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Assessment of Diyarbakır Basalt Aquifer Hydrogeological Analyzed and Obtains Thematic Maps with GIS Geostatistical Analyst Tool

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Abstract: Diyarbakır basalt aquifer is volcanic-rock aquifers which contain high quality water. It was main resources for Diyarbakır city center drinking supply up to 2005. Somewhere, basalt aquifer groundwater is still used for irrigation in rural areas of Diyarbakır city. In the study, Diyarbakır city center's (which is located on the Tigris river basin) basalt aquifer groundwater potentials and hydrogeological features are examined and modeled by using GIS programmer. Firstly, general geological data, meteorological data and general information about natural water sources are collected together, afterwards, logs of well drilled by public institutions and private individuals within the Diyarbakır city center are analyzed. Static water level, dynamic water level and well pumps yields are classified in these logs. Then, thematic maps produced with the help of Arc Info Professional GIS programmer with geostatistical analyst tool. Groundwater source potential of Diyarbakır is examined by means of these thematic maps. In hydrogeological research, productivity by aquifer features, water retention capacity and groundwater level data evaluated with geological structure of area are taken into consideration.

Key words: Diyarbakır city center, basalt aquifer, groundwater, groundwater static level, dynamic water level, pump yield efficient, Geographical Information Systems (GIS).

1. Introduction

Volcanic rocks have a wide range of chemical, mineralogical, structural and hydraulic properties, mostly due to variations in rock type and the way the rock was ejected and deposited. Basaltic lavas tend to be fluid, and they form thin flows that have considerable pore space at the tops and bottoms of the flows. Numerous basalt flows commonly overlap, and the flows are separated by soil zones or alluvial material that forms permeable zones. Columnar joints that develop in the central parts of basalt flows create passages that allow water to move vertically through the basalt. Basaltic rocks are the most productive aquifers in volcanic rocks. Groundwater is mostly stored in vesicular basalt that may be fresh to highly weathered, and movement of this water is facilitated by pathways through both vesicular and fractured basalt. Groundwater movement mainly occurs in the shallow basalt aquifers due to their higher hydraulic conductivity.

Groundwater has used for long time as an alternative source in landscape irrigation or when city water falls short. Initially for the metropolises, for every city center, tap water and landscape irrigation requirements can be provided by groundwater sources, these sources should be observed regularly and databases should be created. UNESCO report point out water is also very important for the humankind's future, and there must be expedient water scarcity [1]. Through unbalanced distribution of water sources and overpopulation in last decade, approximately at 80 countries, 40% of the population will have more demand of water and water sources will not be able to meet the water demand [2].

Diyarbakır has moderate groundwater sources relatively. It is very crucial for the east of Turkey, therefore, important of the Turkey that how much are

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they, quality of water and quality of usable water ought to be decided. While world population increases rapidly, potable and useable water sources decreases due to water pollution and climate change. Therefore, as an important alternative, groundwater potential should be regularly measured and established as well as surface water sources. The Karacadağ basalt aquifer is used to a major source of groundwater supply for drinking, irrigation and other agricultural use before Diyarbakır drinking project built. Still, it has been used for rural drinking and irrigation demand. The main route for groundwater flow is from Karacadağ recharge areas to Tigris river discharge zones in the basalt aquifers

In the study, determination of groundwater source potential of Diyarbakır city center settlement groundwater basalt aquifer hydrogeological featured is researched. Most comprehensive research work is done by DSİ (Turkish State Hydraulıc Works and Water Database) on the basis of river basin [3]. This research is hydrogeological analysis of upper Dicle river basin, it gives a general idea about Diyarbakır basin, and there is a chance that lost its validity in present conditions. Furthermore, this study took place on a very wide area, it is not enough clear for specific details of Diyarbakır city center. Similar studies by Çelik, R. [4, 5] are made in the basis of Diyarbakır basin and in some way it updated DSİ's work. In these studies, Diyarbakır city center's level maps and water quality values are identified. Micro level delicate studies are much needed in prior usage of groundwater although the studies in this area. Many studies conducted for preparation of region and city center with GIS. Hydrogeological research of Adana city settlement was made by Çobanoğlu, İ. et al. [6] with the GIS, groundwater level maps and water quality analyze maps prepared. Studies are made for wider areas with the same method for river basins and aquifers. Pohang city of Korea's groundwater potential is determined with GIS technique by Hyun-Joo, O. et al. [7]. Some researcher mapped Jordan and Azraq basin of basalt aquifer with GIS and Fuzzy methods [8]. Last but not the least, Syria's Banyas area and coast area's groundwater risk map of evaluation with GIS and RISKE methods are emphasized and shown by Kattaa, B. [9].

