraulic cycle.

c- Geothermal affect: In general, the composition of ground water usually depends on the composition of materials it contacts. The long period of contacting gives more time to minerals for dissolving, where the thermal water affect on the contact directly.

d- Pollutants originated from geological formation: The water quality can be impaired if the salty water and fresh water are mixing together because of the wrong drilling methods used in formations containing salt, gypsum, etc. .

2- Groundwater Pollution Produced by Human Activities :

They can be grouped in to three resources ;

a- Municipal Disposal including; sewer leakage, liquid waste, and solid waste.

b- Industrial Disposal.

c- Agricultural Pollutants including; pesticides and fertilizers.

Table (1-2) major , secondary , and trace constituents to natural groundwater ,
(UC ANR Publication 8084)

Major Constituent	Secondary Constituent	Trace Constituent	
1.0-1,000 mg/l	0.01-10 mg/l	0.0001-0.1 mg/l	Less than 0.001 mg/l
Cations :_____ Sodium Potassium Calcium Iron Magnesium Strontium Anions :_____ Bicarbonate Carbonate Sulfate Nitrate Chloride Fluoride Silica Boron		Antimony Aluminum Arsenic Barium Bromide Cadmium Chromium Cobalt Copper Germanium Iodide Lead Lithium Manganese Molybdenum Nickel Phosphate Rubidium Selenium Titanium Uranium Vanadium Zinc	Beryllium Bismuth Cerium Cesium Gallium Gold Indium Lanthanum Niobium Platinum Radium Ruthenium Scandium Silver Thallium Thorium Tin Tungsten Ytterbium Yttrium Zirconium

1.5 Aims of Study

The aims of this study include:

1- Classifying the groundwater in Um-Qasr area.

2- Investigating the practicability use of the groundwater in Um-Qasr for domestic and agriculture purposes by studying its quality and comparing it with universal standards of water quality for the different purposes.

CHAPTER TWO
LITERATURE REVIEW
2.1 Some Previous Studies on Groundwater in The Region

2.1.1 Studies on Safwan-Al-Zubair Area

Haddad 1977, made an extensive study about the hydrological features of the Safwan area, which includes the water balance. He stated that the decrease quantity of groundwater in Safwan area is due to the increase in quantities of fructification for agricultural purposes and the decrease in the recharge quantities of this groundwater.

Haddad and Hawa 1979 introduced comprehensive study about the hydrogeological of Safwan area. This study concentrated on the chemical properties of groundwater and hydraulic properties for upper and lower aquifer in this zone.

Al-Dabbass et. al. 1989, studied the behavior of probable interaction between groundwater and the sediments of upper part of the Dibdibba formation, and their study showed that the sediment of the upper part of the aquifer is in general and especially clay unit has an important effects on the salinity of ground water.

Al-Dabbass 1993, also conducted a study concerning the action of baron element contained in the sediments of Dibdibba aquifer through the wet and dry periods of year.

Al-Kubaisi 1996, presented a new study about hydrogeological of Safwan–Al-Zubair area. This study includes water balance in the water year (1995-1996) and determined some limits to the qualitative and quantitative

consumption for aquatic source and also described the chemical characteristics of water in the region.

Al-Manssori 2000, studied the hydraulic and hydrogeochemical characteristics of the upper unconfined aquifer. He calculated its transmissivities by using 50 % and 90 % recovery test and they ranged from 115 to 3266 (m^2/day) and from 18 to 135 (m^2/day) respectively. The calculated values using numerical method ranged from 235 to 5880 (m^2/day).

Al-Aboodi et. al. 2008 studied the suitability of groundwater in Safwan -Al-Zubair area south of Iraq, for human use, animal drinking, and several crops, and they found that it is not good for using except for irrigating some crops, beef, cattle, and sheep. They studied other factors that affecting the suitability of groundwater for agriculture purposes like the sodium absorption ratio (SAR), and they found there were nine wells lied as satisfactory limits, while the other wells lie in the marginal limits. Also, they determined the factors (r Na /r Cl), (r (Na-Cl) / r SO$_4$), and (r SO$_4$ / r Cl), and used them for determining the origin of groundwater.

Al-Aboodi et. al. ,2008 classified the groundwater in the same area (Safwan–Al-Zubair area), by using Scholler–Suline method and found that the dominant anions were sulphate and chloride ions. They concluded that the origin of the groundwater divided into two types, the first one is of marine and the other of the meteoric water.

Also, Al-Aboodi 2008, studied the groundwater hydro chemical classification, but this time in Bahr Al-Najaf, western desert, Iraq. He used Scholler–Suline method, and he found that the groundwater in this area characterized by their wide variations in total dissolved solids contents (TDS) because of the variation in lithological or mineralogical contents of

the aquifer. Moreover, the water type of the Bahr Al-Najaf area is of marine origin located in semi-confined basin.

2.1.2 Groundwater Studies in Other Countries

McWhorter and Sunada 1977, introduced a two-dimensional groundwater model, which may be used for analysis of the areal distribution of hydraulic head in aquifers. This model was based upon fully implicit central difference scheme. They used Gauss elimination method for solving the finite difference equations and they were able to use this model to treat either the confined groundwater flow problems and their interactions.

Voucline et. al. 1979, used numerical model for studying two-dimensional unsaturated water table recharge problem. Finite difference equations have been solved using alternating direction implicit (ADI) method. They showed that the validity of the model is shown by the excellent agreement between simulated and experimental results obtained from sand box model.

Gureghian 1981, designed a two-dimensional Galarkin finite element model to predict the steady and transient, saturated-unsaturated movement of water in homogeneous and non homogeneous ditch-drained aquifers. The obtained results for the case drainage with incident rainfall under steady state conditions for a homogeneous and for layered soils have been compared with numerical solutions for the case where the saturated region is considered alone. Model results have also been compared with data obtained from laboratory experiments for transient state problems.

Al-Bader 1987, presented a numerical methods for analyzing the two-dimensional flow in unconfined aquifer using implicit finite difference scheme for steady state as will as unsteady state flow . The alternating

direction implicit (ADI) method was used for analyzing steady state two-dimensional flow in a vertical plane of unconfined aquifer. The analysis includes both saturated and unsaturated flow.

Lerner D. N. 1988, presented a study about predicting pumping water levels in single and multiple wells in Lema–Peru by using two dimensional regional groundwater models. He put several parameters included by the simple algebraic procedure like; water table conditions, partial penetration, interfacing effects between wells, boundaries, and well losses.

Crowther 1989, presented a study about the wide inter– and intra site variations in cations budgets (calcium and magnesium) that may be encountered in tropical karst groundwater. He noticed that dissolution activity is concentrated at the limestone surface. In additional to that, the tropical limestone forests annually take up amounts of calcium and magnesium equivalent to the net solute output in ground waters.

Salman W. D. 1991, used Boundary Element Method (BEM) for the simulation of both steady and transient two dimensional unconfined flow through homogeneous and isotropic porous media.

Rupert M. G. 2001 improved the effectiveness of modified DRASTIC groundwater vulnerability map by calibrating the point rating schemes to actual groundwater quality data by using non parametric statistical techniques and a geographic information system (GIS). His calibration was performed by comparing data on nitrite plus nitrate as nitrogen (NO_2+NO_3-N) concentrations in groundwater to land use, soil, and depth to first encountered groundwater data. These comparisons showed clear statistical difference between (NO_2+NO_3-N) concentrations and the various categories.

Al-Sabakh 2002, used the specific electrical resistance method–Schlumberger arrangement–to find the level of groundwater in Baghdad

City (Al-Rosafa zone), and he found that the level of groundwater ranges between 0.5 m to 3.5 m under the ground surface. He concluded that the source of the groundwater from the human sources (bad sanitary disposal system). He noted that in the depth about 3 m to 12 m, there was low specific electrical resistance area, and concluded that there was another aquifer in the level or may be the specification of soil in Baghdad City.

Kumar and Seethapathi 2002, assessed the natural groundwater recharge (rainfall) in upper Ganga Canal, Command Area in India. They studied the seasonal ground water balance for the area. An empirical relationship has been suggested for estimation of the groundwater recharge from rainfall with reasonable accuracy.

Al-Moosa 2003, presented a study about groundwater management of Debaga basin, in north of Iraq. He used (Modflow-2000) program as groundwater simulation tool. This study divided into three parts. The first one was to refine the understanding of the basin groundwater system and made a hydrogeological data base. The second one was to develop and calibrate the two-dimensional groundwater model. The third one was to simulate the area of contribution for the trail and error optimal management procedure of supply wells.

Abdul-Rahman et. al. 2004, studied the concentration of the nitrate in groundwater and agricultural activities and land use. The existing of the nitrate concentration over the standard concentration lied to change the characteristics of water and became unsuitable for human use. They collected 1063 samples from wells used for drinking in the thirteen zones in K.S.A. and appointed the land use around wells. They discussed the relationship between nitrate concentration and wells depth, and found that the wells had high concentration in area located in agricultural and residential zones. Also they found that 46 % from wells that categorized as

superficial wells exceeded the allowable concentrations. In other hand, there was only 1 % of wells categorized as deep wells exceeded the allowable concentrations.

Lashkaripour and Nakhaei 2005, studied the groundwater conditions (depth, thickness, and aquifer boundaries) in the Shooro basin in south east Iran by using geoelectrical investigations. They used vertical electrical sounding (VES) by Schlumberger array were conducted in this area. They saw that the west part of the study area which divided with Shooro River had resisting and average permeability coefficient higher than the east part of the river, because the west part had salinity water existence of alluvial from with coarse grain material. The east part had finer material and also brackish water infiltration from adjacent basin especially in the center part of aquifer. The VES test showed that are four subsurface geological layers. So the aquifer thickness increases towards the west. It has about 40 m thickness in west and 24 m in the east.

Babiker et. al. 2006,evaluated the groundwater quality for Nasuna basin, Tochigi prefecture, in center of Japan, by using GIS model. This model indicated that the parameters which reflect relatively lower water quality and those of important special variability include larger impact on the groundwater quality index and must be carefully and accurately mapped.

In Jordan, El-Naqa et. al. 2006, used DRASTIC model combined with GIS to evaluate the groundwater in Russeifa area. Russeifa area is known as Russeifa landfill, which is placed on the most important aquifer in Jordan, which is known as Amman–Wadi Sir. It is used as a site to undertake the largest solid waste disposal. Therefore, the groundwater in this area is contaminated. The major geological and hydrogeological factors that affect and control groundwater contamination were incorporated into the DRASTIC model to produce groundwater vulnerability and risk map.

Moreover, a GIS used to create a groundwater vulnerability map by overlaying the available hydrogological data. The vulnerability index of Russeifa area indicated that the groundwater resources in the surrounding area were susceptible to pollution to a moderate degree by Russeifa landfill. The vulnerability maps ranged from the most vulnerable to the least vulnerable for contamination.

Asadi S. S. et. al. 2007 used the remote sensing and GIS techniques for the evaluation of groundwater quality in Municipal Corporation Hayderabad (Zone V), India. They found that the overall view of water quality index of the study area revealed that most of the study area with > 50 standard rating of water quality index exhibited poor, very poor, and unfit water quality except in places like Banjara Hills, Erragadda, and Tolchowki. They suggested that the comprehensive sewerage system for safe disposal of wastes should be developed to safe guard groundwater quality in most of the residential areas.

Mishra D. et. al. 2009, assessed the groundwater of Bhavnagar village – Gujarat – India. They collected twelve samples from different locations of Bhavnagar region for winter, summer, and post monsoon, and analyzed them for physical and chemical parameters (pH, TDS, EC, turbidity, suspended solids, chloride, alkalinity, sulphate, hardness, nitrate, fluoride, sodium, potassium, and heavy metals). They concluded that the groundwater in this region requires precautionary measures before drinking.

2.1.3 Groundwater Pollution Studies

Ayob et. al. 1989, presented geochemical study concerning the variation in the heavy elements concentration in the groundwater in the Safwan area. He said that the increase of well age because of pollution

irrigation water percolating to the aquifer as a result of chemical usage of fertilizers and antacids in agricultural practice.

Ravenscraft P. et. al. 2001, explained that the arsenic pollution of groundwater in Bengal basin of Bangladesh and west Bengal (India) related to the Late Pleistocene and Holocene evolution of the Bengal basin. This evolution controlled by climatic fluctuations and sea-level changes, therefore, a general model emerges for predicting the occurrence of ground water that is naturally polluted by arsenic. They showed that the pollution by arsenic occurred because the biodegradation of buried peat deposits drives extreme degree of iron oxy hydroxide (FeOOH) reduction and supplies high concentration of arsenic to ground water (hundreds of µg/l).

In Walkerton, Ontario in Canada, seven people died and 2300 illness cases occured because of bacterial contamination occurred in water well in carbonate aquifer. Therefore, Worthington et. al. 2002, made a study to explain this contamination. They interpreted that by several causes including that the carbonate aquifers are karistic, and they contained solutionally enlarged conduits which can transmit groundwater and contaminants at rates of hundreds of meters per day. Therefore, it must be taken precautionary procedures to prevent the losses when carrying out hydro geological investigation in carbonate aquifers.

Gemitzi A. et. al. 2005, presented a methodology to estimate the risk of an aquifer to be polluted from concentrated and/or dispersed source. They applied an overlay and index method involving several parameters. This method had been applied in the region of eastern Mecedonia and Thrace (Northern Greece). The methodology had been tested and calibrated against measured nitrate concentration.

Adekunl I. M. et. al. 2007, declared that the groundwater in most of study area in Igbora, south west Nigeria is not suitable for drinking because

it wase near of pollution sites (municipal waste dumps and defecation sites). They took twelve samples from hand–dug wells distributed in typical rural settlement. They found that the groundwater samples in the vicinities of pollution source and those in the residential areas contained Pb, Cd and coli form levels (FC and TC) above the WHO standards for drinking water and domestic use.

Sagnak C. 2007, discussed the groundwater pollution from geological formation in Konya–Cumra–Karapinar in Turkey. He observed that the geological formation in this zone containing gypsum and anhydrite, which cause natural pollution. He used the (Arc GIS 9.0) to collect and map the data of all wells and water analysis. He suggested that the wells should be designed to prevent seepage of poor quality water (salty water) into them, and, the salty water must be sealed with closed pipe and cement.

Rajankar P. N. et. al. 2009, evaluated the groundwater in Khoper Kheda in Nagpur region, India, based on water quality index (WQI), which was calculated by using water quality index calculator given by National Sanitation Foundation (NSF). They concluded that the underground drinking water was highly polluted as indicated by WQI. The water of ordinary had pumps should not used because it was discouraged. Moreover, the quality of water was found began to deteriorating after the onset of monsoon. It was required enhance the drinking water quality.

CHAPTER THREE
DESCRIPTION OF STUDY AREA

3.1 Physical Properties

3.1.1 Geology of The Study Area

Um-Qasr located in southeast edge of the earth formation named "Dibdibba Formation", which is known as Pliocene – Upper Miocene age, and it extends to the middle of Iraq toward northwest, and to the Kuwait and Saudi Arabian toward south and southeast (see figure (3-1)).

Dibdibba formation consists mainly from sand and gravel with some cementing materials like silt and clay, especially in the west of Al-Zubair area (Macfadyen, 1983).

Al-Dabbas et. al., 1989, mentioned that Dibdibba's deposits also contain some minerals such as quartz, feldspar, gypsum, and calcite while clay minerals consisted of montmomrillonite, chlorite, illite, kaolinite in addition to polygroskite.

The previous studies differ in specifying the maximum thickness of Dibdibba formation. Buday and Jassim (1987) and Al-Aboodi (2003) indicated that the thickness reached to (350 m). Bellen (1959) said that the formation thickness about (314 m) in north wells of Zubair oil field. On the other hand, Jassim and Goff (2006) mentioned that the thickness of Dibdibba formation is up to (500m) in some of wells southern Iraq, and they said that one of its depocentes located in the south east of Iraq, in Zubair sub zone of the Mesopotamian zone.

The formation in the south of Iraq dips slightly towards the northeast and forms sedimentary plain named Dibdibba plain (Buday, 1980).

The upper part of Dibdibba formation was divided by Al-Kubaisi, (1999) into two hydrogeologic units. The first one is unconfined aquifer (Quatemary in age) which contains brackish water, and its saturated thickness extended from (15 m) to (20 m). The second aquifer is semi-confined (Tertiary) and it is separating from the first one by hard clay bed.

Dibdibba formation is underlain by the Fatha formation (M. Miocene), which is composes of anhydrite gypsum, marls, and shallow water limestone. This formation in turn is underlain by the Ghar formation (M/L Miocene), which is compose of sandstone with subordinate gravels and occasional clay, and is about (150 m) thick (Haddad and Hawa, 1979).

3.1.2 Climate of The Area

In general, the study area located within semi-arid zone, so the climate in this zone is hot and aneroid in summer and temperate with little rainfall in winter. The climate elements include: rainfall, temperature, evaporation, relative humidity, wind, and sunshine.
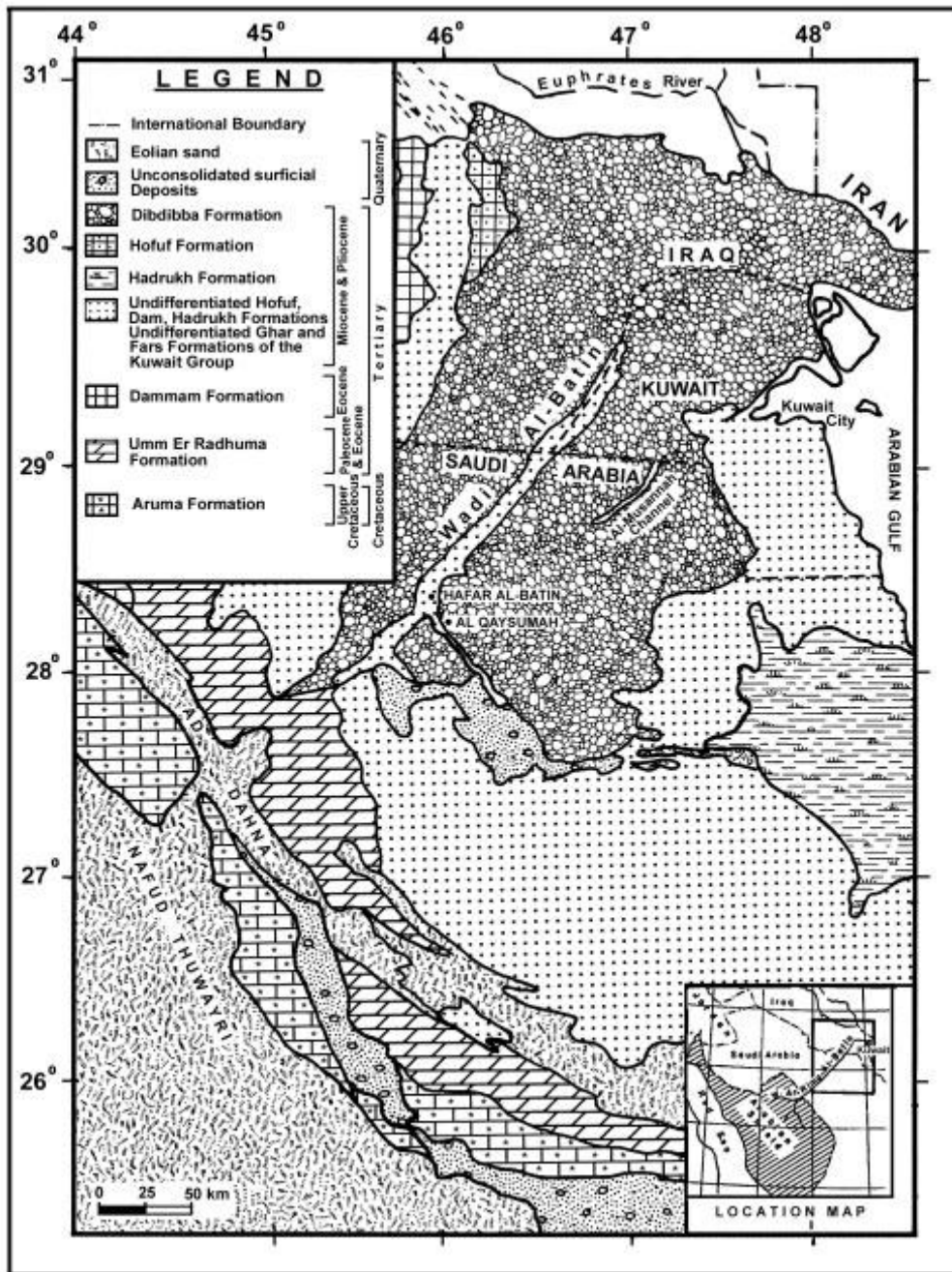
Figure (3-1) : The extension of the Dibdibba formation in the study area
(after Al-Sulaimi et. al. 1992a)

3.1.2.1 Rainfall

Rainfall is the only type of precipitations which occurs in the study area (as it mentioned in chapter one). Therefore it has an important effect on the groundwater amount.

