Importance of Water in Morphology

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Abstract. Numerous huge landslides and a lot of springs are located in Ecemiş Fault Zone between Adana and Niğde, in the south of Turkey. The water-discontinuity-clay trinity plays a significant role in the formation of these landslides and morphology of the area. A large-scale dam and a highway were planned in this valley where is highly rich in terms of flora and fauna and composed by huge slopes. This study showed that the water in the area is meteoric and one of the main cause of landslides. Any big project can cause many geotechnical problems with remedial works. Because, the safety coefficient of huge landslides is 1 which means their stability is critical and any operation will disrupt this balance. Because of this and/or similar geotechnical problems; the projects were canceled. Besides, water is potable and suitable for irrigation and the valley stands as national wealth.

Keywords: Ecemiş, fault, landslide, water.

1 Introduction

The study area is located on Ecemiş Fault Zone; between Pozantı, district of Adana and Bademdere, district of Niğde with 0.5 - 5 km wide and about 60 km long (Figure 1). The trinity water-discontinuity-clay (WDC) is the main cause of geotechnical problems in the zone; especially huge landslides with several billions cubic meters have been formed by this trinity.

The aims of this study are to reveal the role of water in the formation of landslides by identifying the origin of water and to understand the geochemical properties of it.

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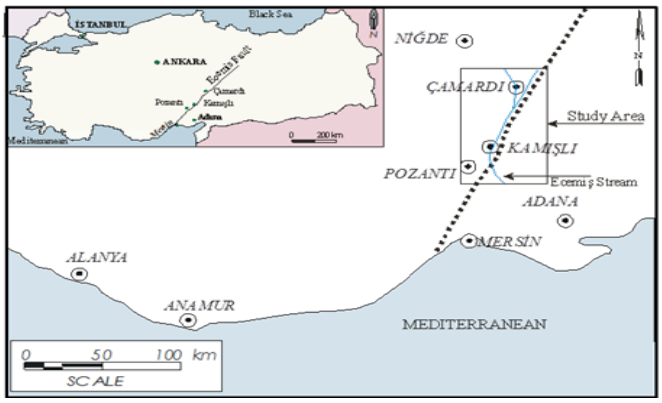

Fig. 1. Location map of study area.

2 Materials and Methods

2.1 Materials

The study area is a hallway with about 60 km long and 0.5 - 5 km width between Adana and Niğde, is located in Ecemiş Fault Zone which is one of the important tectonic places in Turkey (Figure 2). The zone was formed between Paleocene and Lutetian. The main fault has a direction with N20E, left-lateral, vertical strike-slip. The second major fault in the study area is Cevizlik Fault which is more or less parallel to the Ecemiş Fault.

Numerous sources and ponds were created in the study area, along Ecemiş Fault Zone. Three sources called Ecemiş Balık Çifliği, Elekgölü and Zekinin Damları were selected to get the samples.

2.2 Methods

First, the geological, geotechnical and hydrogeological properties of the area had been determined. Then, three sources called Ecemiş Balık Çifliği, Elekgölü and Zekinin Damları, were selected. Subsequently, water samples from these three sources were taken in February and July to represent the seasons of winter and summer. Isotope analysis of these samples have been made, in laboratory of Tubingen University, to understand relationship between groundwater and landslides. Geochemical analysis have been made to determine the potability and availability of irrigation. The ions in water samples taken from sources were determined.

3 Results and Discussions

3.1 Geology

The geological map of the study area is shown in Figure 3. The Mesozoic and Cenozoic units are located in the study area. Upper Triassic settlement aged rocks, schist and marble, are situated in the north and northwest of the study area and form the basis. Cretaceous settlement aged melange with limestone and serpentine lies tectonically over this unit. This melange is located on south, southeast and east of the study area. This unit is overlaid tectonically by Tertiary– Cretaceous settlement aged melange with spilitic basalt, gabbro, limestone and similar components.

These complex are overlaid unconformably by Middle - Upper Paleocene aged Çamardı formation which is marl-mudstone-sandstone-clayey limestone in the northwest of the study. Eocene aged Kaleboynu formation overlies unconformably Çamardı formation with limestone-sandstone-conglomerates. Than Oligocene aged Çukurbağ formation comes unconformably with sandstone-conglomerate-siltstone and mudstone in the north and northeast of the study area. Miocene aged Burç formation consisting of marl and sandstone comes on Çukurbağ formation unconformably in the north of the study area. Later, Miocene aged flysch comes with angular unconformity in the south. Pliocene aged lake sediments are located unconformably in a narrow area in the north. Plio-Quaternary settlement aged Çatalca formation overlies on the old units unconformably in the east. Finally, Quaternary aged units, terrace sediments, talus, clay cover and alluvium deposits are located in the area (Yetiş, 1978).