2. Material and Methods

2.1 Studied Area

Diyarbakır is a city, which is in the middle of south-eastern Anatolia. It is on the northwest of Mesopotamia that also called El-Cezire. It is covered with Batman and Muş from east. From north, it is covered with Mardin, from west, it is covered with Şanlıurfa, Malatya and Adıyaman, and from south, it is covered with Elazığ and Bingöl. Diyarbakır, as can be seen in the Fig. 1 is stated 37°30' and 38°43' in the north latitude, 40°37' and 41°20' in the east longitude. Square measure of provincial border is 15.355 km^2. The working field, city centre and centre's towns Sur, Yenişehir, Bağlar and Kayapınar borders measurement is 779 km^2 [16]. The morphologyof the basin is dominated by the 2,280 m peaks of the Karacadağ mountain range in the west, with altitudes dropping below 650 m in the Tigris plain in the east. Prominent volcanic peaks are scattered throughout the Karacadağ mountain range and the plateaus to the east.

2.2 Diyarbakir's Hydrogeological Features

Geological formations that are rich by groundwater are formations that contain limestone, pebble and sandstone (Fig. 2). Paleoasen old, limestone, clayey and marl formations don't have groundwater. Diyarbakir's main water table spring is Midyat aquifer and basalt aquifer. Midyat aquifer's general construction is limestone and has two different flux units. First unit is 160 meter depth, low permeable and second unit is 90 meter depth, which is more permeable than first unit. Twenty-three percent of this aquifer is fed by north of catchment basin and 77 percent of aquifer is fed by rain water of south area. Because Midyat aquifer is deep down, to reach that aquifer is

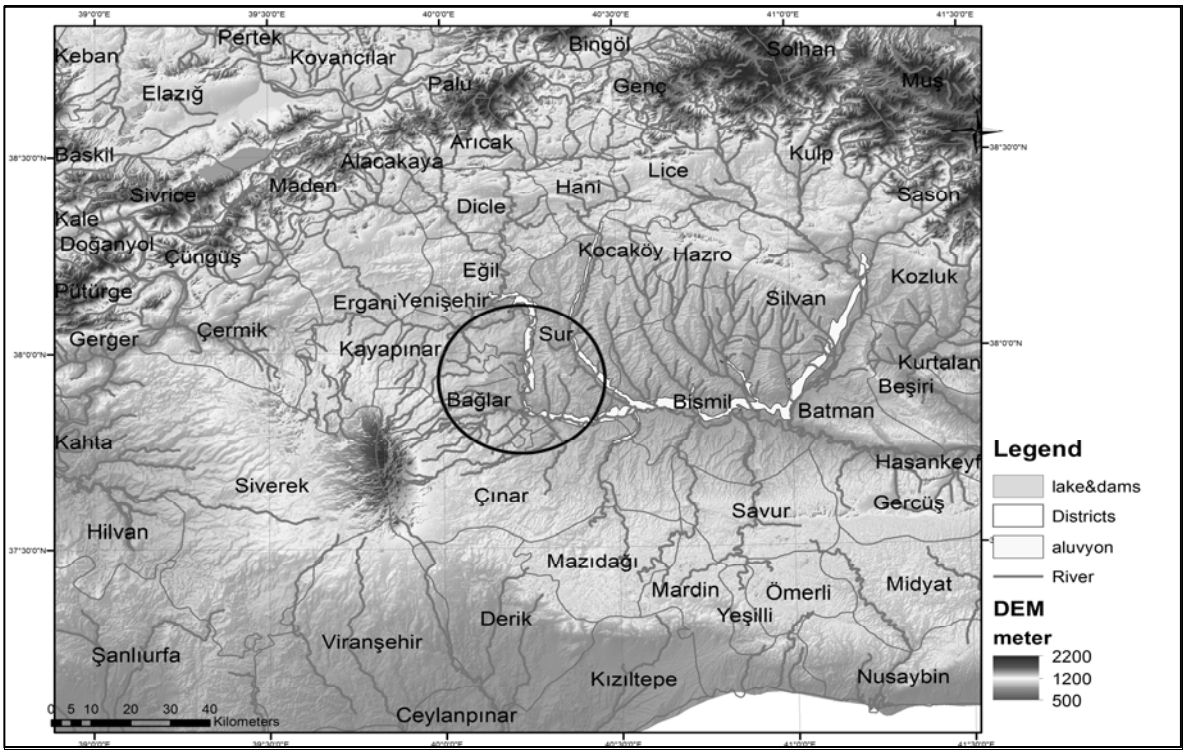

Fig. 1 Diyarbakır city center location.