The rainfall season stretches from October to May. The maximum and minimum monthly average of rainfall are (39.0 mm) in January and (0.4 mm) in May respectively, see Table (3-1). The number of rain days effects directly on the amount of the rainfall. In general, they are mostly low at the rainfall season, see Table (3-2).

3.1.2.2 Temperature

The temperature affect on the other elements of climate. The maximum and the minimum monthly average of highest temperature are (47.53 ℃) in August and (17.58 ℃) in January respectively, and the annual average is (34.13 ℃). While, the maximum and minimum of monthly average of lowest temperature are (30.0 ℃) in July and (7.85 ℃) in January respectively, and the annual average is (19.66 ℃), see Table (3-3).

3.1.2.3 Wind Speed

The wind blows on the study area is approximately every days of the year, but it is varying in its speed value and direction. Its speed extends from (3.52 m/sec.) in October to (6.25 m/sec.) in June with annual average equals to (4.45 m/sec.). In general, the direction of the wind is north and northeast and dominate than south and southeast winds, see Table (3-4).

Table (3-1) : Distribution of monthly average of rainfall (mm) in Um-Qasr during the period (2000-2008) , (Basrah International Airport)

Month	Average of Rainfall (mm)	Month	Average of Rainfall (mm)
January	39.0	July	0.0
February	18.1	August	0.0
March	3.2	September	0.0
April	14.0	October	2.9
May	0.4	November	8.4
June	0.0	December	32.9

Table (3-2) : Distribution of monthly average of rain days (After Sadoon , 2005)

Month	Rain Days	Month	Rain Days
January	7	July	0
February	5	August	0
March	6	September	0
April	6	October	3
May	2	November	4
June	0	December	5

Table (3-3) :Distribution of monthly average of highest and lowest temperature (ºC) during the period (2000-2008) , (Basrah International Airport)

Month	Temperature (ºC)		Month	Temperature (ºC)	
	Highest	Lowest		Highest	Lowest
January	17.58	7.85	July	47.47	30.00
February	21.86	9.96	August	47.53	29.50
March	28.66	14.80	September	42.32	25.36
April	34.00	20.18	October	37.55	21.57
May	41.11	26.24	November	26.70	13.61
June	45.28	28.00	December	19.57	8.95

Table (3-4) : Distribution of monthly average of wind speed (m/sec.) during the period (2000-2008) , (Basrah International Airport)

Month	Wind Speed (m/sec.)	Month	Wind Speed (m/sec.)
January	3.88	July	5.40
February	4.16	August	4.84
March	4.47	September	4.55
April	4.36	October	3.52
May	4.55	November	3.54
June	6.25	December	3.95

3.1.2.4 Evaporation

Evaporation value depends mainly on solar radiation, wind speed, and relative humidity. It can be measured by using standard evaporation pan (class A) [Dia. = 1.22 m , depth = 0.245 m], (Wilson E. M. 1983).

In study area the maximum average of monthly evaporation is (517.8 mm) in July, and the minimum is (70.9 mm) in January, see Table (3-5). The total annual average evaporation is about (3322.9 mm).

Table (3-5) : Distribution of monthly average of evaporation (mm) during the period (2000-2008) , (Basrah International Airport)

Month	Average of Evaporation (mm)	Month	Average of Evaporation (mm)
January	70.9	July	517.8
February	104.0	August	475.6
March	209.5	September	430.8
April	276.7	October	254.7
May	359.4	November	138.8
June	467.2	December	72.0

3.1.2.5 Relative Humidity

Relative humidity can be represented as a percentage ratio (%) and may be defined as the ratio of the actual vapor pressure to the saturated vapor pressure and acting directly on the evaporation. The maximum monthly average is (69.8 %) in January, and the minimum is (20.4 %) in July, see Table (3-6).

Table (3-6) : Distribution of monthly average of relative humidity (%)
during the period (2000-2008) , (Basrah International Airport)

Month	*Average of Relative Humidity (%)*	*Month*	*Average of Relative Humidity (%)*
January	69.8	*July*	21.6
February	56.6	*August*	24.3
March	43.0	*September*	27.8
April	39.3	*October*	39.1
May	26.14	*November*	51.7
June	20.4	*December*	68.8

3.1.2.6 Sunshine Period

It is means that the period in hours between the shine of the sun and the sunset per day. The maximum and minimum sunshine durations are (11.3 hour/day) occurs in June , and (6.9 hour/day) occurs in December, see Table (3-7).

Table (3-7) : Distribution of monthly average of sunshine duration (hour/day)
(After Sadoon , 2005)

Month	Sunshine Duration (hour/day)	Month	Sunshine Duration (hour/day)
January	7.00	July	11.00
February	7.70	August	10.60
March	8.00	September	10.20
April	8.70	October	9.40
May	10.00	November	7.70
June	11.30	December	6.90

3.2 Hydraulic Characteristics of The Aquifer

There are two levels of Dibdibba formation as be mentioned before, the first one has changeable thickness up to (30 m). The second level has depth increases more than the first one. Al-Aboodi (2003), said that the two levels are separated by a hard layer known as " Jaojab ".

3.2.1 Hydraulic Conductivity

Hydraulic conductivity (K) employed for practical work in groundwater hydrology, where water is the prevailing fluid (Todd, 1980).

The hydraulic conductivity has units of velocity (m/day) as shown in Equation (3-1), (Todd, 1980).

$$K = - \frac{V}{dh/dl} = - \frac{m/day}{m/m} = m/day \qquad ....(3-1)$$

Therefore, the hydraulic conductivity can be defined as the velocity of flow that occurs through total cross-section area of the aquifer with unit hydraulic gradient.

3.2.2 Specific Yield

The yield of aquifer can be defined as the volume of groundwater extracted by gravity drainage from a saturated water bearing material. In other hand, the term of specific yield means that the yield in ratio with volume of the total material drainage.

$$\text{Specific Yield} = \frac{\text{Volume of water obtained by gravity drainage}}{\text{Total volume of the material drained}} \quad \dots(3\text{-}2)$$

In Dibdibba aquifer specific yield values ranged between 0.0012 and o.4500, while the average equals to 0.1600, (Sadoon, 2005).

CHAPTER FOUR
GROUNDWATER QUALITY, CLASSIFICATION, & ASSISSMENT

4.1 General

The importance of groundwater quality is essential as its quantity. In fact, domestic, agriculture, and industrial use of groundwater are dependent mainly on determining the chemical and physical characteristics of this groundwater. Therefore, this chapter deals with both the chemical and physical properties of groundwater. To know the validity of groundwater to use for above demands, the results were evaluated and compared with universal standards like World Health Organization (WHO) standards, American standards, and Iraqi standards.

If the characteristics of the groundwater deviates away from accepted standard limits, it must be treated by several physico-chemical methods which will be mentioned latter in this chapter.

Twenty two groundwater samples were taken from eleven wells (two samples from each well) distributed over the study area as shown in Figure (1-1) in Chapter One. These samples were used for physical and chemical analysis like pH, total dissolved solids (TDS) and groundwater temperature, and the concentration of major ions.

4.2 Data Collection

In this study, the collected data are classified into two groups as following:

4.2.1 Field Data Collection

Field data collection is the first group and includes the location of wells, and the temperature of water. They are taken at once in field. Table (4-1) shows these data.

Table (4-1) : Field data collection in January , 2010

Well No.	Location		Temperature (^{o}C)
	Latitude Lines	*Longitude Lines*	
1	30º 2' 11.1'' N	47º 55' 41.0'' W	27
2	30º 2' 14.9'' N	47º 55' 44.3'' W	28
3	30º 2' 17.7'' N	47º 55' 23.3'' W	27
4	30º 2' 0.64'' N	47º 54' 37.6'' W	26
5	30º 2' 16.8'' N	47º 54' 21.5'' W	27
6	30º 2' 0.17'' N	47º 55' 44.7'' W	25
7	30º 3' 44.9'' N	47º 54' 42.0'' W	27
8	30º 3' 17.1'' N	47º 54' 30.3'' W	28
9	30º 3' 22.8'' N	47º 54' 25.3'' W	27
10	30º 3' 28.7'' N	47º 54' 20.0'' W	27
11	30º 3' 30.7'' N	47º 54' 41.9'' W	27

4.2.2 Water Samples Collection for Laboratory Analysis

Groundwater samples collection is the second group of data which involve the chemical analyses of these samples (major ions : cations and anions concentration) . The analyses were done in laboratories of Soil Department in Agriculture College – University of Basrah. The obtained results are shown in Table (4-2). This table explains the concentrations by "ppm" (part per million) with red color, and by "meq/l" (mellequivalent per liter) with blue color.

Table (4-2) : The chemical analysis of groundwater

Well No.	Cations					Anions					TDS	pH
	K⁺	Na⁺	Mg⁺²	Ca⁺²	Cl⁻	SO₄⁻²	HCO₃⁻	NO₃⁻				
					ppm / meq/l						ppm	
1	14.75 / 0.337	1165 / 50.68	72.91 / 6.00	192.38 / 9.60	1251 / 35.30	1238.4 / 25.80	187.93 / 3.08	11.2 / 0.181			4910	6.7
2	12.25 / 0.313	910.5 / 39.61	68.05 / 5.6	200.4 / 10.0	709.1 / 20.0	2001.6 / 36.5	134.2 / 2.2	1.8 / 0.029			4550	6.9
3	13.84 / 0.354	886.2 / 38.55	106.94 / 8.8	200.4 / 10.0	755.1 / 21.2	1752.0 / 36.5	151.32 / 2.48	5.6 / 0.09			3580	6.4
4	12.69 / 0.325	1311.0 / 57.03	82.64 / 6.8	136.27 / 6.8	716.2 / 20.2	2414.4 / 50.3	156.2 / 2.56	9.3 / 0.15			5280	6.8

Table (4-2) : Continue

Well No.		Cations					Anions				TDS	pH
		K⁺	Na⁺	Mg⁺²	Ca⁺²	Cl⁻	SO₄⁻²	HCO₃⁻	NO₃⁻		ppm	
						ppm / meq/l						
5	ppm	12.01	1214	60.76	168.34	797.7	2020.8	219.66	9.3		4840	6.6
	meq/l	0.307	52.81	5.0	8.4	22.5	42.1	3.6	0.15			
6	ppm	12.14	1210	63.19	164.33	900.5	2078.4	183.05	5.6		4810	6.6
	meq/l	0.313	52.63	5.2	8.2	25.4	43.3	3.0	0.09			
7	ppm	18.40	1315	111.8	216.43	1276	1924.3	130.57	3.7		8930	6.9
	meq/l	0.471	57.20	9.2	10.8	36.0	40.1	2.14	0.06			
8	ppm	14.75	1319	111.8	160.32	1259	2121.6	96.41	3.7		7670	7.1
	meq/l	0.377	57.38	9.2	8.0	35.5	44.2	1.58	0.06			

Table (4-2) : Continue

Well No.	Cations				Anions				TDS	pH
	K^+	Na^+	Mg^{+2}	Ca^{+2}	Cl^-	SO_4^{-2}	HCO_3^-	NO_3^-	ppm	
				ppm / Meq/l						
9	18.4 / 0.471	1821 / 79.21	140.96 / 11.6	160.32 / 8.0	1634 / 46.1	2889.6 / 60.2	97.63 / 1.6	5.6 / 0.09	9040	6.9
10	17.03 / 0.436	1182 / 51.42	75.34 / 6.2	220.44 / 11.0	1088 / 30.7	1939.2 / 40.4	103.73 / 1.7	5.6 / 0.09	8070	6.9
11	17.95 / 0.458	1445 / 62.86	92.26 / 7.59	216.43 / 10.8	1071 / 30.2	2413.6 / 55.7	97.63 / 1.6	4.7 / 0.076	8540	6.9

4.3 Accuracy of Results

It is very important to check the results of the groundwater chemical analysis before using them for the hydrochemical classifications. The correctness of groundwater analysis can be carried out cation-anion balance (Al-Aboodi, 2003). The sums of cations that expressed by (meq/l) must be in equivalent with the sums of anions by (meq/l), because all groundwater are electrically neutral. The error can be found as follows:-

$$\text{Error} = \frac{\Sigma \text{ cations} - \Sigma \text{ anions}}{\Sigma \text{ cations} + \Sigma \text{ anions}} \times 100 \% \quad \text{with in} \pm 5\% \quad \text{……..(4-1)}$$

Table (4-3) shows the sum of cations, anions, and the percentage of error of chemical analysis results. The maximum percentage error is (- 4.20) in well No. 9 and it is within the above limits (± 5%). Therefore, the chemical analysis results can be used for hydrochemical classification.

Table (4-3) : The sums of cations , anions , and the percentage error of chemical results for each well

Well No.	Σ Cations	Σ Anions	Error %
1	66.65	64.36	1.752
2	55.52	58.73	-2.806
3	57.70	60.27	-2.175
4	70.95	73.21	-1.564
5	66.51	68.35	-1.359
6	66.34	71.79	-3.943
7	77.67	78.30	-0.403
8	74.95	81.34	-4.083
9	99.28	107.99	-4.201
10	69.05	72.89	-2.701
11	81.71	87.57	-3.465

4.4 Temperature

Groundwater temperature must be taken immediately after withdrawing the sample from the well. Therefore, temperature is one of the field data collection because the climate conditions effect and change water temperature whenever offend to it.

In marked contrast to the large seasonal variation of surface water temperatures (except in tropical regions), groundwater temperatures tend to remain relatively constant, an important advantage for drinking water and industrial uses (Todd, 1980).

In study area, the values of groundwater temperatures were taken in winter season of (2009-2010), and it had venial variation from well to another. It is ranged between (25 ℃) and (28 ℃) as shown in Table (4-1). Figure (4-1) shows the distribution of groundwater temperatures of study area.
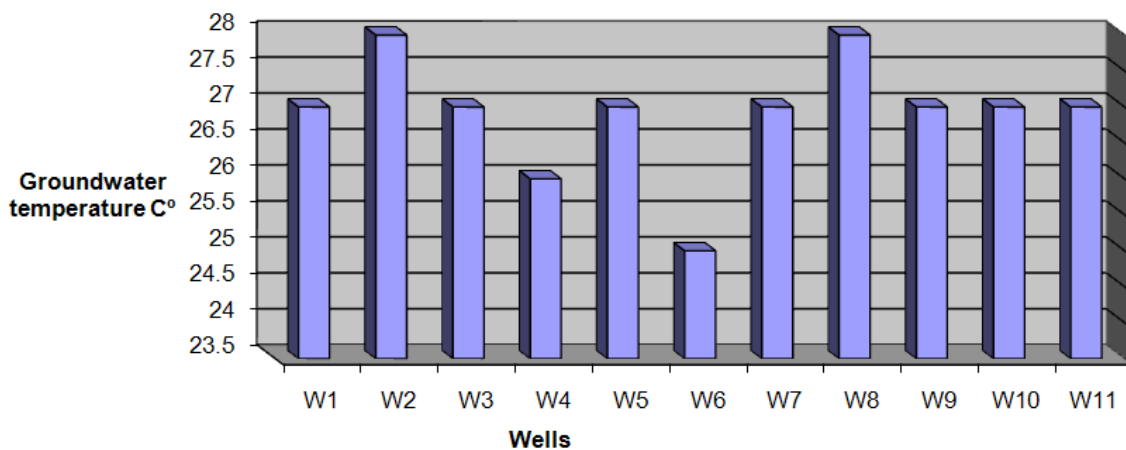
Figure (4-1) Distribution of groundwater temperature (Cº) of study area

4.5 Total Dissolved Solid (TDS)

Total dissolved solid in groundwater is defined as the total of all matter (inorganic and organic with little amounts) in unit volume of water filtered through (2 μm) pore size filter and boiling it to (180 ºC), the residue solid obtained by evaporation of water called total dissolved solids. The TDS concentration in groundwater vary over many orders of magnitude (Freeze and Cherry, 1979). See Table (4-4).

Table (4-4) : Simple groundwater classification based on total dissolved solids
(after Freeze and Cherry , 1970)

Category	*TDS (mg/l)*
Fresh water	0 - 1000
Brackish water	1000 – 10000
Saline water	10000 – 100000
Brine water	More than 100000

In fact, the water that falls upon the earth as rain contains only small quantities of dissolved mineral matter. As soon as it reaches the earth, it begins to react with the minerals of soil and rocks with which it comes into contact. The amount and character of the minerals matter dissolved by precipitation depends upon the chemical composition and physical structure of the rocks with which they have been in contact, the temperature, the pressure, the duration of the contact, the materials already in solution, hydrogen and hydroxyl-ion concentration (pH), and redox potential (Eh), (Wilton, 1970).

In study area, the maximum and the minimum values of TDS is (9040 ppm) in well No. (9) and (3580 ppm) in well No. (3) respectively as shown

in Table (4-2) . Figure (4-2) shows a map of the distribution of TDS over the study area .
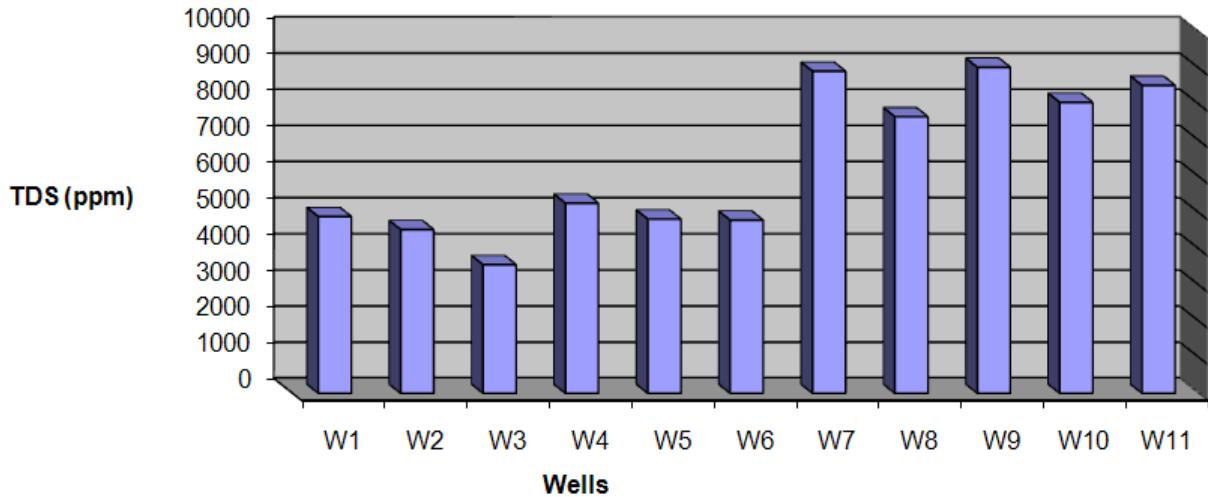
Figure (4-2) Distribution of groundwater TDS (ppm) of study area

4.6 pH

pH is a measure of concentration of free hydrogen ion in water. It is important in the control a number of water treatment and in control of corrosion (Steel and McGhee, 1979).

