O 86. HYDROGEOCHEMICAL INVESTIGATION OF THE SPRİNGS IN SILLE (KONYA) REGION

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ABSTRACT Sille (Konya) is an important settlement where different cultures with traces of Roman, Byzantine, Seljuk and Ottoman periods live together. With the restoration work carried out in recent years, Sille Culture Valley has been opened to tourism. There are many water springs in and around Sille. These springs are widely used as drinking water by the people of the region and Konya. In addition, the Sille dam pond located in the region is used for both irrigation water and tourism purposes.
In the study area are the units belonging to the Sızma, Ardıçlı and Dilekçi groups. Bozdağ and Bağrıkurt formations belonging to the penetration group are Paleozoic and consist of limestone and metacarbonates.
The metacarbonates belonging to the Ardıçlı group and the dolomites and limestones are of Mesozoic age. The Dilekçi group consists of Cenozoic aged dacite, tuff, tuffite, sandstone, mudstone and limestones. All these units are unconformably overlain by the Quaternary alluvium.
The temperature of the springs in the study area is between 10-14 ºC, the discharges are 0,02 – 1,71 lt / s, the pH is 7,19-8,04, the EC values are 210-882 µs / cm, the hardness is 9-43 FS and the total mineralization is 269,15 – 817,24 mg / l. The mineral rich spring in the study area has a pH of 7.19, EC value 1932, hardness 87 FS and total mineralization 2148,66 mg / l. The aquifers of the springs are composed of volcanics and limestones. According to the Schoeller diagram, waters are of the same origin and the springs 4 and 6 are ionic rich. Weld water according to the Wilcox diagram Good and good water class springs 4 and 6 are in good water class.

Keywords: Sille, hydrogeochemical, total mineralization, discharge, spring

1. INTRODUCTION

Sille (Konya) is an important settlement where different cultures with traces of Roman, Byzantine, Seljuk and Ottoman periods live together. With the restoration work carried out in recent years, Sille Culture Valley has been opened to tourism. There are many water sources in and around Sille. These sources are widely used as drinking water by the people of the region and Konya. In addition, the Sille dam pond located in the region is used for both irrigation water and tourism purposes.
Considering the characteristics of Sille, the ancient antique settlement, the southern hillsides of Aya Elenia Church, monasteries and graveyards were registered by the Konya Conservation Council for Cultural and Natural Heritage in 1995, and the main settlement area was registered as the Urban Conservation Area.
The study area is located within the borders of Selçuklu district in the Central Anatolia Region, about 10 km northwest of Konya (Figure 1). 1/25000 scale topographic map of Konya m28b1 and m28b2 is located in the Map and covers an area of approximately 110 km^2. The lithological units outcropping in the study area are defined on the basis of lithostratigraphy.

Figure 3. Location map of the study area

The aim of this study was to determine the physicochemical properties of spring waters around Sille (KONYA) and to interpret them in terms of hydrochemical and pollution. The average annual temperature in the study area between 1929-2018 is 11.6 ºC and the total annual precipitation is 323.3 mm (Table 1).

Table 2. Temperature and precipitation values of the study area (1929 – 2018)

Konya	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Average Temp. (ºC)	-0,2	1,4	5,6	11,1	15,8	20,1	23,5	23,2	18,5	12,5	6,3	1,7	11,6
Average monthly total precipitation (mm)	37,6	28,5	28,9	31,9	43,6	25,5	6,3	4,6	12,3	30	32	42,1	323,3

2. MATERIAL AND METHOD

1/25000 scale geology map and generalized stratigraphic section of the study area were prepared. Temperature (T), pH, EC, total mineralization and dissolved CO_2 values were measured at the beginning of welding with Hanna brand pH and conductivity meter. Welding discharges were measured by certain volume method. Physico-chemical analyzes of water samples taken from the sources were carried out in Koski Water-Quality Laboratory. The obtained values were evaluated according to various diagrams and TSE 266, WHO and EPA standards.

