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HYDROGIOLOGIC CONDITIONS WITHIN AL-ANBAR GOVERNORATE

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Abstract : This study covers the examination of the hydrogeologic conditions and the hydraulic characteristics of the aquifers within the hydrologic regime of Al-Anbar Governorate. Also, the research shed light on the flow behavior regime and its effectiveness on the groundwater movement, considering the regional geologic settings including, geomorphologic, structural and sediment logical phenomena. The results that derived from this study are:
1-Determination of groundwater quality zones throughout the distribution maps of hydrochemical facies (Water Type) and TDS. 2-Compilation of various hydraulic parameters and hydro chemical characteristics of the groundwater.3-determination of main productive aquifers. 4-Compilation the hydraulic parameters and hydro- chemical characteristics of groundwater in unite maps from the available previous hydrogeologic studies.5-determination & selection groundwater zones depending on preferable procedures for future significant exploitation aiming to various groundwater uses.

Key words : HYDROGIOLOGIC CONDITIONS , AL-ANBAR GOVERNORATE

Introduction :

The studied area lies in the center of western Iraq, its area is approximately 137808 (km2).The roughly area lies between latitudes (300 30' – 350 00') , longitudes (380 55' – 440 10').The governorate is bounded from the North West by Syria, from the north east by Tikrit and Nenava governorates, from the east by Karbala and Najaf, from the south west by Saudi Arabia and from the west by Jordan .

The six physiographic provinces in the studied area; Al-Hamad basin, upper Wedian plain, Al- Hijra plain, Lower Wedian plain, Al-Jizera plain and Mesopotamian plain, see fig.(1) .These are defined by differences in drainage patterns, topography, litho logy of the formations and geologic structures. These plains are characterized by elevations range between (700 – 900) ,(400 – 700) ,(200 – 400) ,(60- 200) , (175 – 225) and < 60 meters ,above sea level, respectively .
The Euphrates River of about 425 km in length is the major physiographic feature in the Governorate extends between Iraqi-Syria borders and Babel. The river incised it's valley on a high plateau which dips gently eastwards .South and West of the Euphrates is a vast plain which rises gradually from the river to (900) meters in the west portion of Iraq.

Purpose:

The purpose of this study is to discuss and examine a preliminary qualitative and evaluation of the groundwater for possible future development in different uses , also the results of the hydro geologic information and interpretation presented in this study give essential guide for the selection of the most favorable groundwater areas in the future program.

Hydrology:

The main source of water supply in the governorate is provided from the Euphrates River. The upper section between Husaiba and Rawa, the river flows generally due east along the northern flank of Ana Anticline which mainly composed of Miocene and Oligocene rocks. The river cuts the Ana anticline in the environs of Rawa and Ana. Then the valley widens and flattens where the terrace relics scattered far from the river course. Strongly meandering river continues south east approximately along the contact between Al-Fatha and the underlying carbonate Formation till Ramadi city ,where the Quaternary sediment of Mesopotamian Plain appears at the left bank , then the Euphrates river flows between Injana and Quaternary sediments for the rest part of river (Ramadi – Falluja) .The Euphrates River represents Allochtonus River with no perennial tributary in the Iraqi territory, accordingly the river carries smaller amount of coarse grained load .

The mean daily discharge of the river at Hit gauge station is 909 m3/sec. ranged between (55 – 7460) m3/sec. The annual sediment budget at the station was calculated for the period (1958 -1982).

A total of 1586 x 106 tons of sediments are transported through the station for this period, annually 66 x 10 6 tons of sediments ,[1].

The Euphrates river losses 40% of it's water through intensive agriculture purposes, high rate of evaporation and storage in lakes, thus causing decreasing in water discharge down stream. The over all rates of erosion on the catchments area of Hit gauging station reaches an average of 208 ton/ Km2/year,[1].

•Storage Schemes :

1-Al-Qadisiya Dam:

This dam is located at Euphrates river valley in a distance of about 7 km. upstream of Haditha town. The dam is of multi purposes development, such as electric energy generation, irrigation, partial storage and serves in flood control. The scheme characteristics are:

Length of zoned earth dam : 8.7 km.
Long of reservoir : 100 km.
Average width : 4 km (2-11)
Average depth : 17 meter
Catchments area : 234 600 km2
Natural mean annual run off : 31.5 km3
Natural mean annual discharge : 998 m3/sec.
Natural mean annual evaporation : 2200 mm .
Full storage at elevation147.0 m a.s.l:8.2 km3.
Usable storage: 8.0 km3 .
Operational water storage: 6.46 km3 .
Reserve: 2.39 km3.

The total load upstream Al-Qadisiya reservoir is 17250 ton/day, ranged between (900-34 500)ton/day, [2].

2- Al-Habbaniya Lake:

Habbaniya depression is located to the south east of Ramadi with an area of about 400 km2 .This lake receives flood water from Euphrates river by Warar canal in a designed discharge of about 8800 m3/sec.. The water leaves the lake by Theban canal in a discharge capacity of about 285 m3/sec. The reserve of lake at 51.2 meter a.s.l is 3.34 km3 , [3].

3-Tharthar Scheme:

The Tharthar depression located between the Tigris and Euphrates Rivers .The storage capacity is 85 km3 at a maximum water level reaches 65 m a.s.l. it helps in flood control and water regulation between Tigris and Euphrates Rivers by Tharthar Euphrates canal and Dijla arm projects.

4-Al-Razzaza Lake :

This lake situated south of Habbaniya Lake .The capacity of the lake is 25 km3 at 40 meter a.s.l, where, this depression is used for flood control and mitigation of flood risk by discharge the water surplus in Habbaniya Lake.

5- Agricultural Schemes :

These schemes comprised Al-Sagllawia and unitive canal projects which intake water from Euphrates River upstream of Falluja scheme. The intake discharge of Al-Sagllawia project is of about (10 m3/sec.), which the intake discharge of unitive canal project including (Abu-Ghraib, Al-Radhwania ,Al-Yousifiya, Al-Latifiya division canals) is about 35 m3/sec. Finally, intermittent streams have cut canyons and broad valleys to depth of (30 – 100) meters below the surface. Large and small valleys flow NE and SE of the plateau and drain into the Euphrates. These valleys are named – Al-Walaj, Swab, Aukash ,Ruttga ,Al-Manee, Al-Qaem, Al-Qaseer, Fehayme, Horan Al-Marij, Muhemidi, Ghadaf and Al-Aubayidh valleys ,see fig.(1)

Climate:

• Temperature :

The mean annual of minimum and maximum air temperature values which were recorded in Ramadi, Haditha, Ana, Al-Qaem Al-Nukhaib and Al-Ruttba gauge stations for the period (1967-2000) are ranged between (15-28.9)0C,(14.2-28.5)0C,(13.3-27.9)oC,(13.2-27.7)oC (12.7-26.5)oC and (11.4-25.5)oC, respectively, see fig.(2).The mean seasonally temperature degrees in the governorate ranged between (28-34) o C in summer and between (8-12)oC in winter .The mean monthly of air temperature within the governorate are ranged between (2-42)oC for the period(1967-2000).Finally, the minimum and maximum air temperature which were recorded within the governorate are (-7.6 oC and 50.7oC), respectively. The annual sun radiation energy within the studied area ranges between (240-750) milliwatt /cm2 in each 8.8 hours of day radiation [4].

• Rain fall :

The mean annual rainfall which were recorded in Ramadi, Haditha ,Ana ,Al-Qaem, Al-Nukhaib and Ruttba gauge stations for the same period (1967-2000) are ranged between (50-150) mm/year, see fig.(2) ,usually the rainfalls is sporadic and extremely variable in time and space.

On rainy days rain fall may exceed 40mm in 24 hours.

