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GROUNDWATER QUALİTY ASSESSMENT USİNG GEOGRAPHİC INFORMATİON SYSTEMS (GİS) IN BUCAK BURDUR, TURKEY

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Abstract
The Bucak catchment area is located in Turkey's Mediterranean region, south of Burdur Province; it has an area of 684 km^2. The area is one of the most important karst regions on the west side of the Taurus belt; it includes Bucak and Çeltikçi counties and numerous villages.

In the current study, 20 groundwater samples were collected from different parts of the Bucak catchment area to assess water quality by analyzing several physical and chemical parameters. The coordinates of 20 boreholes were recorded by using Global Positioning System (GPS). All of the data was imported using Geographic Information Systems (GIS), and the inverse distance weighted (IDW) method was used to prepare thematic maps for groundwater quality in the Bucak catchment. Total dissolved solid (TDS) and electrical conductivity (EC) features and power of hydrogen (pH) were acquired by using a DO700 Portable Dissolved Oxygen Meter device in the field, and the chemical parameters were analyzed at the Acme (Canada) laboratory using the inductively coupled plasma mass spectrometry (ICP-MS) method. The results showed that the values of the parameters were within permissible limits according to the Turkish criteria (TSE-266, 2005)and World Health Organization (WHO, 2006),and that there were no significant contaminants in the groundwater.

Introduction
Water is a fundamental need of all living beings, including humans. Each day, the world faces new environmental problems because of the unconscious consumption of natural resources and the rapid growth of the world's population. Already, 1.1 billion people do not have access to safe drinking water, and by 2025, 1.8 billion people will face scarcity in different countries and regions (World Water Council 2003; UNESCO 2006).

Water quality can deteriorate by the destruction of wetlands and freshwater resources; the discharging of waste; and the addition of substances and contaminants of all kinds to the world's oceans, rivers, and lakes. Such deterioration may cause potential health risks to humans and livestock, the death of aquatic species, and crop failure (Demirci 2008; Nwankwoala et al. 2012; Zhang et al. 2013; Çelik 2014).When the data are examined over a long period of time, Turkey's average annual precipitation is 643 mm; runoff is approximately 186 billion m^3/year; 98 billion m^3/year is surface water; 12 billion m^3/year is groundwater, and 110 billion m^3/year is used for consumption (World Water Council 2003; Başçiftçi et al. 2013).

Today's computer-aided data analysis and visualization tools play an important role in development and management studies for the protection of water resources (Özşahin 2013). In recent years, the use of GIS for groundwater management and research has grown rapidly (Adhikary 2013). GIS and spatial analysis are very powerful tools for representing and analyzing laboratory data and for integrating them with geographical data. This capability makes GIS a useful tool for making spatial distribution maps of water quality parameters that are both robust and accurate (Shomar et al. 2010; Singh 2011; Nwankwoala et al. 2012; Narsimha et al. 2013).

In this study, GIS was used to assess and map the groundwater quality characteristics in the Bucak-Burdur catchment area, and to check the groundwater's suitability for drinking.

Material and methods
Study area
The study area is located between 37° 16' N and 37° 35' N latitutes and 30° 16' E and 30° 41' E longitudes; it is in southern Turkey, 80 km from Antalya Province to the south and 44 km from Burdur Province in the north (Fig. 1).The catchment area covers 684 km^2 and has a population of 43,282 (Tuik 2015).

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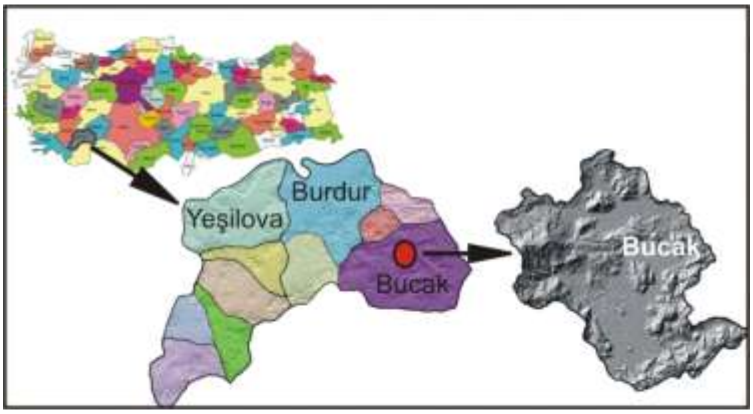