Figure 2. Slide masses in Ecemiş Fault Zone.

3.2 Mechanism of Landslides

The study area is bounded by Aladağlar between 2000 and 3700 meters elevation on the east. This area has more precipitation than the study area (800 - 1600 m) and precipitation type is usually snow. This mountain mainly consists of karstic limestone besides peridotite, serpentinite and clastic rocks. As seen in Figure 4,

Miocene aged impermeable and semi-permeable sedimentary units with claystone-mudstone (Mif) overlay on karstic limestone unit of Cretaceous settlement aged complex (Kkk). Groundwater table changes more than 300 m (30 bar) annually, in the Kkk under the Mif (Leventeli, 2002). Meteoric waters enter to the Kkk from the higher parts of Aladağlar and creates several meters thick slide masses (Qk) by artesian under the Mif. Billions of cubic meters of slide masses are located in the eastern part of the Ecemiş Fault Zone with this type of mechanism. Flow of resources on the heel depends on thickness of the impermeable-semipermeable unit overlies karstic limestone as well as the season.

3.3 Isotope Hydrology

Water samples taken from the field were performed to determine the origin and during these studies SMOW method was used (Craig, 1961; Canik, 1998). The results of the analysis are shown in Table 1, Table 2 and Figure 5. The analysis show that the origin of water is meteoric. This result means that water is one of the main causes of the landslide in the study area.

3.4 Geochemical Analysis

Geochemical analysis were performed to determine physical and chemical properties of water in the study area.

Samples of water taken from sources contain ions are determined as mg/lt by Atomic Absorption Spectrophotometer. The obtained results are given in Table 3. However, the chemical reaction power of the molten element, is not its weight, is related with the number of reactive equivalents. So, besides the values which were determined as milligrams per liter of cations and anions, they were also determined in milliequivalents per liter (Table 4).