The maximum daily recorded rain fall at some station exceeds the total recorded during a whole dry year. On the other hand, 46% of rain fall recorded on winter while the other percent is recorded on Autumn & Spring[5 &6].

• Evaporation:

The mean monthly and annual evaporation within the studied area are ranged between (150-183)mm and between (1260-2200)mm ,respectively, increased SE direction see fig.(2). Some times (400-500)mm of evaporation occurs in both July & August alone from the mean annual evaporation of some gauge station .

• Relative Humidity :

The mean monthly of relative humidity values for the period (1967-2000) ranged between (22-76)% where the mean annual relative humidity is less than 50% ,accordingly ,Al-Anbar Governorate classified as a region of arid air .

According to the climatological factors, Al-Anbar Governorate is mainly affected by desert arid climate.
The distribution map of the climatological factors(fig. 2) Shows three integrated zones, these zones characterized by the following information .see(table - 1) .

Hydro geologically, and due to the abovementioned information, zone No.1 has good climate condition and can be selected as first class zone in the region due to the relatively high water surplus than other zones, which means good recharge process occurs to the groundwater .This zone followed by the second class zone No.2, which characterized by low water surplus and may classified as transition zone.
The third class zone No.3 characterized by water deficit which means low recharge process can be occurred to the groundwater and may classified as discharge zone.
Previous Works:
The hydrogeologic data that are used in this research are mostly available in unpublished reports. Theses studies are;
•Ralph, M. Parsons, Groundwater resources, volume-10, 1957,[5].
•Marinov, et.al.1974, study the hydrology of Iraq within the hydrogeologic scheme of Asia,[6].
•Idrotecnico,1977,Regional hydrogeological study for block No.4-Nukhaib area,[7]. •Theses studies comprise drilling and regime observation where, the deepest drilled well reaches 1600 meter. West Iraq, near Gara.
GEOSURV carried out regional and local hydro geological studies as well as studies during geological mapping projects such as:
•Al- Hadithi,T,et.al.,1978,proceeds report on geological photo-interpretation of Ruttba area, block - 5,[9].
•Ahmed.H.S, et.al. 1984 carried out a report of the groundwater within Hit area.[10].
•Araim.H.I .et.al, 1990; compiled hydrogeological data in regional hydro geologic map,[11].
•ECSAD carried out a final report ,Annex-4 about groundwater resources of Al-Hamad basin,No.13 ,1983, including the western part of Iraq,[12].
•Ministry of Agricultural ,carried out a study about the water resources in Euphrates basin including main axes of groundwater studies compiled by Al-Jabbari ,et.al.2002 ,[13].
•Jassim, S.Z and Goff, J.C, 2006, in chapter 9 compiled many hydrogeological studies in text book named Geology of Iraq,[14].
•Hussein .B.M and Gharbi,M.A,2008; study the hydrogeological condition within Abu-Jir fault zone (Hit –Kubaiysa),[15].
The abovementioned studies are used in compilation and achievement of this research. From the tectonic point of view, the studied area lies within the main zone represented by Afro-Arabian platform. Most of the area lies within the stable shelf which characterized by low thickness of sediments. The stable shelf comprises western zone (Gara &Ana blocks) and Abu-Jir sub zone ,which the eastern part of the area lies within the unstable zone represented by Mesopotamian zone, (fig.3) .
The depth of rock basement range between (2-4) Km. [16]. The cover of basement rocks characterized by small depression, reflected as low amplitude structures on the surface (gentle fold-like or block faulting),[14].
The western part of the studied areas is highly irregular surfaces plateau which descends towards NE & E .Geophysically, a remarkable elongated positive zone exists in west extending from SW to NE & coincides with the course of wadi Horan. The area has been influenced by many tectonic events that resulted in several fault system, tilting of strata and uplifting, horst and graben structures, fig. (3) Shows:
-NW-SE Fault System named Najid Fault system [14]. These fault system are Ramadi-Musayib Fault, Euphrates boundary Fault and Tar Al-Jil Fault.
-NE-SW Transferred Fault Systems, such Ana-Qalat, Dizeh Fault, Amij-samarra Fault & Sirwan Fault.
The Paleozoic units dip towards South and South east ,while the Triassic, Jurassic and early Cretaceous units dip towards south east,[17]. The late Cretaceous Paleocene units (in the western part) dip towards ;
-North & North East in the area among Gara-Ana-Syria border.
-North West & West (South national high way).
-South East, East & North East (in the eastern part).

Fault System:

From the studies of [9],[17],[18],[19], compiled structural elements map contains several fault system.
-North-South Faults, these faults originated to fault lines in the basement related to Hijaz Orogeny such as (Nukhaib Graben).
-North West –South East Faults, these faults originated along the old fault lines of the Najid Orogeny in the basement, expressed in Horan area.
- East West and NE-SW Faults, these NE-SW Faults are the youngest in the area and may be related to Late Cretaceous Laramide movements which may reactivated the older E-W faults system in the area contributed to the development of Ana Graben .
[9] prepared lineaments density map , shows highest density of lineaments intersections is found mainly in a zone of Horan Anticlinorium extends from National border to the Gara depression extends to Qaser Muhaiwir. Another complicated fault zone that underwent several tectonic events are present in the area named Abu-Jir fault zone, [20]describes this fault as right lateral strike slip faults and its zone considered as proposed boundary between stable and unstable shelves.

Fold System:

The main folds in the Governorate as determined by [9]are:

-Gara Anticline is a kind of dome – shaped structure (asymmetrical plunge anticline) trending almost E-W. It's western nose recognized by large main drainage of wadi Al- Walej. The western plunge is not well visible but it could be proposed on the basis of lithologic unit distribution.

-Al-Mangi Anticline ,the indication supposed on the basis of drainage pattern with length of about 45 Km. The general trends is almost NE-SW which form en echelon pattern with Gara Anticline .The geological map of Jordan shows the western continuation of this anticline.

-Huran Anticline: This anticline extends from Saudi border to the NE of Ruttba town trending NE-SW. This structure occupies a zone which separate two different drainage patterns. This structure is well identified by gravity survey.

-Amij E-W trend structure located between Wadi Amij & Wadi Ghadaf this structure might be related to the morphology of the basement.

-Al- Walaj syncline ;this syncline is located between Huran & Al-Manji anticline with NE –SW general trend where the drainage pattern collected to Al-Walaj valley directed to fold axis. The length of syncline reaches 55km.

- Ana Anticline is a symmetrical fold located in the north eastern part of the area, its length reaches 85km, between south Ana & Qaem, extends east- west trends. The dip of the north limb (6o-20o) while the south limb is 72o.

Geology :

The cretaceous sediments in the western desert of the studied area lie unconformable on Jurassic, Triassic and Paleozoic sediments.

According to the erosion surface which marks the base of the cretaceous sediments ,the western area is morphologically irregular with an elevation difference of about 4km. The highest slop of unconformity is found in the NE part (towards Ana Graben) ,reaches 10m/km, while the slop is gentler in the western part of the area not exceeds 4m/km (south of Ruttba) ,[17].

Paleozoic sediments:

The Paleozoic sediments in the area inclined towards SE, the oldest of these sediments is Al-Tawil Formation (Devonian), which was found underlying the late cretaceous sediments in al-Jalameed area NW Saudi Arabia [21] . In the northern parts of the area the cretaceous units are underlined by Devonian-carboniferous units (Swab well No.1/Syria) followed by Early carboniferous in (Akas well No.1/Iraq) followed by perm carboniferous sediments (Gara and Swab/Iraq,TinifwellNo.1/Syria).

Late Triassic Sediments: These units are represented by the Mullusa and Zor Huran Formations. Those units were found underlying the cretaceous units in subsurface sections south Ruttba – Aman highway extends to Rish wells in Jordan.[8].

