

## Geoelectric investigation of groundwater potential in Khor Abu Habil drainage basin

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**Abstract:** Geoelectric investigation for groundwater in Abu Habil water shed, northern Kordofan and it's environ was done using the Vertical Electrical Sounding (VES) method. Twenty two vertical electrical soundings data were acquired within the locations in the study area Borehole data were also acquired. Electrical resistivity methods are frequently used as investigation tool in groundwater exploration to obtain, details about the location, depth and apparent resistivity of the subsurface layers. Schlumberger Vertical Electrical Sounding (V.E.S) measurements were conducted using a portable ABEM SAS1000 instrument. The acquired data cover a wide range of resistivity values from 3.0  $\Omega\text{m}$  to more than 5500 $\Omega\text{m}$ , which generally reflects the variation of resistivity within the sediments and the basement complex. However, the interpretation of vertical electrical sounding is presented in the form of geoelectrical sections. The general trend of The depth to the basement .these geological sections is east – west and north – south and structural contour maps are constructed on the basis of present VES interpretation. The present work can be correlated to previous gravity research which shows low gravity anomalies in Kordofan Province that indicate presence of thick sediments. The aquifer mostly sandstone and, sand with gravel, which is associated with intermediate resistivity range between (25 to 60  $\Omega\text{m}$ ) and, the average static water level of about 72 meters in the study area. The study reflects the existence of relatively thick sediments, whereas the thickness does not exceed 25 m in the southwest.

**Keywords:** *geoelectrical, underground water, aquifer, borehole section.*

المستخلص: تم إجراء مسح كهربي للكشف عن المياه الجوفية في خور أبو حبل -شمال كردفان وهذه التقنية تعرف ( vertical electrical sounding ) تقنية التيار الكهربي الرأسية حيث تم تجميع البيانات الكهربية للطبقات الأرضية بتنفيذ عدد اثنين وعشرون محطة قراءة كما تم جمع بيانات بنوية في منطقة الدراسة. كما هو معلوم تستخدم تقنية الاستكشاف الكهربي للكشف عن خزانات المياه الجوفية حيث تعتبر هذه الطريقة سريعة وقليلة التكلفة. تم استخدام جهاز ABEM SAS1000 مع ملحقات حيث يوفر تيار كهربي كاف يمكن إرساله حتى عمق 100متر وذلك في حال كانت المسافة الفاصلة بين أقطاب للتيار بحدود 300متر. ومن بعد ذلك يتم التعامل مع القراءات المتحصل عليها بمعايرتها بمعامل هندسي يعتمد علي كيفية النشر والمسافة الفاصلة بين الأقطاب ومن ثم تحويلها لمقاومة ظاهرية. ومن القراءات المتحصل عليها وبطرق تفسير دقيقة يتم حساب المقاومة الحقيقية ومن ثم حساب سمك الطبقات المستهدفة. البيانات المتحصل عليها في هذه الدراسة تشمل قراءات بين 3.1 أوم إلي أكثر من 5527 أوم مما يعكس التغييرات الكبيرة في قيم الكهربية بين الصخور الرسوبية وصخور الأساس. تم عرض النتائج في صورة مقاطع كهربية أرضية اتجاهها العام شرق-غرب وشمال جنوب حيث توجد مكاشف صخور الأساس فس جبل الداير ومنطقة السميح وأقصى الجنوب الشرقي عند جبل كون. كما يمكن ربط نتائج هذا العمل مع معطيات أبحاث سابقة بطريقة الجاذبية والتي أعطت قيم منخفضة للمجال الجاذبي مما يعبر عن وجود صخور رسوبية سميكة.

الخران الجوفي في المنطقة عموماً من متكون من صخور رملية مع تداخل الحصى الرملي حيث مستوي الماء الجوفي حوالي 72 متر. عموماً معطيات الدراسة هذه دلت علي وجود صخور رسوبية سميكة جداً كما أشارت لسماكة لاتتعدى الـ 25 متراً في جنوب غرب منطقة الدراسة.