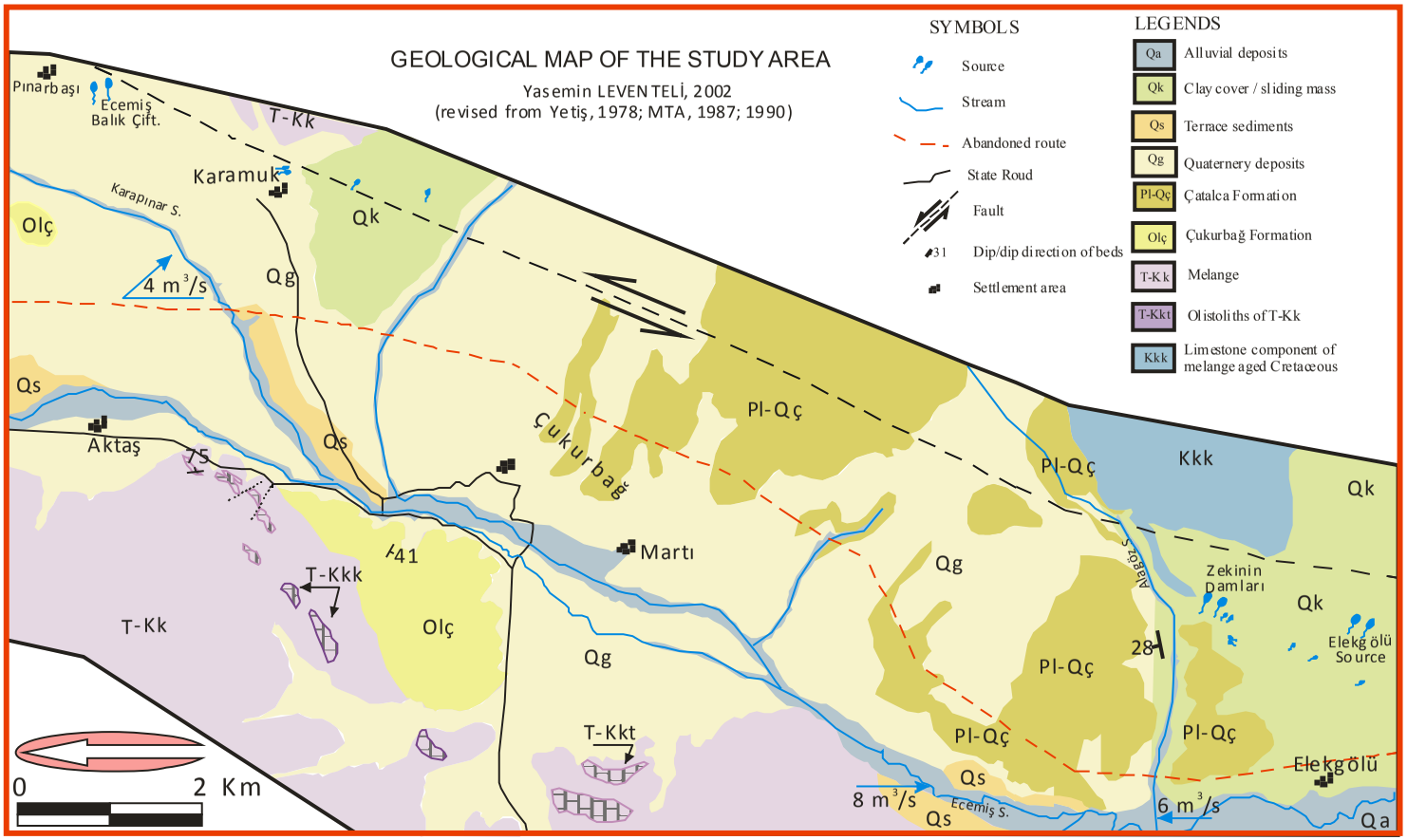

Figure 3. Geological map of study area.