Jurassic Units : These units cover the pre- cretaceous unconformity surface in the eastern part of Gara Dome see fig. No. (4) .They are found in exposed & subsurface sections. Older unit in the west & younger in the east having a general NE-SW strike trend dip towards SE.

They are intersected in all subsurface section east of Ruttba & south of Ruttba –km160 highway as well as east of wadi Huran north of highway . These formations are Ubaid, Hussainiyat, Amij, Muhaiwir and Najma Formation, while these units are missing in the western part of the investigated area .

Cretaceous Sediments:

The unconformity surface is overlain by early cretaceous sediments in the area east of Ruttba, exposed by two clastic-carbonate units (Naher Umer-Mauddod & Ruttba –Msad Formations). In the western and NW parts, the overlying units are of late cretaceous age or of Paleogene age. In the eastern rim of Gara depression, where, Gara formation (permo-carboniferous) is overlained by Tayarat –Hartha, Digma Formations . These units inclined towards N and NW in the area west of Gara depression and towards E and NE in the area east of depression. [17] .

The Paleocene units represented by Akashat, Um-Urdhuma, Ruttba and Damam formation cover an area except along axis of Huran High. The thickness variation of the cretaceous and Tertiary units conforms with the morphology of the unconformity surface – thicker sediments are present in the depressed zones& the thinner sediments are found in the elevated part. Sediments of the Oligocene epoch are restricted to four out crops in the area.[14].

1-Narrow strip extending for about 40 km. SE wards until it is over lapped by L. Miocene sequences near wadi Rattga like: - Shaikh Alas of 6 meter thick.

- Shuraa White Limestone of thickness range between (6-30) meter ,in wadi Swab and Akashat valleys with upper contact of Ghar Fn. (L.Miocene)

2- The core of Ana anticline along Euphrates river like:

-Baba Fn. In wadi Fehamee underlined by Tarjil Fn.

-Ana limestone formation of upper Oligocene ,the type section is about 15 km. east Nehaya village on Euphrates river .

3- Deep cuttings of the Euphrates valleys and its incoming main Wades between Haditha and Khan-el Baghdadi.

4- Deep cuttings of Wadi Huran south H-1 pump station and some beds in cuttings of Wadi Al-Aubayidh 30 km. west of Qaser-el-Akhydher.

Neogene Sediments:

-Euphrates Formations: The type section of 8 meter (Dolomitic, Chalky limestone) is located in Wadi Fehayme overlying on Oligocene deposits extends from Al- Qaem to near Najaf.

- Zahra Formation overlies Euphrates near Najaf, also Fatha formation overlies Euphrates Formation in the area east of Euphrates river .Some times Ghar

Formation overlies Euphrates Formation in the area between Huran and Syrian border.

-Ghadaf beds (Miocene-Pliocene mollass) : These beds are composed of cycles of sandstones and lime stones introduced from Nukhaib Graben area, these restricted to a down faulted block and probably the reason of its preservation at this place[22].

Upper Miocene sediments represented by Injana Formation(Habbaniya beds) which are distributed in the area west of Euphrates river starting from Ramadi area in the north & Najaf area in the south.

The sequences in these cliffs is about 20 meters thick and reach 25 meters of inter- bedded sandstones and clay stone in some water well south Habbaniya lake.

Quaternary Sediments: The most extension areas are covered by thin veneer of residual soil (0.3-0.5) meter thick, as an average. The considerable thick deposits are accumulated in the main depression and valleys. The main differential deposits in the studied area are: residual soil, valley and depression fills, terraces, Horan and Habbaniya gravel (fig. 4). Sabkhas, Gypcrete, Calcrete, slop and eolian sand, also present within this Governorate The main recognized Quaternary deposits in Mesopotamia province are: flood plain , crevasse splay ,depressions ,marshes and sheet run off deposits are presence in the eastern part of the area extends from Ramadi of Falluja and Baghdad area, the thickness of these deposits may reach 40 meters north Falluja. Finally , (table -2) concludes the geologic formation in Al-Anbar governorate.

Hydrogeologic Conditions:

Sedimentological , geomorphological and structural settings , determine the distribution and extend of hydrogeological system and its hydrogeological units such as (aquifers , aquitards and aquicludes) . These nine systems as shows in (fig . 5)[23] are:

4.1-Hydrogeologic System of Fractured cretaceous – Tertiary carbonates: It comprises the hydrogeologic units of :

- Rattga Formation consists of limestone and chalky limestone. Its thickness range between (0 – 120) meters in depth.

-Akashat Formation and Um-Erdhuma Fn., consists of carbonate rocks(dolostones ,limestone and phosphatic limestone) . The depth of this hydrogeologic unit range between (120-200) meters from the ground surface.

-Hartha –Tayarat Formations , consists of dolomitized limestone with shale beds. The depth of this unit ranges between (200-330)m from the ground surface. These hydrogeologic units are characterized by secondary porosity resulted by rupturing and karstification process, which may reflect the heterogeneity in storage aquifer properties and the productivity of wells. Also, this system includes sands and sandstones water bearing horizons of Ruttba Formation at depth range between (330 – 400) meters from the ground surface. The main structural boundaries within this hydrologic system are Huran and Al-Manji subsurface anticlines and its beneath syncline named Al- Walaj syncline, where these folds structures affect the condition of the aquifer throughout discharge and recharge condition and the flow behavior in the space (spatial distribution). Rattga horizons is not classified as main hydrologic unit, because it represents the aeration & transitional zones and the groundwater table is deeper than the lower part of this formation, while the water bearing horizons of Um-Erdhuma , Akashat ,Tayarat, Hartha and Ruttba sandstone Formations represent the main aquifer. The transmissivity and storage coefficients in carbonate horizons at depth (250-300) meters is ranged between (10-90) m2/day and (1 x 10 -4 – 5 x 10 -4) , respectively . The transmissivity and storage coefficients in sandstone horizons at depth range between (250 – 350) meters under the land surface are ranged between (100 -350) m2/year, (1 x 10 -2 - 5 x 10 -2) ,respectively. In this province, the effective productive thickness ranges between (50 – 150) meters, & the safe yield is of about 0.725 x 10 6 m3/day . The estimated exploitation from this province is 0.037 x 10 6 m3/year . The specific capacity values which is determined from the production wells range between (0.5 – 2.0) m3/hr/m, finally ,the total storage of the groundwater is 2.28 x 10 9 m3 , [12].

Hydrogeologic System of Permo-Carboniferous Sandstones :

This system Includes multi water bearing horizons of Ga'ara sands and sandstones .These horizons are important in the area of its outcrops and below the hydrologic units of the adjacent hydrologic system. The first water bearing horizons lies at a depth of (200-400) meters, where , at the NE direction of the Ga'ara depression ,the sand bearing horizon produced water from wells at depth of about (90-100)m . In Akashat area the homogenous sandstones of Ga'ara Fn. produced water from depth (400-700) m. The main structural boundaries that affect the hydrologic condition of this system are Ga'ara (High) anticline bounded by Huran anticline from the south. The transmissivity of Ga'ara sandstones ranges between (30-250) m2/day, where the aquifer is confined and the storage coefficient is in the order of 10-2. The groundwater depths ranges between 150 m in the NE direction and 300m in the SW direction .The average effective productive thickness is 350m range between (35-726)m & the safe yield is of about 46 x 106) m3/year [12]. The estimated exploitation from this system is 1.2 x 106 m3/year. The specific capacity values of the production wells range between (0.1 – 3.0) m3/hr/m, finally, the total storage of the groundwater is of about 28 x 109 m3.

