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Subterranean Water's Quality Characteristics in the Vicinity of Alasehir, Turkey in Respect of Vineyard

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Abstract: Alaşehir is a district where viniculture is the most intensively performed in Gediz valley in the Aegean region, Turkey. Grapevine is a crop sensitive to salinity and boron mineral element. Therefore, the quality of irrigation water is of great importance. In this study, in representing the district, 60 water samples from underground water sources used in the irrigation of vineyards in Alaşehir district have been taken and important quality criteria such as pH, electrical conductivity, cations, anions, boron in irrigation have been analyzed. The results obtained were evaluated in respect of viniculture. It was determined that waters were generally included in the class of C_3S_1 and in same districts, they are not available in terms of irrigation.

Key words: Vineyard, irrigation water, cations, anions, boron

INTRODUCTION

Turkey is one of the first vineyard growers in terms of both the area and the production in the world. Viniculture is mostly practised in the district of Alaşehir which is in the county of Manisa province in the Aegean region. The total grapevine area of the region is 728 16 ha and 160 00 ha of the total figures belongs to Alaşehir which means 22% of the total area (Anonymous, 1998).

As it is true for all crops, the increase of the productivity in grapevine depends on the factors such as the application of advanced agricultural technology, struggling with pests and diseases, fertilization and irrigation. Apart from supplying the adequate amount of irrigation, the appropriateness of the quality of water is of great importance in terms of both the increase of productivity and quality and the providing of continuity in the production.

The underground waters and the dam waters are the main sources used in the irrigation in viniculture in the region. The dam waters main source of which are rain consist of low amount of soluble salts. The underground waters, on the other hand, generally consist of more soluble salts than dam waters (Bagenstos, 1994 and Stromberg and Tisdale, 1979).

The waters employed in irrigation have some negative effects both on soils and in growing plants depending on the amount and kind of salts contained and the method of irrigation. Those negative effects can be classified under four groups;

1. The effect of soil to the salt contents
2. The effect of soil to alkaline
3. The effect of soil over the permeability of water
4. The accumulation of toxic elements in soils and direct effects of these elements over plants (Stromberg and Tisdale, 1979).

The electrical conductivity (EC) of spil saturation extract of the soils can change between 1.5-2.5 ds m^{-1}. If the exchangeable sodium percentage (ESP) < 10%, chlorine <10 me L^{-1}, boron < 1 mg L^{-1}, there is no problem with the grapevine production. If EC= 2.5-4.0 ds m^{-1}, ESP= 10-15%, chlorine = 10.30 me L^{-1} and boron = 1-3 mg L^{-1}, a problem occurs and there is a 10-25 % decrease in the production. When EC= 4-7 ds m^{-1}, ESP> 15 %, chlorine >30 me L^{-1} and boron >3 mg L^{-1}, a great problem takes place and the yield decreases at a percentage of 25-50% (Anonymous, 1978 and Aillery and Gollehon, 1997).

Such problems in the soil arise from the usage of irrigation waters including mainly boron and a large amount salt if there is no natural salinity process in the soil itself. Therefore, in this study, some quality criteria of the underground waters which are used in the irrigation of the vineyards in the region are evaluated in term of viniculture.

MATERIALS AND METHODS

Sixty water samples brought from the areas where irrigation is made through underground waters have composed the research materials (Table 1). In obtaining the samples, the regions where grapevine production is intensively made and the regions where irrigation is a problem are taken into consideration.

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Table 1: Locations where water samples are taken