Figure 1. Study area

The climate varies between a continental and a Mediterranean climate. The weather in winter is moderate and rainy, and the summers are warm and arid (Hepdeniz 2014). The mean daily maximum and minimum temperatures of the study area range from 28° C (August) to 9.8° C (January). Maximum rainfall is 91.5 mm (December), the minimum is 12.5 (August), and annual rainfall is about 61 mm. The east side of the catchment area consists primarily of Cretaceous-age Davraz limestone; the west side consists of ophiolites and Jura-Cretaceous–age Akdağ limestone, and the middle of the area consists primarily of alluvia. The vegetation of the area includes scrub, pine, fir, and ground cedar forests (Hançer 1996).

Field collection, analysis, and GIS mapping

The Bucak area has been digitized from 1/25000 scale topographic maps; 20 well locations were selected for this study (Fig. 2). The groundwater sampling points' coordinates were recorded by a Garmin eTrex handheld GPS device and transformed into a point layer for GIS analysis. The chemical parameters of the groundwater samples were analyzed in the Acme laboratory (in Canada), and the pH, TDS andEC features were acquired by a DO700 Portable Dissolved Oxygen Meter device used on the study area. All of the results from the 20 wells were then used as input data in ArcGIS v.10.

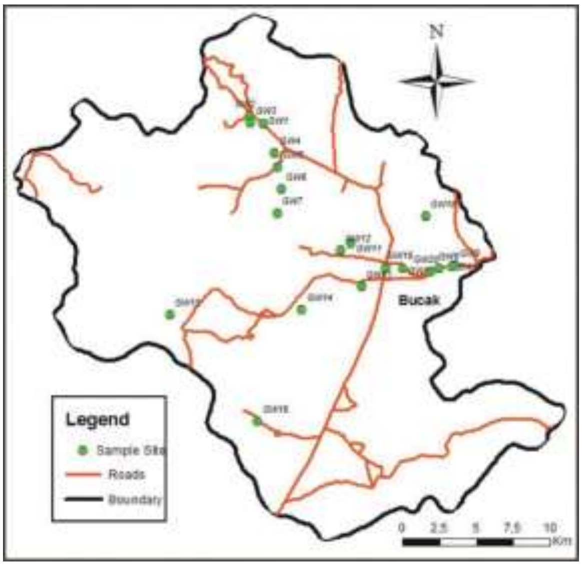

Figure2. Location of sampling stations

The IDW interpolation method was used to obtain thematic maps. The IDW method does not extrapolate beyond the maximum and minimum values, and it gives accurate results on the observation area (Mantzafleri et al. 2009).TSE-266 (2005) and WHO (2006) standards were adopted to classify the water quality data.

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Results and discussion

Chemical composition of groundwater

Chemical Composition of Groundwater is shown in Table 1 above.

Table 1: Chemical Composition of Groundwater Samples

Parameters	Range	Mean ± Std	WHO Standards	TSE-266 Standards
pH	6.73-7.8	7.28 ± 0.23	6.5-8.5	6.5-9.2
EC (µS/cm)	343-955	659.75 ± 153.59	500	650
TDS (mg/l)	233-640	458.05 ± 98.53	1000	1500
Salinity	0.17-2.29	0.418 ± 0.43	NS	NS
Ca (mg/l)	59.4-132.76	94.08 ± 18.85	200	NS
Cl (mg/l)	2-60	16.4 ± 11.9	250	600
K (mg/l)	0.52-4.62	1.52 ± 0.87	200	12
Mg (mg/l)	4.96-59.79	28.01 ± 15.10	50	50
Na (mg/l)	2.64 – 55.33	17.32 ± 12.03	200	175
Hardness ($CaCO_3$)	21-53	35 ± 7.54	500	NS

(NS: Not Stated)

Twenty borehole’ s groundwater chemical composition is shown in Table 2 above.