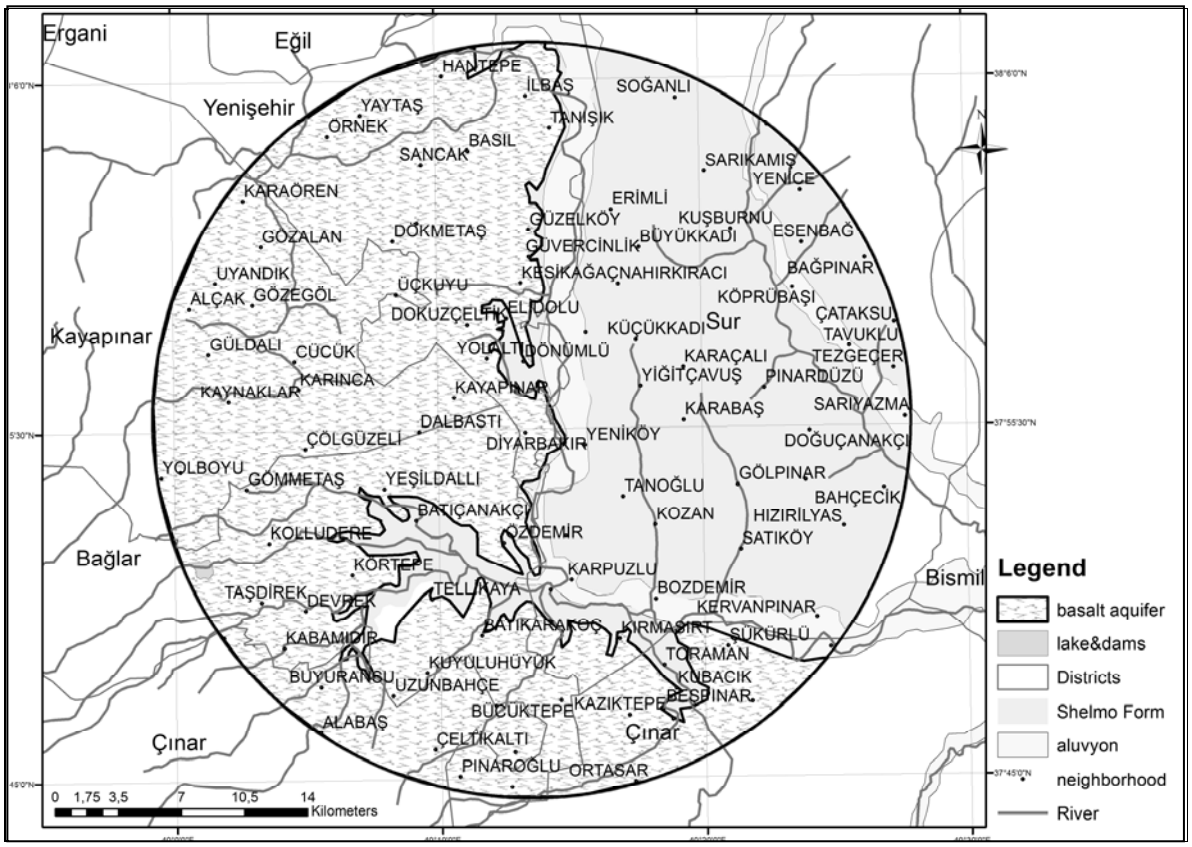

Fig. 2 Diyarbakır city center geological map.

costly. People sometimes prefer to use basaltic aquifer and after that respectively Selmo and Germik formations. For that reason from Selmo and Germik formations, water produced with filter and most times they produce mix water from Selmo-Germik-Midyat aquifer and basaltic Selmo-Germik-Midyat aquifer. Basalts on the Selmo formations are articulated and faulted and for that reason, it is a really good aquifer [11, 12]. Natural elements which had been effective in the location of establishment were the shield shaped Karacadağ volcanic cone, and the river Tigris with its plateau of basalt formation. Again the steep basalt rock formations of the plateau which are interrupted by the river of Tigris have provided a fortified space in terms of defense.