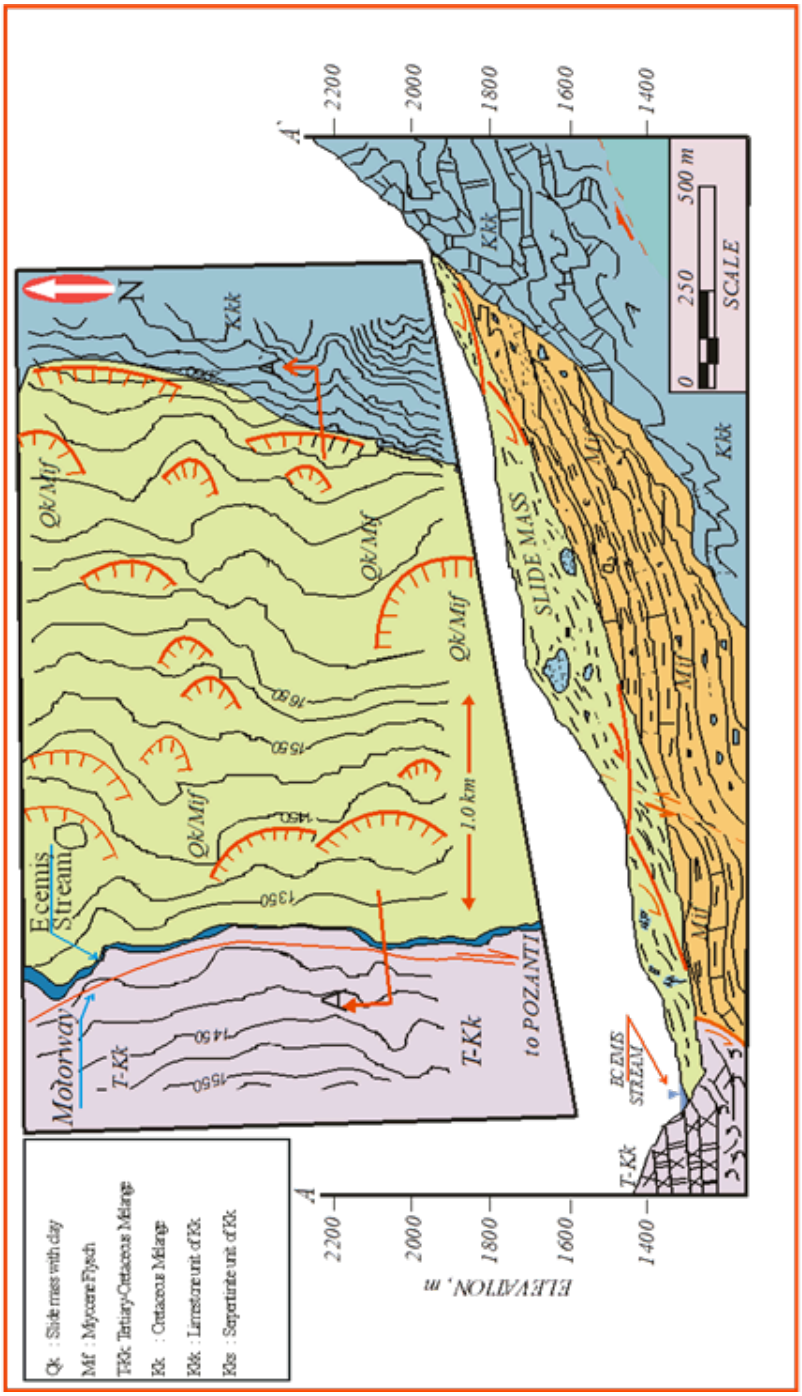

Figure 4. A typical landslide observed in Ecemiş Fault Zone (Leventeli and Yilmazer, 2003, Leventeli et al., 2013)

Table1. The results of isotope analyzes of water samples taken on February 2001.

SOURCE		$\delta^{18}O$ (‰) VSMOW	$\delta^{18}O$ (‰) raw	SOURCE		δD (‰) VSMOW	δD (‰) raw
Ecemiş Balık Çiftliği		-11,27	-12,08	Ecemiş Balık Çiftliği		-79,63	-75,95
		-11,51	-12,32			-78,63	-74,94
	Average	-11,39	-12,20		Average	-79,13	-75,45
	Standard Deviation	0,12	0,12		Standard Deviation	0,50	0,51
Elekgölü		-10,30	-11,11	Elekgölü		---	-64,76
		-10,33	-11,14			---	---
	Average	-10,31	-11,13		Average	-68,47	---
	Standard Deviation	0,02	0.02		Standard Deviation	---	---
Zekinin Damları		-9,91	-10,72	Zekinin Damları		-67,86	-64,15
		-9,94	-10,75			-66,91	-63,19
	Average	-9,92	-10,74		Average	-66,90	-63,18
	Standard Deviation	0,01	0,02		Standard Deviation	0,79	0,80

Table 2. The results of isotope analyzes of water samples taken on July 2001.

SOURCE		$\delta^{18}O$ (‰) VSMOW	$\delta^{18}O$ (‰) raw	SOURCE		δD (‰) VSMOW	δD (‰) raw
Ecemiş Balık Çiftliği		-11,88	-13,16	Ecemiş Balık Çiftliği		-76,8	-81,7
		-11,71	-12,99			-75,9	-81,1
	Average	-11,79	-13,07		Average	-76,4	-81,4
	Standard Deviation	0,09	0,09		Standard Deviation	0,4	0,3
Elekgölü		-10,35	-11,63	Elekgölü		-63,2	-72,6
		-10,35	-11,63			-65,3	-74
	Average	-10,35	-11,63		Average	-64,3	-73,3
	Standard Deviation	0.00	0.00		Standard Deviation	1.0	0,7
Zekinin Damları		-10,05	-11,33	Zekinin Damları		-60,8	-71
		-10,02	-11,3			-59,8	-70,3
	Average	-10,04	-11,32		Average	-60,3	-70,7
	Standard Deviation	0,01	0,01		Standard Deviation	0,5	0,3

The French hardness preferred to determine the hardness of water samples taken from study area and the following equations were used for it (Şahinci, 1991); the results are given in Table 5.

Total Hardness (FS) = 0.2497Ca + 0.4115Mg (1)

Total Hardness (FS) = 5 (rCa + rMg) (2)

Schoeller diagram, which is common in hydrogeolgy, has been used to determine water potability (Figure 6).

Excess of dissolved ions in irrigation water affect plants and soil by physical and chemical ways and reduce the yield. These ions cause to reduce the osmotic pressure in the cells of the plant and the water can not reach to the branches and leaves; then they disrupt the metabolism of plants. Therefore, Wilcox (Figure 7) and U.S. Salinity Laboratory (Figure 8) diagrams were used to determine the chemical properties of water in the study area, due to be evaluated in terms of agriculture. However, first SAR and % Na values were determined in these diagrams (Table 6).

Table 3. The chemical analysis results of water received during the months of February and July (mg/lt).