Table 2: Water Quality Parameter of Twenty Borehole Samples

Sample	pH	EC	TDS	Salinity	Ca	Cl	K	Mg	Na	Hardness
GW1	7.5	682	462	0.33	59.4	15	1.85	24.84	15.69	250.34
GW2	7.2	690	480	0.35	82.73	9	1.6	35.18	12.54	351.06
GW3	7.2	618	424	0.3	83.4	7	1.16	23.22	10.33	303.70
GW4	6.9	838	584	0.39	64.12	12	1.54	44.33	15.72	342.05
GW5	7.1	736	455	0.35	94.81	17	0.83	31.8	15.68	367.40
GW6	7.2	625	455	0.34	90.02	25	1.28	47.99	27.71	421.80
GW7	7.3	386	265	0.19	86.95	5	1.21	4.96	4.89	237.71
GW8	7.1	809	556	0.4	125.19	14	1.02	24.83	11.52	414.77
GW9	7.0	613	425	0.28	120.71	12	0.59	13.47	10.13	357.00
GW10	6.9	940	578	0.43	132.76	24	1.76	47.26	15.86	525.66
GW11	7.4	521	537	0.26	111.73	8	1.8	8.38	8.24	313.68
GW12	7.3	955	640	0.46	86.66	60	0.7	59.79	55.33	461.78
GW13	7.3	640	448	0.32	100.31	20	0.88	30.94	19.12	377.62
GW14	7.4	573	404	2.29	80.51	11	1.14	19.17	15.3	279.87
GW15	7.8	343	233	0.17	73.94	2	0.52	6.7	2.64	212.32
GW16	7.4	708	494	0.32	79.48	25	2.06	43.88	40.87	378.60
GW17	6.7	558	379	0.27	98.66	10	2.33	16.39	14.15	313.84
GW18	7.5	772	533	0.36	100.71	12	2.18	38.71	27.02	410.48
GW19	7.2	635	439	0.29	108.33	24	4.62	25.71	12	376.23
GW20	7.5	553	370	0.27	101.29	16	1.38	12.77	11.68	305.58

Table 2, shows twenty borehole’ s water parameters that are experimented from the field and laboratory.

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Spatial distribution of water quality parameters

Power of hydrogen (pH)

In the Bucak catchment area, the pH level of the water varies from 6.73–7.8, with a mean value of 7.28, suggesting that the groundwater is alkaline; this is within acceptable limits, as specified by the TSE-266 (2005)and WHO (2006) standards. A pH level of 7 or less is likely to be corrosive; higher than this range accelerates the formation of scaling in water heating devices. pH has no direct effect on human health, and no health-based guideline value has been identified for pH (WHO2006; Narsimha et al. 2013).Fig. 3shows that the pH level increases from the east to the west side of the study area in a regular manner.

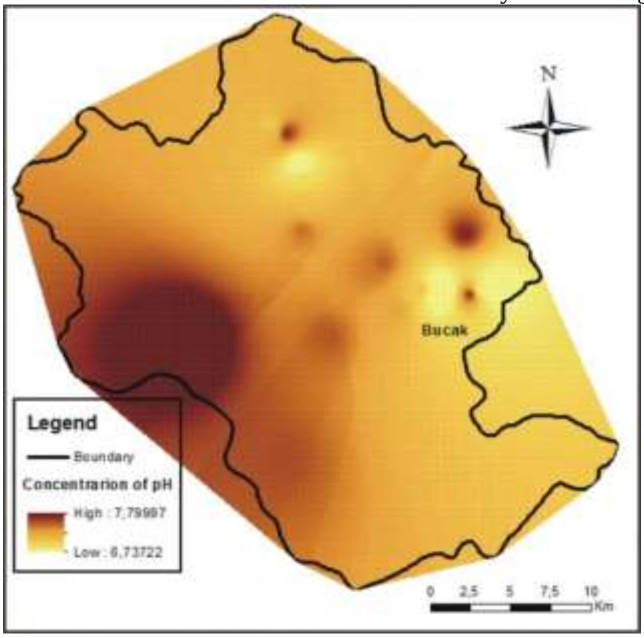

Figure 3. Spatial distribution of pH

Electrical conductivity (EC)

EC is the capacity of electrical currents to pass through water (Singh et al. 2011); EC and TDS are both related to salinity (Kadhem 2013). In the study area, EC values range from 343 to 955 µS/cm, and they increase from west to east (Fig. 4). Except for the GW 7 and GW 15 samples, all of the samples exceed the limits of the WHO (2006) standard.

