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Obtain Thematic Maps of Diyarbakir Basalt Aquifer's Water Quality Parameters with Using GIS Technique

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Abstract: In this study, groundwater quality and water features of Diyarbakir urban basalt aquifer which contains Bağlar, Kayapınar, Sur and Yenişehir residential areas aimed to be determined. At this location, water wells opened for drinking water and irrigation water are used in the agricultural field. Therefore, in the study area, which opened in water samples taken from water wells were examined. It was reformed in the field, water samples were taken from the predrilled water wells. Water wells in the same coordinates are determined by Garmin etrex 30 handheld GPS system. Chemical analysis of water samples taken in the laboratory was made. The wells water's pH, Electrical Conductivity (EC) and Dissolved Solids (TDS) features were acquired by Portable Hanna HI 98125 pH/EC/TDS/°C meter device at the field. At this study, basalt aquifer features are considered, and water quality and water chemical properties were determined in Diyarbakir city centre. pH, EC and TDS values of the water samples taken on site and those water chemical analyses were measured in the laboratory. Then, they were modelled by using ARC INFO 10.2.1 GIS programme and geostatistical analyst extension tool. At the end of this process, thematic map of Diyarbakir's basalt aquifer pH, EC and TDS were produced.

Key words: Groundwater, GIS, water quality, Diyarbakır city center.

1. Introduction

Groundwater quality can be adversely affected or degraded because human activities introduce contaminants into the environment. It can also be affected by natural processes that result from geochemical reactions between the water and rock matrix as the water moves along flow paths from areas of recharge to areas of discharge. In general, the longer groundwater remains in contact with soluble materials, the greater the concentrations of dissolved materials in the water. The quality of groundwater also can change as the result of the mixing of waters from different aquifers. In aquifers affected by human activity, the quality of water can be directly affected by the infiltration of anthropogenic compounds or indirectly affected by alteration of flow paths or geochemical conditions. Contamination of fresh groundwater by saline water would be a common problem in the region because of agricultural activities. Generally, salinity of groundwater is measured in terms of total dissolved solids or EC parameters [1]. In humid areas and where recharge is abundant, potential groundwater salinization is limited because of the natural flushing by freshwater. Conversely, in semiarid areas, the absence of natural flushing by freshwater enhances the accumulation of salts and saline water.

Between 1990 and 2008, the proportion of the world's population with access to improve drinking water sources increased from 77% to 87%. This constitutes an increase of almost 1.8 billion people worldwide and puts the world well on track for meeting the MDG drinking water target of 89%. At the current rate of progress, 672 million people will not use improved drinking water sources in 2015. It is likely that more than many hundreds of millions will still lack sustainable access to safe drinking water [2]. Regional environmental or public health authorities have an important task in participating in the preparation of integrated water resource management plans to ensure the best available drinking-water source quality. If municipal wastewater is used for

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irrigation (agricultural irrigation or urban irrigation, including parks, road plantings, sports fields, golf courses, residential areas, etc.), the many additional chemicals found in such wastewater can pose a serious threat to groundwater quality [3, 4]. Water quality is determined by the presence and quantity of contaminants, physical/chemical factors such as pH and conductivity, the number of salts present and the presence of nutrients. Humans largely influence all these factors, as they discharge their waste in water and add all kinds of substances and contaminants to water that are not naturally present.

By definition pH is the negative logarithm of the hydrogen ion concentration of a solution, thus, it is a measure of whether the liquid is acid or alkaline. The pH scale (derived from the ionisation constant of water) ranges from 0 (very acid) to 14 (very alkaline). The range of natural pH in fresh waters extends from around 4.5, for acid, peaty upland waters, to over 10.0 in waters where there is intense photosynthetic activity by algae. However, the most frequently encountered range is 6.5-8.5. According to TS-266, WHO and EPA standard [5-8], ideal drinking water pH value must be between 6.5 and 8.5. At the TS 266 standard, it's allowed to 6.5-9.2. This parameter does not inform direct water quality. In waters with low dissolved solids, changes in pH induced by external causes may be quite dramatic. Extremes of pH can affect the palatability of water but the corrosive effect on distribution systems is a more urgent problem [9].