Months	Source	Cations(mg/lt)			Anions (mg/lt)				Totol Ions (mg/lt)
		Na	K	Ca	Mg	Cl	SO_4	HCO_3	
February	Ecemiş Balık Çift.	1,00	0.25	40.0	5.0	10,6	2,32	129,3	188,47
	Elekgölü	2,50	0.25	55.0	3.0	15,9	2,73	175,6	254,98
	Zekinin Damları	2,75	0.50	52.5	12,17	11,5	4,4	207,4	291,22
July	Ecemiş Balık Çift.	0,2	0,29	12,75	2,8	5,3	2,5	122	145,84
	Elekgölü	2	0,29	22,75	1,87	6,2	2,65	146	181,76
	Zekinin Damları	2,57	0,29	21,25	6,33	7,1	3,95	190,3	231,79

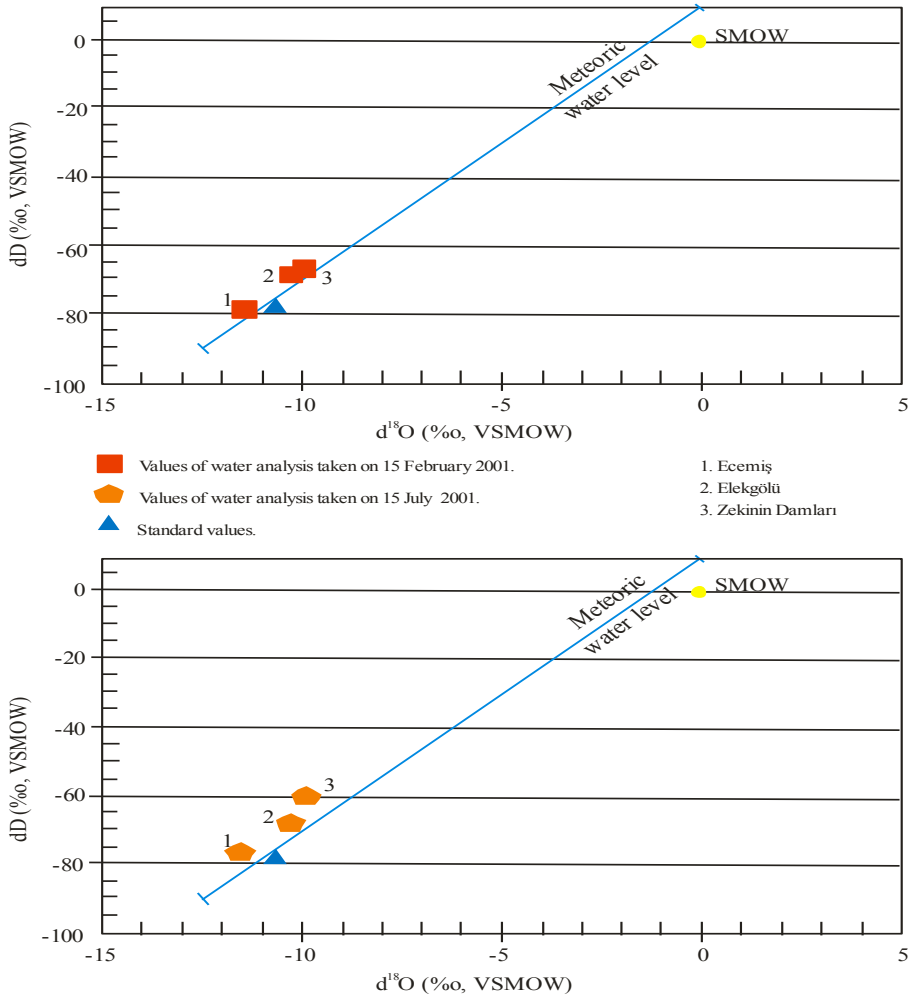

Fig. 5. Result of isotope analysis.

Table 4. The chemical analysis results of three different sources water taken on February and July (mek/lt).

Months	Source	EC	Cations (mek/lt)				Anions (mek/lt)			Total Ions (mek/lt)	French Hard.
			Na	K	Ca	Mg	Cl	SO_4	HCO_3		
February	Ecemiş Balık Çiftliği	269.24	0.043	0.0064	2.000	0.416	0.298	0.048	2.119	4.930	12
	Elekgölü	364.26	0.108	0.0064	2.750	0.25	0.447	0.056	2.878	6.495	15
	Zekinin Damları	416.03	0.119	0.0128	2.625	1.058	0.323	0.091	3.400	7.629	18
July	Ecemiş Balık Çiftliği	208.34	0.0087	0.0074	0.637	0.233	0.149	0.052	2.000	3.087	4.3
	Elekgölü	259.66	0.086	0.0074	1.137	0.155	0.175	0.055	2.393	4.008	6.4
	Zekinin Damları	331.13	0.111	0.0074	1.062	0.527	0.200	0.082	3.119	5.108	7.9

Table 5. Classification of water according to French Hardness (Şahinci, 1991).

