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أستخدام النظائر البيئية (أكسجين 18- ديوتيريوم - تريتيوم) والتحليل الكيميائي لتحديد التداخل بين المياه الأرضية والمياه السطحية

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الخلاصة

في هذه الدراسة تم اختيار تأثير المياة السطحية على المياه الجوفيه بواسطة التحاليل الفيزيو- كيميائية والنظائر البيئية. تمت الدراسة في منطقة أولوفا التي تبعد 10 كم شمال شرق مدينة إليازج (تركيا). جمعت عينات المياه من المياه الجوفية في أولوفا وبحيرة سد كيبان وبحيرة هازار وجدول هارنجت خلال فصل الجفاف وفصل الأمطار. حللت العينات للبحث عن الأكسجين 18 والديوتيريوم والتريتوم بمعرفة درجة الحرارة والتوصيل الكهربائي والكلور الأحادي. وفق نتائج تحليل النظائر البيئية تم التعرف على ثلاث مجموعات في الموسمين الجاف والممطر. الخط البياني للأكسجين 18 لعينات المياه عرفت للموسم الممطر والجاف. قيم التريثيوم لعينات المياه صنفت كما يلي: (4-0) و (6-4) للموسم الممطر و(12-6) للموسم الجاف. بناء على ذلك. وجد أن المياه الجوفية في منطقة أولوف تغذي يومياً بترسبات المياه السطحية المستخدمة للري من بحيرة سد كيبان وبحيرة هازار تؤثر على المياه الجوفية في موسم الري. هذا لم يؤثر على محتوى التريتيوم في المياه الجوفية.

Determination of the interaction between groundwater and surface water using environmental isotopes (Oxygen-18, Deuterium and Tritium) and chemical analyses in Uluova Region, Elazig, Turkey

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ABSTRACT

In this study, the effects of surface waters on groundwater aquifers were examined via physico-chemical analyses and environmental isotopes. The study was carried out in the Uluova region located 10 km northeast of the city of Elazig (Turkey). Water samples were acquired from the Uluova aquifer, Keban Dam Lake, Hazar Lake and Haringet stream during the wet and dry seasons. The water samples were analyzed for Oxygen-18, Deuterium, Tritium, temperature (T), electrical conductivity (EC) and Chloride (Cl^-). According to the results of environmental isotope analysis, three different groups of water masses were identified in the basin in the wet and dry seasons. The equation of the line formed by the points in the Oxygen-18 – Deuterium graph for water samples received from the Uluova region was defined as $\delta D=6\delta^{18}O$ – 10.50 for dry season and as $\delta D=6\delta^{18}O$ – 8.66 for wet season. Tritium values of water samples were classified as 0-4 TU, 4-6 TU and 6-12 TU for wet and dry seasons, respectively. Consequently, it was found that Uluova groundwater aquifer is fed by daily precipitations. The surface water irrigations from Keban Dam Lake and Hazar Lake affect the aquifer during irrigation season. This has not changed the classification made by the Tritium content of the aquifer.

Keywords: Environmental isotopes; geographic information systems (GIS); hydrogeology hydrogeochemistry; Uluova region.

INTRODUCTION

Environmental isotopes of water are extensively used as tracers to understand hydrogeological processes like precipitation, age of groundwater, origin of groundwater, groundwater recharge, groundwater-surface water interactions, and basin hydrology (Fontes, 1980; IAEA, 1981; Gat, 1996; Clark & Fritz, 1997; Yurtsever & Araguas, 1993; Atilla, 2002; Gibson *et al.,* 2005). Naturally occurring isotopes present themselves in both stable and radioactive forms in the environment and are

valued as environmental isotopes (Clark & Fritz, 1997). The most frequently used environmental isotopes involve those of the water molecules, hydrogen (^2H or D, also called deuterium and ^3H, also called tritium) and oxygen (^{18}O). ^2H and ^{18}O are stable isotopes of the respective elements whereas ^3H is a radioactive isotope (IAEA, 2007). Environmental isotope content in water samples are expressed as δ values ($\delta^{18}O$, δ^2H), which are permil deviations from an internationally accepted standard. The δ unit is defined as:

$$\delta\ (‰)=(R_{sample}-R_{VSMOW})/(R_{VSMOW})\times 10^3 \quad (1)$$

where, R is the isotope ratio ^2H / ^1H or ^{18}O /^{16}O. Whereas Vienna Standard Mean Ocean Water (VSMOW) is the internationally accepted standard for water (Craig, 1961; Gonfiantini, 1978). The relation between δ^2H and $\delta^{18}O$ values largely plots along a trend line. This is the "Global Meteoric Water Line" (GMWL) (Craig, 1961), and is characterized by the relation;

$$\delta D = 8\delta^{18}O + d\ (‰) \quad (2)$$

where d is defined as the ^2H excess (Dansgaard, 1964). The mean global value for d in freshwater is 10 (Craig, 1961), but it may have different values in some areas (Hershey *et al.,* 2007). Isotopically light waters are plotted near the GMWL, but isotopically heavier waters are offset to the right of the line (Craig, 1961). ^{18}O composition of atmospheric water and temperature decreases with increasing altitude (Craig, 1961; Dansgaard, 1964; Yurtsever & Gat, 1981). The d values within a range of 10% refer to waters of Atlantic origin while values within a range of 22% are characteristic of waters from the Eastern Mediterranean and values within a range of 14% are intermediate values between the first two detected in rainwater pouring over the Western Mediterranean (Gat & Carmi, 1970; Celle-Jeanton *et al.,* 2001).

Owing to this relatively short half-life; tritium was used in hydrogeology as an excellent environmental tracer to identify modern recharge in aquifer systems (IAEA, 2007). One TU is identified as one atom of ^3H per 10^{18} atoms of ^1H, which is equivalent to an activity of 0.118 Bq or 3.193 pCi per litre of water. The half-life of tritium is 12.32 years (Yurtsever & Araguas, 1993; Lucas & Unterweger, 2000).