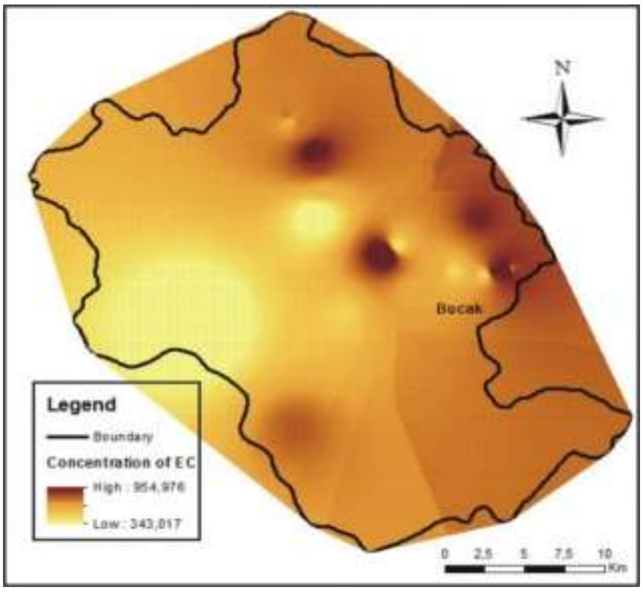

Figure 4.Spatial distribution of EC

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Total dissolved solids (TDS)

Sewage, urban runoff, and industrial waste can all affect the TDS values in groundwater (Joseph 2001; Swarna Latha 2008). TDS values higher than 500 mg/l may cause gastro-intestinal irritation (Singh et al. 2011) and can decrease the quality and taste of water (GuruPrasad 2005). In the study area, TDS values fluctuate between 233–640 mg/l; all of the samples are below the maximum permissible limit in the WHO (2006) standards. Fig. 5 shows the spatial distribution of TDSs in the area, with values increasing from west to east.

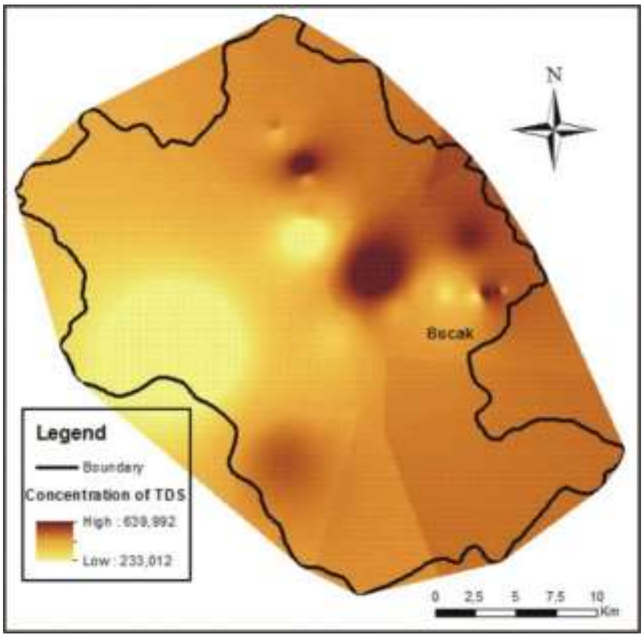

Figure 5. Spatial distribution of TDS

Salinity

Salinity is not desirable in irrigation water because it accelerates aridity and it decreases the water's palatability. The use of manure around agricultural areas, and the existence of domestic waste water and geologic structures in the field, can cause increased salinity of groundwater (Taş 2006). As is seen in Fig. 6, the salinity of the study area ranges from 0.17 to 0.46, except in the GW 14 sample area, where the value is 2.29.