كلمات مفتاحية: كهربية أرضية – مياه جوفية - خزان جوفي- مقطع بنري

### Introduction:

Groundwater is characterized by a number of parameters which are determined by geophysical methods such as electrical resistivity, seismic, magnetic and gravity. In this work, electrical resistivity survey was employed. Electrical resistivity method in geophysical exploration for groundwater in a sedimentary environment has proven reliable. Records show that the depths of aquifers differ from place to place because of geo-structural occurrence. Electrical resistivity method is one of the most useful techniques in underground water geophysical exploration because the resistivity of rock is very sensitive to its water content. In turn, the resistivity of water is very sensitive to its ionic content.

There are various studies in kordofan province about environmental degradation, desertification, soil and fix sand dune, but the studies for water supply and water management is not cover. <sup>(1)</sup> He talk about sand dunes in Western Sudan and provide that they were produced from weathering, erosion, transportation and deposition by aeolian and rainfall. <sup>(2)</sup> Did interpretation of low gravity anomalies in Kordofan Province. <sup>(3)</sup> Conduct geophysical, geological, and hydrogeological research in Kordofan province. <sup>(4)</sup> The hydrogeological principles for planning groundwater exploration projects in western Sudan. <sup>(5)</sup> Suggested that saline lakes, and the depth of Um Ruwaba reach to about 15000ft (4573.171meters). <sup>(6)</sup>

Hydrogeological zones for planning groundwater exploration projects in western Sudan. <sup>(7)</sup> Did soil survey in Kordofan based on satellite imagery interpretation, <sup>(8)</sup> studied, mapped and locate Aeolian features (sand dunes) using land sat imagery.

Environmental studied of khor Abu Habil and management of natural resources and desertification, <sup>(9)</sup> Groundwater hydrology of west- central Sudan <sup>(10)</sup> project in sedimentary facies of Abu Habil terminal fan. <sup>(11)</sup> project in geomorphologic studied in Abu Habil drainage basin. <sup>(12)</sup> Final report on water supply situation and future development plans in Kordofan province.

The purpose of this study is to evaluate the groundwater potentiality in Khor Abu Habil drainage basin, which is extends to about 1000 Km and covers an area of approximately 6000 km<sup>2</sup>. The geological units in the study area are mainly; the basement complex, sedimentary rocks and alluvial deposits. The sedimentary rocks include: Cretaceous sedimentary rocks, Um Ruwaba and Nawa Formations, where superficial deposits include clayplain and sand dunes <sup>(1)</sup>. The rainfall ranges between 680 mm and 310 mm per year. Khor Abu Habil originates from Nuba Mountains through Delleng hills and flows eastward toward the White Nile. The present study focuses on groundwater resources between longitudes 29° 30' - 32° 50' E and latitudes 12° 00' - 13° 40' N.

### Methodology:

The resistivity variations of formations enable to delineate different layers using measured values. Electrical resistivity varies with rock or sediment type, porosity and the quality and quantity of water, and is a fundamental property of earth materials. Electricity can be conducted in the earth electrolytically by interstitial fluids (usually water) and electronically by certain materials, such as clay minerals, by cation exchange. As

a result, poorer quality ground water (that water with higher concentrations of dissolved solids) or sediments with higher clay content are usually more conductive<sup>(13)</sup>. Resistivity is expressed in ohm-meters, and is an estimate of the earth resistivity calculated using the relationship between resistivity, an electric field, and current density (ohm's law), and the geometry constant, spacing of the current and potential electrodes. Where the earth is not homogeneous and isotropic, this estimate is called the apparent resistivity, which is an average of the true resistivity in the measured section of the earth.

Schlumberger Vertical Electrical Sounding (V.E.S) measurements were conducted using a portable ABEM SAS1000 instrument with transmitter capable of producing a maximum of 500 voltages, enough to ensure a penetration depth of about 100 m for a separation of 300m between the current electrodes. Then these measurements are converted to apparent resistivity values by scaling them by geometrical factor which depends on the type of array as well as

spacing between the electrodes. The results were then plotted on log-log paper, after that the appropriate method of interpretation was used to compute the true resistivity and thickness of the layers. The Land - sat Thematic Mapper (TM) as remote sensing Technique was used for hydrogeological map preparations.