The groundwater hydraulic features of the Uluova (Elazig) aquifer were tried to be put forth in this study as well as artificial feeding arising from surface irrigations and the effect of lateral feeding from Keban Dam Lake via chemical data and environmental isotopes. The agricultural irrigation area of Uluova Region is 13207 ha with a 5000 ha section irrigated by groundwater and the remainder irrigated via open channels as surface irrigation within the scope of Eyupbaglari pumping irrigation project.

Study Area

Elazig city is located in the Eastern Anatolia Region of Turkey (Figure 1). The area lies between latitudes 38° 17′N and 38° 43′N and longitudes 38° 36 ′E and 39° 07′E and has a drainage area of 672 km². The study area has a continental climate with an average annual precipitation of 418.2 mm (1929 – 2007). The maximum monthly air temperature (42.2°C) occurs in July, and the minimum monthly air temperature (–22.6 °C) in January (DMI, 2007).

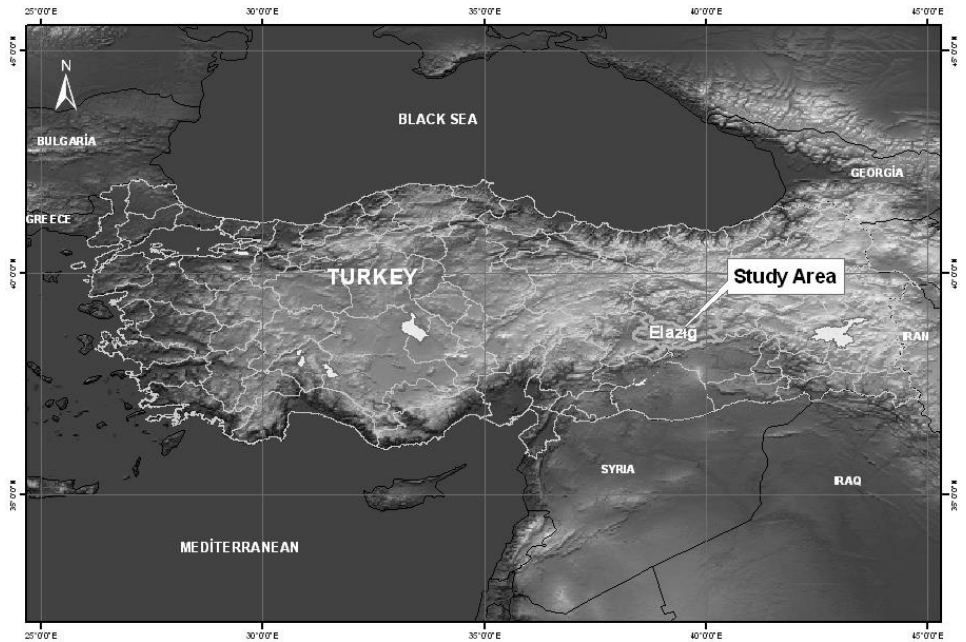

Fig. 1. Location map of the study area

Grain is the most commonly cultivated product in the irrigation area. Together with grains, vineyards, fruit growing along with fodder plant and vegetable cultivation are carried out. Cotton was planted in the past years, however it is now observed that cotton has been removed altogether. The reason for this is either the lack of irrigation resources or the high cost of the groundwater irrigations that are rarely carried out.

Geology

The Permo-Triassic aged Keban metamorphic limestones are the oldest rocks in the region. The researchers state that regional metamorphites are ordered from the base to the top as recrystallized limestone, calcschist, marble, metaconglomerate & chalcophyllite. However they are generally represented in the study area by crystallized limestones (Akgul, 1987; Cetindag, 1989; Cetindag & Okan, 2004; Palutoglu, 2006;

Celiker, 2008). The Sanonian aged magmatic rocks in the study area are known as Elazig magmatites and are represented by granite, andesite and diabase. Akgul (1993) has stated that magmatic rocks are made up of three consecutive stages. In the first stage, basic composition depth and surface rocks have formed, in the second stage, acidic composition depth and surface rocks and in the third stage, aplite and lamprophyre composition dyke rocks have been formed. Tectonically, the zone between Elazig magmatites and Keban metamorphites has been completely smashed and destroyed. Alcicek (1996) has stated that in magmatic rock contacts there are mineral groups such as olivin, granat, spinel and magnetite which shows pyroxene hornfels facies metamorphism conditions and the marbles are made up of calcite and dolomite. Elazig Magmatic rocks and Keban metamorphic rocks are related with tectonic contact at places and with discordant contact at others. The Lutetian – Upper Oligocene aged Kırkgeçit formation made up of sandstone, marl, sandy clayey limestone and conglomerate levels that have surfaced to the north, northeast, east regions of the study area and near Harput, overlies older units with angular discordance and are covered in the study area by Pliocene units. The plain region of the study area is made up of Pliocene aged sand, clay, silt units and recent alluvium (Figure 2). The narrow alluvium formations observed along the Haringet Stream crosses the study area from southwest to northeast.