3. RESEARCH FINDINGS

The total annual rainfall in the study area in 2017 is 329.9 mm and the average temperature is 13.18 ºC. Using temperature and precipitation values, according to Thornthwaite (1948), precipitation is 329.9 mm, potential evaporation - perspiration is 684.14 mm, actual evaporation - perspiration is 304 mm, excess water is 77.27 and water defect is 472.45 mm. Evaporation - transpiration in the study area is equal to 92.2% of precipitation.

The Silurian - Lower Carboniferous Bozdağ formation is the basis of the study area. Bozdağ formation consist of recrystallized limestone in different colors and tones ranging from black, dark and light gray, cream and white, dolomitic limestone, dolomite and marbles. Bozdağ formation, generally composed of flysch type rocks, shows lateral and vertical transition to Devonian - Lower Permian aged Bağrıkurt formation.

Bağrıkurt formation consists of green, gray colored phyllite, schist, turbiditic metasandstone, metaconglomerate, recrystallized limestone and metachert alternation and exotic metacarbonate blocks of different sizes. Bağrıkurt formation, which presents lateral and vertical transitions with Bozdağ formation and covers this unit in conformity, is unconformably covered by the Bahçecik formation at its upper parts.

Bahçecik formation, which consists of terrestrial sediments, is the basis of the Ardıçlı group. The unit consists of purple, red, brown metaconglomerate, metasandstone and phyllite alternations. Bahçecik formation of Ardıçlı group, which unconformably overlies the Sızma group, shows lateral and vertical transition to Ertuğrul formation.

Ertuğrul formation consists of recrystallized limestone, dolomite and dolomitic limestones. The unit, which is in conformity with the lower parts, is intricately related to the Kızılören formation.

Kızılören formation consists of dark gray, blackish, occasionally light gray colored, laminated, bituminous, cracked and fractured and brecciated dolomites with fresh cracked surfaces. Kızılören formation is unconformably overlain by units belonging to the Dilekçi group from the top.

Lorasdağı formation is generally composed of recrystallized limestone, dolomite and dolomitic limestones. Lorasdağı formation overlies the Permian aged units with angular unconformity. It passes from the top to the Upper Cretaceous limestones.

Sille formation is composed of red - brown colored, occasionally gray conglomerate sandstone and mudstone intercalations, which are observed in different parts of the study area. Sille formation unconformably overlies the rocks that make up the Lorasdağı formation at the base and laterally and vertically shows the transition to Ulumuhsine and Küçükmuhsine formation.

The lithology of the Ulumuhsine formation consists of limestone, clayey limestone, marl, mud, conglomerate and sandstone. Ulumuhsine formation presents lateral and vertical transitions with the Sille formation at the lower parts of the formation.

The lithologies of Küçükmuhsine formation are generally white, light gray, pink, massive tuff, layered tuffites, agglomerate, volcanic breccia and volcanogenic sandstones. In the study area, Küçükmuhsine formation presents lateral and vertical transitions with terrestrial Sille and lacustrine Ulumuhsine formations. This unit cut by Sulutas volcanics is also unconformably covered by Topraklı formation to the west of the study area.

Sulutas volcanics are generally composed of calc-alkaline dacite, rhyodacite, rhyolite and andesite as well as to a lesser extent basaltic rocks. Sulutas volcanics cut Ulumuhsine, Küçükmuhsine and Sille formations in the southern parts of Sille.

Topraklı formation, conglomerate, mud, pebble and sand deposits are formed by brown, red, yellowish soil. Topraklı formation is overlain by angular unconformity over all older units.

It consists of alluvial, poorly sorted pebbles, sand, silt and clay grains containing all kinds of crumbs derived from the lithology. The unit is Quaternary aged. It covers all units older than it unconformably (Figure 2, 3).