The electrical conductivity of water is an expression of its ability to conduct an electric current. As this property is related to the ionic content of the sample which is in turn a function of the dissolved (ionisable) solids concentration, the relevance of easily performed conductivity measurements is apparent. In itself, conductivity is a property of little interest to a water analyst but it is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solids content of the water. UK methods manuals report the results at 20 °C while the standard US reference manual uses 25 °C [9]. A difference of 10 percent can arise depending on how the results are quoted. An error of this magnitude could not be tolerated, especially where conductivity readings are being used to estimate salinity [9].

Total Dissolved Solids (often abbreviated TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form. Generally, the operational definition is that the solids must be small enough to survive filtration through a filter with two-micrometre (nominal size or smaller) pores [9]. Where TDS are high, the water may be "saline" and the applicable parameter "salinity". The presence of high levels of TDS may also be objectionable to consumers, owing to excessive scaling in water pipes, heaters, boilers and household appliances [10]. The relationship of TDS and specific conductance of groundwater can be approximated by Eq. (1):

$$TDS = k_e \cdot E \cdot C$$

Where, TDS is expressed in mg/L and EC is the electrical conductivity in microsiemens per centimetre at 25 °C. The correlation factor k_e varies between 0.55 and 0.8 [11]. Many studies conducted about region and city center's groundwater quality modeling with GIS technique, such as Diyarbakir basin groundwater quality [12]. In different study, rainfall and water levels in the reservoir and down gradient of the reservoir, groundwater level and EC are monitored from December of 2011 to January of 2012 and statistical analysis is performed on this data [13]. New Zealand Heretaunga plain's groundwater quality monitoring with GIS geostatistical analyze and drastic method studied by Baalousha [14]. Some researcher study on Iran groundwater resources water quality and modified Drinking Water Quality Index (DWQI) [15]. At this study, basalt aquifer features are considered, and water quality and water chemical properties were determined in Diyarbakir city centre. PH, EC and

TDS values of the water samples taken on site as well as those water chemical analyses measured in the laboratory.

2. Material and Methods

2.1 Studied Field

Diyarbakir 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 towns Sur, Yenişehir, Bağlar and Kayapınar borders measurement is 779 km^2 [16].

2.2 Diyarbakir's Basalt Aquifer Features

Geological formations that are rich by groundwater are formations that contain limestone, pebble sandstone and basalt (Fig. 2). Paleoasen old, limestone, clayey and marl formations don't have groundwater. Basalts on the Selmo formations are articulated and faulted. For that reason, it is a really good aquifer [17]. Karacadağ basalts have a very good aquifer feature. Its thickness varies between 2-50 meters and its thickness decrease towards to Karacadağ Mountain where some value is 300 meter. Basalts are not spread uniformly, because of the cracked and source of slag it revealed as spring in some areas such as Serapgüzeli, İçkale and Anzele location. Basalt separate Transmissivity (T) values vary 0-500 m^3/day/m. It can be obtained 2-7 liter/second pump yield from basalt wells.

2.3 Obtaining Thematic Maps

In this study, approximately 41 wells water samples (Fig. 3) which were drilled for drinking water and irrigation were analysed. Their coordinates were taken by Garmin Etrex hand GPS. It was reformed in the field, water samples were taken from the predrilled water wells. Water wells in the same coordinates are determined by Garmin etrex 30 handheld GPS system. Chemical analysis of water samples taken in the laboratory was made. Some of the wells water's pH, EC and TDS features were acquired by Portable Hanna HI 98125 pH/EC/TDS/°C meter device at the field. All data with coordinates are classified with Microsoft Excel. ARC MAP is used to open the data. These data are converted to Shape (Shp) format and modelled with ARC Info 10.2 geostatistical analyst extension IDW tool. The prework is done with "Open Street Maps and Contributes" which is placed under the Arc Info menu. UTM Datum 1950-37 is used as projection. With all these operations EC (Electrical Conductivity) maps (Fig. 4), pH maps (Fig. 5) and TDS (Total Dissolve Solid) maps (Fig. 6) are provided.