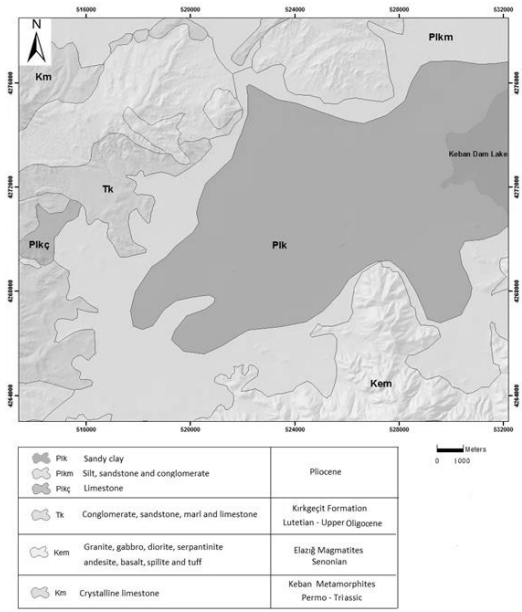

Fig. 2. Geological map of the study area

MATERIAL AND METHOD

This study was carried out in two different seasons during 2006-2007 as field and sampling studies in 19 locations (Figure 3). Field studies were carried out to map geological structures and to sample waters for physico-chemical and isotopic analyses. The chemical and isotopic components ($\delta^{18}O$, $\delta^{2}H$ and Tritium) of water samples were analyzed in State Hydraulic Works (Ankara, Turkey) TAKK laboratory, Ankara. The water temperature and electrical conductivity were measured in situ, by using a WTW Cond 720 measuring instrument. The chemical analysis was carried out for chloride by volumetric titration method (APHA, 1995). Samples for deuterium and oxygen-18 analyses were collected from well, spring, surface waters and rain in a 1000 ml polyethylene bottle without filtering. The deuterium and oxygen-18 isotope ratios of the water samples were determined via mass spectrometric methods by an IsoPrime dual inlet isotope-ratio mass spectrometer measuring instrument. Tritium content was measured by counting its radioactive decay, using liquid scintillation spectrometers. (IAEA, 2009; 2010). The maps formed in the study were drawn by using ArcGIS 9.3 software, a specific brand of Geographic Information Systems (GIS) software (ESRİ, 2008).

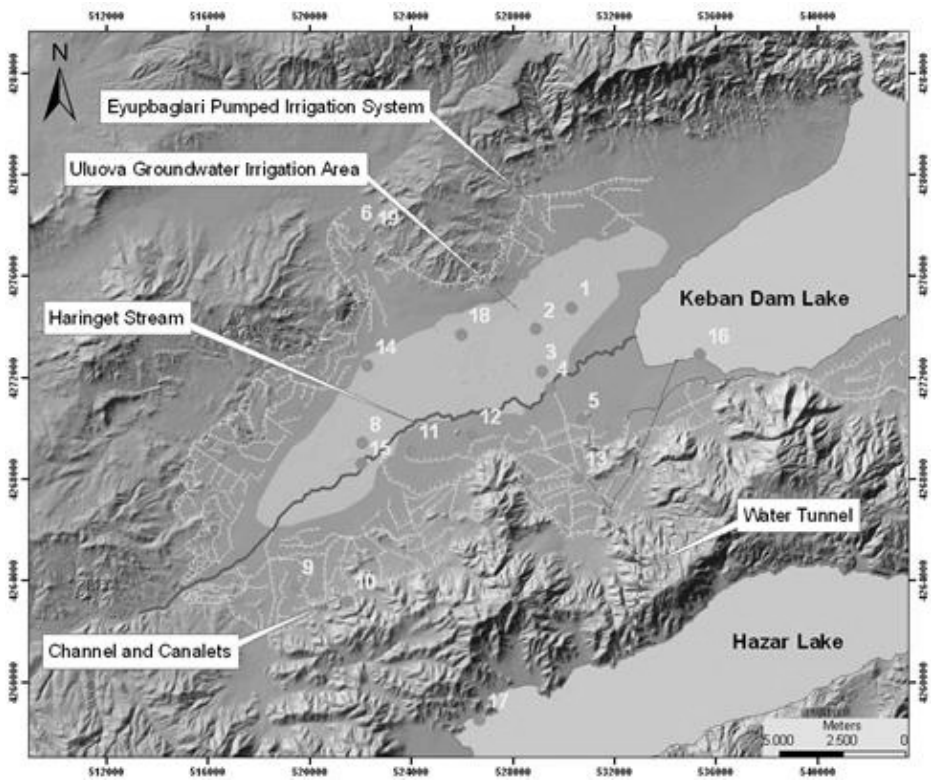

Fig. 3. Sampling locations in study area

RESULTS AND DISCUSSION

Surface Waters

In the study area, Haringet stream is the only drainage of the lowland and surface waters flow into Keban Dam Lake through this stream. In summer, Haringet stream gets dry in summer months, however, low flow is observed because irrigation water in Karsibag village arrives at Haringet stream (DSI, 2006). Flow gauging stations were established by DSI IXth Regional Directorate to the inflow part of Haringet stream to Uluova and to the outflow part around Kehli village, and monthly changes of water quantities were recorded for the year 2006 (Table 1). Keban Dam Lake is located in the eastern part of the study area with an altitude of 845 m maximum from the water level, and the tectonic lake Hazar is located some 5 km north of that with an altitude of 1240 m (Figure 3).

Table 1. Haringet stream input and output flows (DSI, 2006)

Months	1	2	3	4	5	6	7	8	9	10	11	12
Plain Input(m^3/s)	0.35	0.91	1.63	2.88	0.22	0.04	dry	dry	dry	dry	0.68	0.31
Plain Output(m^3/s)	0.55	1.9	1.5	5.77	1.02	0.11	0.08	0.2	0.11	0.11	1.74	0.5

Eyupbaglari Pumping Irrigation Project

Keban Dam Lake and the mixing waters from Hazar HES I discharge affluent constitute the water resources of the project that went into action in 1988. Eyupbaglari pumping station (the first degree) steps up the water from Keban Dam Lake to the start of the S1 and S2 main channels. The backing water (2.2 m^3/s) coming from Ikitepe pumping station (the second degree) and S2 main channel, and from the discharge of Hazar-I HES is stepped up to S3 and S4 main channels and 13207 hectare of area is irrigated in total. Hazar HES I project comprises five units and was designed to make 280 m of drawdown by allocating a total of 4.7 m^3/s of water taken from Hazar Lake at 1240 m of altitude with a 5 km tunnel (Figure 3). The water quantity given to the lowland through open channels within the scope of Uluova Eyupbaglari pumping irrigation has been given in Table 2. Water intake from the Hazar Lake to the project, which started power generation in 1960, was stopped in 2006.