Hydrogeologic System of Triassic – Cretaceous –Tertiary Carbonates and Sandstones:

The system includes the following water bearing horizons:

-Water bearing horizons of Mullusa carbonates formations produced water from depth (120-180) m in the vicinity of Ruttba town.

-In a penetrated drilled wells east of Ruttba the thickness of water bearing horizons of the Formations (Muhaiwir, Amij, Hussainiyat ,Ubaid, Zor Huran and Mullusa are 70,40,120,90,50 and180 m respectively ,while Ga'ara Fn. Can be reached by 550m in depth.

-Water bearing horizons of (Naher-Umer –Maudod) (Ruttba-Msad), (Hartha –Tayarat) and Um-Erdhuma Formations. The main aquifer is of Hartha –Tayarat confined aquifer, recharged from outside the border, definitely from Saudi Arabia.

The transmissivity varies from 200 m2/day – 1234 m2/day due to the variability of the sedimentological characteristics and their thickness.[12].The main structural boundaries that affect this hydrologic system are Horan Anticlinorium, subsurface Amij anticline, and also, the several Fault systems as mentioned in the item of structural setting. The storage coefficient is in the order of 10-4, where the effective productive thickness ranges between (200-350)m.[13]. The specific yield (rejuvenated storage) is of about 800 x 106 m3/year , where the estimated exploitation from these units is of about 0.75 x 106 m3/year .The specific capacity values of the productive wells are ranged between (0.2 -7.5) m3/hr/m. Finally ,the total storage is of about 62 x 109 m3 .

Hydrogeologic System of Tertiary Carbonates: This system includes water bearing horizons of Euphrates Fn. (Karstified and fractured carbonates).The karstification is usually restricted to the 10 m of basal conglomerate unit of carbonate pebble and cobbles. Also ,this system comprises the water bearing horizons of Al-Ghar sandstones and fractured Karstified carbonates of Karkuk Group Formations such as Shura , Shaikh Alas, Ana and Baba Formations. In this system Abu Jir fault zone is the main structural boundary that effects the hydrogeologic conditions throughout the discharge of the groundwater in the form of following springs extend among Hejlan – Hit- Shithatha, some of these springs are rich in bitumen due to the mixing of heavy oil and brine water from deep confined aquifer[15].The total length of the springs line along Abu-Jir faults is about 450 km, the total discharge of springs is 3000 l/sec.[5]. Water wells along this fault zone overflow with big discharge due to the sealing of Euphrates permeable layer by impermeable clay stone of Fatha and /or Injana formations as a result of fault displacement creating confining conditions. In the north part ,also Rattga carbonates may form a part of water bearing horizons with a transmissivity coefficient ranges between (10-90) m2/day and storage coefficient values in the order of 10-4 . The productive thickness of the water bearing horizons of Oligocene and Miocene sediments from Hit to Husaiba ranges between (110-150) m initiated at depth (50-70) m between Hit –Haditha – Ana.[15].

The transmissivity and storage coefficient range between (140-1200) m2/day and (1.3x 10-3 – 3.7 x 10-3) , respectively .The specific capacity values range between (1-10) l/sec/m. The productive thickness of the water bearing horizons of Eocene sediments, west (Razzaza, Habbaniya – Ramadi) ranges between (100-150) m. The transmissivity and storage coefficient of Eocene sediment (Dammam ranges between (84-1600) m2/day, (5x 10-5 -9x10-5) .The specific capacity Values of the production wells is > 10 l/sec/m. The specific yield of this province may be of 100 x 106 m2/day.[13].

Hydrogeologic system of Paleogene Carbonates: The Um-Erdhuma Formation consists of dolomite and dolomitic limestone with beds of Gypsum and Anhydrite. The upper part of about 125 m thick of limestone and dolomite represents the main aquifer. Argillaceous and chalky carbonate form an aquiclude between this system and the adjacent hydrologic system of Hartha – Tayarat units. The Karstification in the Underlying Gypsum due to the dissolution mechanism producing sinkholes and depressions in the overlying carbonates .The permeability of the aquifer in the recharge area is controlled by the intensity of karstification . The Dammam carbonate is the important water bearing horizons in the SE part of the studied area. Fractures ,fissures, joints, karst porosity controls the storage properties of water bearing horizons, where infiltration of rain water occurs quickly throughout karsts and sinkholes in the recharge area of this system. The transmissivity and storage coefficients of Um-Erdhuma Formation range between (0.88-2000) m2/day and (1.2 x 10-4 – 4.3 x 10-2) .The safe yield in this province is of about 75 x 106 m3/year [12] . The transmissivity and storage coefficient of Dammam Formation range between (100-1500) m2/day and (1 x 10-2 -3 x 10-2) ,respectively .[13].

Hydrogeologic system of middle Miocene sandstones and Pleistocene conglomerate: Miocene sandstone of 20 m thickness presents in a Graben near Nukhaib, while 18m of Quaternary conglomerates fill Nukhaib Graben. The exploitation wells in the Nukhaib depression penetrate Dammam aquifer , that means the sands and conglomerate play as a bypass media for groundwater percolation from this system to the Dammam Hydrologic unit, accordingly ,the excellent groundwater quality (TDS < 1000 ppm.) are present in this system as perched water, where the regional groundwater is of slightly brackish water. The depth of groundwater ranges between (100-200) m

from the land surface & the specific capacity values exceeds 10 l/sec/m.[14].

Hydrogeologic system of Jizera Euphrates (M. Miocene Gypsum): The water bearing horizons of Fatha Formation in this system extends from Dair-el-Zor depression in the west to Al-Tharthar Lake in the east and Euphrates River from the south. It includes beds of gypsum, marl and thin beds of limestones. Gypsum acts as an aquifer when it has been extensively karsitified , some times, the beds of limestone may act as an aquifer .The recharge of water bearing horizons is mainly controlled by rainfall infiltration, which is influenced by drainage patter and karst phenomena . The discharge of wells from this system is very low, where the transmissivity of Fatha aquifer for the major parts of the zone is about 1 m2/day, some times, locally due to karst phenomena, the transmissivity reaches 400 m2/day [14].The productive thickness may reach 30m from the land surface, while the effective thickness don't exceed 12m of limestone and /or karstified Gypsum, with a permeability value around 10 m/day.

Hydrogeologic system of the U. Miocene Sandstones: The water bearing horizons of Injana Formation (Habbaniya beds) represented by multi sandstones and siltstones beds Interbedded with the aquiclude sediment (Clay stones). The aquifer sediments exist in the area around Habbaniya Lake with its extension to the east of Al-Razzaza depression. These horizons overly the M. Miocene water bearing horizons represented by Euphrates and Fatha Formations, at the same time it is over land by the Quaternary deposits. . The hydrogeologic condition of these units is laterally, affected by the subsurface leakage process from M. Miocene aquifer which influenced by vertical upward mixing mechanism throughout Abu-Jir Fault zones. The groundwater depth within this system is not exceeds 40 m below land surface .The total thickness of the aquifers, aquitards and aquiclude sediments may reach 110 m to the SE of Habbaniya lack, where the productive thickness may reach 70 m ,[14] with, a permeability coefficient of (0.5 -10) m/day , Transmissivity coefficient of (30-200) m2/day and Storage coefficient of 5.3 x 10-3

Hydrogeologic system of the Quaternary alluvial Sediments:

The water bearing horizons of Quaternary sandy Gravel sediments represents the discharge zone of the regional groundwater flow, which acts as regular zone between groundwater and surface water of the Euphrates River. The hydrogeologic condition of Quaternary water bearing horizons is of unconfined bank storage state. These units extends from SE of Hit to the south of Falluja at the two banks of Euphrates river. The groundwater in this province has been high light due to its role in soil salinisation, because it is founded in the shallow subsurface zone (few meter depths). The upper aquicludes and aquitards thickness is usually of about (5-10) m. It's underlained by an aquifer of ten meters thick. The permeability of the aquifer ranges between (0.8 -10) m/day[14], while the transmissivity of the Quaternary deposits range between (10-200) m2/day.