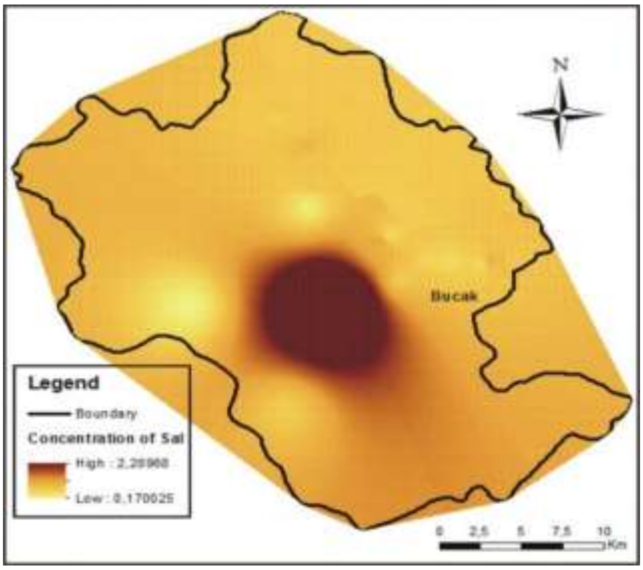

Figure 6. Spatial distribution of Salinity

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Calcium (Ca)

Calsium is a basic building block for living skeletons; it is necessary for developing proper bone growth, and it is also a necessary component in soil (Kaya and Öztürk 2003; Taş 2006; Narsimha et al. 2013).The concentration of Ca in the sample area varies from 59.4 to 132.76, which is below the WHO (2006) standards' limit. Along with magnesium, calsium is the most common mineral to affect the hardness of water (Taş 2006; Shomar et al. 2010;Singh et al. 2011).Fig. 7 shows the spatial distribution of calcium in the study area; the concentration of calcium is highest on the east side of the Bucak catchment area.

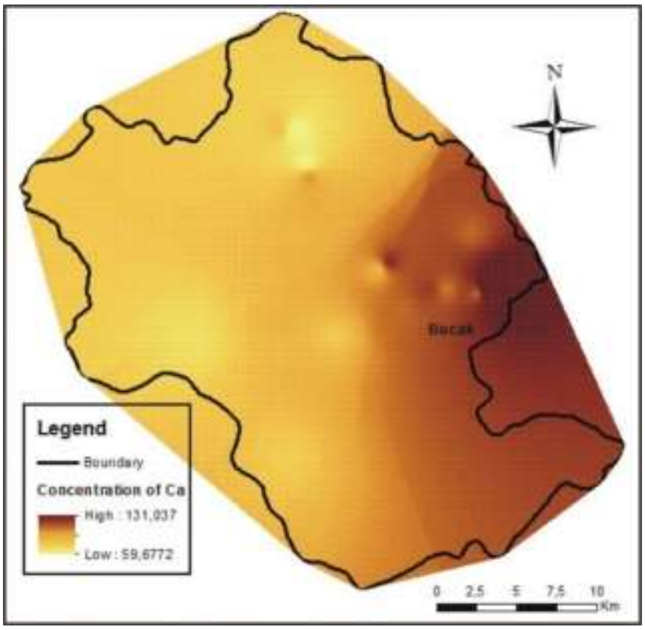

Figure 7. Spatial distribution of Calcium

Potassium (K)

Potassium levels in the study area vary between 0.52 to 4.62 mg/l (Fig. 8), which is below the permissible TSE-266 (2005) and WHO (2006) limits. Potassium in low concentrations is necessary for plant development (Kaya and Öztürk 2003); there is no evidence that high potassium levels are harmful in municipally treated drinking water (WHO 2006).