Table 2. The water quantity given to the Uluova through open channels during the irrigation season (May through October)

Water pump location	Date	The irrigation canal water (m^3/year)
Keban Dam + Hazar Hydroelectric Power Plant	1988	21.400.000
Keban Dam + Hazar Hydroelectric Power Plant	1989	45.300.000
Keban Dam + Hazar Hydroelectric Power Plant	1990	58.700.000
Keban Dam + Hazar Hydroelectric Power Plant	1991	61.000.000
Keban Dam + Hazar Hydroelectric Power Plant	1992	58.700.000
Keban Dam + Hazar Hydroelectric Power Plant	1993	64.300.000
Keban Dam + Hazar Hydroelectric Power Plant	1994	91.500.000
Keban Dam	1995	34.316.000
Keban Dam	1996	63.792.000
Keban Dam	1997	63.925.000
Keban Dam	1998	72.722.000
Keban Dam	1999	50.583.000
Keban Dam	2000	42.810.000
Keban Dam	2001	60.397.000
Keban Dam	2002	64.012.000
Keban Dam + Hazar Hydroelectric Power Plant	2003	79.580.000
Keban Dam	2004	32.630.000
Keban Dam	2005	40.677.385
Keban Dam	2006	8.758.000

Groundwaters

There are two aquifers in the study area; an unconfined and a confined one. While unconfined aquifers are formed in Pliocene sandy, clayey units and conglomerates; confined aquifers are formed in underlying silt, clay, sandstone and conglomerates. The northwest-southeast direction forms the dominant groundwater flow direction in the study area (Cetindag & Okan, 2004; Celiker, 2008). When the hydrogeological properties of the geological units encompassing Uluova are examined, it is observed

that karstification has developed even further, thus, increasing the permeability and porosity as well as the water storage property of the rocks. This karstification occurs as a result of the fractured structures, such as karst cavities and chanels, developing due to crystallized limestones of metamorphites as well as tectonism. The fracture systems and alterations of magmatites and volcanic rocks are among the factors that developed the permeability of these units. Hence, magmatic rocks can store water. Large amounts of water can be obtained from the contact point between the magmatics and metamorphites. The clayey limestones that make up the surrounding heights around the study area can also store water due to their fractured and porous structure. Water wells are drilled into the silt, sandstone, conglomerate and sandy clay of the Pliocene aged formations in the study area, which make up the Uluova aquifer.

Hydrochemical properties

Groundwaters that belong to unconfined aquifer are the waters with Na-Cl and Na-HCO_3 facies and the ones that belong to confined aquifer are Ca-HCO_3, Mg-HCO_3 and Na-HCO_3 type waters. The dominant cation and anion in the chemical analyses of waters received from Hazar Lake were Na and HCO_3, and these were determined as Ca and SO_4 in the analyses of the waters received from Keban Dam Lake (Cetindag & Okan, 2004).

In this study, electrical conductivity (EC) and Chloride (Cl) parameters of the water samples were analyzed. The EC values of the water samples varied between 240 – 2050 µS/cm, whereas the Cl values varied between 29.4 – 386 mg/L. Highest EC and Cl values among the water samples acquired from the study area were observed in the water sample from the Hazar Lake. These high values are considered because Hazar lake is a small closed basin that is fed along the tectonic fractures on the base of the lake and the wastewater is drained into the lake from settlements.

Isotope Hydrology

Water samples were taken from water well, spring and surface water during wet and dry seasons between 2006-2007. The reason for this was to shed light on the groundwater feeding in Elazig-Uluova, pumping water out of the wells, the impact of Keban Dam to groundwater and the complex hydrogeological structure. The locations from where water samples were taken are shown in Figure 3. Oxygen-18, deuterium and tritium analyses were carried out in DSİ TAKK Department Isotope Laboratory and the results have been given in Table 3. Oxygen-18 and tritium contents and distributions of groundwaters are shown in Figures 4, 5, 6 and 7.

Table 3. Physico-chemical and isotopic composition of the water samples

No	Date	Location	Elavation (m)	T ºC	EC (µS/cm)	Cl (mg/l)	$\delta^{18}O$ ‰VSMOW	$\delta^{2}H$ ‰VSMOW	T ‰VSMOW	±TU Uncertainty	d exceses
1	9.8.2006	Well	860	17.4	718	63.1	-8.4	-57.92	4.45	0.85	9.28
	20.6.2007						-8.12	-53.66	3.9	1	11.3
2	9.8.2006	Well	917	18.1	722	26.94	-8.68	-64.58	0.55	0.7	4.86
	19.6.2007						-8.82	-64.53	0.2	0.8	6.03
3	9.8.2006	Well	855	15	458	56.2	-8.79	-62.16	8.4	1.4	8.16
	19.6.2007						-8.91	-60.8	8.1	1.55	10.48
4	9.8.2006	Well	855	16.5	502	44.5	-8.99	-64.89	6.6	1.2	7.03
	19.6.2007						-8.95	-63.84	6.45	1.35	7.76
5	9.8.2006	Well	868	16.5	680	81.5	-8.02	-57.32	12.1	1.45	6.84
	19.6.2007						-8.01	-56.54	10.75	1.9	7.54
6	10.8.2006	Well	970	17.5	844	72.74	-8.14	-62.08	8.1	1.4	3.04
	19.6.2007						-8.17	-59.53	9.1	3.65	5.83
7	10.8.2006	Spring	1261	15.8	290	38.6	-9.18	-65.37	10.85	1.45	8.07
	20.6.2007						-9.16	-66.83	10.05	4	6.45
8	10.8.2006	Well	895	15.5	755	59.6	-8.47	-61.65	11.45	1.5	6.11
	19.6.2007						-8.46	-65.82	7.85	3.35	1.86
9	10.8.2006	Well	953	16.8	737	80.4	-8.64	-65.66	9.65	1.45	3.46
	20.6.2007						-8.66	-56.33	8.4	3.4	12.95
10	10.8.2006	Spring	1022	18.7	240	36.4	-9.19	-64.54	9.7	1.45	8.98
	20.6.2007						-9.11	-61.38	9	3.6	11.5
11	10.8.2006	Well	884	16.1	639	60.12	-8.36	-61.86	10.15	1.4	5.02
12	10.8.2006	Well	877	17.2	770	70.05	-8.56	-65.14	5.45	1.25	3.34
	19.6.2007						-8.89	-62.05	1.15	0.8	9.07
13	10.8.2006	Well	938	14.95	885	121.95	-6.87	-53.28	7.95	1.4	1.68
	19.6.2007						-7.45	-50.65	8.25	3.3	8.95
14	14.8.2006	Well	906	18.85	804	38.85	-7.95	-63.19	4.3	1.25	0.41
	20.6.2007						-8.07	-58.77	7.5	3.05	5.79
15	22.11.2006	Haringet Stream	987	23.4	326	32.8	-8.4	-59.36	8.65	0.95	7.84
	20.6.2007						-8.18	-55.93	7.7	3.1	9.51
16	22.11.2006	Keban Dam Lake	845	14.8	344	29.4	-8.86	-60.43	7.35	0.95	10.45
	19.6.2007						-9.6	-65.7	8.25	3.3	11.1
17	22.11.2006	Hazar Lake	1240	14.5	2050	386	-1.44	-18.23	10.8	1.05	-6.71
	20.6.2007						-1.02	-15.32	10	3.95	-7.16
18	22.11.2006	Elazığ Rainfall Station	987				-9.87	-44.74	8.40	1	34.22
19	13.3.2006	Airport Rainfall Station	884				-8.48	-52.43	9.95	1.3	15.41