Groundwater Depth:

Generally , the depth of the water table or peizometric surface range between (0.0 -350)m , increasing westwards near Jordanian – Iraqi border, (fig.6) [23] .The zero depth which presents the flowing artesian condition of the groundwater area found in the zone of Abu-Jir –Shithatha. The groundwater depths in the main physiographic province represented by Jizera and Mesopotamia province at the both banks of Euphrates , lower valleys province , Al-Hijara province, upper valleys province and Al- Hamad province are ranged between (5-20)m, (0-100)m, (100-150)m ,(150-250)m and (150-300)m ,respectively. The groundwater depths in the main hydrologic units , secondary perched aquifers and the depths of the exploitation bore holes are shown in table -3.

Groundwater Movements:

The hydrogeologic basins (systems) that are determined in the Governorate comprise many hydrogeologic units in the stable shelf area which represents the main hydrogeologic boundary conditions that affects the regional flow behavior of the groundwater. Regional slow groundwater may be found in the deeper zone west of Abu-Jir Fault zone, vertically upwards flow behavior of tortuous movement , caused obvious mixing mechanism observed as a deteriorate contaminated water as proved in the item of groundwater quality and facies in the area east of Abu-Jir fault zone. It reaches the Mesopotamian depression and Euphrates River which are defined as drainage discharge zones. An intermediate hydrogeologic zone was observed in the zone of Al-Hijara province and obviously detected in Hy-5 , 6 (Nukhaib Graben) ,(fig.7) , [23] where ,the groundwater moves towards this zone from three directions (NW , W , SW) ,this phenomenon shows that the groundwater seem to be discharged in this zone but , actually, the groundwater retarded in this zone reflected by low velocity , in any case ,the groundwater moves towards east with the regional flow direction. Shallow intensive hydrologic conditions are observed, in the Arial extent of upper Wedian and Al-Hamad provinces, also in many limited Arial extent, especially, in the valleys basins forming perched unconfined aquifers of good groundwater quality.

The groundwater movement is to the N and NW direction in the hydrogeologic units No.1 with a hydraulic gradient of about (0.0015). The groundwater flow in the hydrologic units No. (Hy-2) is towards north with a hydraulic gradient of about (0.0018), and towards north east with a hydraulic gradient of about (0.0016). The hydrologic gradient of

the groundwater within the hydrogeologic units No. (Hy-3) is 0.0025 east wards.
The ground flow within the hydrologic units no. (Hy-4) is:
-Towards NE in the northern part with a hydraulic gradient of about 0.0017.
-Towards E in the middle part with a hydraulic gradient of (0.0011).
-Towards E in the southern part with low hydraulic gradient of about 0.0008.
The groundwater movement in the hydrologic units (Hy-5, 6) is towards ENE with low hydraulic gradient of about 0.000006. The hydraulic gradient of the groundwater in the hydrogeologic units of (Hy-8, 9) is about (0.00058) east wards. Finally, the groundwater flow is towards SW and SE in Al- Jezira (Hy-7) with a hydraulic gradient of about 0.0015 and 0.0037, respectively. Uni-elongated model anomaly of high water table levels is observed from the groundwater flow map as shown in fig.(7) .The phenomenon represents the spatial distribution of major groundwater divide coincides with Horan valley direction. In the western part , the groundwater divide represents the divergent flow towards NE and SE from Horan valley zone , which means the groundwater is recharged from surface water run off along Horan valley during water surplus periods (rainy months) .
Regionally the eastern part of Horan valley represents convergent flow sector of groundwater from NW and SE directions. Locally, in this valley some perched aquifers which are present, recharged from seasonally water run off forming limited bank storage condition of good water quality. In the south part of the studied area ,the recharge zone is restricted to the outcrops of Um-Erdhuma Formation. The rain water and its run off infiltrates into the aquifer. The mechanism of the infiltration occurs through karst and sinkhole quickly. Generally, active recharge and infiltration of rain water may occur through the outcrops of the hydrologic units in the governorate, especially, in the valleys of exposed cut section. The rejuvenated water that recharges the hydrogeologic units from the rain water and run off is of about 1.2 x 109 m3 /year [13].The amount of water inflow that recharges the groundwater of the carbonates and sandstones hydrologic units is of about (0.82 x 109) m3 /year and (0.38 x 109) m3 / year and (0.38 x 109) , respectively. The water recharge within Al-Razzaza and Ruttba High Basins is (0.52 x 109) m3 /year and(0.68 x 109) m3 /year respectively. Another study of the rejuvenated recharge presented by[12], shows that the total specific yield in the hydrologic province is of about 92,000000 m3 /year. According to the abovementioned studies the inflow recharge to the groundwater, which represents the specific yield in the hydrologic units ranges between (0.921 x 109 -1.2 x 109) m3 /year.

Groundwater Salinity:

Shallow groundwater salinity map ,(fig. 8) [23], generally ,shows increasing of TDS values with the flow direction (from the west towards east). The salinity of the groundwater of the western hydrologic units of Al-Hamad and upper Wedian provinces is of slightly brackish water, where ,the TDS values range between (1000-3000) mg/l, with three produced zones of fresh water near Ruttba (Horan Valley), Swab valley and Nukhaib area. The salinity of the groundwater of the middle hydrogeologic Units is Al-Hijara and Lower Wedian provinces are of brackish water, where the TDS values range between (3000-6000) mg/l with pockets of salty water in playa basin such as (Bawara and Abu-Garis) and along Abu-Jir Fault zones , especially in Hit region the groundwater is of oil field water. The groundwater of the Mesopotamia plain, lower wedian provinces & east of Abu-Jir Fault zone is generally of brackish to salty types, where the TDS values range between (6000-10000) mg/l.

8- Groundwater Quality:

The phenomena that obtained from fig. (9),[23] are:
1- Generally ,the quality of the Groundwater in Al-Hamad province is of SO4 –Bicarbonate type. This type of water is naturally exist in the recharge zone of carbonate water bearing horizons , where Bicarbonate originated to the carbonate rocks which forming the media held water(aquifer) .The local discharge subzone of Al-Walaj syncline is of HCO3 – chloride type.
2- The quality of the Groundwater in upper Wedian province is of CL-Bicarbonate type, HCO3 – Sulphate type and Cl- Sulphate exists in the transitional zone (Intermediate Hydrodynamic Zone between recharge and discharge zones). Bicarbonate ions is originated to the dolostones, while sulphate ions is originated to the Gypsum in Um-Erdhuma ,Gypsious marl in Ubaid and Zor Huran Formations and gypsious sands of Najma Formation.
3- In Al- Hijara province ,the groundwater is of HCO3-Sulphate type represents the transitional zone and HCO3 –Chloride type which represents the initial part of discharge zone.
4- The groundwater quality of the lower Wedian ,Al-Jezira and Mesopotamian are of HCO3 –Chloride type and CL- Sulphate type , where the sulphate ions originated to the Gypsum and Anhydrite of Al-Fatha Formation and also to the Gypsious soil and Gypcrete of Quaternary deposits. Finally , upward deep leakage of groundwater is of SO4-Chloride type of oil field water.

Groundwater Use:

According to the hydrologic properties of the groundwater, spatial distribution map of groundwater uses is achieved as shown in (fig.10),[23] from this map the following zone can be deduced:
-Two elongated zones of potable perched groundwater (TDS ; <1000 mg/l) can be used for human drinking these zones are within Swab and Horan basin.