4. Results and Conclusion

4.1 Diyarbakır Basalt Aquifer Groundwater pH Values

Forty-one locations in the area of data pertaining to the evaluation revealed that the groundwater pH value range between 6.00 and 9.50. The average groundwater pH value is 7.80. The minimum PH is 6.02 where the Kayapinar-Kesikagac neighbourhood. The highest pH value is 8.98 in the Kayapinar Basil village. Besides, Kayapınar-Yolati (pH = 6.04) pH values below the recommended value (pH ≤ 6.5) and their features are basics. In the city's west and north territories, Cicekliyurt villages, from Suleyman Demirel Campus to Peyas neighbourhood, Elidol, Geyiktepe and Yenice neighbourhood's pH values are between 6.5 and 7 in the scene. This region is Basalt aquifer. The values of the pH range are the minimum recommended.

As shown in Fig. 4, almost like 80%-90% the center of Diyarbakir city's basalt aquifer groundwater pH is between 6.5 and 8.5. These values provide recommended ideal values. In vicinity of Diyarbakir

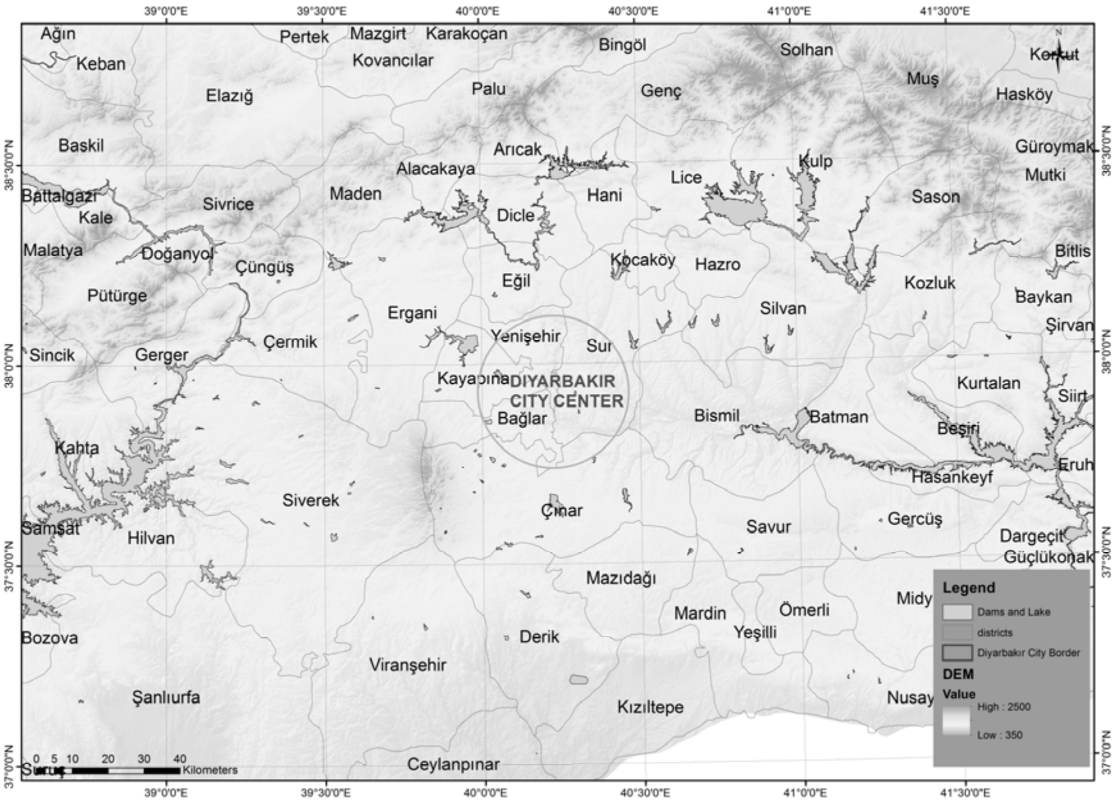

Fig. 1 Diyarbakır basin location map.