		French Hardness					
Months	**Source**	**0-7.2**	**7.2-14.5**	**14.5-21.5**	**21.5-32.5**	**32.5-54.0**	**>54**
February	Ecemiş Balık Çiftliği		*				
	Elekgölü			*			
	Zekinin Damları			*			
July	Ecemiş Balık Çiftliği	*					
	Elekgölü	*					
	Zekinin Damları		*				
	Classification	Very soft	Soft	Moderate Hard	Quite Hard	Hard	Very Hard

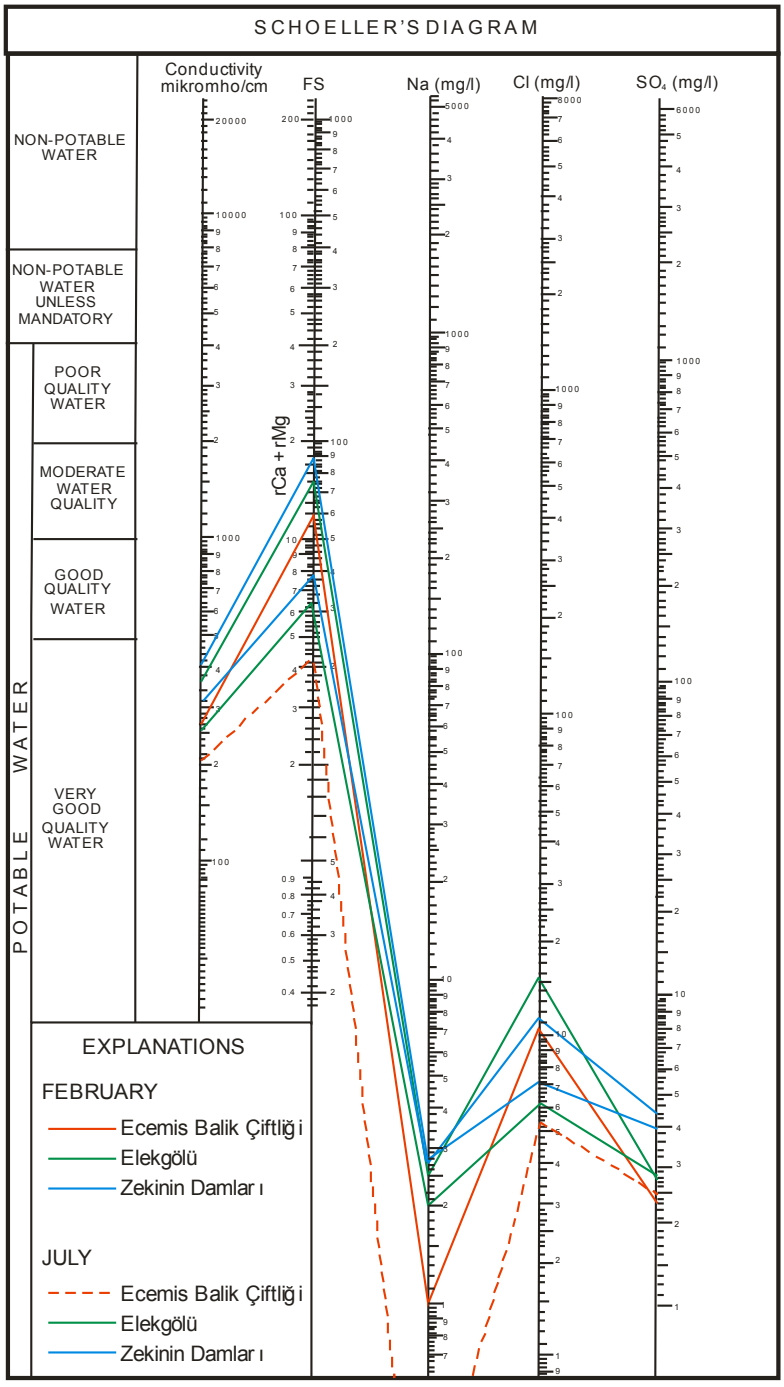

Fig. 6. Water classification according to Schoeller.