-Three zones of groundwater can be used for domestic purpose (TDS ; (1000 – 1500)mg/l) .These are situated in swab , Horan and Nukhaib area.
-Domestic zone of high groundwater majority can be used for agricultural purposes such as irrigation and animal drinking (TDS ; (1500– 3000) mg/l .
-Local zone of salty groundwater controlled the production in saltern pan exists in Abu-Gharis and Al-Bawara basins (TDS ; > 10000 mg/l).
-Zone of groundwater exists in both sides of Euphrates river obtained (Lower Wedian province ,Al-Jezira and Mesopotamian province). The groundwater in this zone can be used for irrigation the tolerant plants in good drain soil , also can be used for medicinal uses, (TDS ; (3000-10000) mg./l
-Zones of oil field water associated with the bituminous production in Hit and Abu-Jir areas.

Discussion:

This hydrogeologic study covers the examination of quantitative and qualitative evaluation of the groundwater within the hydrologic systems in Al-Anbar Governorate .The conclusions are abstracted in the following items:-

1- It is difficult to face the hydrological phenomena in the area of large surface , without using many scientific aspects such as atmospheric , topographic, structural , geological settings and environmental aspects, accordingly , this study depends on physiologic classification of the area which comprises the abovementioned aspects to solve proceed reliable hydrological interpretation. The physiographic provinces in the studied area are ; Al-Hamad , upper Wedian Al-Hijara , Lower Wedian , Al –Jezira and Mesopotamian plain.

2- The combination among the atmospheric aspects (rainfall, evaporation and temperature) shows three class zones of water replenishments , the best zone is situated in the North and North East of the governorate. The second zone is in the middle portion of the governorate which may represents the transitional zone between recharge and discharge zone . The third zone is in the South and South East of the governorate which represents the discharge zone .

3- This regional hydrological study needs many bases such as : hydrological structural and sediment logical studies to classify the hydrological problems and prevent the bias interpretation for each phenomena .Accordingly , the hydrological parameters and aspects are discussed and classified in nine hydrologic systems, these systems are:

-Hydrogeologic system of U.Cretaceous – Paleogene Fractured Carbonates: this system includes the water bearing horizons of Hartha Tayarat Formations, Digma , Akashat – Rattga Formations.
-Hydrogeologic system of Permo-Carboniferous sandstones : This system includes the water bearing horizons of Ga'ara Formation.
-Hydrogeologic system of Mesozoic Fractured Carbonates and Porous sandstones : This system includes the water bearing horizons of Mullusa , Zor-Horan , Ubaid , Hussainiyat – Amij, Najma –Muhaiwir , Naher Umer – Maudod , Hartha –Tayarat Formations.
-Hydrogeologic system of Tertiary (Paleogene – Neogene) Carbonates : this system includes the water bearing horizons of Euphrates ,Karkuk group (Shura , Shaikh Alas , Ana , Baba Formations.
-Hydrogeologic system of Paleogene karstified , fractured Carbonates : this system includes the water bearing horizons of Um-Erdhuma , Dammam Formations.
-Hydrogeologic system of Pleistocene –Miocene sandstones and conglomerate: this system includes the water bearing horizons Ghar and Zahra Formation and Nukhaib Graben fills.
-Hydrogeologic system of Middle Miocene of the Jezira area : this system includes the water bearing horizons of Fatha Formation (Karstified gypsum and limestone)
-Hydrogeologic system of U. Miocene sandstones: this system includes multi water bearing horizons of Injana (Habbaniya) Formation.
-Hydrogeologic system of Quaternary Sands and Sandy Gravel: this system includes the water bearing horizons of various alluvial sediments in the Mesopotamian province.

4- The Hydraulic parameters of the hydrologic units within the hydrologic systems are abstracted in the table No.(4) .

5- The Groundwater depth in the main aquifers ranges between (< 10-350) m below land surface , while the groundwater depth in perched aquifers ranges between (< 50-120) m below land surface. Also ,the depths of the exploitation boreholes in the governorate are ranged between (5-700) m below land surface.

6- Two regional recharge zones of high groundwater levels affects the groundwater movement separated by Nukhaib Graben . The first recharge zone is the area that influenced by Hail Arc and its extension, especially in Ruttba High. The second recharge zone is in the area that influenced by Wagssa High in the south and South East of Nukhaib Graben .On the other hand highest permeability occurs in a depression where storage water circulation take places , and the run off water flow into Nukhaib Graben from many valleys. Another high groundwater levels vary from (250-300) m above sea level is presented in Abu-Rassayin High which represents the recharge zone in the north portion of Al-Jezira district. Also, the groundwater is replenished by rain and run off water , where , the amount of the in flow recharge to the groundwater which represents the safe yield of the hydrogeologic units ranges between (0.921 x 109 – 1.2 x 109) m3/year. The direction of the groundwater movement is towards N, NE, E in Al- Hamad district with a hydraulic gradient of about 0.0015 , and towards NE ,

E in the other districts with a hydraulic gradient ranges between (0.000006 – 0.0037). Abu-Jir Fault zone and Euphrates river represent the discharge zone of the groundwater in the governorate.

7-The groundwater is of slightly brackish water in the recharge area , where ,TDS ranges between (1000-3000)mg/l graduated to brackish water in the transitional zone where TDS values ranges between (3000-6000) mg/l .Then the groundwater becomes of brackish to salty water in the discharge zones east of Abu-Jir Fault zone and the area near Euphrates rivers in Mesopotamian province, where the TDS values range between (6000 - > 10000) mg/l

8- Three groups of groundwater types are existed in the studied area, these are :-

-Bicarbonate group observed in the recharge zone (Al-Hamad region)

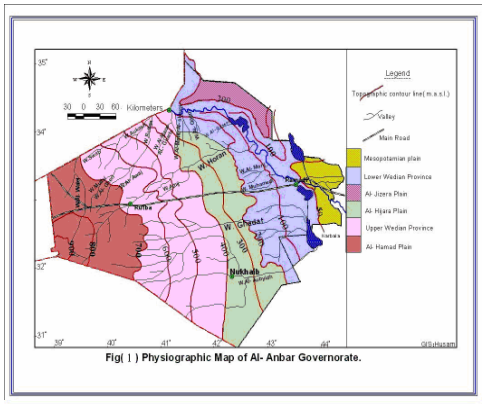
-Sulphate group observed in the transitional zone (U. Wedian , Al-Hijara and Al-Jezira Districts).

-Chloride group observed in the discharge zone (L. Wedian and Mesopotamian Districts)

9- the groundwater of perched aquifers classified as water used for human drinking water and domestic purposes. The majority regional groundwater classified as water can be used for agricultural purposes, especially , in the areas of recharge and transitional zones, while the groundwater in the discharge zone can be used for irrigation the plants that tolerate salts in good drained soils. Some of water points in this zone can be used for medicinal purposes (needs advance researches) . Deep upward groundwater flow controls the production of tar in some spring, also, groundwater controls the precipitation of Halite in Sabkhas and salt pans, such as in Abu-Gharis and Al-Bawara depressions. Finally, the groundwater zones that recommended for potable and domestic uses exist in the valleys fill sediments (sands and Gravels) , also occurred beneath shoulders and banks of valleys composed of high permeable rocks.

Recommendations : The groundwater in the studied area is mainly recommended for Agricultural purposes (Irrigation Animal Drinking purposes). A significant Arial extent zone includes groundwater of unsuitable uses for irrigation but it can be used for tolerant plants, in the availability of good drain soils. The groundwater of unsuitable uses for Human Drinking , can be used for medicinal purposes, especially , there is a significant existence of some chemical uses as medicinal evidences factors, such as ions , elements , Gases are observed in the chemical composition of the groundwater. According to the qualitative and quantitative evaluation of the groundwater within the hydrogeologic units; ten suggested preferable zones of groundwater for different uses are determined as shown in the spatial distribution map (fig. 11) .