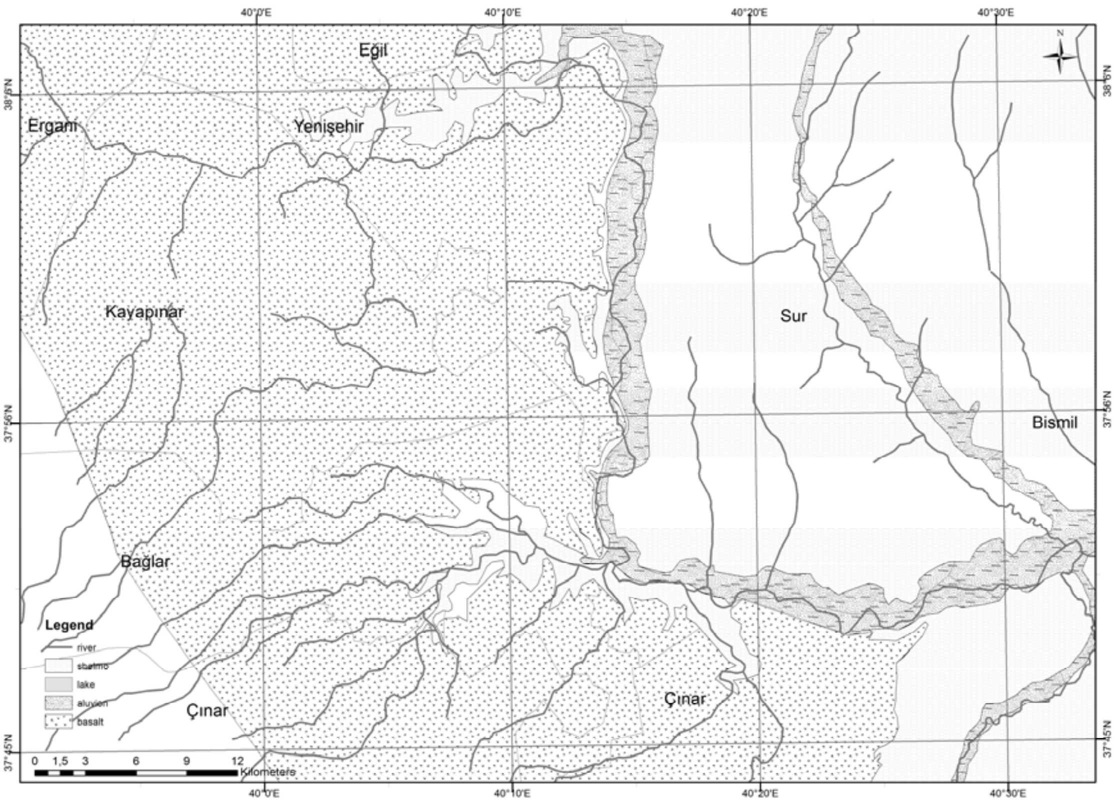

Fig. 2 Diyarbakır geologic map of the city centre.