**Data Acquisition and Processing:**

A total of twenty two vertical electrical soundings have been made, for the major part located near surveyed profile lines. The maximum spread length (L) generally between 250m and 1400m. The VES locations are shown on the map in Figure (1). The spread directions and spread lengths are given in Table (1). With the VES technique the apparent  $\rho_a$ .  $L/2$  distances are plotted on double logarithmic paper; the relationship usually shown as a smooth curve. Then the field data were plotted on semilogarithmic paper, with the apparent resistivity data along the vertical logarithmic axis, and the location of the stations on the horizontal scale.

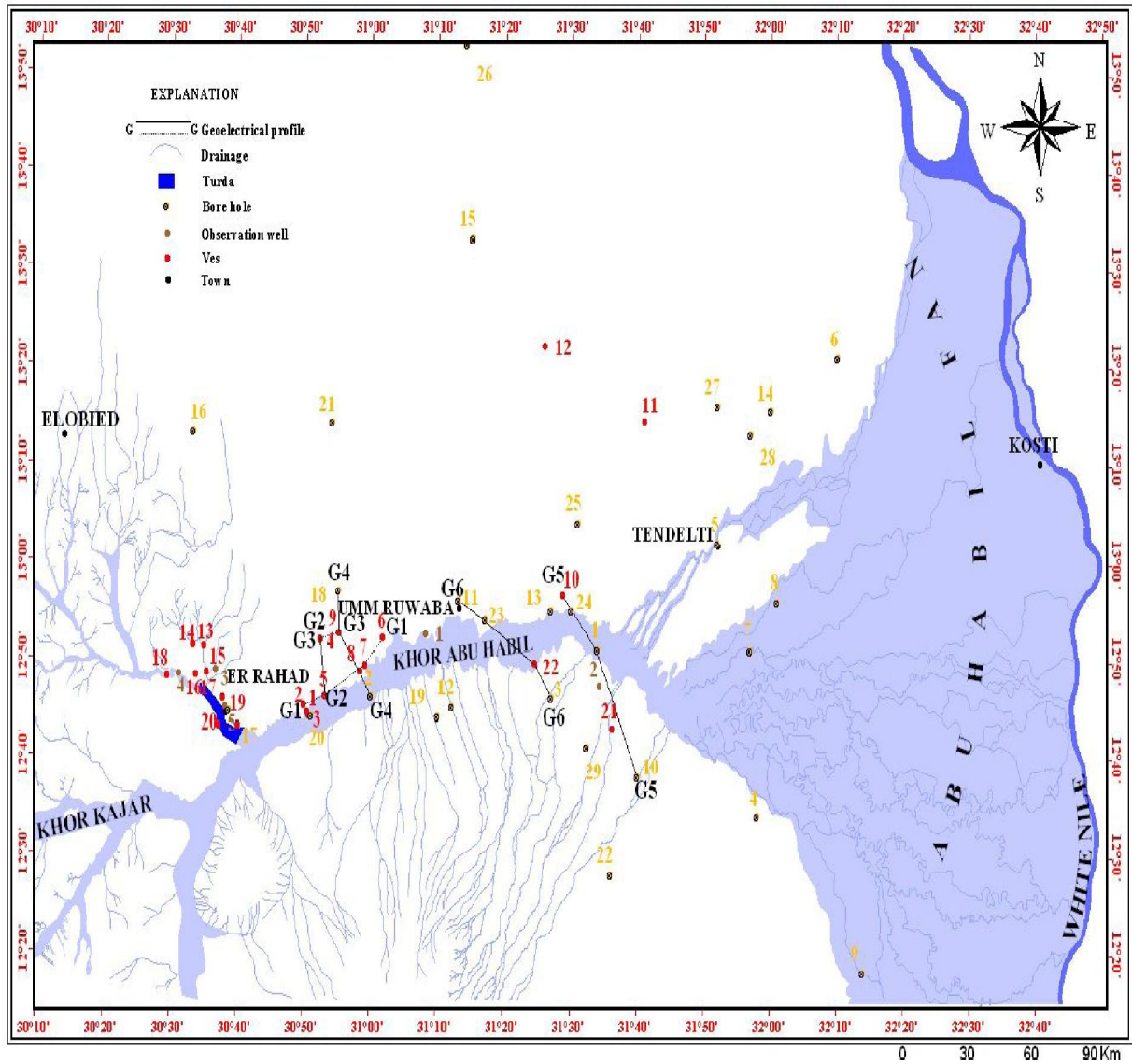


Figure (1): locations map: VES locations and line sections

Table 1: list of sounding and simple interpretation

VES. No	Long	Lat	No of layers	Depth to basement (meter)	Spread A-B(meter)
1	30.83898	12.72279	3	56	250
2	30.83167	12.73424	3	7.8	250
3	30.84316	12.71728	3	8.5	400
4	30.87193	12.84859	4	44	800
5	30.88450	12.74974	5	43	400
6	31.02973	12.85195	6	58	500
7	30.98427	12.80510	5	ND	1000
8	30.97190	12.79555	5	ND	600
9	30.91758	12.85904	7	25.5	1200
10	31.48013	12.92725	4	ND	1200
11	31.68264	13.22366	5	141	1200
12	31.433	13.35	5	347	1400
13	30.58081	12.83445	3	9.5	1000
14	30.55188	12.83625	4	8	1400
15	30.58598	12.792166	5	19.5	1200
16	30.55956	12.787733	3	3.8	1000
17	30.62751	12.746116	3	3	600
18	30.48663	12.783116	4	18	1400
19	30.66691	12.7003	6	ND	1600