The hydrogeologic properties of these preferable zones are complied in table No.(5) .



Fig(1) Physiographic Map of Al- Anbar Governorate.

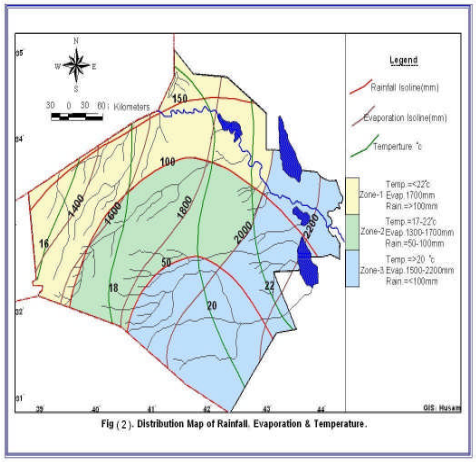


Fig (2). Distribution Map of Rainfall, Evaporation & Temperature.

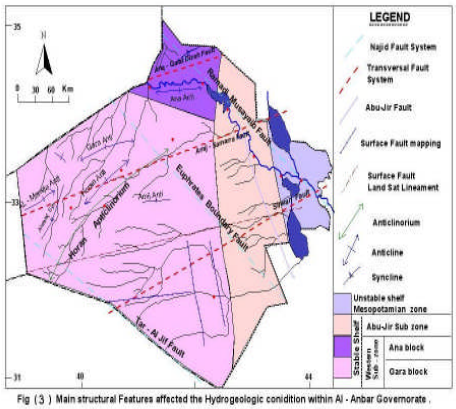
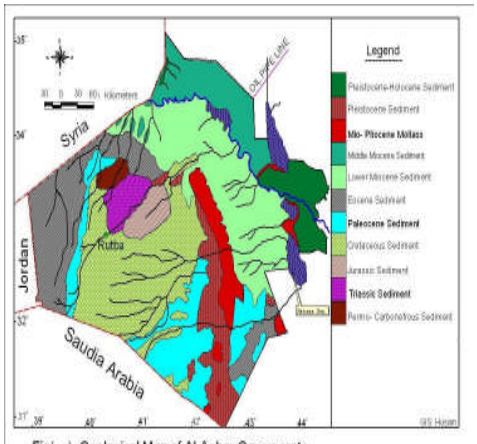


Fig (3) Main structural Features affected the Hydrogeologic conidition within Al - Anbar Governorate .



Fig(4). Geological Map of Al-Anbar Governorate.

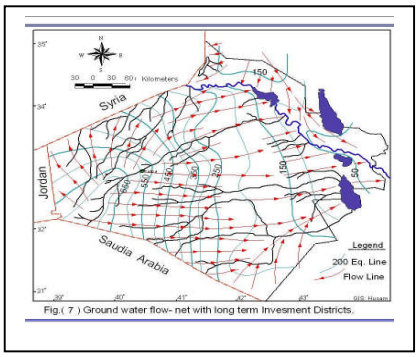
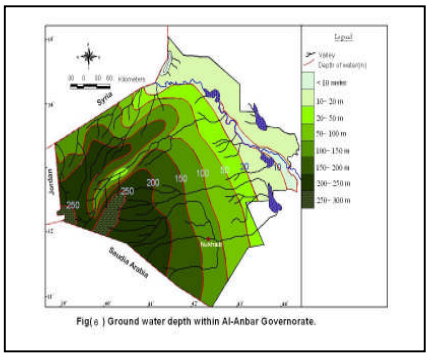


Fig.(7) Ground water flow- net with long term Invesment Districts.



Fig(6) Ground water depth within Al-Anbar Governorate.

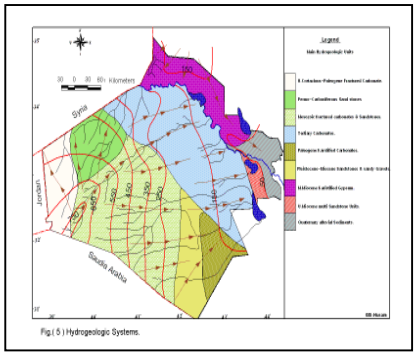


Fig.(5) Hydrogeologic Systems.

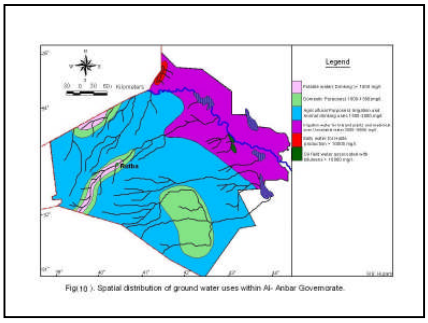


Fig.(10) Spatial distribution of ground water uses within Al- Anbar Governorate.

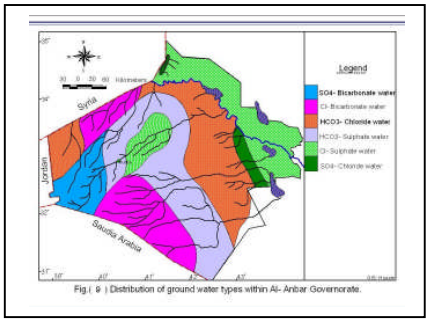


Fig.(9) Distribution of ground water types within Al- Anbar Governorate.

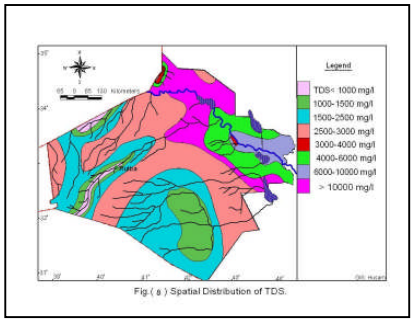


Fig.(8) Spatial Distribution of TDS.

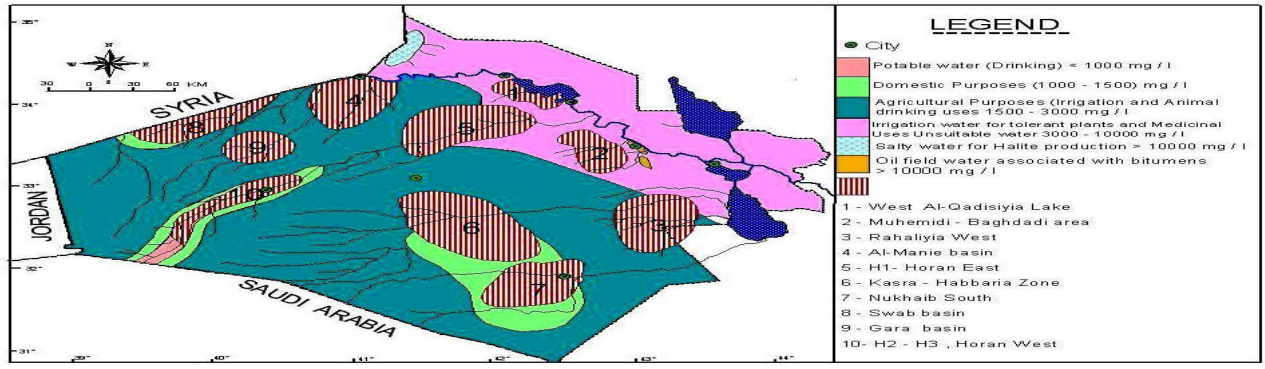


Fig (11)Spatial distribution of ground water districts for exploitation.