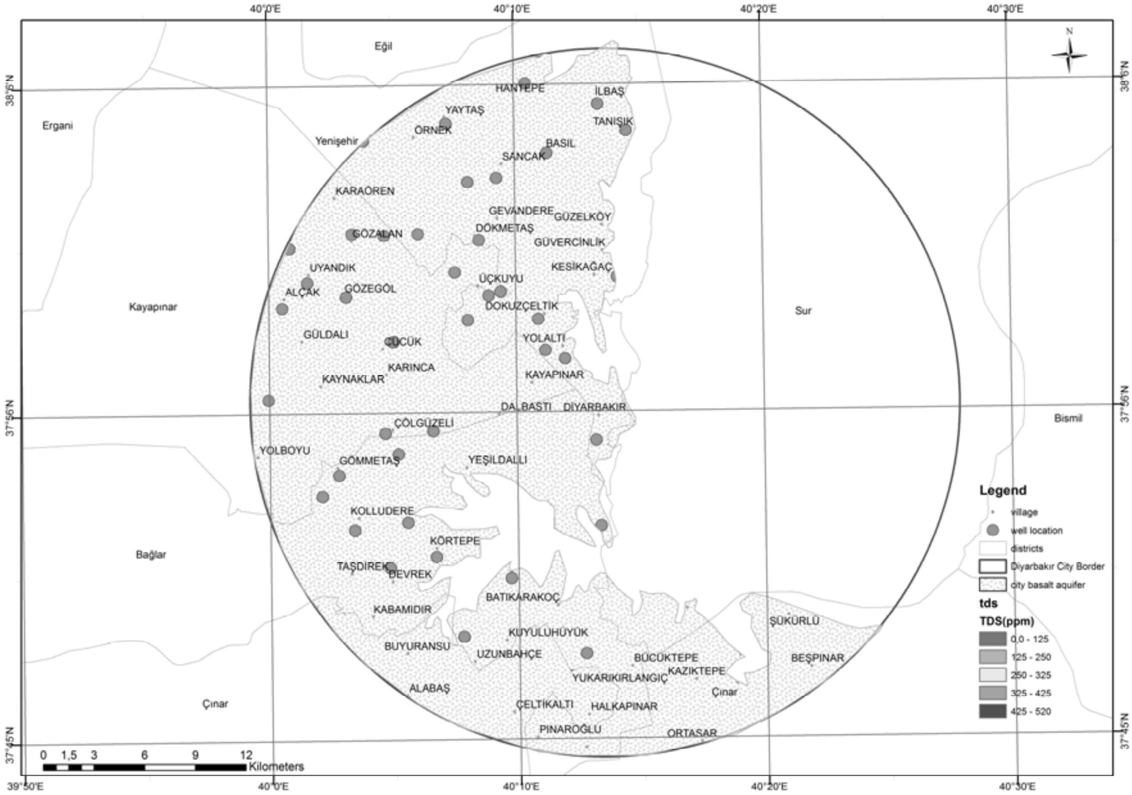

Fig. 3 Basalt aquifer with well location map.

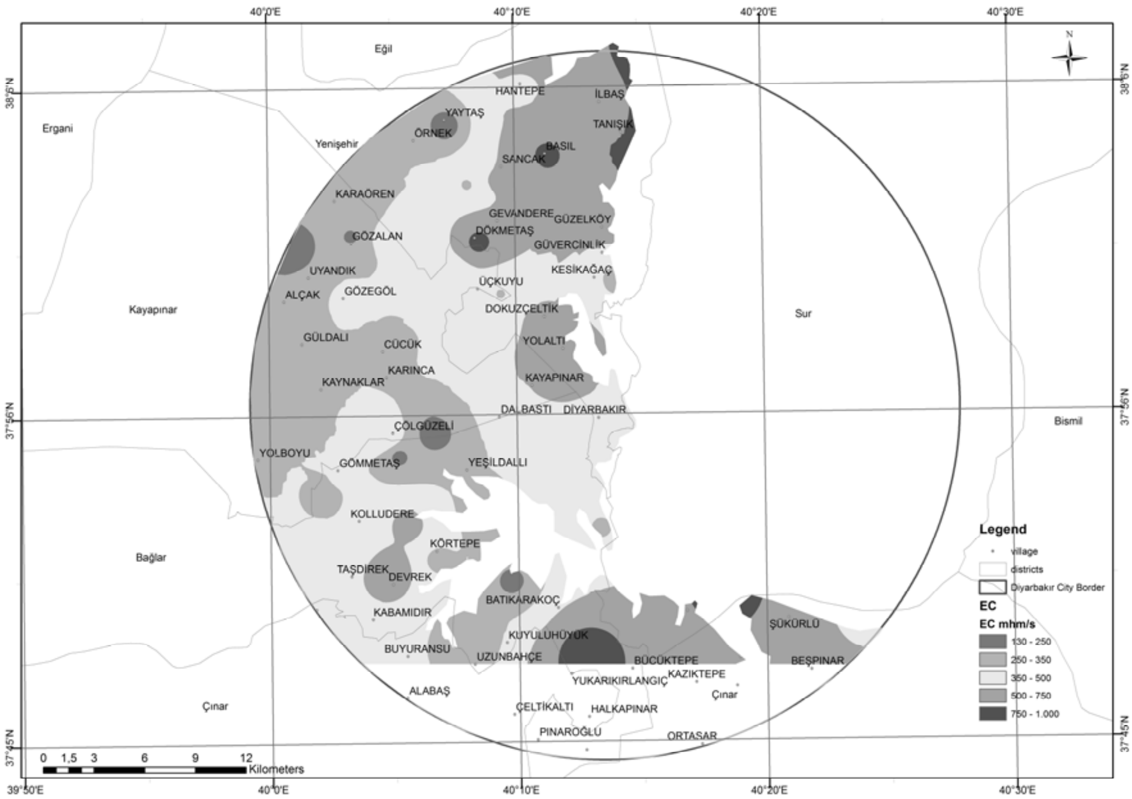

Fig. 4 Diyarbakır city centre groundwater EC thematic map.