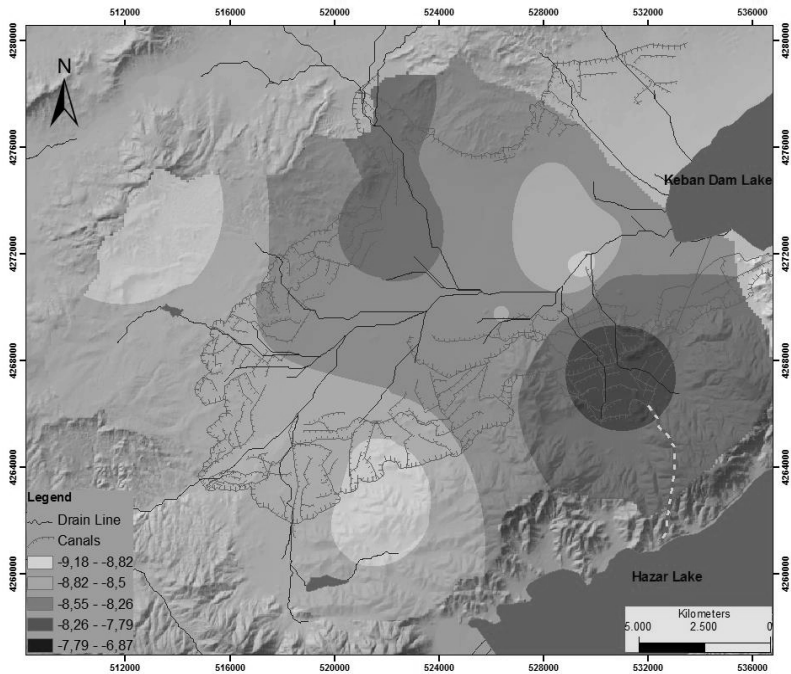

Fig. 4. Oxygen-18 distribution map of groundwater in the study area (dry season)

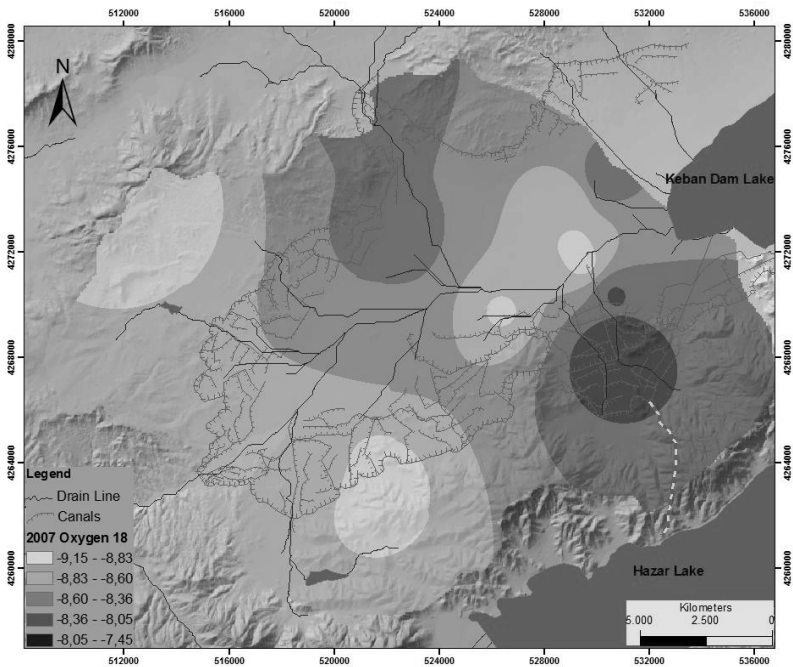

Fig. 5. Oxygen-18 distribution map of groundwater in the study area (wet season)

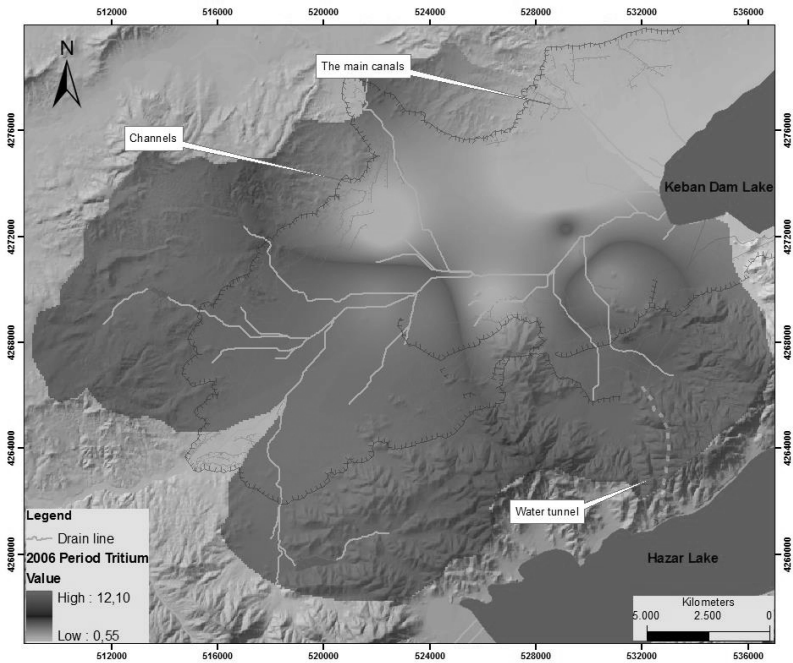

Fig. 6. Tritium distribution map of groundwater in the study area (dry season)