2.3 Methods

In the study, 30 wells (Fig. 3) drilled by public institutions such as DSİ, District Governorships, Provincial Administration (İl ÖzelİdareI), as well as private persons for watering purposes among the years 2009-2011 have been analyzed. The drilling data was ranked according to the opening years with the aid of Microsoft Excel software, and the coordinates have been arranged accordingly. These data were run on the ARC Map software. The data have been converted to Shape (Shp) format, then it has been modelled with Geostatistical analyzed tool extension interpolation "Inverse Distance Weighted (IDW)" tools. In the following maps, a basemap has been prepared through "Open Street Maps and Contributes" found under the Arc Info software. ED_1950_UTM_Zone_37N has been used as projection. Static water level maps, dynamic water level thematic map and pump efficiency thematic map (Figs. 4-6) have been obtained through all these processes.

3. Results and Discussion

In the study, well data which opened between years 2009 and 2011 are used.

Fig. 3 Well location map.

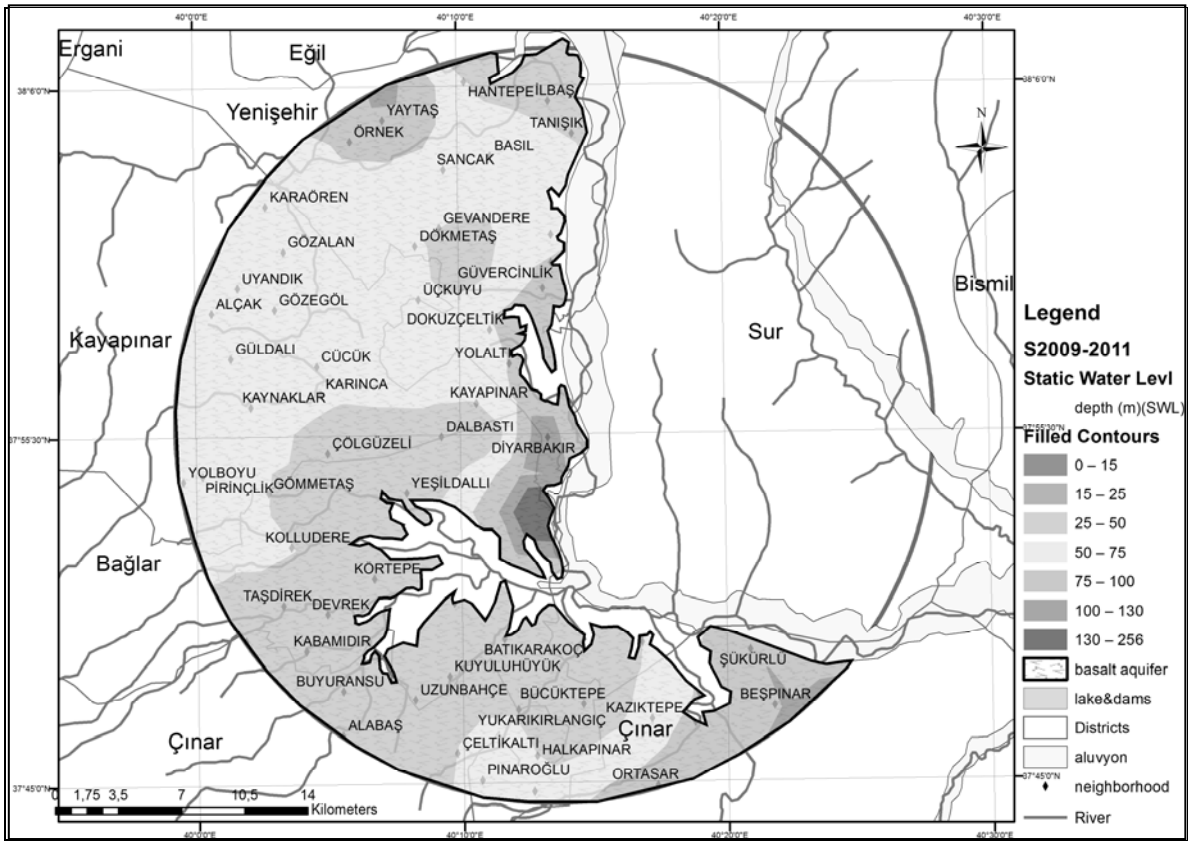

Fig. 4 Diyarbakır basalt region Static Water Level (SWL) thematic map.