The value of groundwater pH in study area is approximately constant and ranged from (6.4) in well No. (3) to (7.1) in well No. (8), see Table (4-2). Figure (4-3) shows the distribution of pH over study area.
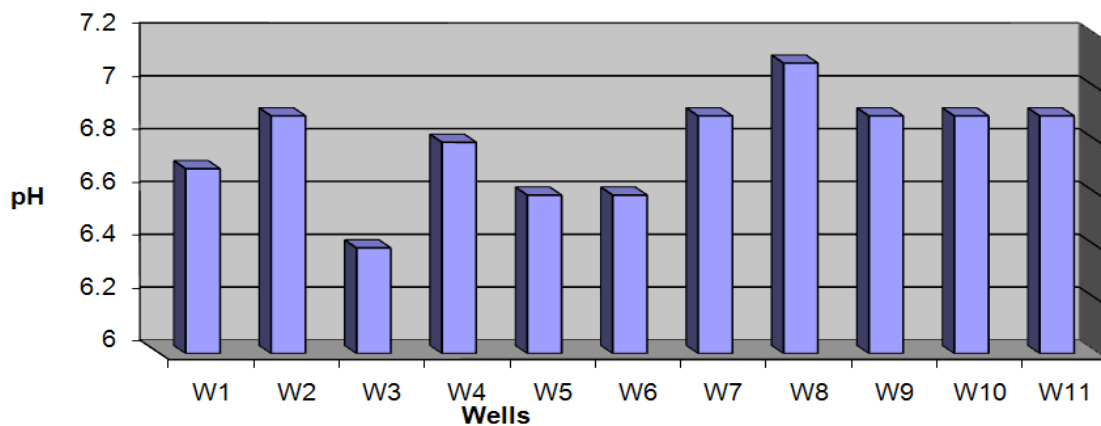
Figure (4-3) Distribution of groundwater pH in the study area

4.7 Electrical Conductivity (EC)

Electrical conductivity is the ability of material to conduct the electrical current through its cross-section area. It is depending mainly on the chemical and physical properties of the material. In water, the EC increases and decreases with increasing and decreasing the salinity of water respectively.

The EC of a water sample provides a rapid estimation of its total mineralization and reliable equipment is readily available. Conductivity of groundwater is normally reported in micromhos per centimeter (μmhos/cm) or in SI units microsiemens per centimeter (μs/cm), (Al-Aboodi ,2003).

The EC represents a rapid method to obtain the TDS. Todd (1980) and Walton, (1970), said that for most natural groundwater, the EC values in the range of (100 to 5000 μmhos/cm) at 25ºC, 1 ppm = 1.56 (EC) × 10^6.

The EC values were obtained using the following relation, Al-Aboodi (2003):

$$EC = 0.0008 (TDS) + 0.9536 \qquad ….. (4\text{-}2)$$

where EC in millimhos per centimeter (mmhos/cm) and TDS in milligram per liter (mg/l) or (ppm). It is important to mention here that the above relation was obtained for groundwater withdrawn from Dibdibba aquifer.

The maximum and minimum values of EC calculated by the above equation are (8.185 mmhos/cm) in well No. (9), and (3.817 mmhos/cm) in well No. (3) respectively as shown in Table (4-5). Figure (4-4) shows the distribution of EC over the study area .

Table (4-5) : Values of EC (mmhos/cm) by using the empirical equation put by Al-Aboodi (2003)

Well No.	EC	Well No.	EC
1	4.881	7	8.097
2	4.593	8	7.089
3	3.817	9	8.185
4	5.177	10	7.409
5	4.825	11	7.785
6	4.801		
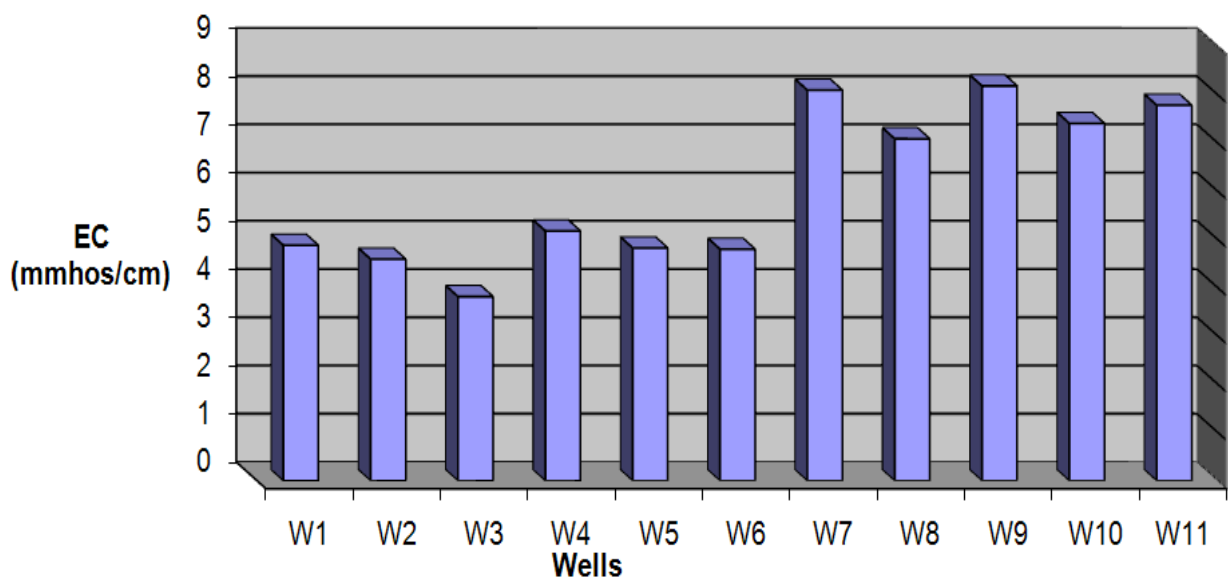
Figure (4-4) Distribution of EC (mmhos/cm) in the study area

4.8 Groundwater's Major Ions in The Study Area

The major ions can be divided into cations (positive ions which gravitate to the cathode) and anions (negative ions which gravitate to the anode).

4.8.1 Cations
These include ;

4.8.1.1 Potassium (K^+)
The common sources of potassium are the products formed by the weathering of the following minerals orthoclase, microline, biotite, leucite, and nepheline in igneous and metamorphic rocks (Walton, 1970). The concentration of potassium in rainfall about (0.1 mg/l) and (350 mg/l) in marine water and less than (10 mg/l) in most of drink water. Its existence in natural groundwater comes in a concentration less than (20 mg/l), (Brown et. al., 1970).
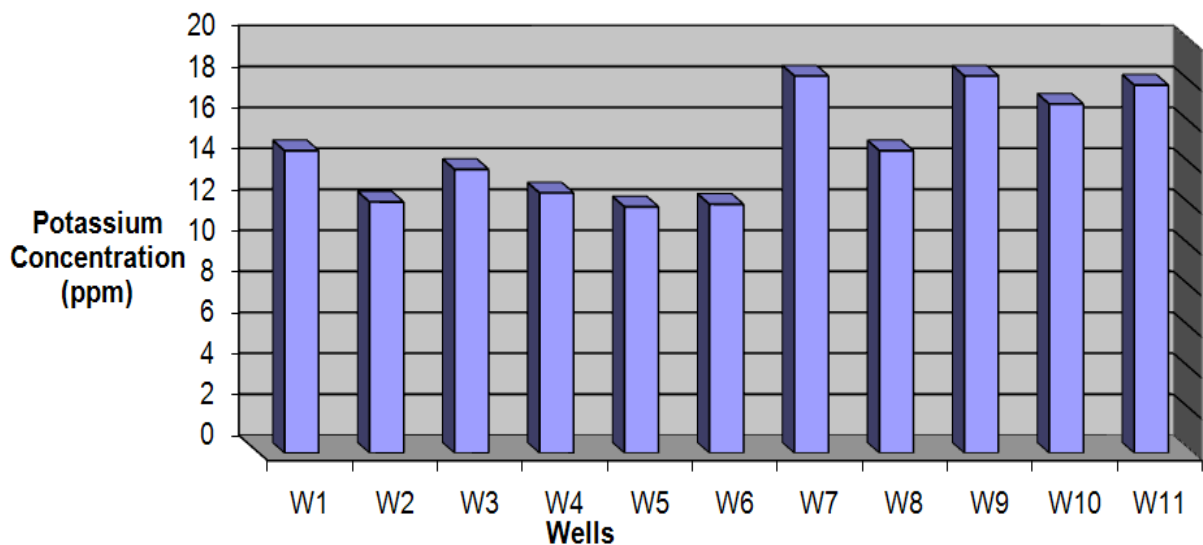
Figure (4-5) Distribution of potassium ions (ppm) in the study area

The maximum and minimum value of potassium in study area are (18.4 mg/l) in wells No. (7) and (9) and (12.01 mg/l) in well No. (5) respectively as shown in Table (4-2). Figure (4-5) represents the distribution of potassium ions (mg/l) over study area .

4.8.1.2 Sodium (Na $^+$)

Sodium reacts quickly with water and also with snow and ice, to produce sodium hydroxide and hydrogen. Davis and DeWiest, (1966), said that the primary sources of most sodium in groundwater are from release of soluble products during the weathering of minerals such as plagioclase feldspars. In addition to that, Chilton J., (1996), mentioned that the natural sources are feldspars, clay minerals, evaporates such as halite, NaCl, and industrial. In other hand, Sadik, (1977), said that the reason behind its existence in such high concentration related to the sedimentation of sandy Dibdibba formation uncover from igneous rock in Arabian shield which are conveyed to sedimentational basin containing a large amount of sodium.

In study area, the maximum and minimum values of sodium are (1821 mg/l) in well No. (9), and (886.2 mg/l) in well No.(3) respectively as shown in Table (4-2). Figure (4-6) shows the distribution of sodium ions (mg/l) over study area.

4.8.1.3 Magnesium (Mg^{+2})

Magnesium and other alkali earth metals responsible for water hardness. Water containing large amount of alkali earth ions is called hard water, and water containing low amount of these ions is called soft water.

The common sources of magnesium in groundwater are dolomite in sedimentary rocks, and minerals such as olivine, biotite, hornblende, and augite in igneous rocks, and serpentine, talc, diopside, and termolite in metamorphic rocks, (Al-Aboodi , 2003).
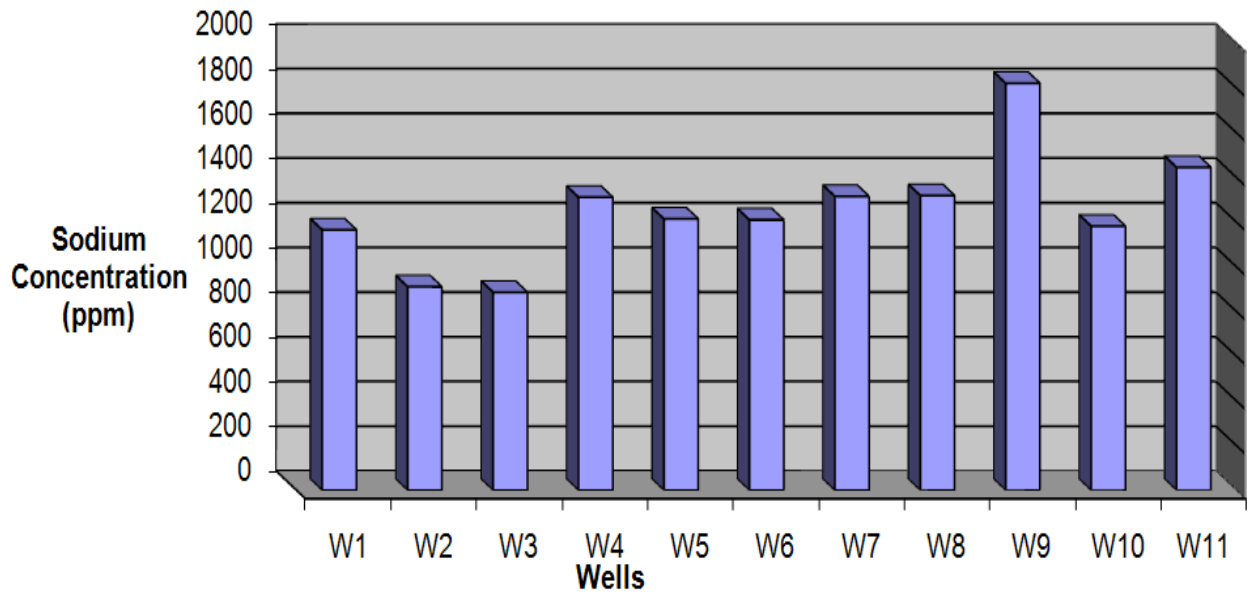
Figure (4-6) Distribution of sodium ions (ppm) in the study area

The concentration of magnesium in drinking water must not exceed (125 mg/l), but in ocean water, magnesium reached to (1000 mg/l) and more. In other hand brines may contain as much as (57000 mg/l). In study area, the maximum and minimum value of magnesium ions concentration are (140.96 mg/l) in well No. (9) and (60.76 mg/l) in well No. (5) respectively as shown in Table (4-2). Figure (4-7) shows the distribution of magnesium ions (mg/l) over the study area.
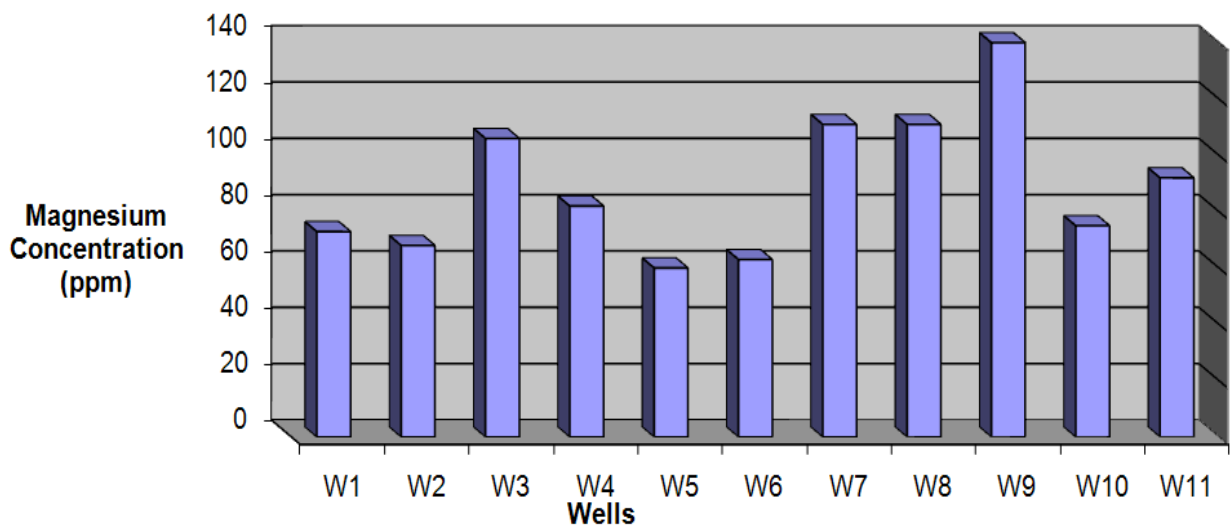
Figure (4-7) Distribution of magnesium ions (ppm) in the study area

4.8.1.4 Calcium (Ca $^{+2}$)

Groundwater in contact with sedimentary rocks of marine origin derives most of their calcium ions from the solution of those minerals such as calcite, aragonite, dolomite, anhydrate, and gypsum (Davis and DeWiest, 1966).

Calcium and magnesium combine with bicarbonate, carbonate, sulfate, and silica to form heat-retarding, pipe clogging scale in boilers and in other heat exchange equipment. Calcium and magnesium combine with ions of fatty in soaps to form soap-suds; the more calcium and magnesium, the more soap required to form suds (Todd, 1980).

The maximum value of calcium is (220.44 mg/l) in well No. (10), and the minimum value is (136.27 mg/l) found in well No. (4) as shown in Table (4-2). Figure (4-8) shows the distribution of calcium ions (mg/l) over study area.
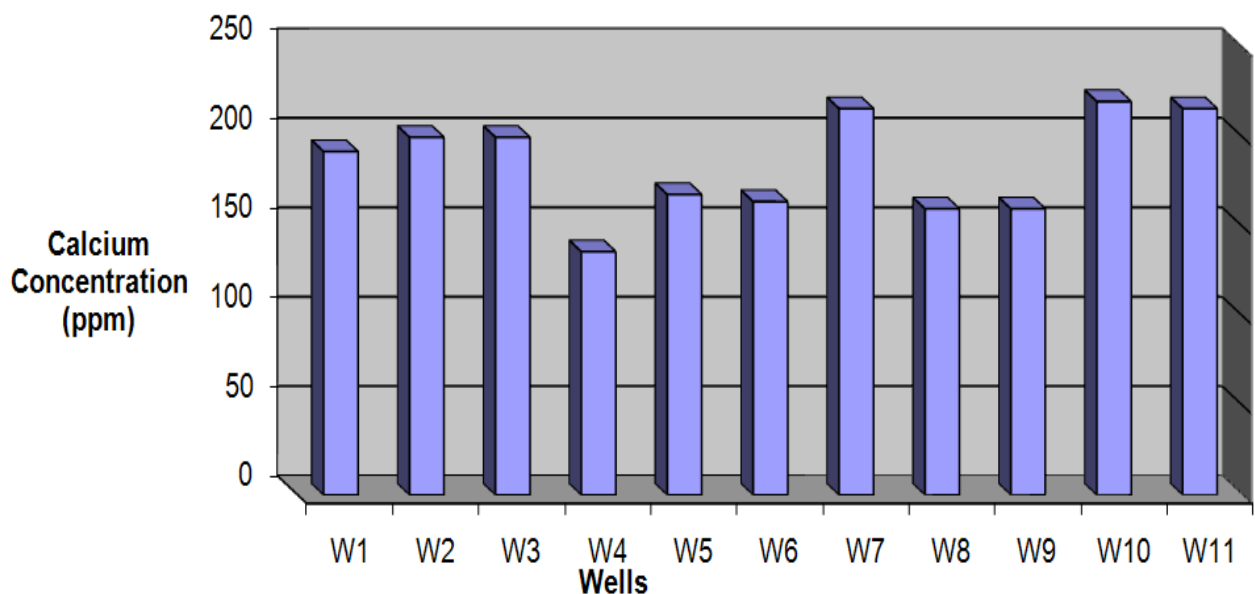
Figure (4-8) Distribution of calcium ions (ppm) in the study area

4.8.2 Anions
These include;
4.8.2.1 Chloride (Cl⁻)

The major natural sources of chloride in groundwater are divided into major sources which are sedimentary rocks (evaporates) and minor sources which are igneous rocks. In additional to that, Walton, (1970) said that the most chloride ions in groundwater come from ancient sea water entrapped in sediments, concentration by evaporation of chloride contributed by precipitation, and solution of dray fallout from the atmosphere.

Chloride in excess of (100 mg/l) imports a salty taste. Concentration greatly in excess of (100 mg/l) may cause physiological damage. Food processing industries usually require less than (250 mg/l). Some industries- textile processing, paper manufacturing desire less than (100 mg/l), (Todd, 1980).