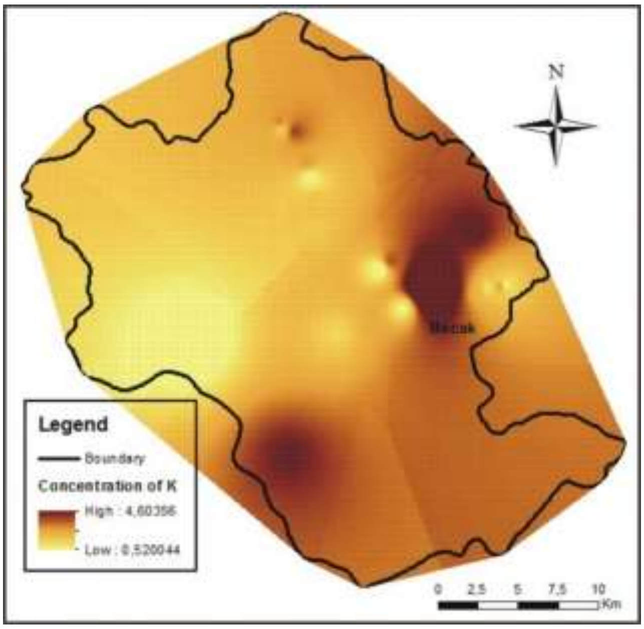

Figure 8. Spatial distribution of Potassium

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Magnesium (Mg)

Except in the GW12 sample, magnesium values are below the permissible TSE-266 (2005)and WHO (2006) standards (Table 2). Contrary to the Ca concentration, the Mg concentration is higher in the northeast side of the catchment area and in the GW 16 sample area (Fig. 9). Magnesium is important for proper cell function; it is used in enzyme activation and by growing plants. It is also a helpful ion for obtaining permeable soil (Kaya and Öztürk 2003; Narsimha et al. 2013).

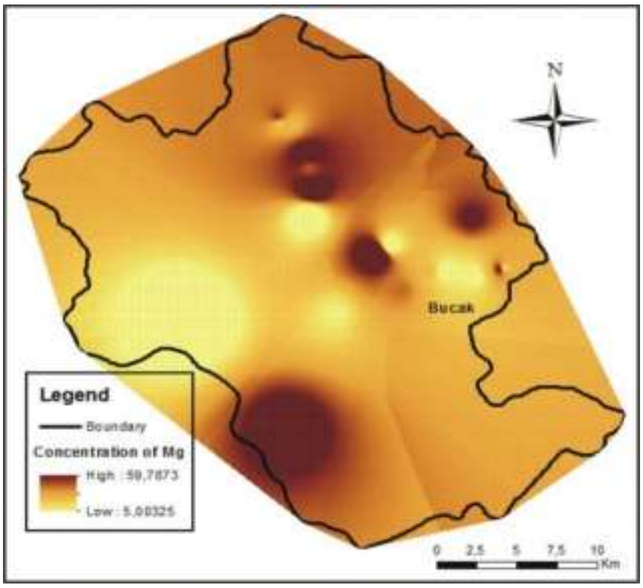
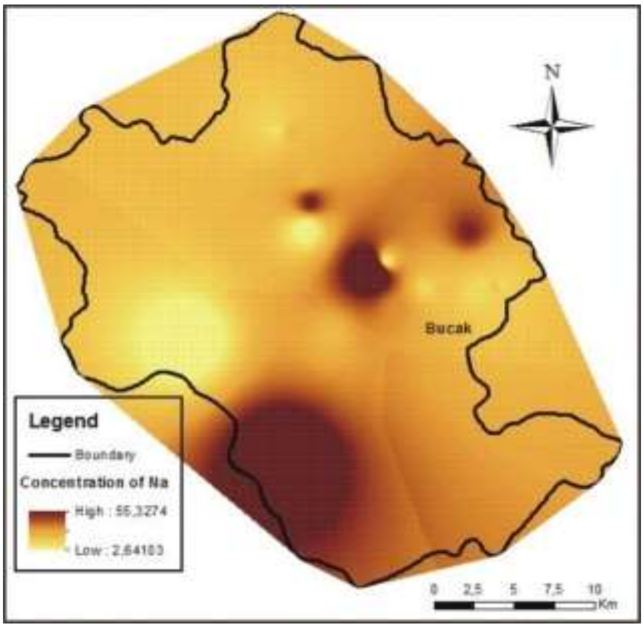


Figure 9. Spatial distribution of Magnesium

Sodium (Na)

Sodium is essential for plant growth in small concentrations, but it can damage soil and plants if it reaches high levels (Kaya and Öztürk 2003). Sodium values in the study area fluctuate between 2.64 to 55.33 mg/l, which are below the TSE-266 (2005)and WHO (2006)standards (Fig. 10).