20	30.61823	12.699416	5	ND	800
21	31.6025	12.698766	5	124	250
22	31.409	12.486 6	6	ND	600

ND: Not Detected

**Results and Discussion:**

The vertical electrical sounding (VES) data of the area covered a wide range of resistivity values from 3.0  $\Omega\text{m}$  to more than 5500 $\Omega\text{m}$ , which generally reflects the variation of resistivity within the sediments and the basement complex. However, the results of vertical electrical sounding are presented in the form of geoelectrical sections along the profile Figure (2) (geo1, geo2, geo3, geo4, geo5 and geo6). The general trend of these geological sections is east – west. Depth to the basement and associated structures contour map Figure (3) is constructed on the basis of present VES interpretation and Boreholes. The map reflects the existence

of relatively thick sediments, whereas these sediments do not exceed 25 m in the southwest. The basement complex crop out in Jebel Ed Dair, Jebel Dumbair, J.Es Semeih and at Northeast area at Jebel Kone, whereas it is found at more than 340 m deep in the north and northeast area. The present work can be correlated to Bouguer contour map <sup>(2)</sup>. Figure (4), which shows low gravity anomalies in Kordofan Province western Sudan that indicate presence of thick sediments.

The aquifer mostly sandstone and sand with gravel, is associated with intermediate resistivity range between (25 to 60  $\Omega\text{m}$ ).

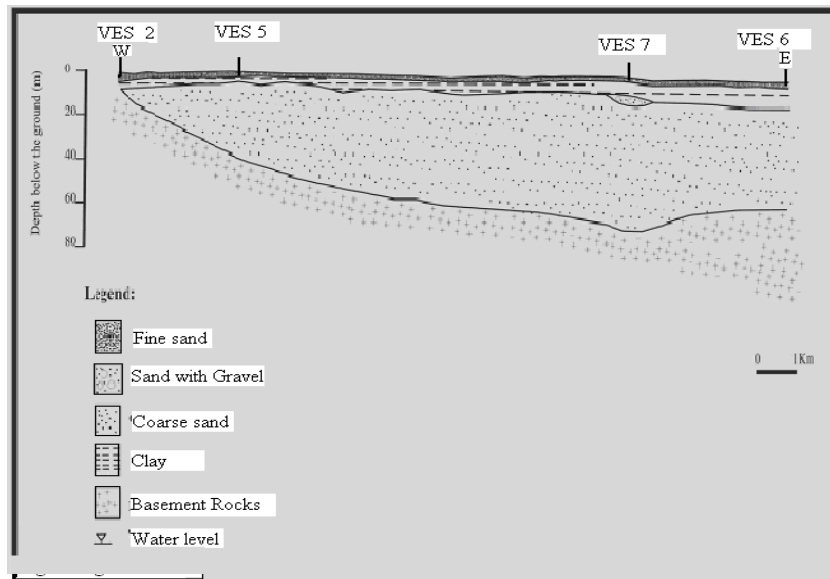


Figure (2): Geoelectrical section (geo 1)