The maximum and minimum values of chloride are (1634 mg/l) in well No. (9), and (709.1 mg/l) in well No. (2), respectively, as shown in Table (4-2). Figure (4-9) explains the distribution of chloride ions (mg/l) over the study area .
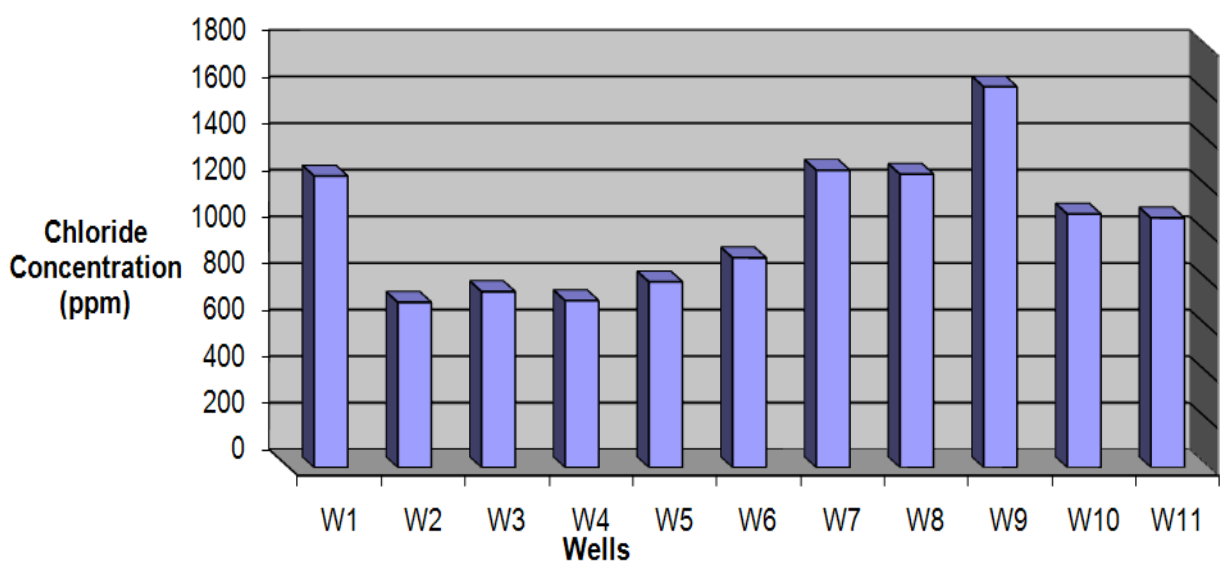
Figure (4-9) Distribution of chloride ions (mg/l) in the study area

4.8.2.2 Nitrate (NO_3^-)

Natural nitrate levels in groundwater are generally very low, but nitrate concentrations grow due to human activities, such as agriculture, industry, domestic, and emissions from combustion engines.The sources of nitrates pollution in groundwater are:

1- cultivation in areas where the soil layer is relatively thin, or has poor nutrient buffering capacity , or where there are changes in land use,

2- over fertilization of crop for intensification of agriculture activity ,

3- spread cultivation of crops which require high fertilizes doses and which leave the soil bare over long period, (maize, tobacco, and vegetable),

4- drainage system which lead to drainage of fertilizers,

5- intensive agriculture rotation cycles involving frequent ploughing and extensive areas of bare soils during winter,

6- organic fertilizers for animal husbandry,

7- and increased urbanization.

Water containing large amounts of nitrate (more than 100 mg/l) is bitter tasting and may cause physiological distress. Water from shallow wells containing more than (45 mg/l) has been reported to cause methemoglobinemia in infants. small amounts of nitrate help reduce cracking of high-pressure boiler steel (Todd, 1980).

The maximum amount of nitrate measured in well No. (1) equal to (11.2 mg/l), and the minimum value was (1.8 mg/l) in well No. (2) as shown in Table (4-2). Figure (4-10) show the distribution of nitrate ions (mg/l) over study area .
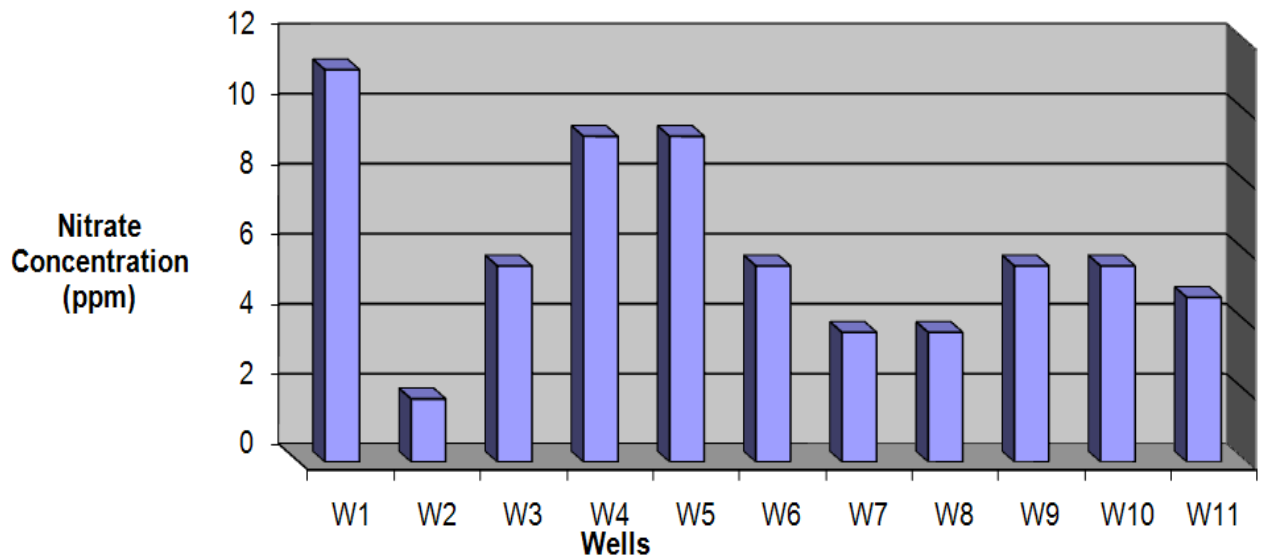
Figure (4-10) Distribution of nitrate ions (ppm) in the study area

4.8.2.3 Sulfate (SO_4^{-2})

The commonly sources of sulfate in groundwater as mentioned by Todd, (1980) and Chilton J. (1996), are oxidation of sulfide ores, gypsum, and anhydrite. The concentration of sulfate in natural water does not exceed (300 mg/l), except in wells in influenced by acid mine drainage and up to (200000 mg/l) in some brines (Chilton J. 1996). Sulfate combined with calcium to form an adherent, heat retarding scale. More than (250 mg/l) is objectionable in water in some industries. Water containing about (500 mg/l) of sulfate tastes bitter, and water containing about (1000 mg/l) may be cathartic (Todd, 1980).

The maximum and minimum values of sulfate are (2889.6 mg/l) in well No. (9), and (1238.4 mg/l) in well No. (1) as shown in Table (4-2). Figure (4-11) shows the distribution of sulfate ions (mg/l) above the study area.
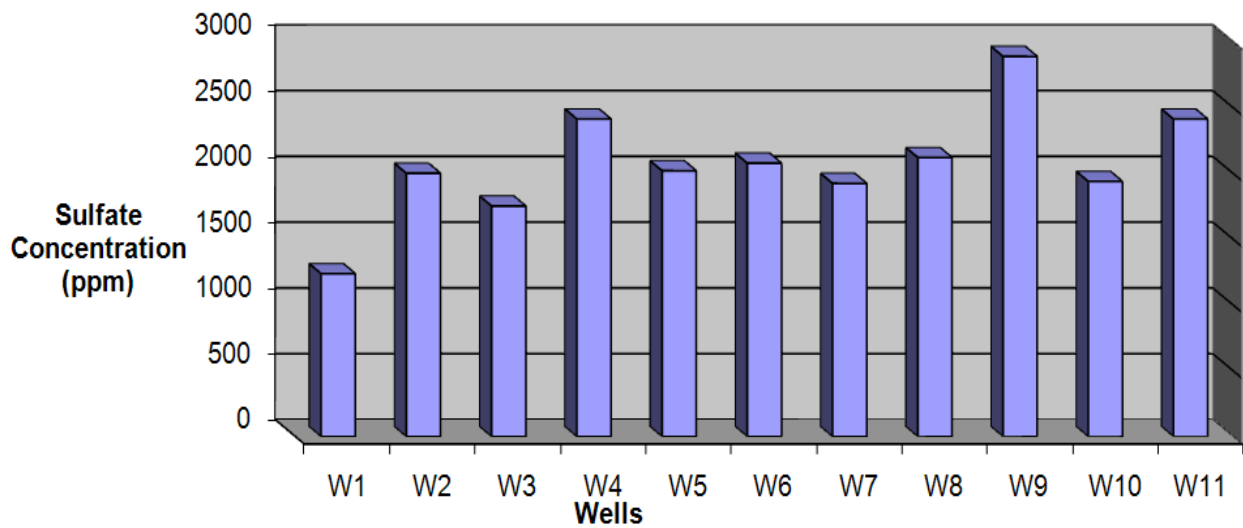
Figure (4-11) Distribution of sulfate ions (ppm) in the study area

4.8.2.4 Bicarbonate (HCO_3^-)

The main sources of bicarbonate are limestone and dolomite. Bicarbonate usually less than (500 mg/l, and may exceeds (1000 mg/l) in water highly charged with carbon dioxide (Chilton J. 1996).

Bicarbonates of calcium and magnesium decompose in steam boilers and water heaters to form scale and release corrosive carbon dioxide gas (Thalman and Bedessem, 2006).

The maximum and minimum values of bicarbonate measured in study area are (219.66 mg/l) in well N0. (5) and (96.41 mg/l) in well No. (8) respectively, as shown un Table (4-2). Figure (4-12) shows the distribution of bicarbonate ions (mg/l) over study area.
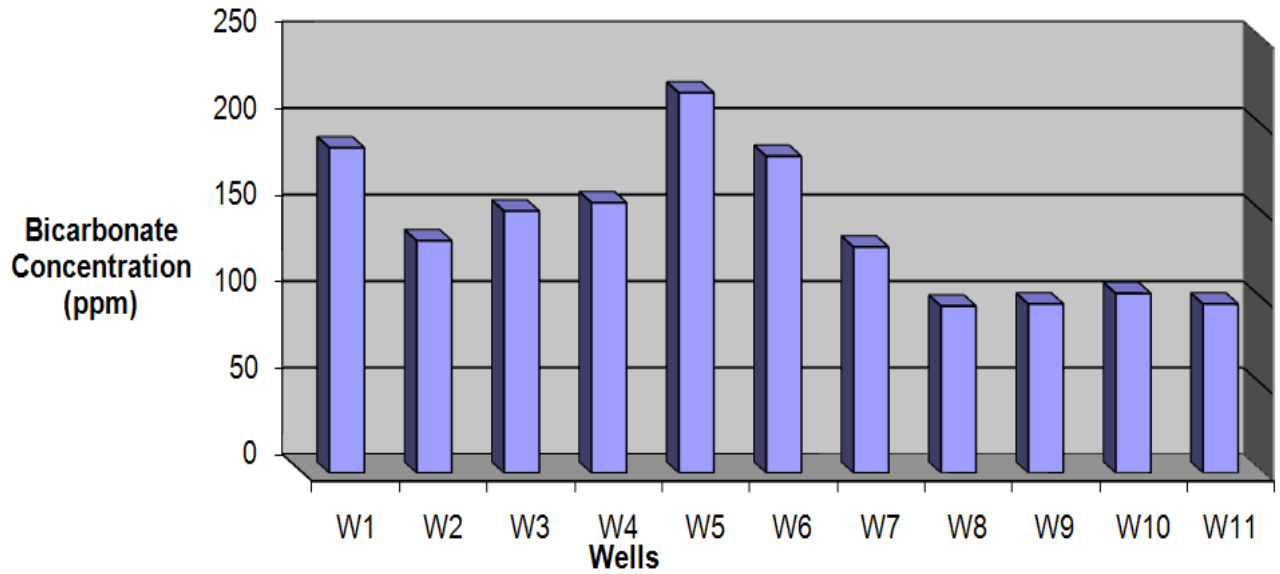
Figure (4-12) Distribution of becarbonate ions (ppm) in the study area

4.9 Hardness of Water

Hardness of water can be defined as its content of metallic ions which react with sodium soaps and produce solid soaps which also react with negative ions, when the water boilers, to produce solid boiler scale (Thomas and Robert, 1973).

The property of water know as hardness is due to mainly to the presence of carbonates bicarbonates sulfates, or other compounds of calcium and magnesium. Calcium, or lime compounds are the most common source of hardness in water supplies, as they are readily dissolved from limestone deposits. However, compounds of magnesium are also an important cause of hardness (Hardenbergh, 1952).

There are two types of hardness, the first one is temporary hardness and can be removed by boiling the water. And the second type is permanent hardness and can be removed by several processes like softening and ion exchange. The better classification of hardness that of carbonate hardness (due to carbonate and bicarbonate of calcium and magnesium), and non-

carbonate hardness (due to sulfates, nitrates and chlorides of calcium and magnesium).

In general hardness can be found and expressed as mentioned by Todd, (1980), which he presented an equation can be shows as following;

$$H = 2.5Ca + 4.1Mg \qquad \qquad \dots(4\text{-}3)$$

where Ca, Mg, and H measured in milligram per liter. In this thesis, and depending on the above equation, the maximum and the minimum total hardness are (999.4 mg/l) in well No. (7), and (669.9 mg/l) in wells No. (5 and 6) respectively as shown in Table (4-6). Figure (4-13) shows the distribution of hardness in the study area.

Table (4-6) : Hardness concentration (H) in (mg/l)

Well No.	Hardness (H)	Well No.	Hardness (H)
1	779.8	7	999.4
2	780.0	8	859.1
3	939.4	9	978.7
4	679.4	10	859.9
5	669.9	11	919.3
6	669.9		
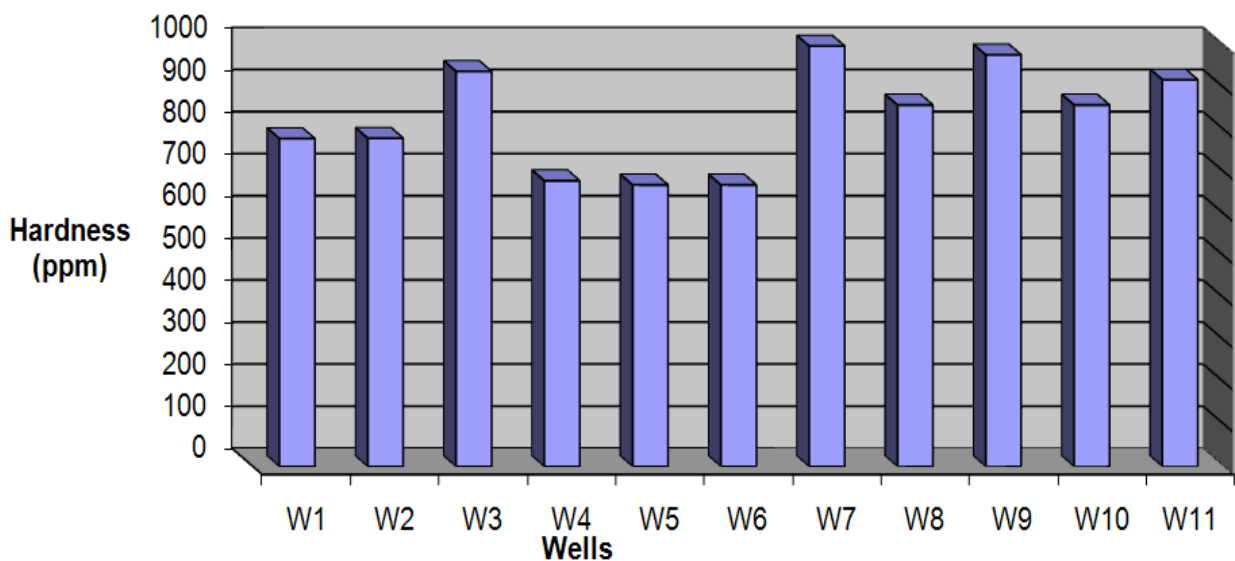
Figure (4-13) Distribution of hardness (ppm) in the study area

4.10 Groundwater Classification Methods

There are large number of classification methods used to treat and describe the chemical analysis results for water samples to obtain the type and use of groundwater for the several demands.

These methods include Sulin (1946), Schoeller (1962), Schoellerr-Sulin (1981), Romani (1981), Richard (1954), etc. .

4.10.1 Sulin's Method (1946)

Sulin's method (1946), represents the most used method to obtain the type and the origin of the groundwater. The method uses the percentage of the cations and anions by millequivalent percent (meq %). In this method, concentrations less than (15 %) can be neglected, (Fetter , 1980) .

Sulin divided the graph into two square as shown in Figure (4-14) depending on the concentration ratio of $[\ r(Na^+ + K^+)/rCl^- \ ]$, where (r) represents the ratio of ions in (meq %). When the ratio $[\ r(Na^+ + K^+)/rCl^- \ ]$ less than one, the result located at the upper square and represents the water of marine origin. According to the ratio;

$$A = \frac{rCl - r(Na + K)}{rMg}, \qquad \ldots (4\text{-}4)$$

the upper square divided into two triangles. When A >1, the water can be represented as marine origin as confined aquifer basin and from the family (Ca-chloride). In other hand, when A< 1, the water represented as marine water in semi-confined aquifer basin and from the family (Mg-chloride).

The lower square, which the ratio $[\ r(Na^+ + K^+)/rCl^- \ ]$ is greater than one, represents the water of meteoric origin (continental). The ratio;

$$B = \frac{r(Na + K) - rCl}{rSO4}, \qquad \ldots (4\text{-}5)$$

divides the square into two triangles. When B>1, the groundwater is of meteoric origin and its type from the family (Na+K-bicarbonate). So when B<1, the groundwater is of meteoric origin and its type from the family (Na+K-sulfate). Table (4-7) and Figure (4-14) show the results and the origin of the water by using Sulin method.

In study area the origin of the all samples of water represents meteoric water and its type from the family (Na+K-sulfate).

Table (4-7) : The results of Sulin's method

Well No.	Ratio r(Na++K+)/rCl-	A	B	Origin	Type
1	1.396	-	0.542	meteoric	Na+K-sulfate
2	2.111	-	0.608	meteoric	Na+K-sulfate
3	1.916	-	0.532	meteoric	Na+K-sulfate
4	2.929	-	0.774	meteoric	Na+K-sulfate
5	2.425	-	0.762	meteoric	Na+K-sulfate
6	2.255	-	0.736	meteoric	Na+K-sulfate
7	1.614	-	0.552	meteoric	Na+K-sulfate
8	1.765	-	0.614	meteoric	Na+K-sulfate
9	1.880	-	0.673	meteoric	Na+K-sulfate
10	1.782	-	0.594	meteoric	Na+K-sulfate
11	2.247	-	0.676	meteoric	Na+K-sulfate
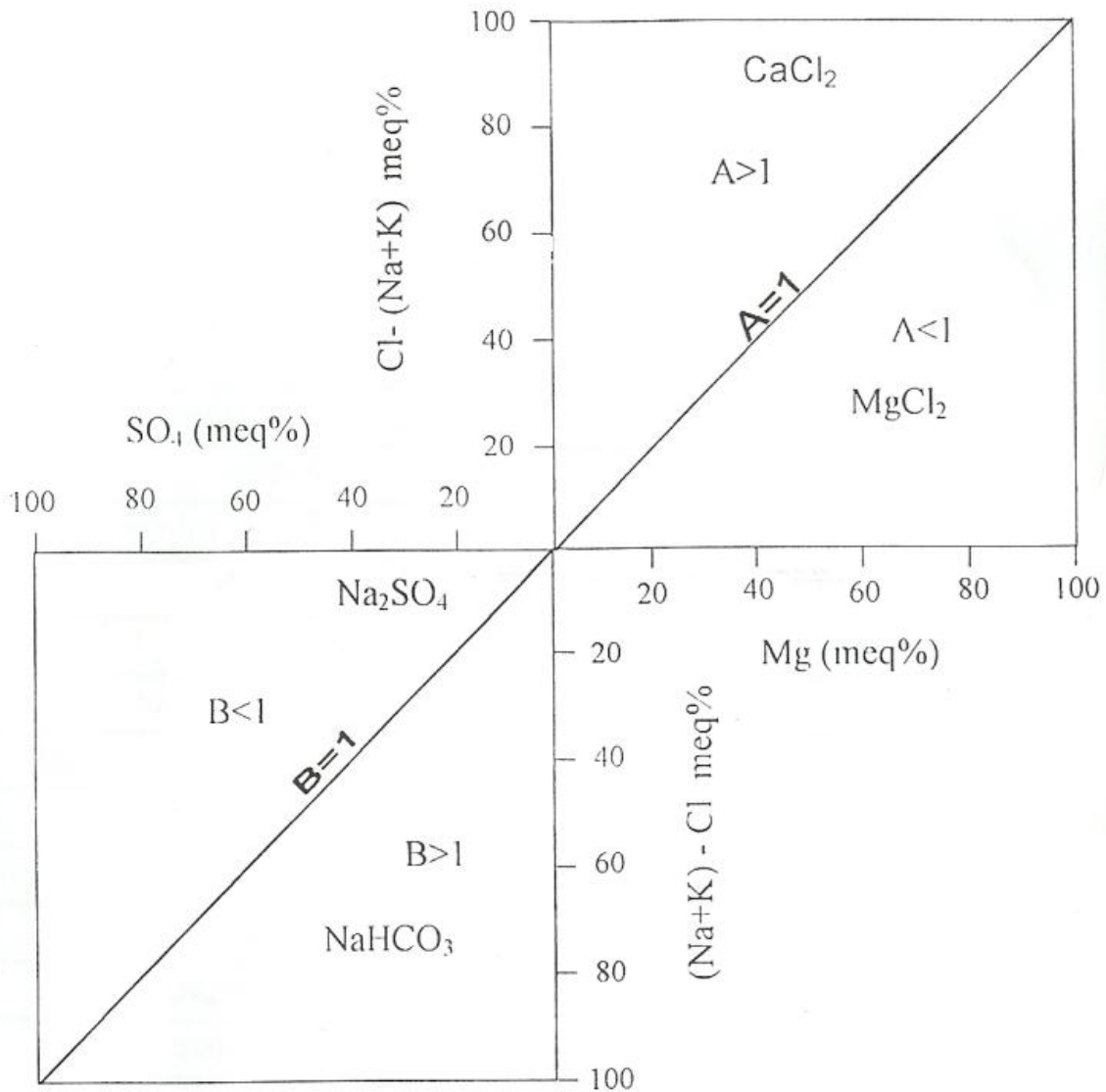
Figure (4-14) : Sulin's Graph

4.10.2 Schoeller's Method

Schoeller used the concentration of major ions to classify the groundwater. He used the deductive arrangement of the concentration of cations and anions and reached by this arrangement to (36) types of water (Al-Aboodi, 2005).