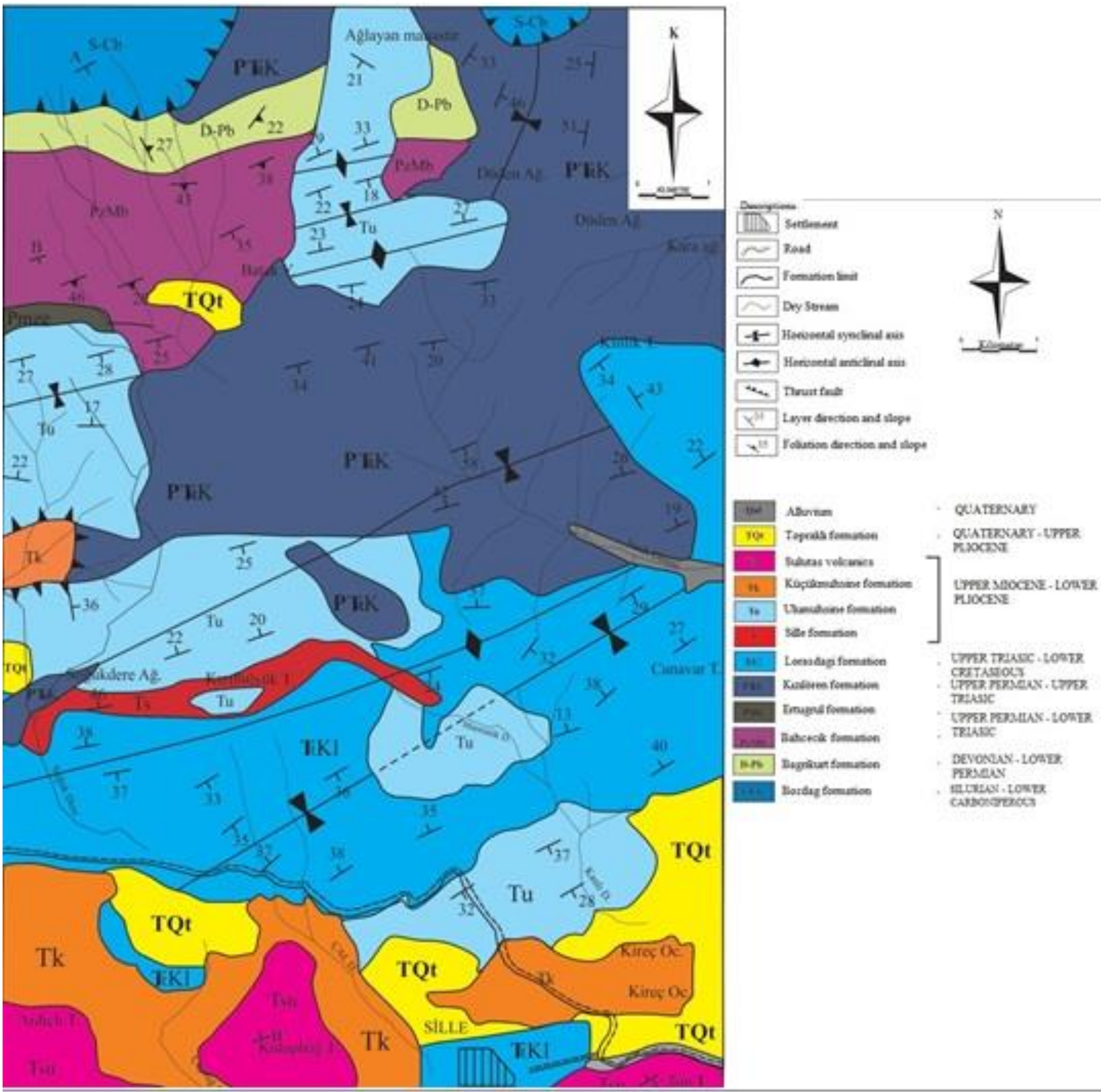

Figure 4. Geological map of the study area (Eren, 1993)