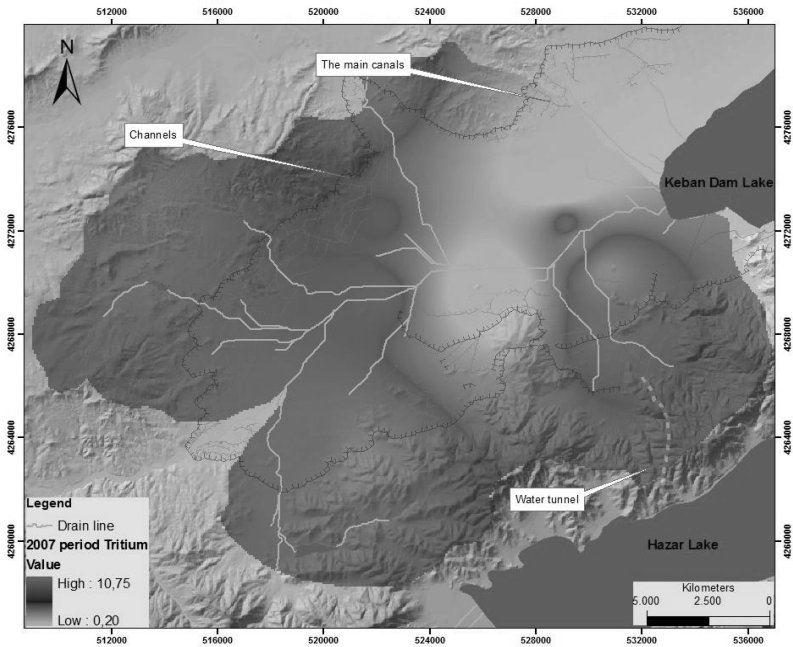

Fig. 7. Tritium distribution map of groundwater in the study area (wet season)

There were no regular and long term isotope analyses of precipitation samples of previous years for the Uluova Basin (DSI, 2012). It was considered that isotope exchanges during precipitation in the basin would not represent precipitation, since precipitation samples were not acquired more than once from Elazig Meteorological Station and Elazig Airport Meteorological Station between the dates of 13.03.2006 and 22.11.2006. Therefore, the precipitation-altitude relation could not be investigated.

2006 August and 2007 June oxygen-18 and deuterium values of water sources in the basin were marked and oxygen-18 and deuterium graph was drawn for dry and wet seasons. Meteoric Water Line and Mediterranean Water Line (IAEA, 1981; IAEA, 1983) in the oxygen-18 and deuterium graph of the water samples received from Uluova in dry season and the location numbers of the water samples were shown on the graph (Figure 8). The equation formed by the points on the graph is $\delta D=6\ \delta^{18}O$ - 10.43. The isotopic compositions of the water samples in dry season show that these water sources are fed generally by terrestrial precipitation, whereas some water sources were fed by waters exposed to evaporation with the effect of waters returning from irrigation due to the slope of line 6 (Figure 8).

Three different groups can be recognized when the year 2006 dry season oxygen-18 and deuterium graph is examined (Figure 8):

1st Group Waters: The isotopic compositions of the L-17 water sample (received from Hazar Lake) show the most positive water source in the field of study; or rather, the water source exposed to evaporation. The other water source in this group is W-13, which is a potable water well.

2nd Group Waters are the sample locations with numbers W-1, W-5, W-6, W-8, W-11, W-14, R-15 and L-16. The oxygen-18 values of water in this group vary between -7.95‰ and -8.86‰ and their deuterium values range between -57.92‰ and -63.19‰. Since the water sources in this group are located along the Uluova irrigation channel, a change was observed in the isotopic composition of the water returning from irrigation and exposed to evaporation.

3rd Group Waters are the sample location with numbers W-2, W-3, W-4, S-7, W-9, S-10 and W-12. The oxygen-18 values of water in this group vary between -8.56‰ and -9.19‰ and their deuterium values range between -64.58‰ and -65.66‰.

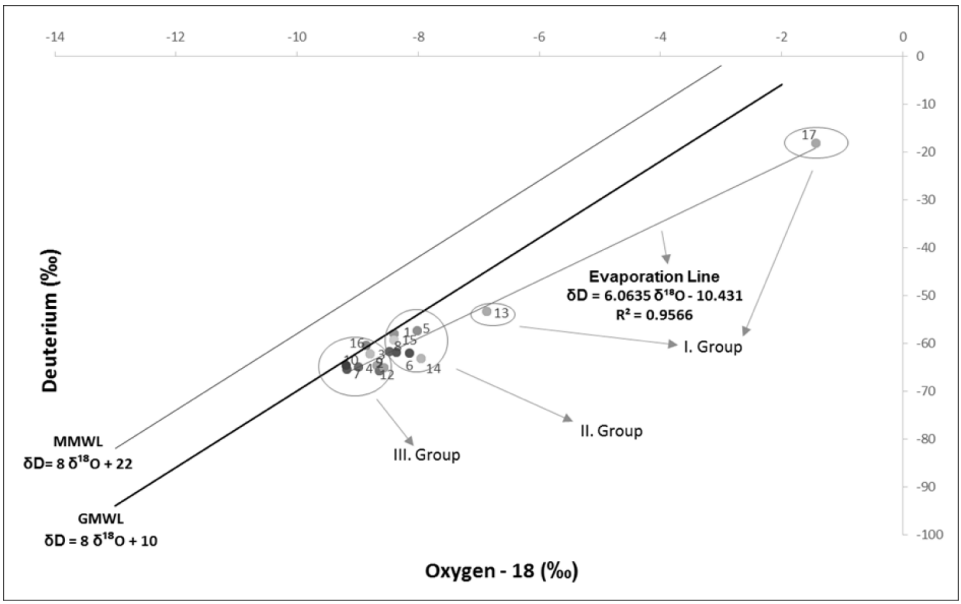

Fig. 8. Relationship between $\delta^{18}O$ and $\delta\ ^{2}H$ values for sampled water (dry season)

The equation of the line formed by the points on the oxygen-18 and deuterium graph of water samples received from Uluova in wet season is $\delta D=6\ \delta^{18}O$ - 8.66 (Figure 9). The isotopic composition of water samples in wet season also shows that these water sources are fed generally by terrestrial precipitation and some water sources were fed by water exposed to evaporation with the effect of water returning from irrigation.