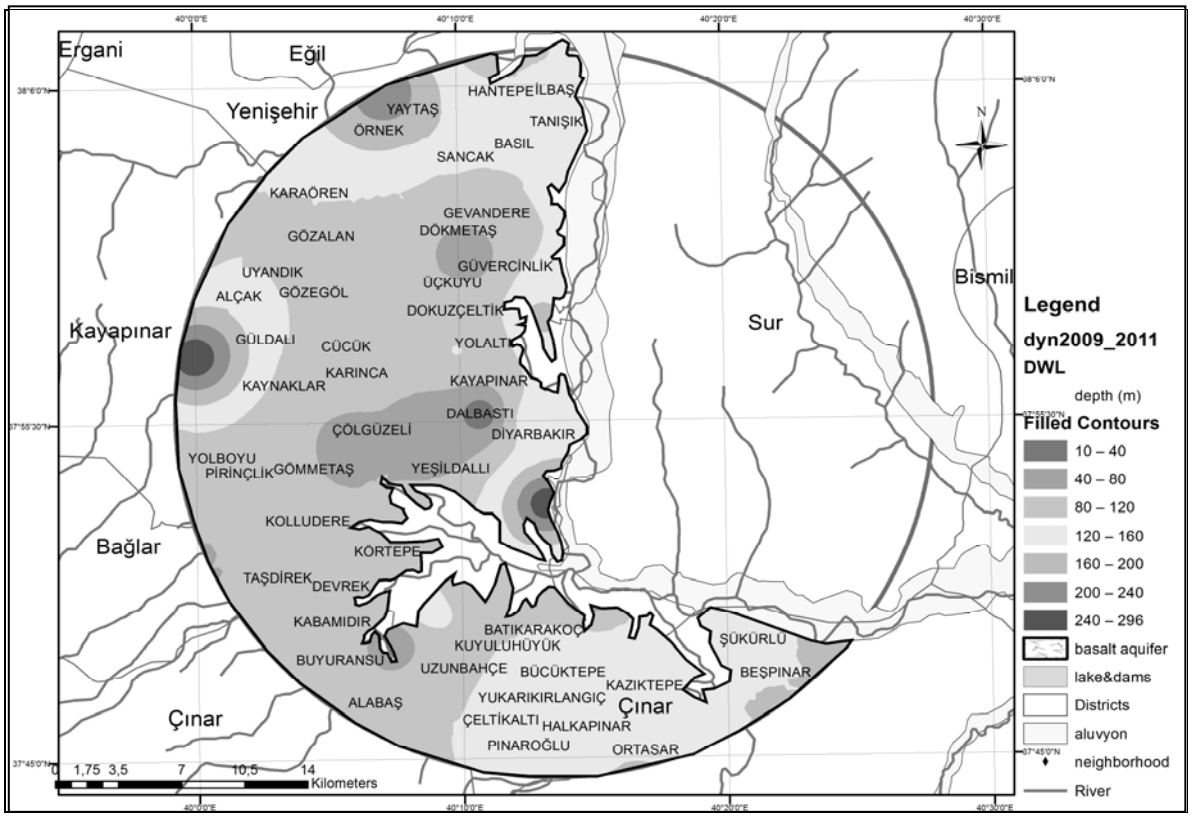

Fig. 5 Diyarbakır basalt region Dynamic Water Level (DWL) thematic map.