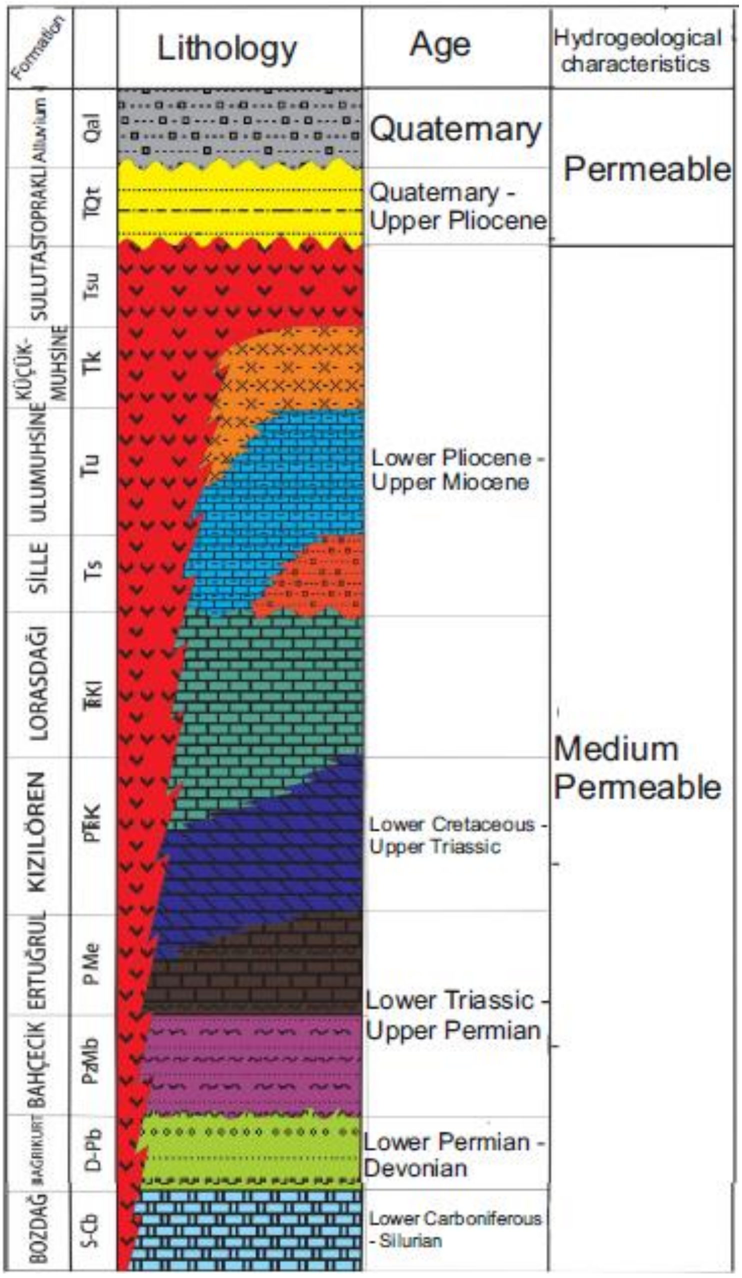

Figure 5. Generalized stratigraphic section of the study area (Eren, 1993)

According to the lithological and structural features of the units in the study area, the limestones forming the Bozdağ, Ertuğrul, Kızılören, Lorasdağı and Ulumuhsine formations have a fractured - cracked and melt cavities and have a secondary porosity. Therefore, these limestones have the characteristics of being aquifer.

The precipitation waters falling to the earth are filtered and form underground waters. Groundwater undergoes physical and chemical changes while passing through geochemical processes from the feeding area to the discharge area, and gains different characteristics. The dissolution of minerals from the rocks where groundwater is in contact continues until the equilibrium concentration in the water is reached. The chemical composition of groundwater depends on the mineralogical and chemical properties of the aquifers through which they pass, the flow rate of the water in the aquifers, the flow conditions and the residence time in the aquifers (Freeze and Cherry, 1979; Appelo and Postma, 1993; Andreo and Carrasco, 1999). Major ions (Na^+, K^+, Ca^+, Mg^+) and anions (Cl^-, SO_4^-, HCO_3^-, CO_3^-) make up more than 90% of the total ionic content of natural waters (Erguvanlı and Yüzer, 1987).