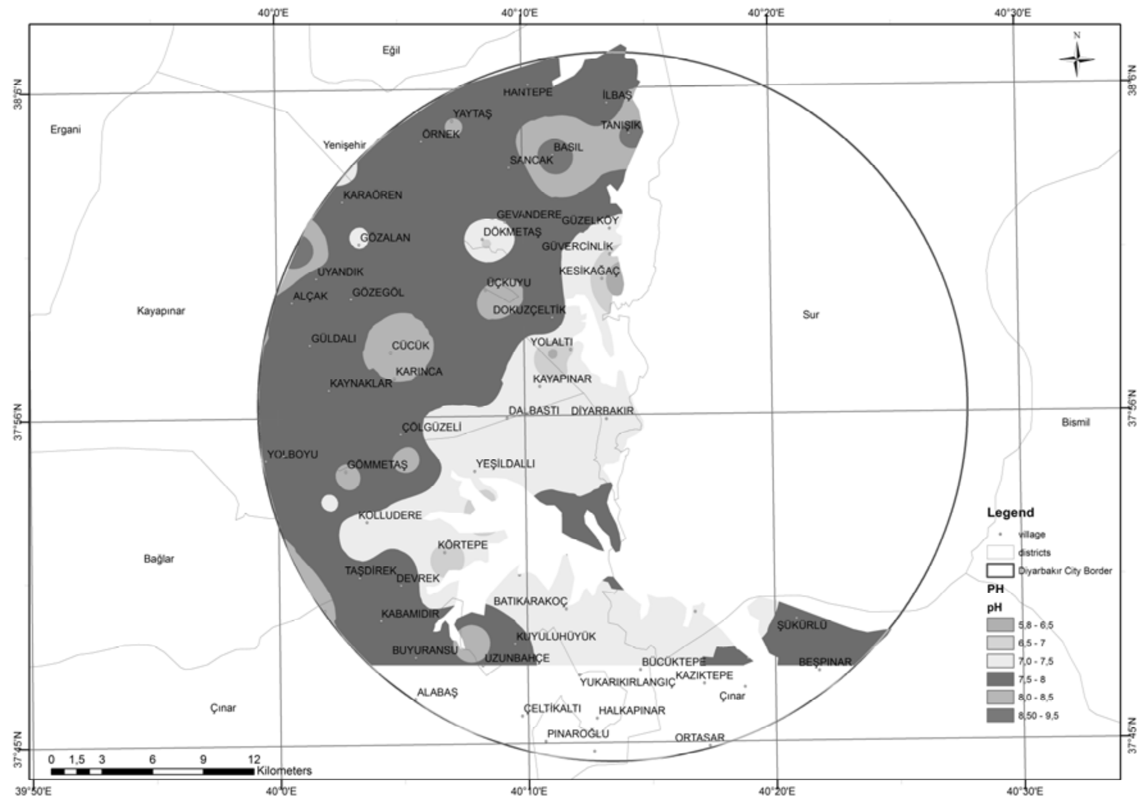

Fig. 5 Diyarbakır city centre groundwater PH thematic map.