Table (4-8) gives the base of Schoeller classification method which shows two groups of numbers, the left group is cations which numbered from (1 to 6), the right group is anions and numbered from (1 to 6) too. Therefore this method gives any sample of groundwater two numbers, one

for cations content and the other for anions content. Table (4-9) shows the results of groundwater samples by using Schoeller's method.

Table (4-8) : Coding number of Schoeller's method with 36 water type , r=meq %

Cations	Code Index	Anions	Code Index
r(Na+K)>rMg>rCa	1	rCl>rSO$_4$>rHCO$_3$	1
r(Na+K)> rCa>rMg	2	rCl>rHCO$_3$>rSO$_4$	2
rMg>r(Na+K)>rCa	3	rSO$_4$>rCl>rHCO$_3$	3
rMg>rCa>r(Na+K)	4	rSO$_4$>rHCO$_3$>rCl	4
rCa>r(Na+K)>rMg	5	rHCO$_3$>rCl>rSO$_4$	5
rCa>rMg>r(Na+K)	6	rHCO$_3$>rSO$_4$>rCl	6

Table (4-9) : The results of Schoeller method

Well No.	Cations Code Index	Anions Code Index
1	2	1
2	2	3
3	2	3
4	1-2	3
5	2	3
6	2	3
7	2	3
8	1	3
9	1	3
10	2	3
11	2	3

It is noted that the results of the eleven wells do not have large imparity in the hydrochemical analysis by using Schoeller's method. It is found that classification of cations located at second group [r(Na+K) > rCa > rMg], which the percentage of (Na+K) is larger than Ca, and Ca is larger than the percentage of Mg except wells number (8) and (9), which are located in first group [r(Na+K) > rMg > rCa]. In other side, the classification of anions are found in the third group [rSO_4 > rCl > $rHCO_3$] except well number (1), which is located in the second group. The high concentration of sodium and sulfate referred to that aquifer located within Dibdibba formation which is containing sand uncover from igneous rock in Arabian shield and the gypsum rock respectively (Sadik, 1977).

4.10.3 Schoeller-Sulin's Method

The method is combining of Schoeller and Sulin's method by using Schoeller's graph with addition to line of 15 % which is taken by Sulin from his classification as shown in Figure (4-15). Their method presents the classification as two numbers. The first number is on the left and represents Schoeller number, taken from Table (4-8). The second number is on the right and depends on Sulin classification as follows:

1- Take number (1) if the last two concentration of cations and anions are less than 15 %.

2- Take number (2) if the last one concentration of cations and anions is less than 15 %.

3- Take number (3) if the all concentration of cations and anions are more than 15 %. Table (4-10) shows the results of Schoeller-Sulin's method.

Table (4-10) : The results of Schoeller-Sulin's method

Well No.	Cations		Anions		Family
	Index	*Subfamily*	*Index*	*Subfamily*	
1	22	Sodium	12	Chloride	Cl-Na
2	22	Sodium	32	Sulfate	SO$_4$-Na
3	23	Sodium	32	Sulfate	SO$_4$-Na
4	21	Sodium	32	Sulfate	SO$_4$-Na
5	22	Sodium	32	Sulfate	SO$_4$-Na
6	22	Sodium	32	Sulfate	SO$_4$-Na
7	22	Sodium	32	Sulfate	SO$_4$-Na
8	12	Sodium	32	Sulfate	SO$_4$-Na
9	12	Sodium	32	Sulfate	SO$_4$-Na
10	22	Sodium	32	Sulfate	SO$_4$-Na
11	22	Sodium	32	Sulfate	SO$_4$-Na

4.10.4 Romani's Method

Romani classification method (1981) is the modified method of Piper (1944) which is used for classifying the natural water and the geochemical water studies like ion exchange , adsorption , and sulfate reducing.

Romani used two right triangles, one for cations, and the other for anions. Each one is subdivided into seven parts which are representing deferent types of water. There is a square area between the two triangles. To classify the groundwater, the percentage of ions must be fall down over Romani graph as shown in Figure (4-16) to obtain the water type by depending on the location of ions with in the seven triangles.

Table (4-11) show the results of Romani's method. We noted that all wells located with in the family (C3-A2) (sulfate-sodium type) except well No. (1) which located with in the family (C3-A3) (chloride-sodium type).

11	rNa	11	rCl
12	rNa > rMg	12	rCl > rSO$_4$
13	rNa > rMg > rCa	13	rCl > rSO$_4$ > rHCO$_3$
21	rNa	21	rCl
22	rNa > rCa	22	rCl > rHCO$_3$
23	rNa > rCa > rMg	23	rCl > rHCO$_3$ > rSO$_4$
31	rMg	31	rSO$_4$
32	rMg > rNa	32	rSO$_4$ > rCl
33	rMg > rNa > rCa	33	rSO$_4$ > rCl > rHCO$_3$
41	rCa	41	rHCO$_3$
42	rCa > rNa	42	rHCO$_3$ > rCl
43	rCa > rNa > rMg	43	rHCO$_3$ > rCl > rSO$_4$
51	rMg	51	rSO$_4$
52	rMg > rCa	52	rSO$_4$ > rHCO$_3$
53	rMg > rCa > rNa	53	rSO$_4$ > rHCO$_3$ > rCl
61	rCa	61	rHCO$_3$
62	rCa > rMg	62	rHCO$_3$ > rSO$_4$
63	rCa > rMg > rNa	63	rHCO$_3$ > rSO$_4$ > rCl

Figure (4-15) : Schoeller Sulin's Graph

Table (4-11) : The results of Romani's method

Well No.	Cations Type	Anions Type	Total Type	Group
1	C3	A3	Chloride-Sodium	G 1
2	C3	A2	Sulfate-Sodium	G 1
3	C3	A2	Sulfate-Sodium	G 1
4	C3	A2	Sulfate-Sodium	G 1
5	C3	A2	Sulfate-Sodium	G 1
6	C3	A2	Sulfate-Sodium	G 1
7	C3	A2	Sulfate-Sodium	G 1
8	C3	A2	Sulfate-Sodium	G 1
9	C3	A2	Sulfate-Sodium	G 1
10	C3	A2	Sulfate-Sodium	G 1
11	C3	A2	Sulfate-Sodium	G 1

4.10.5 Richard's Method

This method was used for the first time by the U.S. Salinity Laboratory Staff (1954) which has proposed the use of the sodium adsorption ratio (SAR) for studying the suitability of groundwater for irrigation purposes (Walton, 1970). It is defined by;

$$SAR = \frac{rNa}{\sqrt{r(Ca + Mg)/2}},　　　　　\text{….. (4-6)}$$

where all concentration are expressed by (meq %). This method used for estimating the water for irrigation use. The high concentration of sodium undesirable because it can became deflocculated and tends to have a relatively impermeable crust (Walton, 1970).

Richard's method depends on SAR and the electrical conductivity measured in micromhos per centimeter at 25ºC) as shown in Figure (4-17). Table (4-12) shows water types after Richard.
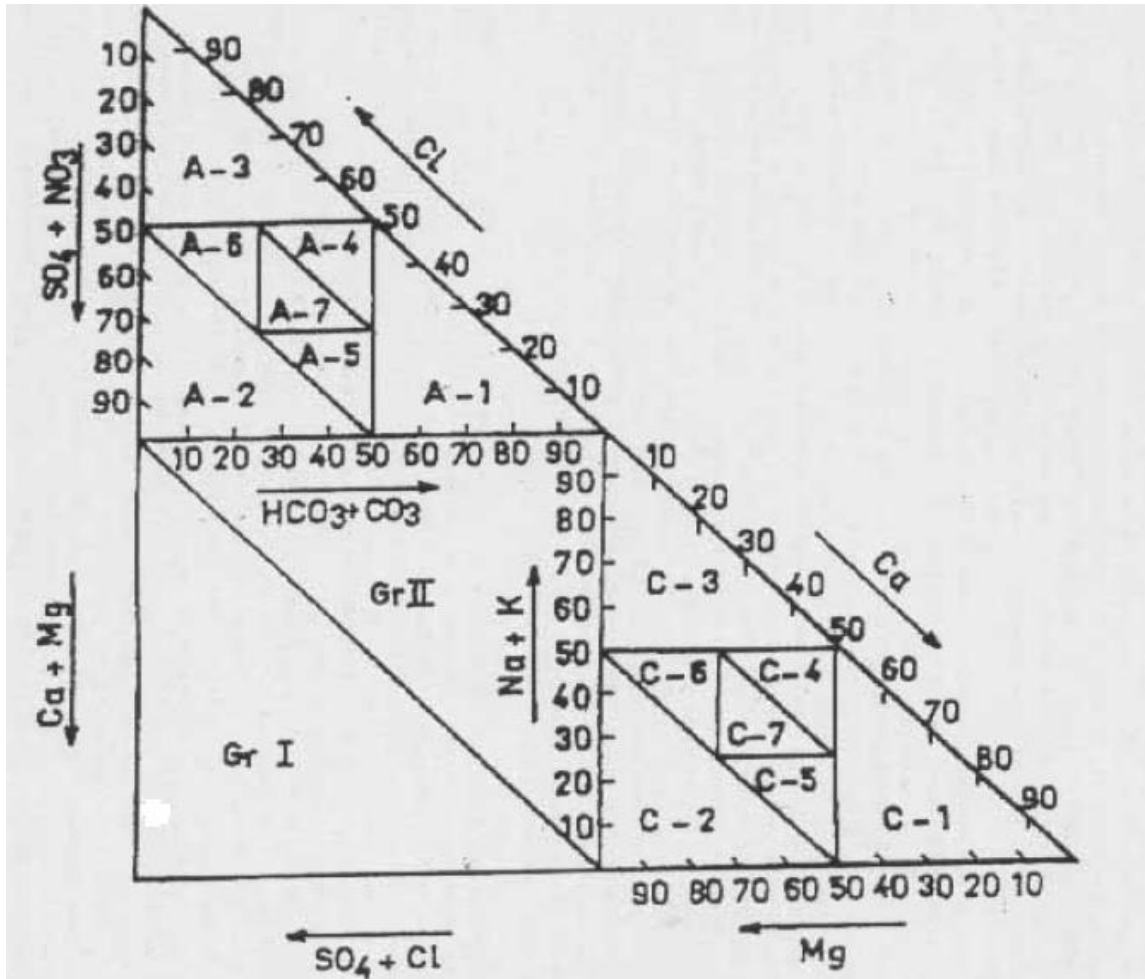
	Cation Triangle		Anion Triangle
C1	Calcium Type	A1	Bicarbonate Type
C2	Magnesium Type	A2	Sulfate Type
C3	Sodium Type	A3	Chloride Type
C4	Sodium-Calcium Type	A4	Chloride-Bicarbonate Type
C5	Calcium-Magnesium Type	A5	Bicarbonate-Sulfate Type
C6	Sodium-Magnesium Type	A6	Chloride-Sulfate Type
C7	Calcium-Magnesium-Sodium Type	A7	Bicarbonate-Sulfate-Chloride Type

Figure (4-16) : Romani's Graph

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Table (4-12) : Types of well groundwater (after Richard , 1954)

Index	Water Class	Index	Water Class
C1-S1	Excellent	C3-S1	Admissible
C1-S2	Good	C3-S2	Marginal
C1-S3	Admissible	C3-S3	Marginal
C1-S4	Poor	C3-S4	Poor
C2-S1	Good	C4-S1	Poor
C2-S2	Good	C4-S2	Poor
C2-S3	Marginal	C4-S3	Very Poor
C2-S4	Poor	C4-S4	Very Poor
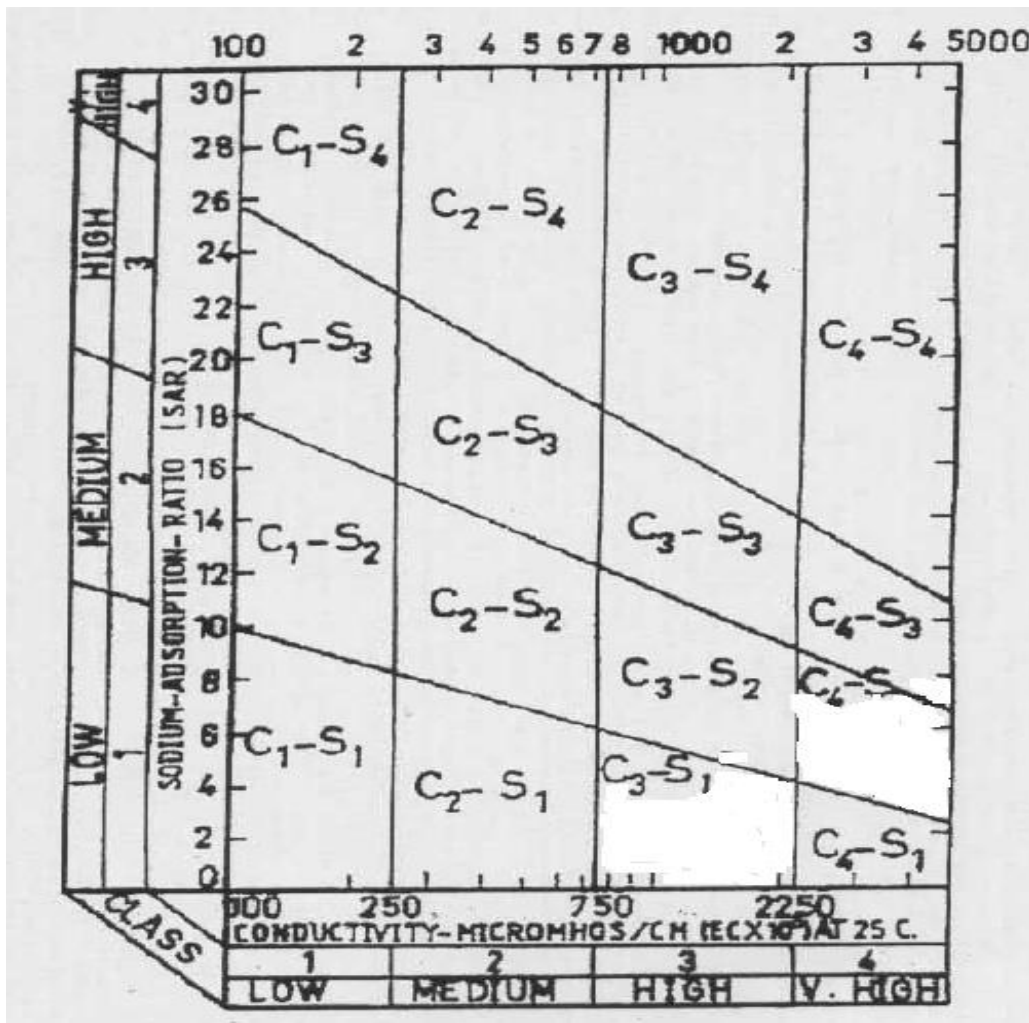
Figure (4-17) : Richard's Graph

4.11 Determining Factors Of Groundwater Origin

There are three types of factors can be discussed in this study to obtain groundwater origin. All of these factors are phrased as ratio between two or more of ions percentage. They can be mentioned as following:

4.11.1 rNa/rCl Ratio

It is one of the more important guide to classify the origin of groundwater. If the value of ratio rNa/rCl is less than (1), then this type of groundwater is marine origin, and if it is more than (1), then the origin is meteoric water (Ivanov et. al., 1968).

In the study area, the ratios ranged from (1.38) to (2.91), which is mean that the origin of groundwater in Um-Qasr is meteoric water as shown in Table (4-13) and Figure (4-18).