The electrical conductivity (EC) values of the springs in the study area vary between 210-882 µS / cm. pH values of the springs are in the range of 7.19-8.04. The discharges are 0.02 - 1.71 lt / s. Hardness values ranged from 9-43 FS and total mineralization values ranged from 269.15 to 817.24 mg / l.
Number 4 spring is rich in minerals and its pH value is 7.19, EC value is 1932 µS / cm, hardness value is 82 FS and total mineralization value is 2148.66 mg / l (Table 2).
Anion, cation, EC (electrical conductivity), sodium percentage (% Na), sodium adsorption rate (SAR) of the samples taken from the study area are shown in Table 3 Schoeller and piper diagrams were prepared and interpreted in terms of water usability and quality.

Table 3. Anion, cation, EC,% Na and SAR values of samples taken from the study area

		1	**2**	**3**	**4**	**5**	**6**
CATIONS	**Ca**	44,24	27,65	54,75	323,29	51,47	131,38
	Mg	2,44	4,08	3,94	15,62	3,60	25,86
	Na	2,12	13,42	11,63	92,39	11,42	36,50
	K	0,24	1,72	5,48	32,84	4,41	3,16
ANIONS	**Cl**	1,56	7,04	8,43	216,55	8,66	84,85
	SO_4	6,85	13,12	16,16	188,21	16,11	143,44
	HCO_3	121,92	99,84	149,76	258,24	156,00	277,44
	CO_3	0	0	0	0	0	0
	EC	214	210	323	1932	326	882
	%Na	3,58	23,4	19,92	159,82	19,52	62,97
	SAR	0,082	0,625	0,425	1,357	0,409	0,757

Table 4. Physico-chemical analysis results of water (mg / l)

PARAMETERS	SAMPLES					
	1	**2**	**3**	**4**	**5**	**6**
TEMPERATURE (^oC)	10	12	14	10	11	13
DISCHARGE	0,236	1,71	0,22	0,022	0,530	-
PH	8,04	7,57	7,64	7,19	7,52	7,78
TURBIDITY (NTU)	1,87	0,80	0,75	0,20	0,55	0,18
EC (20^{o}C DE µS/CM)	214	210	323	1932	326	882
NO_2	0,00	0,00	0,00	0,01	0,00	0,00
NH_4	0,00	0,00	0,00	0,00	0,00	0,00
T. ALKALINITY ($CaCO_3$-MG/L)	121,92	99,84	149,76	258,24	156,00	277,44
CA (PPM)	44,24	27,65	54,75	323,29	51,47	131,38
MG (PPM)	0,2	0,34	0,32	1,3	0,3	2,15
TS (FS)	12	9	15	87	14	43
NO_3 (PPM)	3,80	6,26	21,32	441,39	21,74	1,14
SO_4 (PPM)	6,85	13,12	16,16	188,21	16,11	143,44
CL (PPM)	1,56	7,04	8,43	216,55	8,66	84,85
NA (PPM)	0,09	0,58	0,5	4,01	0,49	1,58
K (PPM)	0,24	1,72	5,48	32,84	4,41	3,16
F (PPM)	0,03	0,24	0,22	0,16	0,22	0,75
PO_4 (PPM)	0,00	0,23	1,38	1,59	0,58	0,01
LI (PPB)	0,58	3,6	2,66	20,33	2,61	17,46
BE (PPB)	0,01	0,02	0,02	0,03	0,00	0,00
B (PPB)	11,36	54,63	40,02	296,39	40,72	24,37
AL (PPB)	33,31	18,06	0,79	0,00	0,78	0,00
V (PPB)	0,52	9,55	6,31	17,45	6,20	1,46
CR (PPB)	0,20	0,07	0,23	0,10	0,25	0,06
MN (PPB)	0,82	0,15	0,03	0,06	0,07	0,09
FE (PPB)	14,78	13,16	0,00	0,00	0,00	0,00
CO (PPB)	0,18	0,17	0,03	0,10	0,01	0,03
NI (PPB)	0,27	0,11	0,00	0,32	0,03	1,39
CU (PPB)	0,71	0,16	0,08	1,42	0,16	0,45
ZN (PPB)	4,31	19,42	1,21	0,27	1,37	-0,24
AG (PPB)	0,00	0,00	0,00	0,00	0,00	0,00
AS (PPB)	1,04	4,40	5,85	14,81	5,74	3,25
SE (PPB)	0,94	0,66	0,54	1,65	0,91	0,67
SE (PPB)	0,75	1,36	1,37	1,55	1,79	0,82
MO (PPB)	0,10	0,74	1,51	4,19	1,43	3,58
CD (PPB)	0,02	0,03	0,00	0,01	0,00	0,01
SB (PPB)	0,38	0,39	0,23	0,33	0,17	0,15
BA (PPB)	15,47	41,30	123,95	219,36	119,48	59,6
HG (PPB)	0,06	0,05	0,04	0,02	0,04	0,00
TL (PPB)	0,03	0,02	0,00	0,00	0,00	0,00
PB (PPB)	0,11	0,02	0,00	0,00	0,01	0,00
BI (PPB)	0,00	0,00	0,00	0,00	0,00	0,00
TDS	269,15	341,75	457,93	2148,66	455,98	817,24