Samp. No.	Locations	Samp. Charac.	Samp. No.	Locations	Samp. Charac.	Samp. No.	Locations	Samp. Charac.
1	Baklaci	Sondage	21	Kasapli	Sondage	41	Girelli	Sondage
2	Baklaci	Sondage	22	Kasapli	Sondage	42	Girelli	Sondage
3	Baklaci	Artesian	23	Kasapli	Sondage	43	Akkeçili	Sondage
4	Işiklar	Sondage	24	Kasapli	Sondage	44	Akkeçili	Sondage
5	Işiklar	Sondage	25	Kasapli	Sondage	45	Akkeçili	Sondage
6	Zeytinçayi	Sondage	26	Kasapli	Sondage	46	Akkeçili	Sondage
7	Tepeköy	Sondage	27	Kasapli	Sondage	47	Akkeçili	Sondage
8	Tepeköy	Sondage	28	Kasapli	Sondage	48	Yahyaalici	Sondage
9	Tepeköy	Sondage	29	Kasapli	Sondage	49	Yahyaalici	Sondage
10	Tepeköy	Sondage	30	Kasapli	Sondage	50	Yahyaalici	Sondage
11	Tepeköy	Sondage	31	Kavaklidere	Sondage	51	Y.San.Sitesi	Artesian
12	Tepeköy	Sondage	32	Şahyar	Sondage	52	Çakircali	Artesian
13	Tepeköy	Sondage	33	Şahyar	Artesion	53	Katirli	Sondage
14	Tepeköy	Sondage	34	Caberfakili	Sondage	54	Katirli	Sondage
15	Tepeköy	Sondage	35	Piyadeler	Sondage	55	Kemer	Sondage
16	Tepeköy	Sondage	36	Piyadeler	Sondage	56	Merkez	Sondage
17	Killik	Sondage	37	Girelli	Sondage	57	Materli	Sondage
18	Badinca	Artesian	38	Girelli	Sondage	58	Çaðlayan	Sondage
19	Badinca	Sondage	39	Girelli	Sondage	59	Alkan	Sondage
20	Badinca	Sondage	40	Girelli	Sondage	60	Alkan	Sondage

In those 60 water samples that were taken from the region, the electrical conductivity in the direct bridge equipment (Anonymous, 1954), soluble Na^+ and K^+ with flame spectrophotometer (Slavin, 1968), Ca^{++}, Mg^{++}, Cl^-, $CO^{=}_3$ and HCO^-_3 with titration method (Anonymous, 1954), $SO^{=}_4$ with gravimetric method (Anonymous, 1973), boron element has been analyzed by using a carmine indicator with colorimetric method (Anonymous, 1954), pH with pH meter (Anonymous, 1973). Sodium Adsorption Ratio (SAR) and Residual Sodium Carbonate (RSC) were calculated by means of special formula (Anonymous, 1954: Anonymous. 1986 and Aillery and Gollehon, 1997).

RESULTS AND DISCUSSION

Findings obtained as a result of the analysis made in 60 water samples taken are presented in Table 2. pH values of water samples were determined from 5.92 to 8.28. Most of the samples were of light acidic neutral and light alkaline character. In another study carried out at this location, the pH values of waters were determined between 5.89 and 7.80 (Konuk and Yener, 1995). In terms of vineyard, it is suitable for the pH values to be between 6.5 and 8.4 (Jacop and Uexkull, 1960). According to this, underground waters of this region do not have any negation in terms of pH.

The values of electrical conductivity were measured between the limits 0.391 and 3.803 ds m^{-1}. The evaluation of these data in terms of vineyard is presented in Table 3. Considering this table, according to ECw value which is an indicator in terms of salinity, 68.33% of waters are at risk in terms of vineyard. In another study conducted in this district, because of salinity, 86.37% of waters in the region were recommended not to used as irrigation water in the soils which have low permeability and insufficient drainage (Konuk and Yener, 1995). Both of the studies are parallel for this respect. The qualities of water samples taken from Balçova, İzmir, in the Aegean region in July and August were reported to be in the class of C_3S_1 (Saatçi *et al*., 1973).

The SAR (Sodium Adsorption Ratio) which are proportional values of Na^+ to $Ca^{++}+Mg^{++}$ soluble are between limits of 0.38 and 6.61. As shown in Table 3, for that respect these waters do not constitute a great problem in terms of vineyard. In another study conducted in this region, similar results to this were obtained (Konuk and Yener, 1995).