Figüre 10. Spatial distribution of Sodium

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Hardness ($CaCO_3$)

Dissolved magnesium and calsium are the main minerals that make water harder (Yisa and Jimoh 2010). The hardness level of the water in the sample area varies from 21 to 53 mg/l; all of the samples are below the permissible limit of 500 mg/l. Soft water is classified as 0 to 60 mg/l; thus, as Fig. 11 shows, all the water in the study area is soft (Kadhem 2013).

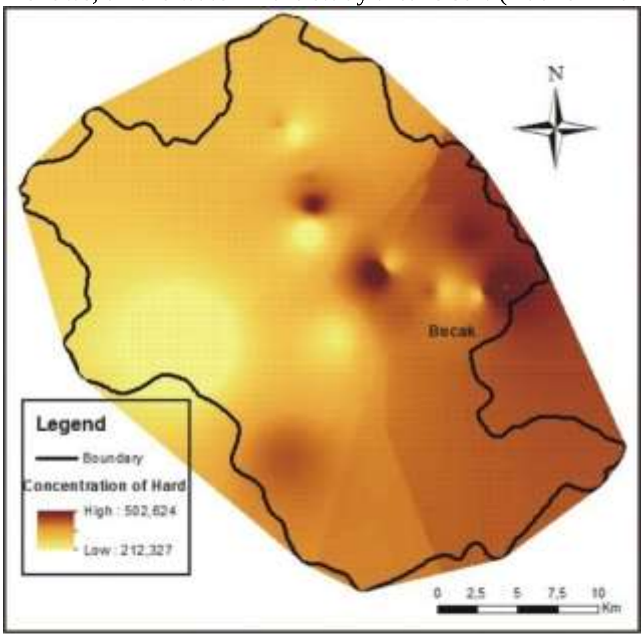

Figure 11. Spatial distribution of Hardness

Conclusion

This study used GIS, combined with groundwater laboratory analysis, and obtained thematic maps of water quality using the IDW method. Specifically, pH, EC, TDS, salinity, Ca, Cl, K, Mg, Na, and water hardness were monitored; the spatial distributions are presented in this study. All of the values of the 20 groundwater samples fall within the permissible limits except for the EC values; only the GW 7 and GW 15 sample areas had permissible limits for EC. In addition, the Mg in the GW 12 sample area exceeded the permissible limits. This study has shown that the groundwater of this area can be used for drinking and domestic purposes, and that GIS is very useful for demonstrating groundwater quality.

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References

1. Adhikary KS, Ahmed AC, Saha CG(2013) Mapping of shallow groundwater quality using GIS: A study from a small catchment in Northwestern region of Bangladesh. In: International Conference on Engineering Research, Innovation and Education, Bangladesh, 687-694.
2. Başçiftçi F, Durduran SS, İnal C, (2013) Konya kapalı havzasında yeraltı su seviyelerinin coğrafi bilgi sistemi (CBS) ile haritalanması. Electronic Journal of Map Technologies, 5 (2): 1-15.
3. Çelik R, (2014) Assessment of Diyarbakır City centre grounwater quality and obtaining thematic maps with GIS technic. Digital Proceeding of the ICOEST, Side, 13-22.
4. Demirci A, (2008) Öğretmenler için coğrafi bilgi sistemleri. Fatih Üniversitesi, Turkey.
5. GuruPrasad B (2005) Assessment of water quality in canals of Krishna delta area of Andhra Pradesh, Nature of Environment and Pollution Technology, 4(4): 521-523.
6. Hançer M(1996) Isparta güneyi, Ağlasun-Bucak civarının jeolojik ve tektonik özellikleri. Dissertation, University of Süleyman Demirel
7. Hepdeniz K(2014) Bucak (Burdur) mermer ocaklarının coğrafi bilgi sistemleri kullanılarak analiz edilmesi. Dissertation, University of Süleyman Demirel