According to the data obtained from the physico-chemical analysis of the waters in the study area, the anion and cation values of the waters were marked on the Piper diagram and the water class was determined. Waters are grouped in zone 1 and are Ca + Mg> Na + K carbonated and sulphated waters (Figure 4).

According to the Schoeller diagram, the sequence of ions in example 1 and 6 is Ca> Mg> Na + K> HCO_3> SO_4> Cl and has the same origin. The sequence of ions in example 2, 3 and 5 is Ca> Na + K> Mg> HCO_3> SO_4> Cl and has the same origin. The sequence of ions in example 4 is Ca> Na + K> Mg> Cl> SO_4> HCO_3 and of different origin. In the evaluation of the samples taken from the study area, these samples are generally in the class of waters with Ca and HCO_3, since the water generally shows similarity and is rich in Ca and HCO_3 ions (Figure 5). The result in the Piper diagram and the result in the Schoeller diagram overlap. According to this, water is mostly fed from carbonated rocks (limestone, marble).

According to the Wilcox diagram, the waters are very good - good class, sample number 6 good - permissible class and sample number 4 is unsuitable class (Figure 6).

US Salinity Laboratory Diagram is divided into 16 zones according to salinity and sodium hazard level. Water is classified using SAR (Sodium Adsorption Ratio) on the vertical axis and EC (electrical conductivity) on the horizontal axis. According to the US Salinity Diagram, the waters in the study area are classified as C1-S1, C2-S1 and C3-S1 (Figure 7). The water of C1-S1 and C2-S1 is low-medium salinity and the water of C3-S1 class can be used for irrigation activities.