From the cations which were analyzed in the samples of water, sodium (Na^+) was determined to vary in the limits between 0.65-17.17 me L^{-1} (average 4.82), potassium (K^+) 0.14-0.65 me L^{-1} (average 0.29), calcium+magnesium ($Ca^{++}+Mg^{++}$) 2.70-26.50 me L^{-1} (average 10.82). The cations average order of distribution is $Ca^{++}+Mg^{++}> Na^+>K^+$. From the anions soluble in the water, Cl (Cl^-) was detected in the limits between 0.20-6.10 me L^{-1} (average1.53), sulphate ($SO^{=}_4$) 0.20-19.60 me L^{-1} (average 3.74), bicarbonate (HCO^-_3) 0.30-27.10 me L^{-1} (average 10.15) and carbonate ($CO^{=}_3$) 0.01-4.40 me L^{-1} (average 0.17) (Table 2). It was seen that anions follow the order of $HCO_3>SO^{=}_4>Cl>CO^{=}_3$ from the most to the least in accordance with the average contents of them. According to these data, it has been understood that the salt in calcium and magnessium bicarbonate from the waters are dominant. The bicarbonates of Ca^{++} and Mg^{++} included in the irrigation waters have not caused to any problem. These salts are more important for drinking, using and industrial purposes. The Residual Sodium Carbonate is of great importance for irrigation (Anonymous, 1954 and Aillery and Gollehon, 1997).

Table 2: The results of the analyses of water samples from the district of Alaşehir