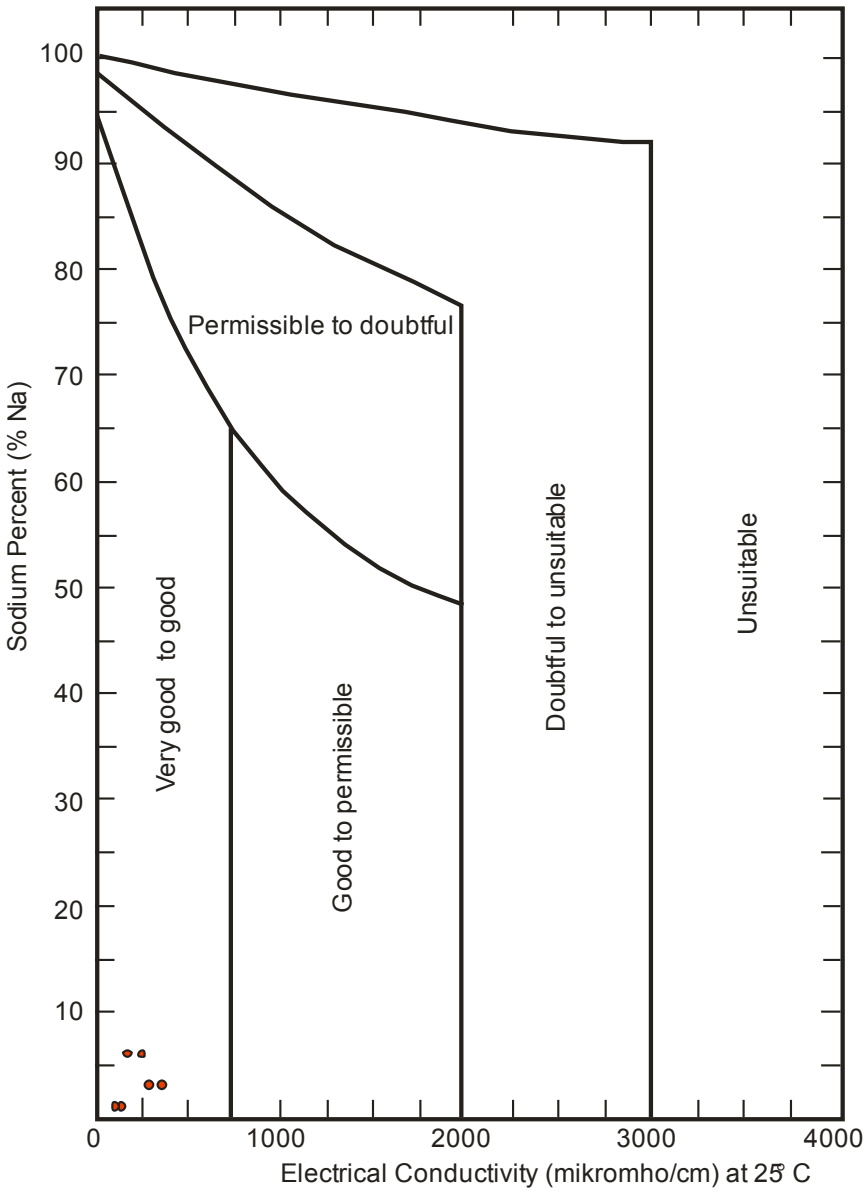

Fig. 7. Water classification according to Wilcox.