Table (4-13) : The factors of groundwater origin of study area

Well No.	rNa/rCl	r(Na-Cl)/rSO4	rSO4/rCl
1	1.38	0.528	0.731
2	2.09	0.600	1.825
3	1.89	0.522	1.721
4	2.91	0.768	2.490
5	2.41	0.754	1.871
6	2.24	0.728	1.704
7	1.60	0.540	1.113
8	1.75	0.605	1.245
9	1.86	0.665	1.305
10	1.76	0.583	1.315
11	2.23	0.667	1.844

4.11.2 r(Na-Cl)/rSO4 Ratio

In this index, if the results limited between (0) and (1), then the groundwater origin is meteoric. In other hand, the ratio of ordinary sea water is about (1.33). In the study area and as shown in Table (4-13) and Figure (4-19) of groundwater are ranged between (0.522) to (0.768), which are mean that the origin is meteoric water.
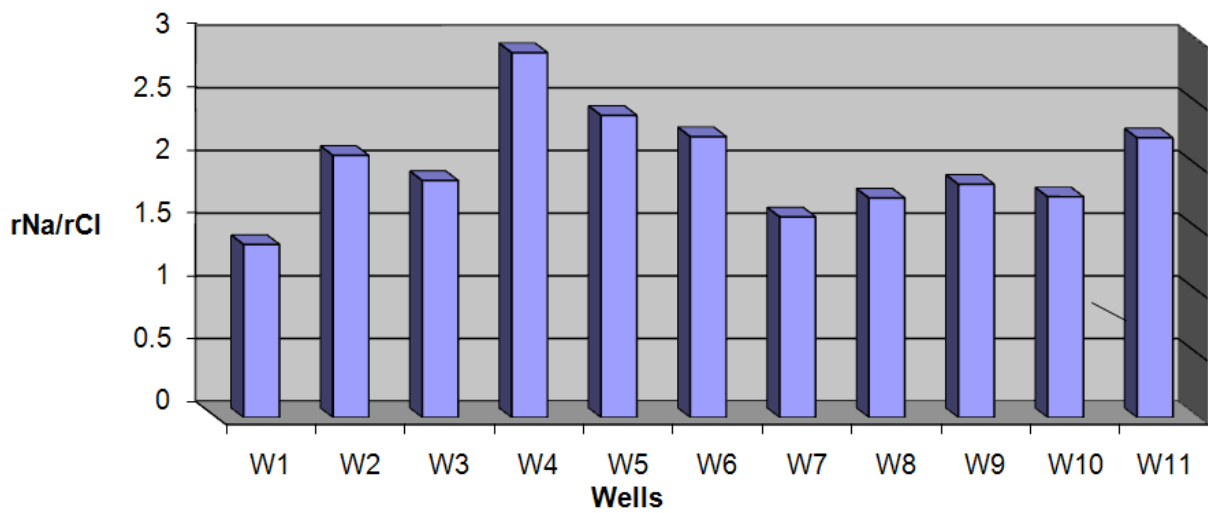
Figure (4-18) : The ratio of rNa/rCl
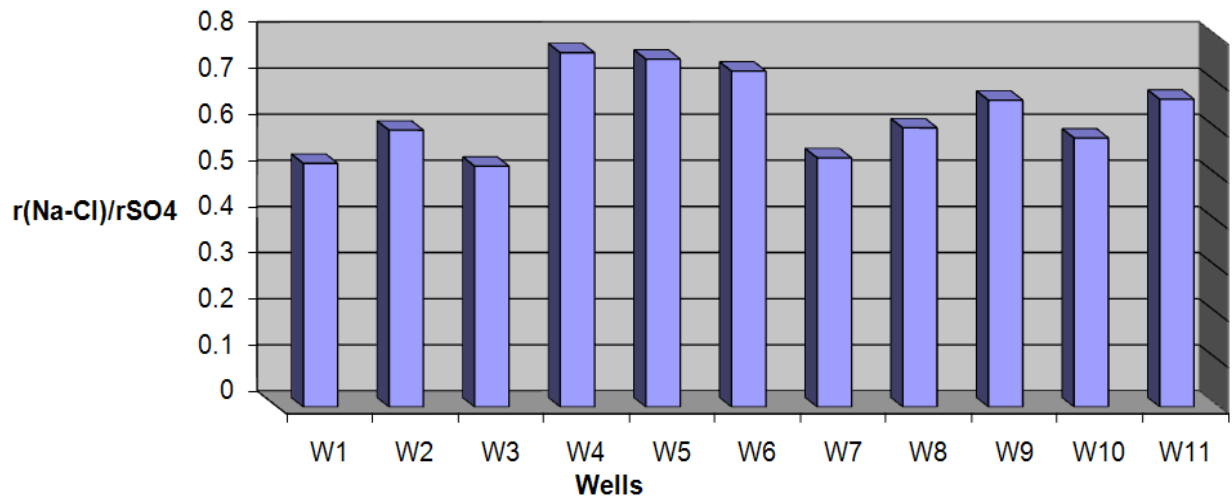
Figure (4-19) : The ratio of r(Na-Cl)/rSO$_4$

4.11.3 rSO4/rCl Ratio

The important of the rSO_4/rCl ratio comes from the identification of the sulfate and chloride ions contained in the groundwater of the study area, (Al-Aboodi, 2005). Table (4-13) and Figure (4-20) show the results of this index. The values of this index ranged between (0.730) to (2.490). So the origin of groundwater for all samples are varying between shallow and deep groundwater, except well number (1) which is marine water.
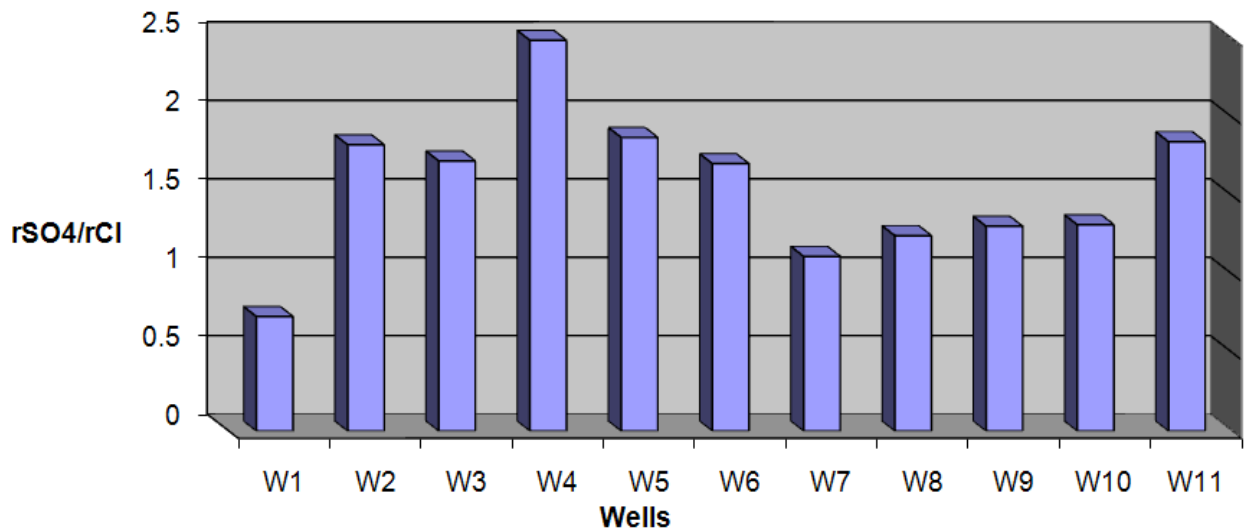
Figure (4-20) : The ratio of rSO_4/rCl

4.12 Assessment of Groundwater Quality Results With Universal Standards

4.12.1 Drinking Water

The use of the potable water as drinking water depends on the value (quantity) of dissolved matters and their kinds (chemical contain), biological contain , and physical characteristics.

In the United States the standards of drinking water quality established by the U.S. Public Health Service for water to be used on interstate carries have received general acceptance and wide application in connection with

nearly all public water supplies. There are two types of limits used in the standards (Thomas and Robert, 1973):

1- Limits which, if exceeded, shall be grounds for rejection of the supply. Substances in this category may have adverse effects on health when present in concentrations above the limit.

2- Limits which should not be exceeded whenever more suitable supplies are, or can be made available at reasonable cost. Substances in this category, when present in concentrations above the limit, either are objectionable to an appreciable number of people or exceed the levels required by good water quality control practices .

In other side , the WHO guidelines divide water quality parameters into two categories :

1- Health guidelines , which take into account chemical and radiological constituents that have the potential to directly adversely affect human health ; and

2- acceptability guidelines , which include parameters that may not have any direct health effects but result in objectionable taste or odor in the water .

In this study, the suitability of groundwater for drinking purposes was determined based on many standards as listed below:

1- Iraqi Standard IRS , 2001 (World Health Organization-CEHA , 2006) .

2- World Health Organization Standard WHO , 1995 .

3- United States Public Health Standard USPHS , 1962 .

4- Egyptian Standard , 1995 (World Health Organization-CEHA , 2006) .

WHO, 1995 standards of drinking water were used to compare the results of the hydro-chemical analyses of the major ions concentration and found the suitability of groundwater to drink.

It was noted that the results of TDS, SO_4^{-2}, Cl^-, Na^+, and Ca^{+2} concentrations exceed the permitted limits in all wells. However, NO_3^-

concentration does not exceed the permitted limit in all wells. The results of other elements (K^+, Mg^{+2}, HCO_3^-, and pH) ranged between conformable and non-conformable, as follows:

- Mg^{+2} concentration conformable to the permitted limits except in well No. (9).

- pH value lies between the maximum and minimum limits in all wells except in well No. (3), which has very little deviation.

- K^+ concentration exceeds the permitted limit in wells No. (1, 7, 9, 10, and 11).

**Table (4-14) : Limits of cations and anions concentrations by
several universal standards**

Elements	Unit	WHO 1995	IRS 2001	USPHS 1962	Egyptian 1995
		Maximum or limits value			
K^+	ppm	12	-	20	-
Na^+	ppm	200	200	200	200
Ca^{+2}	ppm	75	50	200	200
Mg^{+2}	ppm	125	50	125	150
Cl^-	ppm	250	250	250	500
SO_4^{-2}	ppm	250	250	250	400
HCO_3^-	ppm	125-350	-	500	-
NO_3^-	ppm	50	50	-	-
pH	-	6.5-8.5	6.5-8.5	6.5-8.5	6.5-9.2
TDS	ppm	500-1000	1000	1000	1200 (at 120^oC)

4.12.2 Agriculture Water

The type of irrigation water can be assigned by the season of the year. The goodness of irrigation water is depending on sodium ions concentration, sodium absorption ratio (SAR), major ions contain, or salinity.

If concentration of sodium in irrigation water increases, the permeability of soil will decrease, which will affect the quantity of water absorbed by plants. The ratio (Na %) can be obtained by the following method (Todd, 1980);

$$Na\% = \frac{Na}{Na + Ca + Mg + K} * 100, \qquad \dots (4\text{-}7)$$

where the ions concentration measured in meq/l.

Tables (4-15) and (4-16) show the suggested limits of (SAR) and (Na%) respectively, for agriculture purposes. Table (4-17) shows the results of suitability of study area groundwater after comparing these results with the suggested limits to serve agriculture purposes.

Table (4-15) : Suggested limits of SAR for agriculture purposes

Grade	SAR
Satisfactory	< 8
Marginal	12-15
Serious	> 20

Table (4-16) : Suggested limits of Na% for agriculture purposes (after Todd , 1980)

Grade	Na %
Excellent	< 20
Good	20-40
Permissible	40-60
Doubtful	60-80
Unsuitable	> 80

Table (4-17) : The results of groundwater suitability for agriculture purpose

Well No.	SAR	Grade of SAR	Na %	Grade of Na %
1	22.22	Serious	76.03	Doubtful
2	19.03	Serious-Marginal	71.33	Doubtful
3	16.55	Serious-Marginal	66.80	Doubtful
4	25.96	Serious	80.37	Unsuitable
5	25.01	Serious	79.39	Doubtful
6	24.96	Serious	79.33	Doubtful
7	20.52	Serious	73.64	Doubtful
8	22.59	Serious	76.55	Doubtful
9	25.39	Serious	79.78	Doubtful
10	21.09	Serious	74.46	Doubtful
11	22.93	Serious	76.93	Doubtful

Salts harm plant growth physically by limiting the uptake of water through modification of osmotic processes, or chemically by metabolic reaction such as those caused by toxic constituents (Todd, 1980).

Based on EC results given previously in Table (4-6), the types of crops which can be cultivated in study area are specified as shown in Table (4-18), this table shows the relative tolerance of crops to salt concentration. All divisions of crops which have low salt tolerance can not be cultivated in study area, because the EC results exceed the maximum limits of low salt tolerance. The other divisions (medium and high salt tolerance) may or may not cultivated because they are depending on other conditions such as weather conditions, soil containing, geographical zone, etc.

**Table (4-18) : Relative tolerance of crops to salt concentrations
(After U.S Dept. of Agr. Handbook 60 , 1954)**

Crop Division	Low Salt Tolerance	Medium Salt Tolerance	High Salt Tolerance
Fruit crops	Avocado Lemon Strawberry Peach Apricot Almond Plum Prune Grapefruit Orange Apple Pear	Cantaloupe Date Olive Fig Pomegranate	Date plam
Vegetable crops	$EC\times10^3= 3$ Green beans Celery Radish $EC\times10^3= 4$	$EC\times10^3= 4$ Cucumber Squash Peas Onion Carrot Potatoes Sweet corn Lettuce Cauliflower Bell pepper Cabbage Broccoli Tomato $EC\times10^3= 10$	$EC\times10^3= 10$ Spinach Asparagus Kale Garden beet $EC\times10^3= 12$

Table (4-18) : continued

Crop Division	Low Salt Tolerance	Medium Salt Tolerance	High Salt Tolerance
Forage crops	$EC \times 10^3 = 2$ Burnet Ladino clover Red clover Alsike clover Meadow foxtail White dutch clover $EC \times 10^3 = 4$	$EC \times 10^3 = 4$ Sickle milk vetch Sour clover Cicer milkvetch Tall meadow oatgrass Smooth brome Big trefoil Reed canary Meadow fescue Blue grama Orchard grass Oats (hay) Wheat (hay) Rye (hay) Tall fescue Alfalfa Hubam clover Sudan grass Dallis grass Strawberry clover Mountain brome Perennial rye grass Yellow sweet clover White sweet clover $EC \times 10^3 = 12$	$EC \times 10^3 = 12$ Bird's foot trefoil Barley (hay) Western wheat grass Canada wild rye Rescue grass Rhodes grass Bermuda grass Nuttall alkali grass Salt grass Alkali sacaton $EC \times 10^3 = 18$
Field crops	$EC \times 10^3 = 4$ Field beans	$EC \times 10^3 = 6$ Castorbeans Sunflower Flax Corn (field) Sorghum (grain) Rice Oats (grain) Wheat (grain) Rye (grain) $EC \times 10^3 = 10$	$EC \times 10^3 = 10$ Cotton Rape Sugar beet Barley (grain) $EC \times 10^3 = 16$

CHAPTER FIVE
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The conclusions of this study can be listed as following :

1- After the comparison the results of the chemical analysis with several standards of drinking water (WHO (1995), IRS (2001), USPHS (1962), and Egyptian (1995)), it was found that the groundwater in Um-Qasr area is not suitable for human uses.

2- The TDS values of groundwater are distributed between (3580-9040 ppm). These values indicate that the groundwater is not suitable for agriculture uses except for all dates, and some of vegetable crops like tomato, potatoes, and cucumbers.

3- After using Sulin's method, it was found that the origin of the groundwater in Um-Qasr is meteoric origin and its type from the family (Na+K – sulfate). This results are assured by using Romani's method and finding the factor (rNa/rCl). Romani's method shows the groundwater type, is C3 (or sodium type) for cations and A2 (or sulfate type) for anions. On the other hand, the values of the factor (rNa/rCl) are between (1.38-2.91) which mean that the origin of groundwater is also meteoric.

4- Based on Schoeller-Sulin's method, it was found that sulfate ions are the dominant anions in the study area. The group of sulfate contains one family which is sulfate sodium family.

5.2 Recommendations

The following subjects can be considered as suggestions for further works:

1- Simulation of groundwater in Um-Qasr area using mod-flow.

2- Optimum design of water treatment scheme for groundwater in Um-Qasr with the use of proposed hydraulic design of collection system as given in Appendix I.

3- Simulation of groundwater quality in Um-Qasr using Geographic Information System (GIS).

4- Development of optimum strategy for managing the groundwater in southeast of Iraq.

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Appendix I

The Hydraulic Design of Suggested Groundwater Collection System In Um-Qasr

1 Description of The Suggested Hydraulic System

The system components are:

1- Eighteen drilled wells distributed on the study area as shown in figure (5-6). These wells have a discharge ranging between (14.4 m^3/h) to (18 m^3/h). The total discharge of the wells equal to (300.6 m^3/h) suctioned by multistage submersible well pumps chosen from ITT series (Z631) with the characteristics shown in Appendix II.

2- Conveyance lines to transmit the raw water from wells to raw water tanks (RWT). They are using different PVC pipe diameters depending on the discharge.

3- Two raw water tanks (RWT) each with a capacity of (901.8 m^3). These tanks are used to store the raw water which is withdrawn from the wells, and discharged to the treatment plant .

4- Piping system is used to transmit the raw water from RWT to the treatment plant.This system has pipes and fittings in addition to two raw water pumps, one duty and one standby.

2 The Hydraulic Analysis of The System

The Environment Protection Agency software program (EPANET 2.0) was used to perform the hydraulic analysis of the conveyance line which is suggested to transmit the groundwater from wells to two raw water tanks (RWT).

2.1 The Application of EPANET on The Conveyance lines of groundwater Between Wells and RWT in Study Area

The following steps are adopted to view the hydraulic analysis of the conveyance lines of groundwater from wells to the raw water tanks by using EPANET program (Rossman, 2000);

1- Draw a network representation of your distribution system .

2- Edit the properties of the objects that make up the system .

3- Describe how the system is operated .

4- Select a set of analysis options .

5- Run a hydraulic/water quality analysis .

6- View the results of the analysis .

3 Viewing The Results

In this study, the results are viewed as follow:

 - Figure (1) shows pipes numbers .

 - Figure (2) shows nodes numbers .

 - Table (1) shows Hydraulic Design Results of Groundwater Collection System.

- Table (2) shows Nodal Values of Head.
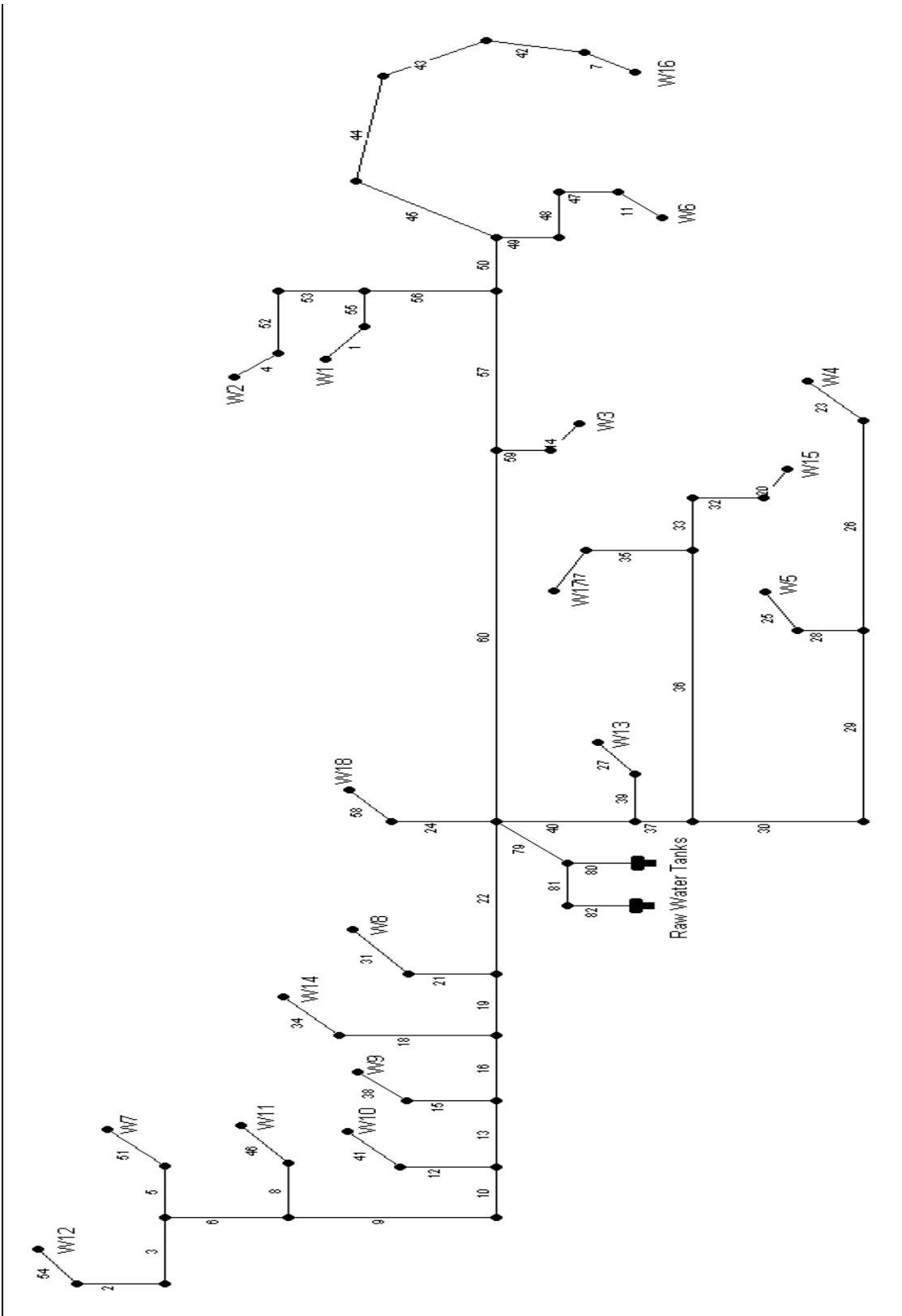
Figure (1) Pipes numbers
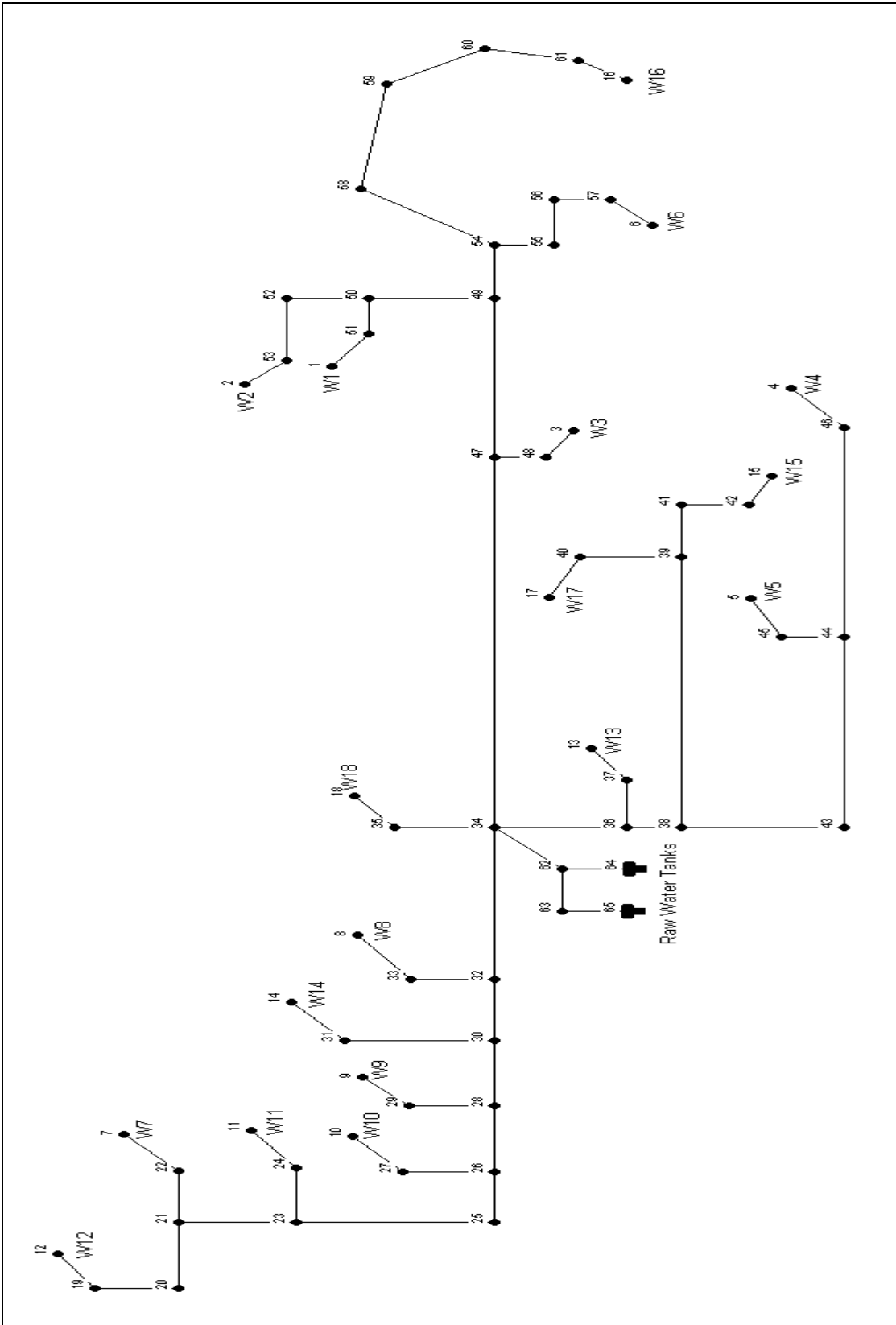
Figure (2) Nodes number