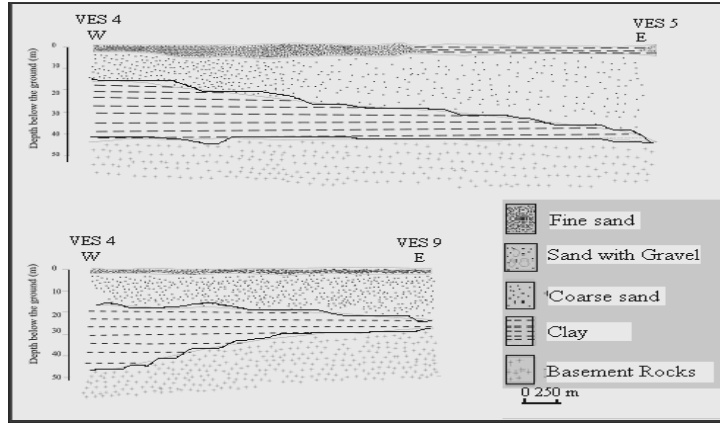


Figure (2): Geoelectrical section (geo 2 and 3)

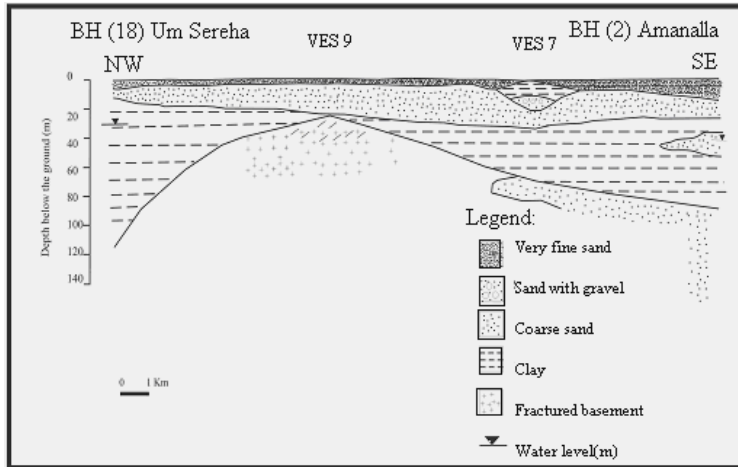


Figure (2): Geoelectrical section (geo 4)

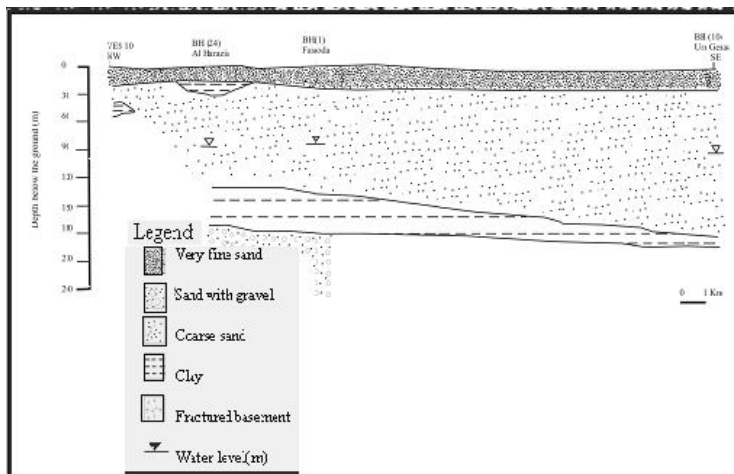


Figure (2): Geoelectrical section (geo 5)