Three different groups were recognized when the year 2007 wet season oxygen-18 and deuterium graph is examined (Figure 9):

1st Group Waters: The isotopic composition of water in this group shows the water samples under the effect of evaporation. These are the water samples received from Hazar Lake (L-17) and a potable water well (W-13).

2nd Group Waters are acquired from sample locations with numbers of W-1, W-5, W-6, W-9, W-14 and R-15. As the oxygen-18 values of these water sources vary between -8.01‰ and -8.66‰ and their deuterium values range between -53.66‰ and -59.53‰.

3rd Group Waters: The sampling locations in this group are W-2, W-3, W-4, S-7, W-8, S-10, W-12 and L-16. As the oxygen-18 values vary between -8.46‰ and -9.60‰ and their deuterium values range between -60.80‰ and 65.82‰.

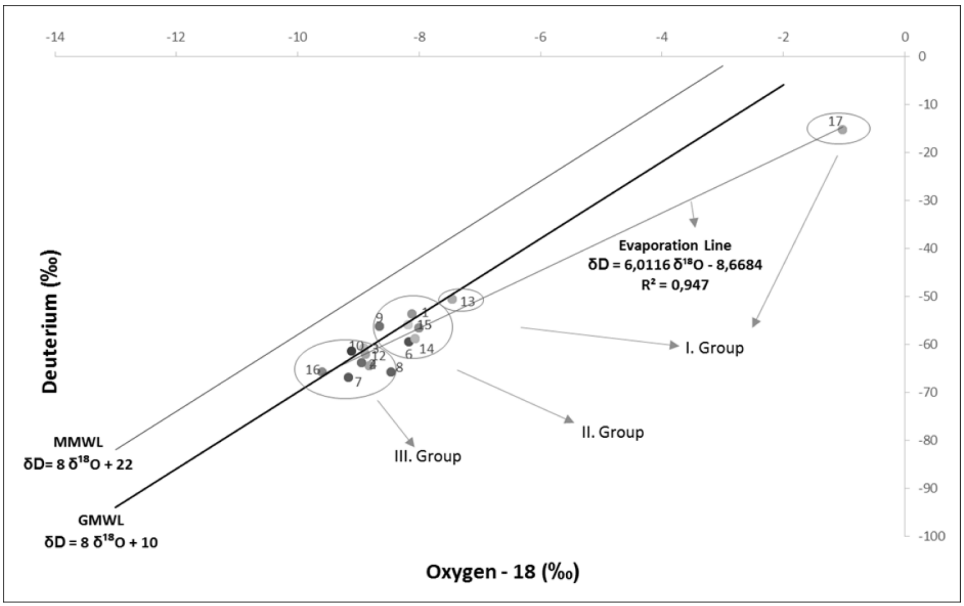

Fig. 9. Relationship between $\delta^{18}O$ and $\delta\ ^{2}H$ values for sampled water (wet season)

Deuterium excess

Contributions from secondary evaporative processes such as open surface evaporation from large water bodies can alter the d-excess of atmospheric vapor mass on the continental landmass (Zimmerman *et al.,* 1967). The d-excess values for surface and groundwater samples are presented in Table 3. For dry season, the ground-water d-excess values range from 1.86 to 12.95‰, while those of the surface water range from -7.16 to 11.10‰. For wet season, the ground-water d-excess values range from 0.41 to 9.28‰, while those of surface water range between –6.71 to 10.45‰. These values show that the water sources in the lowland altitude were fed by terrestrial and Mediterranean precipitation regimes and the ones in higher altitudes were fed by terrestrial precipitations. When d-excess change between June 2006 and August 2007 was examined, it was seen that there was a decrease in S-7 and W-8 and an increase in d-excess value in other water sampling locations. These sample points compared with the other sample points, since feeding altitude and fermeability are different from each other.

Relationship between Oxygen-18 and Tritium

The general distribution of groundwater tritium concentration in Uluova basin was examined and the oxygen-18 and tritium distribution of the water samples from wet and dry season was given in Figures 10 and 11. There is no seasonal change in tritium concentrations of water samples as can be seen in the wet and dry season graphs as

emidenced by Figures 12 and 13. When the graphs are analysed; the water sample location with tritium values of 0-4 TU in the year 2006 (dry season) oxygen-18 and tritium graph indicates the well with the number of W-2. The isotopic value of this sampling location shows the location of the oldest water in the basin, namely, the place where the movement of groundwater is slow. The tritium values of the W-1, W-12 and W-14 locations vary between 4-6 TU. The tritium values of these water sampling locations show the water sources remaining in the groundwater circulation system, which are affected by the waters fed by daily precipitations in the basin and returning from irrigation waters. The water sampling locations of W-3, W-4, W-5, W-6, W-8, W-9, W-11, W-13, S-7, S-10, R-15, L-16, L-17 with tritium values varying between 6-12 TU show similar features with isotopic composition of daily precipitations.

Water sampling locations with tritium values of 0-4 TU in the year (2007 dry season) oxygen-18 and tritium graph indicate W-2 and W-12 wells. The isotopic components of these sources reflects that they were the oldest in the basin, that the groundwater movement was slow and that the time passing between the feeding and discharge of the aquifer, was long. The tritium value of the W-1 well is between 4-6 TU. The tritium value of this water source shows the isotopic composition that remains in the groundwater circulation system which is affected by returning irrigation waters and which is fed by the daily precipitation in the basin. The locations with tritium values varying between 6-12 TU are W-3, W-4, W-5, W-6, S-7, W-8, W-9, S-10, W-13, W-14, R-15, L-16, L-17. These water sources reflect a rapidly discharging system which is affected by the mixing waters fed by daily precipitation and supplied to the Uluova irrigation channel from Keban Dam Lake and Hazar Lake in the irrigation season.