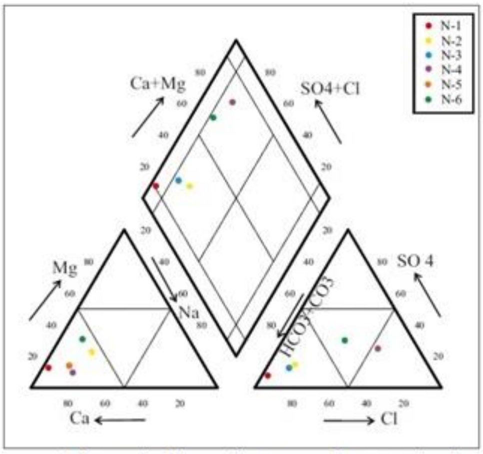

Figure 4: Piper diagram of waters in the study are

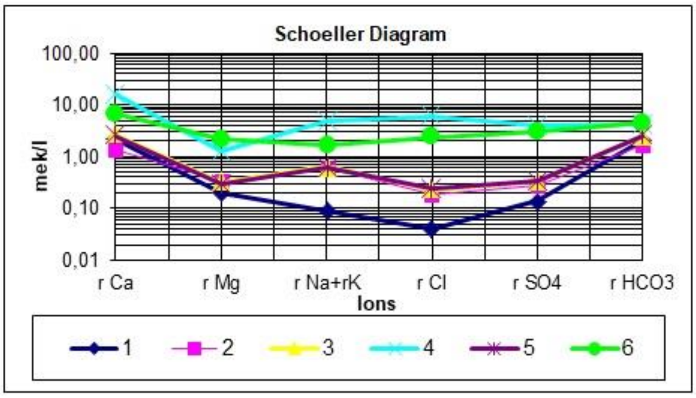

Figure 5: Schoeller diagram of waters in the study area

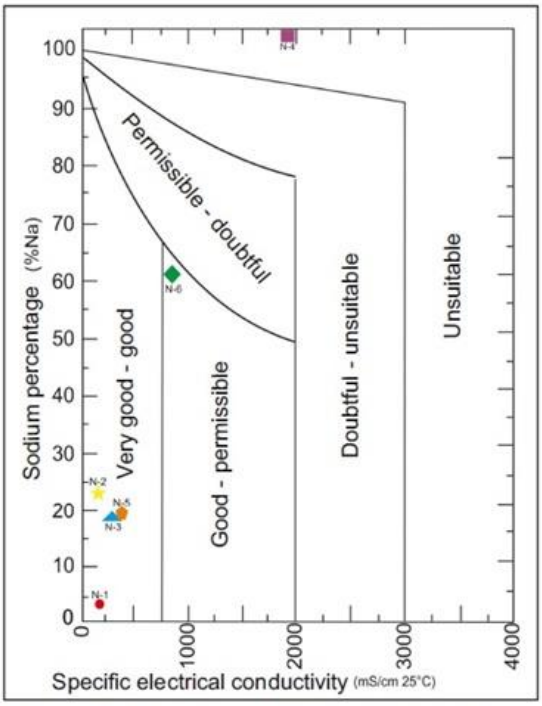

Figure 6: Wilcox diagram of waters in the study area

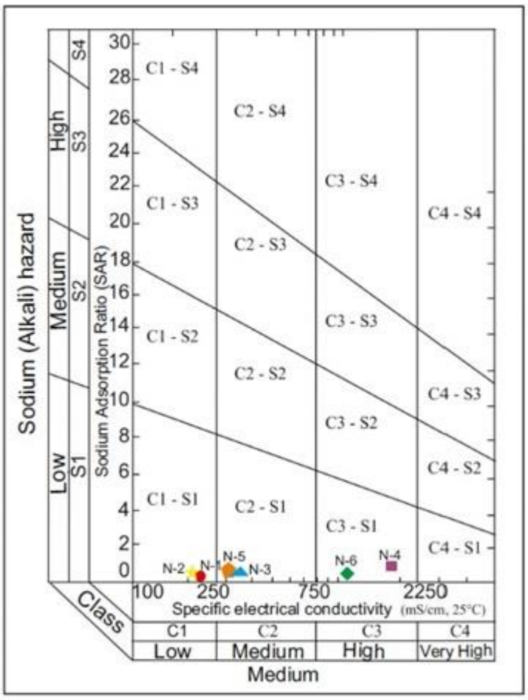

Figure 7: US Salinity Laboratory diagram of waters in the study area

4. CONCLUSIONS

Historical and cultural values such as churches, mosques, streets, fountains and traditional Sille houses in Sille have been invented by Konya Conservation Council for Cultural and Natural Heritage and declared as 1st degree Urban Conservation Area.
In the study area are the units belonging to the Sızma, Ardıçlı and Dilekçi groups.
The aquifers of the waters in the study area are composed of limestones of Bozdağ, Ertuğrul, Kızılören, Lorasdağı and Ulumuhsine formations having a fractured - cracked structure.
The total mineralization range from 269,15 to 2148,66 mg/l, pH values are in between 7,19 to 8,04, electrical conductivity values range from 210-1932 µs / cm, temperatures range from 10-14 ^{o}C
According to the US Salinity laboratory classification, water taken from the study area is C1S1, C2S1 and C3S1 and it can be used in irrigation activities. In the wilcox diagram classification, the waters in the study area are very good - good, good - permissible and unsuitable.
The waters in the study area are rich in Ca and HCO_3 ions. The result obtained in the Piper diagram corresponds to the results of the Schoeller diagram. It is understood that carbonated rocks are effective in the chemical composition of water.

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