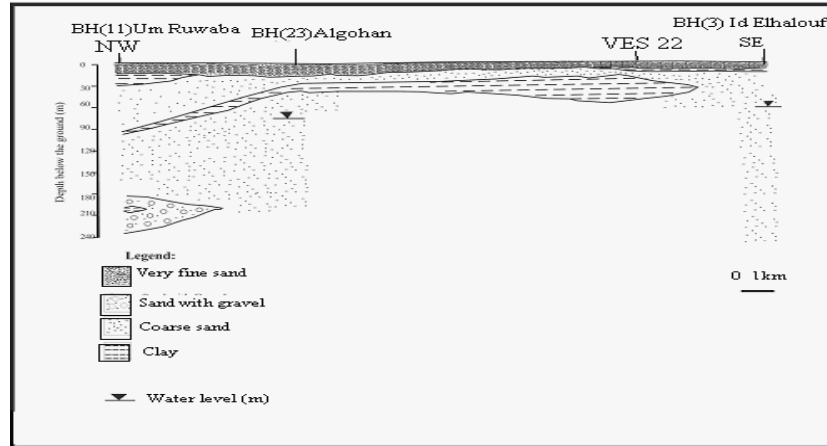


Figure (2): Geoelectrical section (geo 6)

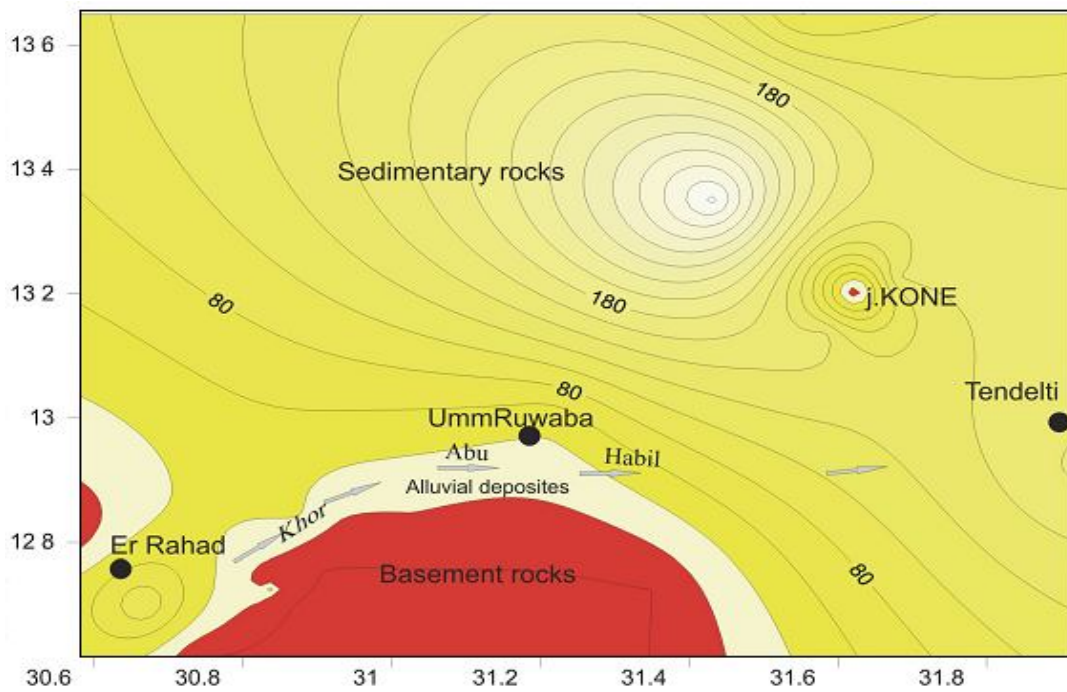


Figure (3): The distribution of the Basement rocks and Sedimentary rocks in study area (Data obtained from resistivity and boreholes)





### Conclusion:

The study area is located in North Kordofan State. The length of Khor Abu Habil about 1000 km, originate from basement rocks at Dilling area and spreading out at Tendelti Town. The geophysical methods used in this study, is the electrical resistivity methods (Horizontal electrical profile and vertical Electrical Sounding) to carry out the expected potential sedimentary thickness in the area. The groundwater system can be identified by two aquifers types, namely, shallow aquifers and deep aquifer. The former includes the upper Umm Ruwaba, Wadies, and sand dunes aquifers; this group is considered as perched water. The aquifer mostly sandstone and sandstone with gravel, which are associated with intermediate resistivity range between 25 to 60  $\Omega$ m, with the average static water level about 72 meters in this area. The depth to water range from 76m to 89 m from the surface at the center of the drainage basin. The main recharge source of groundwater in shallow aquifers in the study area is the seepage from rainfall and surface natural pool percolations, where the deep groundwater aquifers are recharge through the regional groundwater regime.

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