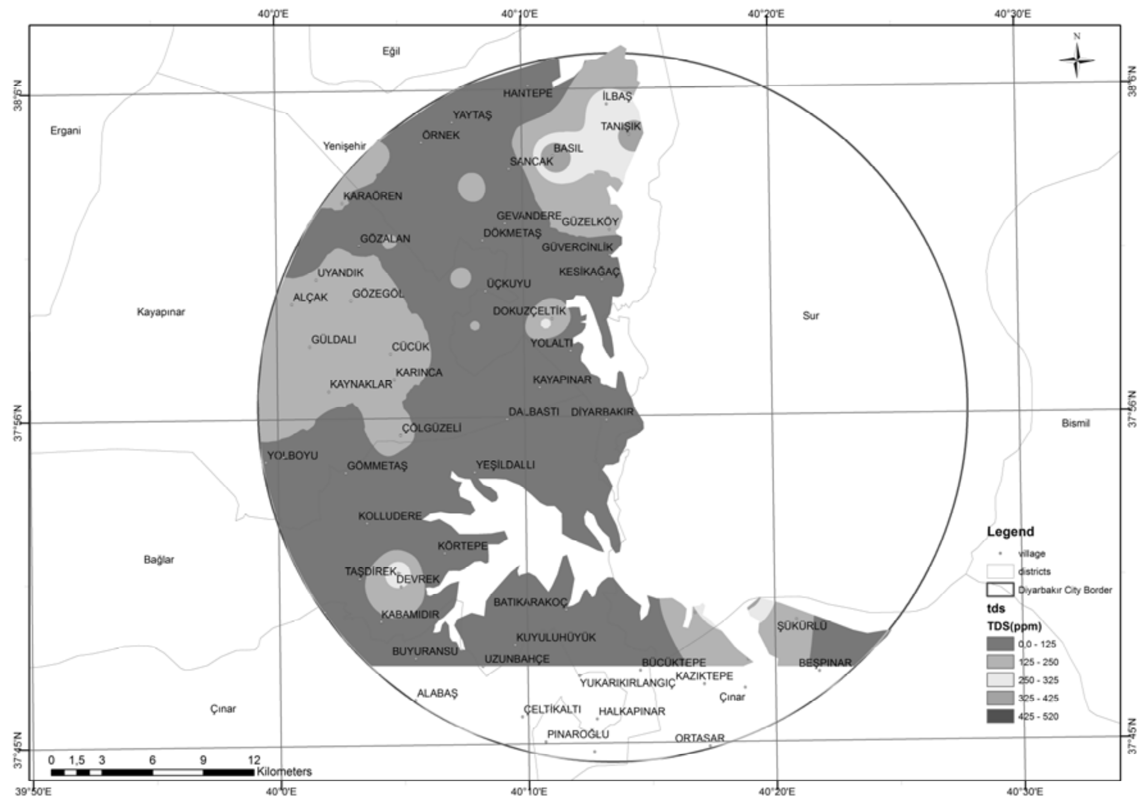

Fig. 6 Diyarbakır city centre groundwater TDS map.

city center and south eastern part of city area's pH is between 7 and 7.5. This area is almost 40 percent of total city basalt area. North to west region's pH value changes between 7.5 and 8.0. The northern coast of the Cucuk, Uckuyu, Sancak, Basil and Tanisik neighbourhoods region's groundwater PH values are between the values of 8 to 9 which can be permitted value according to TS 266 standard.

4.2 Diyarbakir Basalt Aquifer Groundwater EC Features

EC values of groundwater in the study area range between 130 μmho/cm and 922 μmho/cm. The mean EC value is 422 μmho/cm. While the lowest EC values with 130 μmho/cm is Baglar-Sakalli village, in Sur-Yukarikirlangic neighbourhood location, it gave the highest value 920 μmho/cm. Considering the created EC maps, in the basalt aquifer towards Karacadag foothills is the lowest EC values. Finally, it can be classified basalt aquifer water quality that, 20% of Diyarbakir basalts area's groundwater is very good water class, approximately 75% of the groundwater is good water class and the partial 5% of groundwater is usable water class.

4.3 Diyarbakir Groundwater TDS Features

About 87,000 hectares in the Diyarbakir city centre parts were made analysed and TDS values modelled in Fig. 6. The lowest TDS value is at the Sakalli village near the Karacadag as 60 ppm. The highest TDS value is seen at Soganli village where east of Diyarbakir in the Kayapinar Basil as 385 ppm. The mean of Diyarbakir groundwater TDS is 85 ppm. Diyarbakir residential area's groundwater TDS values can be classified that, all of basalt areas value is under 500 ppm, 30% regions' TDS values changes between 125-250 ppm. 5% regions' TDS values changes between 250-325 ppm. Besides, 1.5% changes between 325-450 ppm. The rest 65% basalts groundwater's TDS vary between 60-125 ppm which has very good quality feature. According to WHO [14], the palatability of water with a Total Dissolved Solids (TDS) level of less than about 600 mg/L is generally considered to be good. Drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1,000 mg/L. So, there is no significant problem to use it for drinking safety about Diyarbakir groundwater features.