Table-1 : Annual rain fall (mm), evaporation(mm), temperature ^{o}C .			
Climate factor / zone	Annual rain fall (mm)	Annual evaporation (mm)	Annual temperature C
Zone-1	> 100	< 1700	< 22
Zone-2	50-100	1300-1700	17-22
Zone-3	< 100	1500-2200	> 20

Table (2) Geologic Information of Al-Anbar governorate

era	Period		Age	Formation	Depression
Cenozoic	Quaternary		Holocene- Pleistocene	Recent deposits	Alluvial sediments, valley & depression fills ,etc.
	Tertiary		Pleistocene	Sandy gravel /Huran, Habbarriya, Mesopotamia	Sandy gravel ,conglomerate
			Mio- Pleistocene	Zahra	Limestone, sandy , Limestone
			U . Miocene	Injana Fn. Habbaniya	Interbedded of clay stones & sandstones
			M. Miocene	Fatha Fn.	Gypsum & Anhydrite ,limestone marl & clay.
			L. Miocene	Euphrates Fn.	Fossiliferous , chalky , limestone ,dolomitic
			L. Miocene	Al- Ghar Fn.	Sandstone & calcareous Sandstone
		Paleogene	U. Oligocene	Ana Fn.	Fossiliferous , coralline limestone.
			M. U. Oligocene	Baba Fn.	Hard limestone & Dolomite
			L. Oligocene	Shura / sheikh Alas Fns.	Carbonates
			Eocene	Ruttga / Damam fns	Dolomite . dolomite limestone , limestone's
			Paleocene	Akashat /Um-urdhuma fns.	Phosphates limestone / Dolostone. dolomite .
Mesozoic	Cretaceous		U. cretaceous	Murraybit / Digma Fns.	Sandy limestone interbedded with pebbly sandstone.
			U. cretaceous	Hartha-Tayarat Fns.	Dolomitic limestone , silty clay sandstone
			U. cretaceous	Ruttba-Msad Fns.	Dolomite –sandstones
			L. cretaceous	Naher Umer –Muddod	Silt , Marl , dolostone , limestone
	Jurassic		U. Jurassic	Najma Fn.	Sandstone ,limestone, Marl , Marly limestone.
			M Jurassic	Muhaywir Fn	Marl , sandstones , carbonate
			L-M Jurassic	Amij – Hussayniat Fns.	Claystones , sandstones , Iron Ore & dolomite
			L- Jurassic	Ubaid Fn.	Dolomite ,Gypsious , Marl, Dolomitic Limestone
			U. Triassic	Zor Huran Fn	Marl , Marly limestone . Dolostone ,Gyp .Marl
	Triassic		U. Triassic	Mullusa Fn.	Limestone, dolomite limestone & dolostone.
Paleozoic	Permo-carboniferous			Gara Fn.	Interbedded of clay stones & sandstones

Table (3). The depths of the groundwater in main & secondary hydrologic units:			
Hydrologic unit No.	G.W depths in the main aquifers (m)	Depths of the exploitation bore holes (m)	G.W.D in the secondary perched aquifer
Hy - 1	175-350	(120-200),(200-330),(330-400)	100-120
Hy - 2	125-250	(200-400),(400-700	20-90
Hy - 3	175-250	150-350	35-70
Hy - 4	0.0-150	(50-100),(110-150)	20-30
Hy - 5	100-175	(50-250)	< 50
Hy - 6	100-200	100-250	< 50
Hy - 7	10-20	10-30	/
Hy - 8	10-20	10-70	/
Hy - 9	< 10	5-20	/

Table (4) :Hydraulic Parameters of the Hydrologic System				
Hydrogeologic System	Transmissivity m^2/day	Storage Coefficient	Specific Capacity m^3 / hr./m	Safe Yield m^3 / year
Hy - 1	10-350	$1.0x10^{-4}$ - $5x10^{-2}$	0.5-2.0	$0.725x10^6$
Hy - 2	30-250	$1.0x10^{-2}$ -$9x10^{-2}$	0.1-3.0	$46x10^6$
Hy - 3	200-1200	$1.0x10^{-4}$ – $9x10^{-4}$	0.2-7. 5	$800x10^6$
Hy - 4	10-1600	$5.0x10^{-5}$ - $3x10^{-3}$	3-36	$100x10^6$
Hy - 5	0.9-2000	$1.2x10^{-4}$ - $1.0x10^{-2}$	/	$75x10^6$
Hy - 6	100-1500	$1.0x10^{-2}$ - $3.0x10^{-2}$	/	/
Hy - 7	1-400	/	/	/
Hy - 8	30-200	$1.0x10^{-3}$ - $5.3x10^{-3}$	0.1-1.0	/
Hy - 9	10-200	10^{-3} - 10^{-3}	3.0-10	/

Table (5) Hydrogeologic properties of preferable groundwater zones

Zone No.	Zone Name	Area Km^2	Groundwater Depth From Land Surface (m)	Well Depth (m)	Discharge l/sec.	Specific Capacity l/sec/m	TDS mg/l	Remarks
Zone 1	West of Al-Qadisiya Lake	900	30-50	100-150	10-25	1-10	2500-4000	Tertiary Sediments
Zone 2	Mohemidi-Baghdadi Areas	2000	0-20	80-100	< 20	1-12	3000-5000	Tertiary Sediments
Zone 3	West Rahaliya one	3200	0-50	100-150	1-15	1-10	2000-4000	Tertiary Sediments
Zone 4	Al-Manie Basin	4000	100-230	230-320	4-10	< 1	1500-3500	Tertiary Sediments
Zone 5	Horan East (H1)	4400	150-200	250-350	10-20	5-13	1000-3000	Tertiary Sediments
Zone 6	Kasra-Habbaria Zone	5500	100-150	350-400	10-30	10-25	600-3000	Cretaceous Sediments
Zone 7	South Nukhaib Zone	3600	100-150	100-300	> 15	8-12	1000-3000	Cretaceous Sediments
Zone 8	Swab Basin	2000	35-200	100-300	5-10	1-2	500-3000	Tertiary Permo-Carboniferous Sediments
Zone 9	Ga'ara Basin	2000	40-110 180-200	100-150 250-350	5-30	1-2	600-1500 2000-3000	Tertiary Permo-Carboniferous Sediments
Zone 10	H2,H3 Horan West	1500	35-150	50-250	< 1-5	1-10	400-2500	Triassic-Jurassic Cretaceous Sediments

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الظروف الهيدروجيولوجية في محافظة الانبار

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الخلاصة

خلصت الدراسة إلى تحديد الظروف الهيدروجيولوجية والخصائص الهيدروليكية للخزانات الجوفية ضمن النظام الهيدروجيولوجي الإقليمي في محافظة الانبار بالإضافة إلى تحديد حركة المياه الجوفية من مناسيب المياه الجوفية اخذين بنظر الاعتبار الوضع الجيولوجي العام والذي يشمل الظواهر الجيومورفولوجية والتركيبية والرسوبية في المنطقة .اهتمت الدراسة أيضا بتحديد انطقه نوعية المياه الجوفية من خلال خرائط توزيع تراكيز الايونات والمواد الذائبة الكلية والنتائج المستنبطة من هذه الدراسة هي:

– تحديد انطقة نوعية المياه الجوفية من خرائط توزيع السحنات الهيدروكيميائية للمياه والملوحة و تحديد الخزانات الجوفية الرئيسية ذات الإنتاجية المؤهلة للاستثمار مع إعداد خرائط عمق المياه الجوفية وحركتها في خرائط موحدة مشتقة من دراسات هيدروجيولوجية سابقة.– تحديد انطقه المياه الجوفية وتصنيفها مع إجراء دراسة تفضيلية لاختيار المقاطعات ذات الأولوية للاستثمار المستقبلي وللاستخدامات المختلفة.