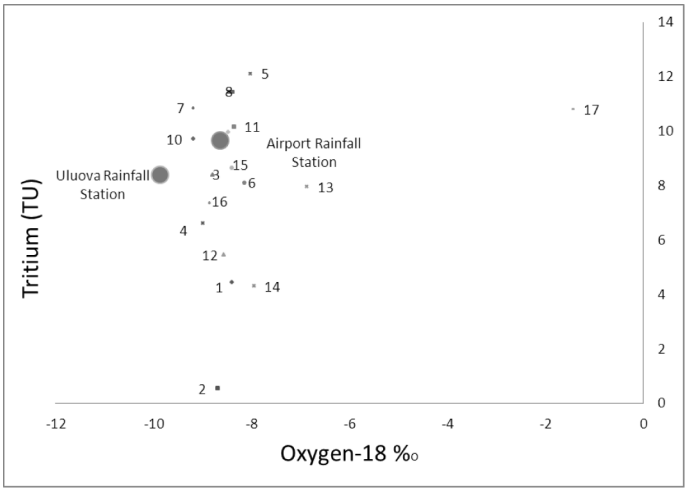

Fig. 10. Relationship between $\delta^{18}O$ and Tritium for sampled water (dry season)

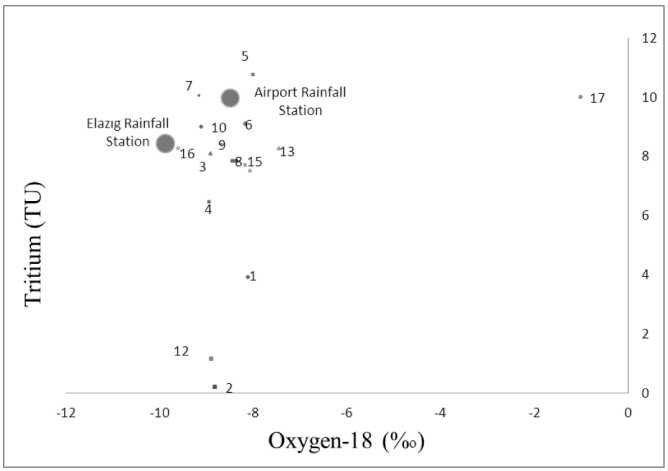

Fig. 11. Relationship between $\delta^{18}O$ and Tritium for sampled water (wet season)

Relationship between Tritium and EC

The August 2006 tritium values of water samples taken from water sources in Elazig-Uluova were examined together with electric conductivity values and tritium-EC graph was drawn (Figure 12). The sample location with tritium values of 0-2 TU and EC value of 722 µS/cm is the W-2 location. This water point represents the oldest water sample where underflow is slow. The tritium values of S-7 and S-10 springs, which are thought to be representing precipitation, are around 10 TU, and their EC values are around 240-290 µS/cm. Tritium and EC values of other water sources on the graph represent the values of mixing waters arising from the impact of the waters returning from irrigation on aquifers, after being fed by daily precipitation.

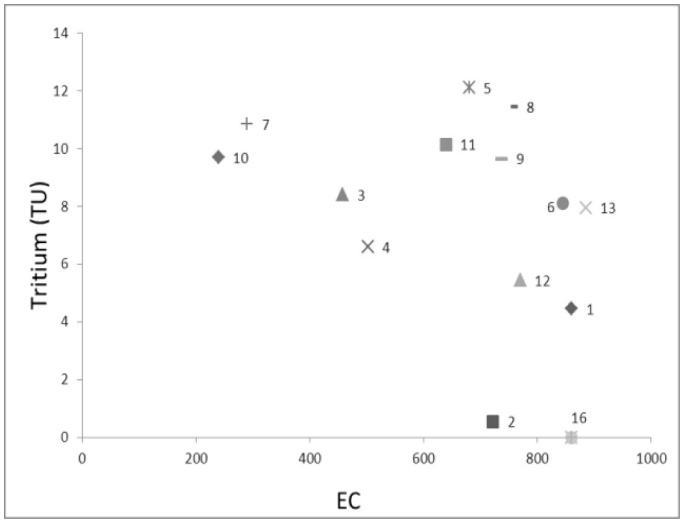

Fig. 12. Relationship between EC and Tritium for sampled water (dry season)

CONCLUSIONS

When the lithology of the geologic formations in Uluova basin were examined with regards to the storage and conveyance of groundwater, two aquifer systems were defined as unconfined and confined aquifer systems. Oxygen-18 and deuterium values of water samples received from the Uluova basin during wet and dry seasons were shown on oxygen-18 and deuterium graphs and efforts were made to determine the precipitation regime that feeds the groundwaters. It was observed that water resources that take part in the lowland altitude were fed by terrestrial downfall and Mediterranean precipitation regimes while the water resources that take part in higher altitudes, were fed by terrestrial precipitation regime. The groundwater feeding of sampling points that takes place in Elazig-Uluova, the drawing from groundwater and the impact of Keban Dam on groundwater, should be researched. A significant change was not observed in the isotopic compositions of sampling points in wet and dry season in the isotope hydrology work carried out. It was determined that the feeding of the groundwaters in the aquifer was due to daily precipitations and that the water spots received from lowland altitude had evaporated isotopic composition checking the effect of mixing waters given to the lowland from Keban Dam Lake and Hazar Lake and the effect of waters returning from irrigation on aquifer. Uluova groundwater aquifer is fed by daily precipitation. The surface water irrigation from Keban Dam Lake and Hazar Lake in irrigation season affects the aquifer. This has not changed the classification made by the tritium content of the aquifer. Groundwater management works should be kept up by taking the results obtained within the scope of isotope hydrology works into consideration.

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