INTERNATIONAL JOURNAL OF RESEARCH SCIENCE & MANAGEMENT

8. Joseph K (2001) An integrated approach for management of Total Dissolved Solids in reactive dyeing effluents, International Conference on Industrial Pollution and Control Technologies, Hyderabad.
9. Kadjem JA(2013) Assessment of water quality in Tigris River-Iraq by using GIS mapping. Natural Resources, 4: 441-448.
10. Kaya N, Öztürk M(2003) Elazığ il sınırları içerisindeki sulama sularının incelenmesi. Doğu Anadolu Bölgesi Araştırmaları, 3: 87-92.
11. Mantzafleri N, Psilovikos A, Blanta A(2009). Water quality monitoring and modelling in Lake Kastoria, using GIS. Assesment and management of pollution sources. Water Resource Manage, 3221-3254.
12. Narsimha A, Sudarshan V, Srinivasulu P, Anitha N, Parameshwar V(2013) An integrated approach to assess the quality of grounwater in part of Cheralapally area, Rangareddy district, Andhra Pradesh, India. Advances in Applied Science Research, 4 (1): 244-253.
13. Nwankwoala HO, Eludoyin OS, Obafemi AA, (2012) Groundwater quality assessment and monitoring using geographic information systems (GIS) in Port Harcourt, Nigeria. Ethiopian Journal of Environmental Studies and Management EJESM 5 (4): 583-596.
14. Özşahin E(2013) CBS kullanılarak su kalitesinin dağılışı ve değerlendirilmesi: Cevizli Dere havzası (Tekirdağ) örneği. International Periodical For The Languages, Literature and History of Turkish or Turkic, 8 (12): 1067-1082.
15. Shomar B, Abu Fakher S, Yahya A(2010) Assessment of groundwater quality in the Gaza Strip, Palestine using GIS mapping. Water Resource and Protection, 2: 93-104.
16. Singh P, Khan IA(2011) Groundwater quality assessment of Dhankawadi ward of Pune by using GIS. International Journal of Geomatics and Geosciences, 2 (2): 688-703.
17. Swarna Lathe P (2008) Studies on spatial and temporal changes of land use and land cover, grounwater quality and shoreline of Greater Visakhapatnam municipal corporation, Andra Pradesh, India using remote sensing and GIS techniques. Dissertation, University of Andhra
18. Taş B(2006) Derbent baraj gölü (Samsun) su kalitesinin incelenmesi. Ekoloji, 15 (61): 6-15.
19. Tokatlı C, Köse E, Uğurluoğlu A, Çiçek A, Emiroğlu Ö(2014) Gala Gölü (Edirne) su kalitesinin coğrafi bilgi sistemleri (CBS) kullanılarak değerlendirilmesi. Journal of Engineering and Natural Sciences, 32: 490-501.
20. TS 266, "Sular-İnsani Tüketim amaçlı sular", Türk Standartları Enstitüsü, ICS 13.060.20, 2005.
21. TUIK(2015)Adrese dayalı nüfus kayıt sistemi. http://tuikapp.tuik.gov.tr/adnksdagitapp/adnks.zul. Accessed 15 July 2015
22. Unesco(2006) Coping with water scarcity a strategic issue and priority for systemwide action. http://www.unwater.org/downloads/waterscarcity.pdf. Accessed 18 June 2015
23. WHO 2006 "Guidelines for drinking water quality" 3rd Edition, Geneva.
24. World Water Council(2003) Ministry of foreign affairs, department of regional and transboundary waters, general directorate of state hydraulic works; southeastern Anatolia Project regional development, administration, Republic of Turkey.
25. Yisa J, Jimoh T(2010) Analytical studies on water quality index of River Land-zu. American Journal of Applied Sciences, 7(4): 453-458.
26. Zhang W, Kinniburgh D, Gabos S(2013) Assessment of groundwater quality in Alberta, Canada using GIS mapping. In: 3rd International Conference on Medical, Biological and Pharmaceutical Sciences, Bali (Indonesia), 199-203.