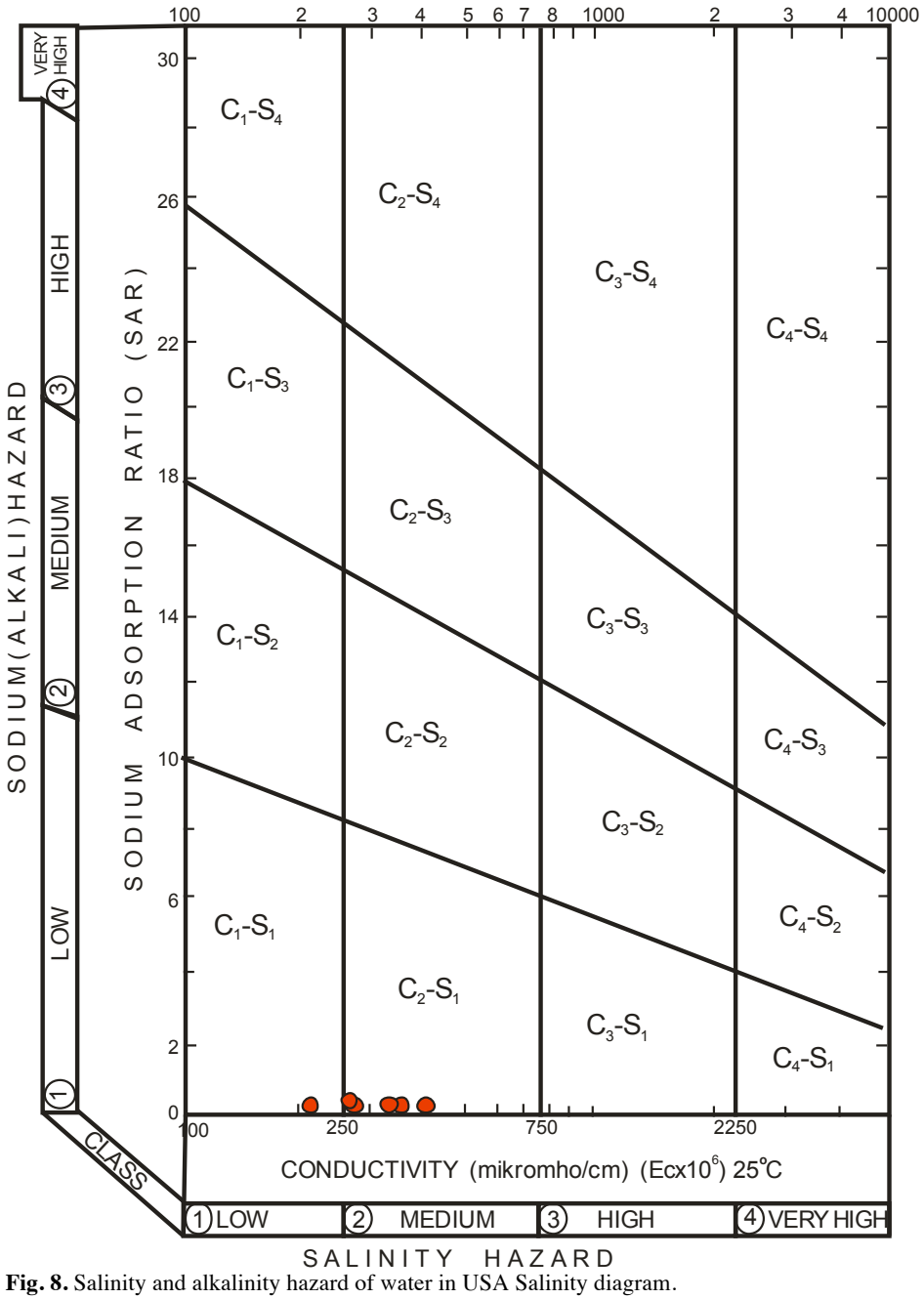

Fig. 8. Salinity and alkalinity hazard of water in USA Salinity diagram.

Table 6. SAR and % rNa values of water.

Months	Source	SAR	% Na
February	Ecemiş Balık Çiftliği	0.039	1.882
	Elekgölü	0.088	3.673
	Zekinin Damları	0.087	3.454
July	Ecemiş Balık Çiftliği	0.013	1.816
	Elekgölü	0.107	6.741
	Zekinin Damları	0.124	6.934

4 Conclusions

This study aimed to reveal the role of water in the formation of landslides and to understand the geochemical properties of it. The conclusions of this study are below:

1. Origin of water is meteoric. This is evidence for being one of the main causes of the slide in the study area. However, water is not alone in sliding. The trinity of water-discontinuity-clay (WDC) is main reason for the billions of cubic meters of large-scale slide in the zone.
2. The water-discontinuity-clay trinity created appreciably fertile lands for farming.
3. Water's hardness ranges from "*very soft*" to "*less hard*" according to the French hardness classes and hardness falls in the summer .
4. The Schoeller diagram used in the study area demonstrated that water is drinkable.
5. According to the Wilcox diagram, water is classified as "very good-good" for agricultural usage.
6. U.S. Salinity Laboratory diagrams show that water is located in C_1-S_1 and C_2-S_1 classes. It means water has low- medium salinity and low sodium. According that; all type plants, except sodium-sensitive plants, can be grown.
7. Therefore, any engineering project implemented without considering geotechnical parameters will lead to the reactivation of landslides and destroy settlement areas and gorgeous fertile plain in the region.

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