Table (1) : Hydraulic Design Results of Groundwater Collection System

Pipe No.	Dia. (mm)	Q (m³/h)	Unit head loss (m/km)	Pipe No.	Dia. (mm)	Q (m³/h)	Unit head loss (m/km)
2	100	14.4	5.68	48	100	18.0	8.58
3	100	14.4	5.68	50	100	32.4	25.49
5	100	18.0	8.58	52	100	18.0	8.58
6	100	32.4	25.49	53	100	18.4	8.58
8	100	18.0	8.58	55	100	18.4	8.58
9	150	50.4	8.02	56	100	36.0	30.98
10	150	50.4	8.02	57	150	68.4	14.11
12	100	18.0	8.58	59	100	18.0	8.58
13	150	68.4	14.11	60	200	86.4	5.36
15	100	18.0	8.58	49	100	18.0	8.58
16	150	86.4	21.75	79	250	311.45	19.42
18	100	14.4	5.68	80	200	155.73	15.95
19	150	100.8	28.94	81	200	155.73	15.95
21	100	28.85	20.56	82	200	155.73	15.95
22	200	129.65	11.36	1	150	18.0	1.19
24	100	14.4	5.68	4	150	18.0	1.19
26	100	18.0	8.58	7	150	14.4	0.79
28	100	18.0	8.58	11	150	18.0	1.19
29	150	36.0	4.30	14	150	18.0	1.19
30	150	36.0	4.30	17	150	14.4	0.79
32	100	14.4	5.68	20	150	14.4	0.79
33	100	14.4	5.68	23	150	18.0	1.19
35	100	14.4	5.68	25	150	18.0	1.19
36	150	28.8	2.84	27	150	16.2	0.98
37	150	64.8	12.77	31	150	28.85	2.85
39	100	16.2	7.06	34	150	14.4	0.79
40	200	81.0	4.75	38	150	18.0	1.19
42	100	14.4	5.68	41	150	18.0	1.19
43	100	14.4	5.68	46	150	18.0	1.19
44	100	14.4	5.68	51	150	18.0	1.19
45	100	14.4	5.68	54	150	14.4	0.79
47	100	18.0	8.58	58	150	14.4	0.79

Table (2) : Nodal Values of Head

Node No.	Head (m)	Node No.	Head (m)	Node No.	Head (m)	Node No.	Head (m)
19	27.51	35	2.27	51	19.89	4	17.38
20	26.86	36	4.98	52	20.92	5	12.27
21	25.58	37	5.93	53	21.48	6	25.02
22	26.06	38	5.87	54	23.62	7	26.08
23	19.21	39	7.86	55	24.31	8	10.72
24	21.83	40	8.91	56	24.61	9	14.96
25	17.41	41	9.19	57	25.0	10	17.5
26	17.01	42	10.19	58	27.65	11	21.85
27	17.48	43	9.61	59	30.89	12	27.53
28	14.47	44	11.82	60	32.17	13	5.95
29	14.94	45	12.25	61	34.44	14	10.79
30	10.12	46	17.36	62	0.16	15	10.2
31	10.77	47	11.37	63	0.08	16	34.45
32	9.54	48	12.91	1	19.91	17	8.92
33	10.67	49	17.51	2	21.5	18	2.29
34	2.10	50	19.67	3	12.93	64	0
						65	0

4 The Details of The Hydraulic Analysis (Manually Determining)

4.1 Head Losses in The Conveyance Lines

Head losses with in the conveyance lines comprise of pipe friction losses and the local losses attributed to the valves and fitting. These losses are consolidated in the table (3).

4.2 Head losses at well points

For each well, head losses for an average well output of (4, 4.5, 5)l/s are calculated in the table (4).

Table (3) : Friction Losses With in The Pipes

Line between		Pipe dia. (mm) DN	Pipe length L (m)	Comp. head loss coe. ΣKL	Darcy Wei. (K_{DW})	Flow Q (l/s)	Flow velocity V (m/s)	Velocity head hw (m)	Head Loss (m)		
									local	friction	total
W 12	N 21	100	335	3.5	0.20556	4	0.51	0.0133	0.047	1.101	1.148
W 7	N 21	100	50	2.5	0.20556	5	0.64	0.0209	0.052	0.257	0.309
N 21	N 23	100	250	0.3	0.20556	9	0.15	0.0674	0.020	4.163	4.183
W 11	N 23	100	300	2.5	0.20556	5	0.64	0.0209	0.052	1.542	1.594
N 23	N 26	150	225	0.6	0.02430	14	0.79	0.0318	0.019	1.072	1.091
W 10	N 26	100	50	2.8	0.20556	5	0.64	0.0209	0.059	0.257	0.316
N 26	N 28	150	230	0.3	0.02430	19	1.08	0.0594	0.018	2.018	2.036
W 9	N 28	100	50	2.8	0.20556	5	0.64	0.0209	0.058	0.257	0.314
N 28	N 30	150	200	0.3	0.02430	24	1.36	0.0941	0.028	2.799	2.827
W 14	N 30	100	110	2.5	0.20556	4	0.51	0.0132	0.033	0.362	0.395
N 30	N 32	150	20	0.3	0.02430	28	1.58	0.1281	0.038	0.381	0.419
W 8	N 32	100	50	2.5	0.20556	5	0.51	0.0132	0.033	0.164	0.197

Table (3) : (continues)

Line between		Pipe dia. (mm) DN	Pipe length L (m)	Comp. head loss coe. ∑KL	Darcy Wei. (K_{DW})	Flow Q (l/s)	Flow velocity V (m/s)	Velocity head hw (m)	Head Loss (m)		
									local	friction	total
N 32	N 34	200	655	0.9	0.00536	33	1.50	0.0563	0.051	3.823	3.874
W 16	N 54	100	1900	2.8	0.20556	4	0.51	0.0132	0.037	6.249	6.286
W 6	N 54	100	120	4.0	0.20556	5	0.64	0.0207	0.083	0.616	0.699
N 54	N 49	100	240	0.3	0.20556	9	1.15	0.0670	0.020	3.996	4.016
W 2	N 50	100	205	3.4	0.20556	5	0.64	0.0207	0.070	1.054	1.124
W 1	N 50	100	20	2.5	0.20556	5	0.64	0.0207	0.052	0.103	0.155
N 50	N 49	100	70	0.3	0.20556	10	1.27	0.0827	0.025	1.439	1.464
N 49	N 47	150	435	0.3	0.0243	19	0.08	0.0590	0.018	3.817	3.835
W 3	N 47	100	175	2.5	0.20556	5	0.64	0.0207	0.052	0.899	0.951
N 47	N 34	200	1730	0.3	0.00536	24	0.76	0.0298	0.009	5.361	5.370
W 4	N 44	100	640	2.8	0.20556	5	0.64	0.0207	0.058	3.289	3.347
W 5	N 44	100	45	2.5	0.20556	5	0.64	0.0207	0.052	0.231	0.283

Table (3) : (continues)

Line between		Pipe dia. (mm) DN	Pipe length L (m)	Comp. head loss coe. ∑KL	Darcy Wei. (K_{DW})	Flow Q (l/s)	Flow velocity V (m/s)	Velocity head hw (m)	Head Loss (m)		
									local	friction	total
N 44	N 38	150	1385	0.6	0.0243	10	0.57	0.0163	0.010	3.366	3.376
W 15	N 39	100	405	3.1	0.20556	4	0.51	0.0132	0.041	1.332	1.373
W 17	N 39	100	180	2.8	0.20556	4	0.51	0.0132	0.037	0.592	0.629
N 39	N 38	150	700	0.3	0.0243	8	0.45	0.0105	0.003	1.089	1.092
N 38	N 36	150	70	0.3	0.0243	18	1.02	0.0529	0.016	0.551	0.567
W 13	N 36	100	130	2.5	0.20556	4.5	0.57	0.0168	0.042	0.541	0.583
N 36	N 34	200	605	0.3	0.00536	22.5	0.72	0.0262	0.008	1.642	1.650
N 34	N 62	250	100	5.8	0.00166	79.5	1.62	0.1338	0.776	1.049	1.825
N 62	RWT 1	200	10	7.6	0.00536	39.75	1.27	0.0817	0.621	0.085	0.706
N 62	RWT 2	200	10	7.6	0.00536	39.75	1.27	0.0817	0.621	0.085	0.706
W 18	N 34	100	25	2.8	0.20556	4	0.51	0.0132	0.037	0.082	0.119

Table (4) : Head losses at well points

Well No.	Q	Suction Side								Discharge Side								
		DN	L	V	ΣK_L	H_L	H_f	ΣH_s	DN	L	V	ΣK_L	H_L	H_f	ΣH_d	ΣH
	(l/s)	(mm)	(m)	(m/s)	-	(m)	(m)	(m)	(mm)	(m)	(m/s)	-	(m)	(m)	(m)	(m)
1	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
2	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
3	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
4	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
5	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
6	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
7	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
8	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
9	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166

Table (4) : (continues)

Well No.	Q	Suction Side							Discharge Side							∑ H
		DN	L	V	∑ K_L	H_L	H_f	∑ H_s	DN	L	V	∑ KL	H_L	H_f	∑ H_d	
	(l/s)	(mm)	(m)	(m/s)	-	(m)	(m)	(m)	(mm)	(m)	(m/s)	-	(m)	(m)	(m)	(m)
10	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
11	5	150	18	0.283	1.8	0.007	0.011	0.018	100	5	0.64	5.9	0.122	0.026	0.148	0.166
12	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106
13	4.5	150	18	0.254	1.8	0.005	0.009	0.014	100	5	0.57	5.9	0.100	0.021	0.119	0.134
14	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106
15	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106
16	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106
17	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106
18	4	150	18	0.226	1.8	0.004	0.008	0.012	100	5	0.51	5.9	0.078	0.016	0.094	0.106

4.3 *Head required for the pumps at well points*

On the basis of the head losses calculated as shown, heads required (Manometric head) for the pumps at well points are consolidated in table (5).

Table (5) : Head required for the pumps at well points

Well No.	Static Elev. @		Static head	Outlet head	Head losses @			Total head required at well point (manometric head)
	RWT (madl)	Well point (madl)			Conve. line	Well point	Total	
1	4.0	- 18	22	0.0817	13.36	0.166	13.52	35.61
2	4.0	- 18	22	0.0817	14.33	0.166	14.58	36.58
3	4.0	- 18	22	0.0817	8.86	0.166	9.12	31.12
4	4.0	- 18	22	0.0817	11.48	0.166	11.73	33.73
5	4.0	- 18	22	0.0817	8.41	0.166	8.65	30.65
6	4.0	- 18	22	0.0817	16.45	0.166	16.70	38.70
7	4.0	- 18	22	0.0817	17.27	0.166	17.52	39.52
8	4.0	- 18	22	0.0817	6.61	0.166	6.85	28.85
9	4.0	- 18	22	0.0817	9.97	0.166	10.22	32.22
10	4.0	- 18	22	0.0817	12.01	0.166	12.26	34.26
11	4.0	- 18	22	0.0817	14.38	0.166	14.63	36.63
12	4.0	- 18	22	0.0817	18.11	0.106	18.27	40.27
13	4.0	- 18	22	0.0817	4.77	0.134	4.98	26.98
14	4.0	- 18	22	0.0817	7.22	0.106	7.41	29.41
15	4.0	- 18	22	0.0817	7.22	0.106	7.41	29.41
16	4.0	- 18	22	0.0817	22.04	0.106	22.23	44.23
17	4.0	- 18	22	0.0817	6.47	0.106	6.66	28.66
18	4.0	- 18	22	0.0817	2.65	0.106	2.84	24.84

4.4 Selection of submersible well pumps

In this study it will be suggested to take the produces of the ITT[*] which is making Z631 series multistage submersible well pumps that will be installed on the well points.

Number of stages required are as listed in the table (6). The characteristics of these pumps can be found in Appendix II.

Table (5-4) : Number of stages required for multistage well pumps

Well No.	Water elev. @ well	Water depth of well	Well type	Calculated pump charac.		Selected pump		Power req.
				Capacity	Head	No. Of stages	Head	Working[**]
				m³/h	m		m	
1	18	2	S[†]	18	35.61	4	45	3.0
2	18	7	S	18	36.58	4	45	3.0
3	18	6	S	18	31.12	3	34	2.4
4	18	2	S	18	33.73	3	34	2.4
5	18	4	S	18	30.65	3	34	2.4
6	18	4	S	18	38.70	4	45	3.0
7	18	4	S	18	39.52	4	45	3.0
8	18	2	S	18	28.85	3	34	2.4
9	18	4	S	18	32.22	3	34	2.4
10	18	3	S	18	34.26	4	45	3.0
11	18	3	S	18	36.63	4	45	3.0
12	18	2	S	14.4	40.27	4	45	3.0
13	18	6	S	16.2	26.98	3	34	2.4
14	18	4	S	14.4	29.41	3	34	2.4
15	18	6	S	14.4	29.41	3	34	2.4
16	18	4	S	14.4	44.23	4	45	3.0
17	18	6	S	14.4	28.66	3	34	2.4
18	18	3	S	14.4	24.84	3	34	2.4

** Working can be optioned by using the following formula (Hardenbergh , 1951):

$$P = \frac{H * Q}{3960}$$

† " S " mean that the well is shallow

Appendix II

The Characteristics of ITT Multistage Submersible Well Pumps, Z631 Series

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Z631 SERIES, 1 TO 15 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

PUMP TYPE	RATED POWER kW	Q = DELIVERY					
		l/min 0	200	400	500	600	666,7
		m³/h 0	12	24	30	36	40
		H = TOTAL HEAD METRES COLUMN OF WATER					
Z631 01	1,5	15,6	14,3	12,3	10,7	8,5	6,6
Z631 02	3	31,7	29,3	25,4	22,2	17,8	14,1
Z631 03	4	47,4	43,8	37,9	33,1	26,4	20,7
Z631 04	5,5	63,1	58,8	51,3	45,1	36,5	29,2
Z631 05	7,5	78,7	73,4	64,0	56,2	45,4	36,3
Z631 06	7,5	93,9	87,2	75,9	66,6	53,7	42,9
Z631 07	9,3	109,2	102,7	89,9	79,1	64,2	51,5
Z631 08	11	124,7	117,3	102,9	90,6	73,5	59,1
Z631 09	11	139,8	130,8	114,0	100,0	80,9	64,7
Z631 10	13	155,7	145,9	127,5	112,0	90,9	73,0
Z631 11	15	171,8	161,1	141,2	124,4	101,2	81,6
Z631 12	18,5	188,1	177,5	156,4	138,3	113,2	91,9
Z631 13	18,5	203,0	191,4	168,2	148,4	121,1	97,9
Z631 14	18,5	218,0	205,2	179,8	158,3	128,7	103,6
Z631 15	22	233,6	219,3	192,3	169,5	138,1	111,4

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DIMENSIONS AND WEIGHTS

ELECTRO PUMP TYPE	RATED POWER kW	DIMENSIONS (mm)					WEIGHT
		L	LM	LP	øD		
					1 Cable	2 Cables	Kg
Z631 01-L4C	1,5	715	348	367	142	144	21
Z631 02-L4C	3	980	544	436	142	144	31
Z631 03-L4C	4	1119	614	505	142	144	35
Z631 04-L4C	5,5	1258	684	574	142	144	40
Z631 05-L4C	7,5	1407	764	643	142	144	44
Z631 06-L4C	7,5	1476	764	712	142	144	46
Z631 03-L6W	4	1088	583	505	144	146	50
Z631 04-L6W	5,5	1187	613	574	144	146	56
Z631 05-L6W	7,5	1296	653	643	144	146	61
Z631 06-L6W	7,5	1365	653	712	144	146	63
Z631 07-L6W	9,3	1464	683	781	144	146	67
Z631 08-L6W	11	1573	723	850	144	146	74
Z631 09-L6W	11	1642	723	919	144	146	75
Z631 10-L6W	13	1751	763	988	144	146	81
Z631 11-L6W	15	1890	833	1057	144	146	90
Z631 12-L6W	18,5	2029	903	1126	144	146	100
Z631 13-L6W	18,5	2098	903	1195	144	146	101
Z631 14-L6W	18,5	2167	903	1264	144	146	103
Z631 15-L6W	22	2276	943	1333	144	146	108