Considering both TDS and EC parameters show that Diyarbakir Basalt aquifer has low salinity feature.

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References

[1] Franzen, D. 2007. *Managing Saline Soils in North Dakota*. Fargo: North Dakota State University.

[2] Yang, H., Bain, R., Bartram, J., Gundry, S., Pedley, S., and Wright, J. 2013. "Water Safety and Inequality in Access to Drinking-Water between Rich and Poor Households." *Environmental Science & Technology* 47 (3): 1222-1230.

[3] Bouwer, H. 2000. "Groundwater Problems Caused by Irrigation with Sewage Effluent." *J. Environ. Health* 63: 17-20.

[4] Qadir, M., Ghafoor, A., and Mur-Taza, G. 2000. "Concentration in Vegetables Grown on Urban Soils Irrigated with Untreated Municipal Sewage." *Environ. Dev. Sustainability* 2: 11-19.

[5] Turkish Standardization Institute (TSE). 1997. *İçme Suları Türk Standartları*. Ankara: TSE Standard. (In Turkey)

[6] World Health Organization (WHO). 1999. *Guidelines for Drinking Water Quality, 2nd Ed*. Geneva: World Health Organization.

[7] World Health Organization (WHO). 2011. *Library Cataloguing-in-Publication Data Guidelines for Drinking-Water Quality 2011: 4th Ed*. Malta: Gutenberg.

[8] Environmental Protection Agency (EPA). 2003. "National Primary Drinking Water Regulations: Stage 2 Disinfectants and Disinfection Byproducts Rule, National Primary and Secondary Drinking Water Regulations: Approval of Analytical Methods for Chemical Contaminants." *Federal Register* 68: 49548-681.

[9] Environmental Protection Agency. 1993. *Parametres of*

Water Quality. Ireland: The Environmental Protection Agency.

[10] En.Wikipedia.org. 2015. "Total Dissolved Solids." Accessed February 25, 2015. http://en.wikipedia.org/wiki/Total_dissolved_solids.

[11] Atekwana, E. A., Atekwana, R. S., Rowe, D., Werkema, D., Legall F., D., 2004. "The Relationship of Total Dissolved Solids Measurements to Bulk Electrical Conductivity in an Aquifer Contaminated with Hydrocarbon." *Journal of Applied Geophysics* 56: 281-294.

[12] Çelik, R. 2014. "Assessment of Diyarbakır City Centre Groundwater Quality and Obtaining Thematic Maps with GIS Technic." *Journal of Selcuk University Natural and Applied Science* 1: 13-22.

[13] Seeboonruanga, U. 2012. "Impacts of Reservoir on Groundwater Level and Quality in a Saline Area, Nakhon Panom Province, Thailand." *APCBEE Procedia* 4: 16-21.

[14] Husam, B. 2010. "Assessment of a Groundwater Quality Monitoring Network Using Vulnerability Mapping and Geostatistics: A Case Study from Heretaunga Plains, New Zealand." *Agricultural Water Management* 97: 240-246.

[15] Mohebbi, M. R., Saeedi, R., Montazeri, A., Vaghefi, K. A., Labbafi, S., and Oktaie, S. et al. 2013. "Assessment of Water Quality in Groundwater Resources of Iran Using a Modified Drinking Water Quality Index (DWQI)." *Ecological Indicators* 30: 28-34.

[16] Governorate of Diyarbakir Provincial Department of Environment and Forestry. 2011. "Diyarbakir Province Environment Status Lecture." Accessed: June 12, 2014. http://www.csb.gov.tr/db/ced/editordosya/diyarbakir_icdr 2011.pdf.

[17] Tarcan, G., Filiz, C., Gemici, U., and Sezer U. 1999. "Hydrochemical Characteristics and Vulnerability to Contamination of Diyarbakir's Aquifers." *Geological Bulletin of Turkey* 42: 22.