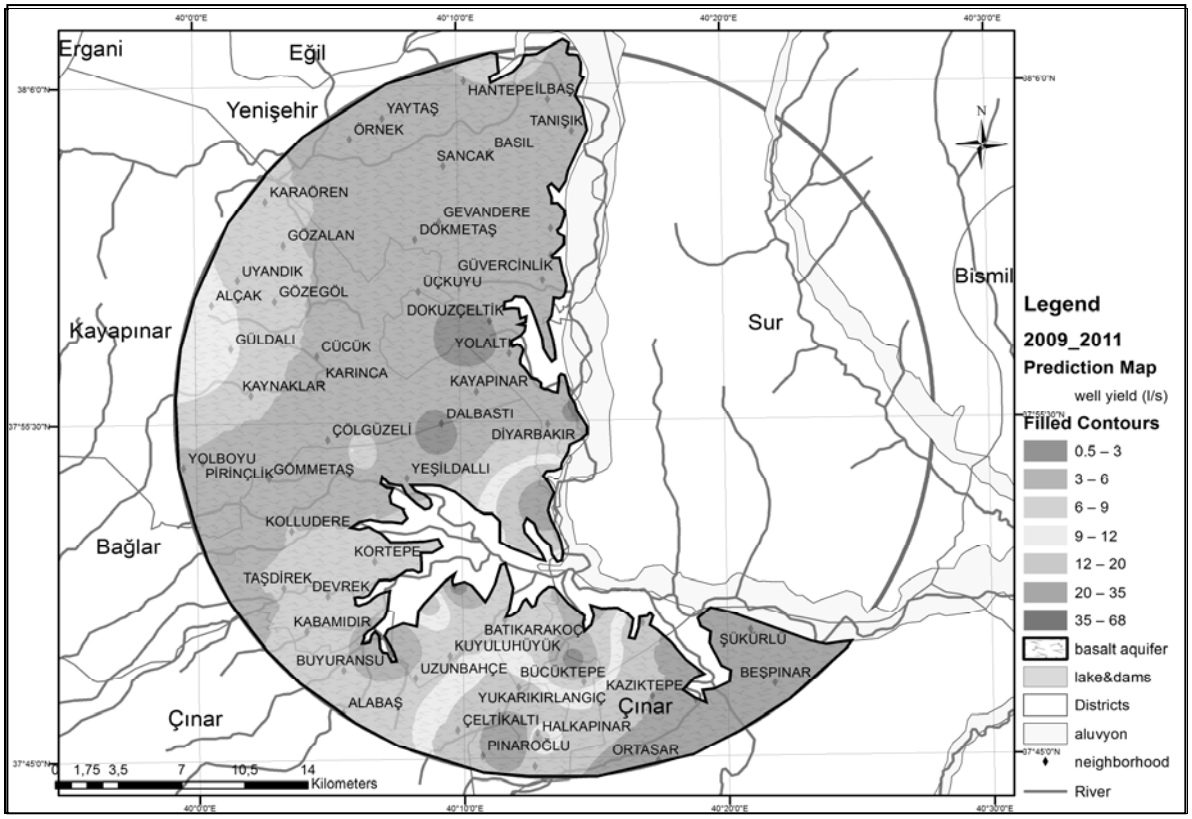

Fig. 6 Diyarbakır basalt region well yield (liter/sec.) thematic map.

Table 1 Basalt aquifer region results.

Reference/region	Static water level depth from ground (meter)	dynamic water level depth from ground (meter)	Pump efficiency (liter/sec)
Çölgüzeli	35	71	5
Uçkuyu	31	69	3
Yaytaş	83	120	4
Sancak	59	121	3.6
Guldalı	121	161	10
Uzunbahçe	40	110	11
Taşhelvası	60	135	18
Kolludere	50	98	6

The results from Figs. 4-6 are collected according to some districts at Table 1. The Table 1 provides some information for evaluating Diyarbakır city center basalt aquifer property.

Static water level changes between 35-121 m (hill points), average static water level is 620-640 m geographic elevation and its change according to elevation and topography. Dynamic water level changes between 71 m and 135 m. It is also depend on elevation and depth aquifer depth. Pump efficiency of Karacadağ aquifer region seems to change between 3 liter/sec and 18 liter/sec.. Actually basalt aquifer doesn't homogeny lie under ground.

In somewhere, static water level and pump efficiency may be change according to basalt elevation situation. In 1994, DSI well in somewhere, for example Serapguzeli and Yenikoy areas, could obtain 18-60 liter/sec.

4. Conclusion

Diyarbakır city had been established on the eastern side of a basalt plateau with a mild inclination and a wide form, which expands from Karacadağ towards the river Tigris, whose average elevation from the sea is 650 m, and elevation from the river is 160 m. The basalt plateau on which the city had been established has provided appropriate conditions in terms of seismicity, soil conditions and groundwater aquifers. Basalt aquifer yield capacity varies among 3-18 liter/second. Otherwise static level average is nearly 65 m. The richest basalt ground capacity is in Taşhelvası

location where southern of Diyarbakır is located. The scarce water resources of the region are in the northern part of the city such as Uçkuyu. Basalt aquifer water capacity increases towards the Karacadağ mountain.

Basalt aquifer is feeding mostly from rainfall. Probably, drought-induced climate change and more using groundwater than feeding affects negatively to basalt aquifer groundwater potential. Although basalt aquifer has limited groundwater capacity, it has very quality water feature. So, basalt aquifer groundwater basin must be protected from huge urbanization and ındustrialization.

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