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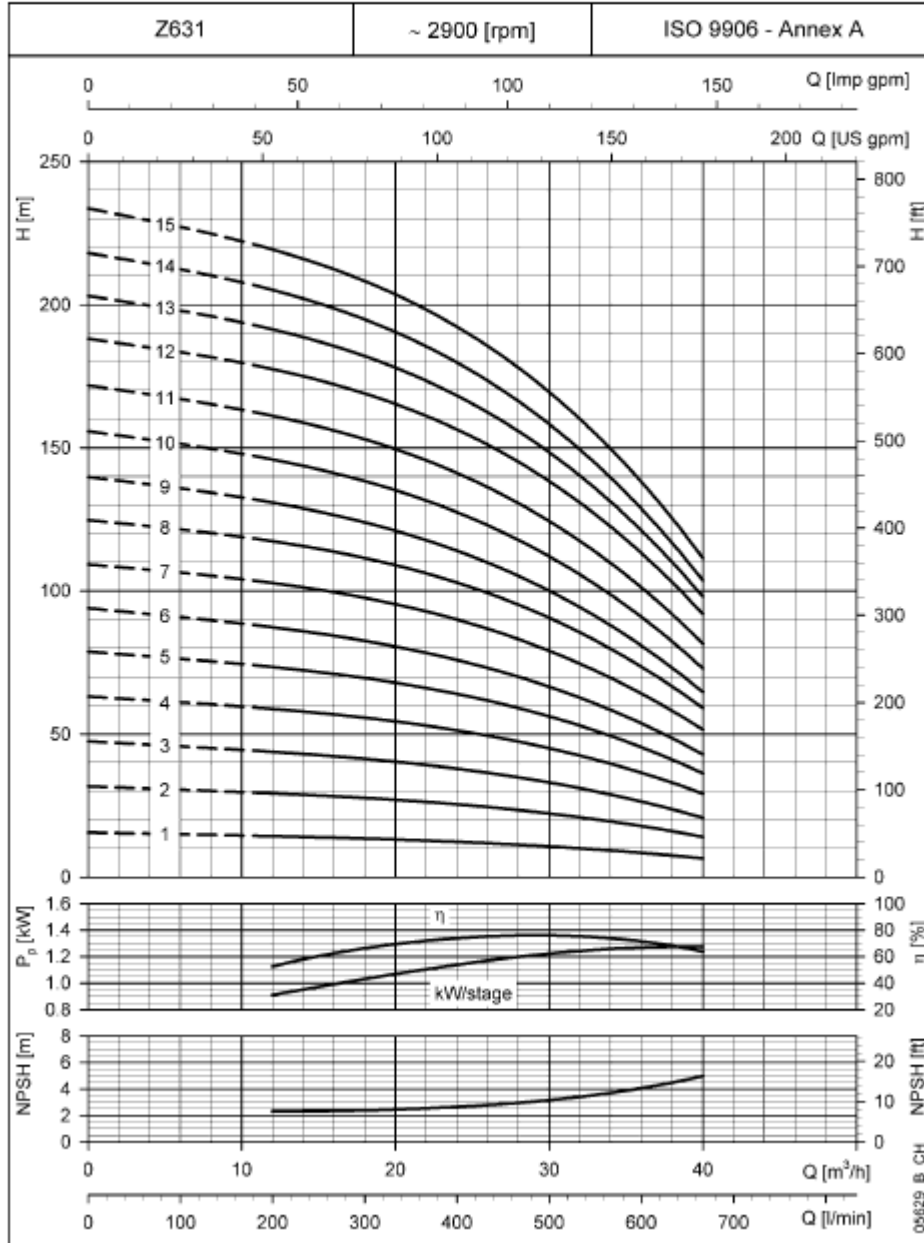
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Z631 SERIES, 1 TO 15 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

These performances are valid for liquids with density ρ = 1.0 Kg/dm³ and kinematic viscosity ν = 1 mm²/sec.

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Z631 SERIES, 16 TO 29 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

PUMP TYPE	RATED POWER kW	l/min 0	200	400	500	600	666,7
		m³/h 0	12	24	30	36	40
		H = TOTAL HEAD METRES COLUMN OF WATER					
Z631 16	22	248,5	233,0	203,9	179,4	145,7	117,2
Z631 17	22	262,4	246,9	215,9	189,7	153,7	123,2
Z631 18	26	280,6	265,1	233,8	206,7	169,1	137,1
Z631 19	26	295,5	279,2	245,7	217,0	177,1	143,3
Z631 20	26	310,6	292,9	257,5	227,0	185,0	149,2
Z631 21	30	327,0	308,8	271,8	240,0	195,9	158,5
Z631 22	30	342,0	322,5	283,5	250,1	203,8	164,5
Z631 23	30	357,2	336,7	296,0	260,7	211,6	169,7
Z631 24	37	376,2	355,7	314,1	277,7	226,5	182,8
Z631 25	37	389,6	367,9	324,5	286,5	233,4	188,0
Z631 26	37	404,7	381,8	336,1	296,4	241,0	193,7
Z631 27	37	419,6	395,6	347,8	306,3	248,6	199,4
Z631 28	37	434,5	409,4	359,3	316,0	255,9	204,8
Z631 29	37	449,1	423,1	370,7	325,6	263,1	210,0

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DIMENSIONS AND WEIGHTS

ELECTRO PUMP TYPE	RATED POWER kW	L	LM	LP	ø D 1 Cable	ø D 2 Cables	WEIGHT Kg
Z631 16-L6W	22	2345	943	1402	144	146	109
Z631 17-L6W	22	2414	943	1471	144	146	111
Z631 18-L6W	26	2611	1071	1540	144	146	121
Z631 19-L6W	26	2680	1071	1609	144	146	123
Z631 20-L6W	26	2749	1071	1678	144	146	124
Z631 21-L6W	30	2898	1151	1747	144	146	134
Z631 22-L6W	30	2967	1151	1816	144	146	136
Z631 23-L6W	30	3036	1151	1885	144	146	137
Z631 24-L6W	37	3255	1301	1954	144	146	153
Z631 25-L6W	37	3324	1301	2023	144	146	154
Z631 26-L6W	37	3393	1301	2092	144	146	156
Z631 27-L6W	37	3462	1301	2161	144	146	158
Z631 28-L6W	37	3531	1301	2230	144	146	159
Z631 29-L6W	37	3600	1301	2299	144	146	161

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Rp 3

LP

L

LM

D

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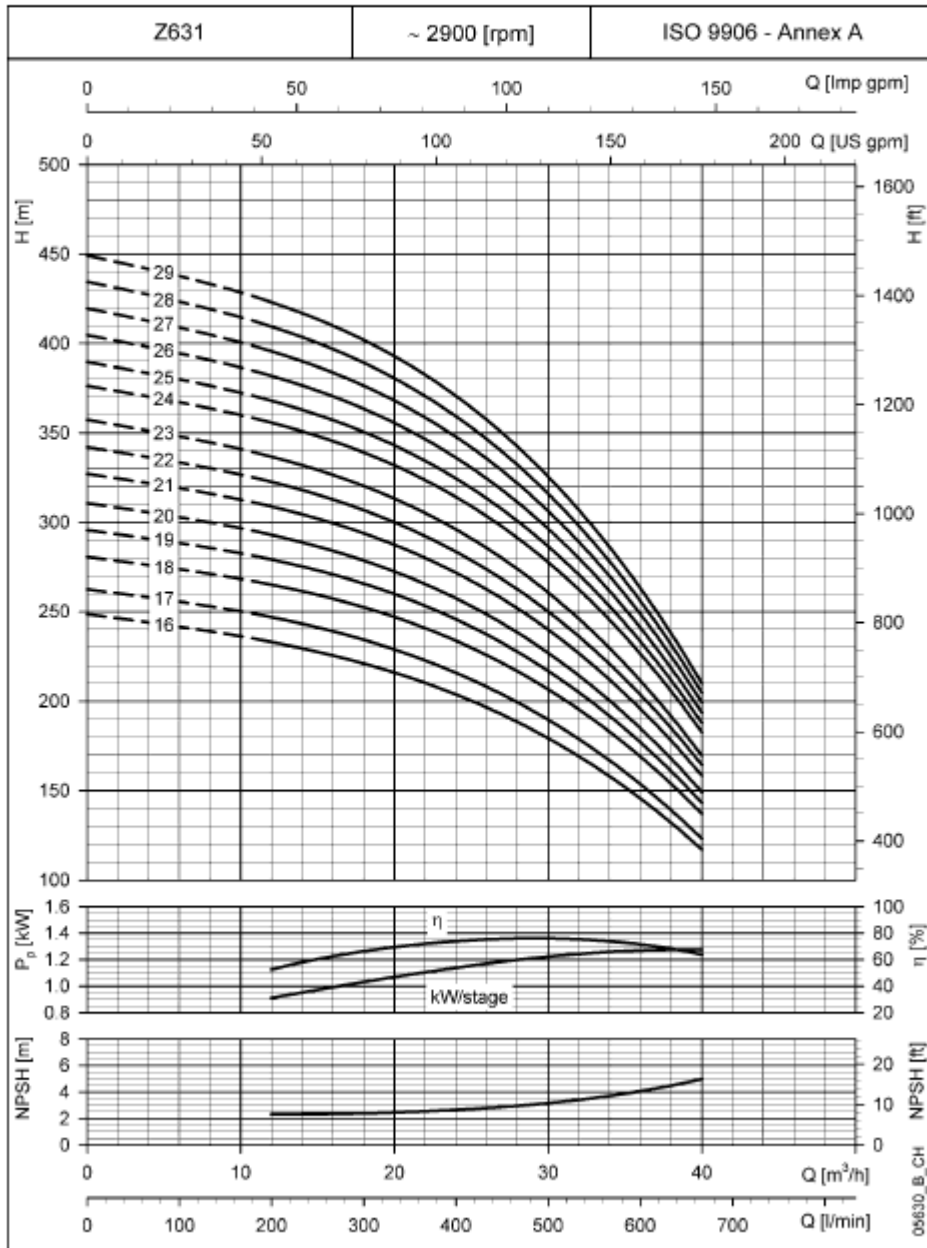
Z631 SERIES, 16 TO 29 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

These performances are valid for liquids with density ρ ≅ 1.0 Kg/dm³ and kinematic viscosity ν ≅ 1 mm²/sec.

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Z631 SERIES, 30 TO 43 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

PUMP TYPE	RATED POWER kW	Q = DELIVERY					
		l/min 0	200	400	500	600	666,7
		m³/h 0	12	24	30	36	40
		H = TOTAL HEAD METRES COLUMN OF WATER					
Z631 30D	45	467,2	440,6	388,4	342,8	279,1	224,5
Z631 31D	45	482,2	454,3	400,1	352,9	286,9	230,4
Z631 32D	45	497,1	468,1	411,8	362,9	294,7	236,3
Z631 33D	45	511,9	481,7	423,4	372,9	302,3	242,1
Z631 34D	45	526,7	495,5	434,8	382,4	309,6	247,5
Z631 35D	45	541,4	509,1	446,3	392,2	317,1	253,0
Z631 36D	52	556,2	522,5	457,5	401,8	324,3	258,3
Z631 37D	52	574,7	542,0	476,8	420,1	341,1	273,7
Z631 38D	52	589,8	555,8	488,3	429,9	348,5	279,2
Z631 39D	52	604,5	569,4	499,8	439,6	355,9	284,6
Z631 40D	52	619,4	583,1	511,1	449,2	363,2	290,0
Z631 41D	52	634,1	596,7	522,4	458,6	370,3	295,2
Z631 42D	55	652,3	614,8	540,5	476,1	386,4	309,8
Z631 43D	55	667,0	628,4	552,0	485,9	393,9	315,4

z631-3-50-en_a_th

DIMENSIONS AND WEIGHTS

ELECTRO PUMP TYPE	RATED POWER kW	DIMENSIONS (mm)					WEIGHT
		L	LM	LP	øD		
					1 Cable	2 Cables	Kg
Z631 30D-L8W	45	4166	1195	2971	193	195	292
Z631 31D-L8W	45	4166	1195	2971	193	195	293
Z631 32D-L8W	45	4166	1195	2971	193	195	294
Z631 33D-L8W	45	4166	1195	2971	193	195	295
Z631 34D-L8W	45	4166	1195	2971	193	195	295
Z631 35D-L8W	45	4580	1195	3385	193	195	308
Z631 36D-L8W	52	4670	1285	3385	193	195	328
Z631 37D-L8W	52	4670	1285	3385	193	195	329
Z631 38D-L8W	52	4670	1285	3385	193	195	330
Z631 39D-L8W	52	4670	1285	3385	193	195	331
Z631 40D-L8W	52	4670	1285	3385	193	195	331
Z631 41D-L8W	52	4808	1285	3523	193	195	335
Z631 42D-L8W	55	4848	1325	3523	193	195	342
Z631 43D-L8W	55	4986	1325	3661	193	195	347

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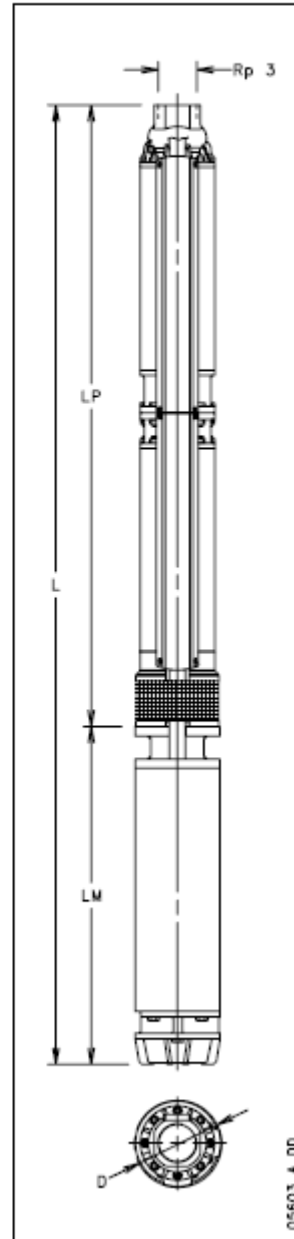
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Z631 SERIES, 30 TO 43 STAGES
OPERATING CHARACTERISTICS AT 50 Hz

| Z631 | ~ 2900 [rpm] | ISO 9906 - Annex A |
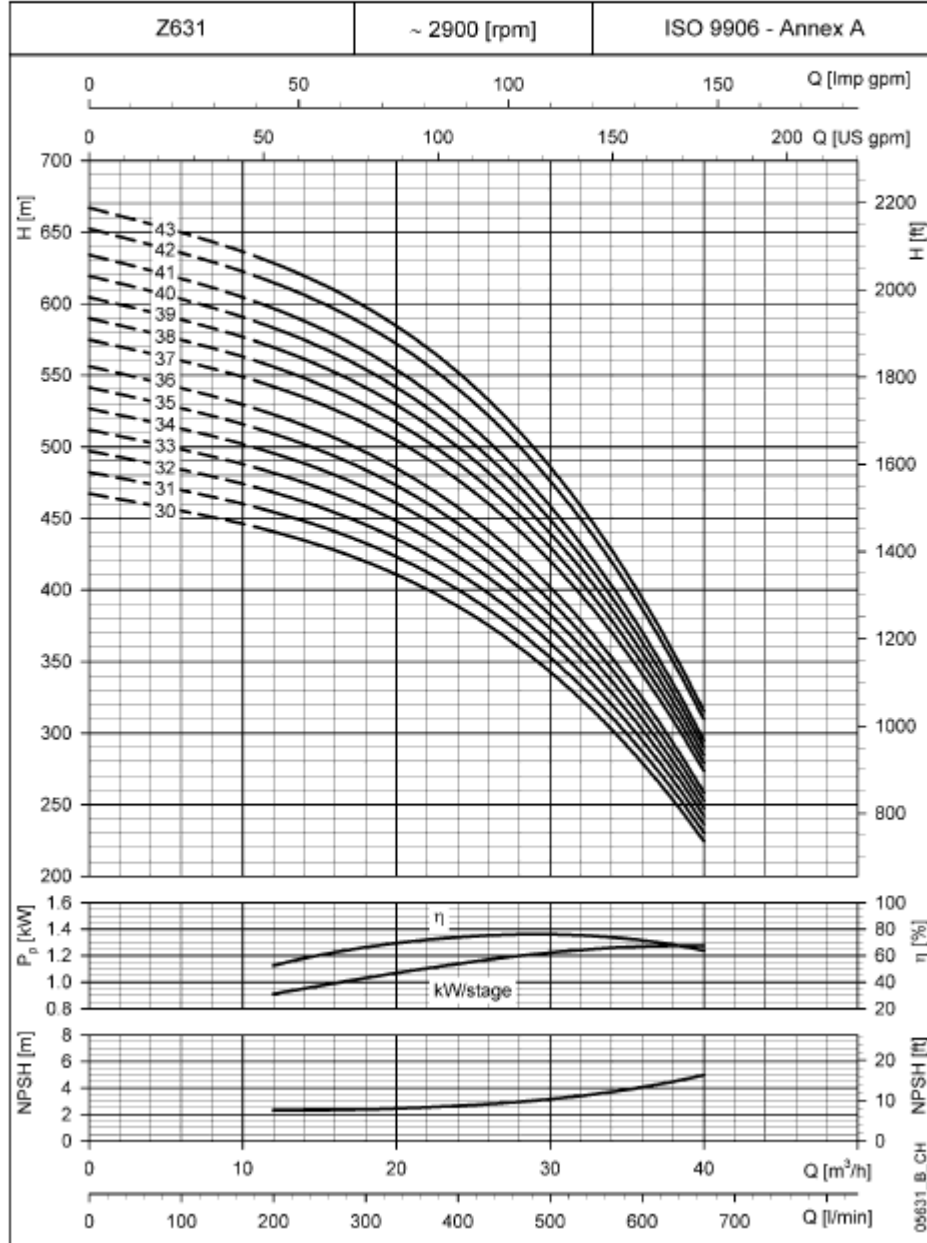
These performances are valid for liquids with density ρ = 1.0 Kg/dm³ and kinematic viscosity ν = 1 mm²/sec.

الخلاصة

أن الدراسة الحالية تهتم بتحري استعمال المياه الجوفية في منطقة أم قصر للأغراض المنزلية و الزراعية. تقع أم قصر في المنطقة الجنوبية الشرقية للعراق, في البصرة, وبمساحة تصل الى (70 كيلو متر مربع). تقع أم قصر ضمن تركيب الدبدبة, و الذي يتكون بصورة رئيسية من الرمل و الحصى مع بعض المواد الإسمنتية كالغرين و الطين.

تم أخذ (11) نموذجا من المياه الجوفية من أبار مختلفة لإيجاد نوعية, تصنيف, وتقييم صلاحية تلك المياه. ظهرت نتائج التحليل الكيميائي بالشكل الاتي: البوتاسيوم (12.01-18.4 ملغ\لتر), الصوديوم (886.2-1821 ملغ\لتر), مغنيسيوم (60.76-219.66 ملغ\لتر), كالسيوم (136.27-220.44 ملغ\لتر), الكلوريد (709.1-1634 ملغ\لتر), نترات (1.8-11.2 ملغ\لتر), الكبريتات (1238.4-2889.6 ملغ\لتر), والبيكاربونات (96.41-219.66 ملغ\لتر). ألـ (TDS), (pH), و درجة حرارة المياه الجوفية تتراوح بين (3580-9040 ملغ\لتر), (6.4-7.1), و (25-28 درجة مئوية) على التوالي .

أصل المياه الجوفية هو أصل قاري و نوعها من العائلة (Na+K-sulfate) كما تم إيجادها بطريقة سولين. كما وجد بطريقة سكويلر أن المياه الجوفية تقع ضمن المجموعة الثانية للايونات الموجبة [r(Na+K)>rCa>rMg] ما عدا البئر رقم 8 و 9 والذي تقع ضمن المجموعة الأولى. باستخدام طريقة سكولر-سولين, وجد بان المياه الجوفية في كل الآبار تصنف ضمن مجموعة كبريتات الصوديوم, فيما عدا البئر رقم 1 و الذي يصنف ضمن المجموعة كلوريد الصوديوم. كما وأن تلك النتائج قورنت بمواصفات منظمة الصحة العالميةً(WHO) لعام 1995 و الخاصة بمياه الشرب، حيث لوحظت بأن المياه الجوفية في هذه المنطقة غير صالحة للشرب. من جهة أخرى وجد بأن هذه المياه غير مناسبة للأستخدام الزراع ما عدا التمور و بعض محاصيل الخضروات كالطماطم, الخيار, و البطاطا.