			Cations (me L^{-1})				Anions (me L^{-1})								
Samp. No.	pH (25^0C)	EC (ds m^{-1} 25^0C)	Ca^{++}+ Mg^{++}	Na^+	K^+	Total cation	Cl^-	$SO_4^=$	HCO_3^-	$CO_3^=$	Total anion	B (mg L^{-1})	SAR	RSC	Classes of irrigation water
1	6.50	2.550	22.60	3.44	0.24	26.28	1.20	1.16	23.80	-	26.16	0.10	1.02	1.20	C_4S_1
2	7.26	1.331	9.00	5.48	0.27	14.75	1.65	1.38	11.20	-	14.23	2.10	2.58	2.20	C_3S_1
3	7.07	2.820	16.80	15.65	0.30	32.75	6.10	10.66	14.30	0.80	31.86	1.75	5.40	-	C_4S_1
4	6.36	1.613	10.80	7.70	0.26	18.76	2.00	1.14	17.30	-	18.54	0.78	3.31	6.50	C_3S_1
5	6.48	2.050	12.50	8.91	0.44	21.85	1.70	3.22	16.00	-	20.92	0.55	3.56	3.50	C_3S_1
6	7.21	0.715	6.70	1.00	0.36	8.06	0.50	7.13	0.30	-	7.13	0.27	0.55	-	C_2S_1
7	7.26	1.296	11.00	2.83	0.62	14.45	1.20	5.93	7.00	-	14.13	0.01	1.21	-	C_3S_1
8	6.86	1.412	7.50	6.85	0.27	14.62	2.50	1.60	10.40	-	14.50	0.01	3.53	2.90	C_3S_1
9	6.13	0.972	8.00	2.22	0.44	10.66	1.20	2.80	6.60	-	10.60	0.01	1.11	-	C_3S_1
10	6.68	2.780	22.00	7.17	0.39	29.56	1.40	0.65	27.10	-	29.15	0.23	2.16	5.10	C_4S_1
11	6.90	1.150	6.10	5.00	0.23	11.33	1.70	3.03	6.50	-	11.23	0.01	2.86	0.40	C_3S_1
12	7.89	1.250	6.20	6.52	0.28	13.00	1.60	2.95	7.30	0.80	12.65	0.01	3.70	1,90	C_3S_1
13	7.25	1.530	10.60	5.39	0.31	16.30	2.90	5.02	8.00	-	15.92	0.01	2.34	-	C_3S_1
14	7.36	1.280	8.50	4.52	0.21	13.23	2.30	4.93	5.60	-	12.83	0.01	2.19	-	C_3S_1
15	7.34	0.900	5.50	4.26	0.18	9.94	1.20	2.42	6.20	-	9.82	0.50	2.57	0.70	C_3S_1
16	6.88	1.733	13.35	7.04	0.31	20.70	2.00	4.52	13.10	-	19.62	1.25	2.73	-	C_3S_1
17	5.92	1.114	7.40	4.48	0.26	12.14	1.80	4.57	5.60	-	11.97	0.12	2.33	-	C_3S_1
18	7.13	0.900	7.70	2.04	0.18	9.92	0.70	1.80	7.10	-	9.60	1.85	1.04	-	C_3S_1
19	7.35	0.889	8.40	1.09	0.33	9.82	1.50	0.30	8.00	-	9.80	0.70	0.53	-	C_3S_1
20	7.22	1.049	7.35	4.09	0.33	11.77	0.80	1.55	9.15	-	11.50	0.13	2.13	1.80	C_3S_1
21	6.81	2.120	15.30	9.57	0.28	25.11	2.45	9.15	13.30	-	24.90	0.01	3.46	-	C_3S_1
22	6.83	1.628	12.00	6.96	0.32	17.48	1.85	0.30	15.95	-	18.10	0.40	3.08	-	C_3S_1
23	6.87	1.485	7.75	7.83	0.23	15.81	1.80	1.10	12.30	-	15.20	0.33	3.98	4.55	C_3S_1
24	6.53	2.016	12.50	12.17	0.31	24.98	2.30	5.70	15.70	-	23.70	1.38	4.87	3.20	C_3S_1
25	6.65	1.600	12.65	6.74	0.32	19.71	1.25	3.75	14.60	-	19.60	0.90	2.68	1.95	C_3S_1
26	6.67	3.030	13.50	17.17	0.41	31.08	4.00	12.10	14.10	-	30.60	0.45	6.61	0.60	C_4S_2
27	6.16	1.875	15.00	2.70	0.36	18.06	1.90	0.32	16.70	-	18.92	0.10	0.99	1.70	C_3S_1
28	6.65	2.860	16.20	14.35	0.32	30.87	2.40	9.16	18.30	-	29.86	1.30	5.04	2.10	C_4S_2
29	6.95	1.600	12.70	6.61	0.28	19.59	2.30	4.93	12.30	-	19.53	0.01	2.62	-	C_3S_1
30	6.85	1.725	13.00	6.26	0.28	19.54	2.30	5.82	11.00	-	19.12	0.40	2.46	-	C_3S_1
31	6.36	0.756	5.70	2.48	0.15	8.33	0.40	0.30	7.70	-	8.40	0.95	1.47	2.00	C_3S_1
32	7.06	1.030	7.00	2.26	0.39	9.65	1.10	2.35	6.35	-	9.80	0.01	1.21	-	C_3S_1
33	7.50	1.890	15.00	5.30	0.33	20.63	1.50	5.43	10.90	2.00	19.83	0.50	1.94	-	C_3S_1
34	6.47	2.100	15.30	8.91	0.36	24.57	2.10	1.47	20.30	-	23.87	0.45	3.22	5.00	C_3S_1
35	7.30	0.885	7.00	2.60	0.21	9.81	0.40	2.82	2.00	4.40	9.62	0.15	1.39	-	C_3S_1
36	6.95	1.007	8.50	2.34	0.17	11.01	1.10	1.10	8.50	-	10.70	0.01	1.13	-	C_3S_1
37	7.50	0.524	3.70	1.65	0.41	5.76	1.30	1.30	1.90	0.80	5.30	0.01	1.21	-	C_2S_1
38	7.49	0.525	3.70	1.70	0.41	5.81	1.40	1.20	1.90	0.80	5.30	0.10	1.25	-	C_2S_1
39	6.81	0.537	3.40	1.61	0.36	5.40	1.20	1.42	2.80	-	5.42	0.01	1.23	-	C_2S_1
40	7.92	0.391	2.70	1.52	0.18	4.40	1.00	0.70	2.00	0.60	4.30	0.10	1.31	-	C_2S_1
41	7.77	0.855	8.00	2.13	0.31	10.44	1.45	1.77	7.10	-	10.32	0.33	1.07	-	C_3S_1
42	7.10	0.831	7.30	1.35	0.36	9.01	0.70	1.00	7.30	-	9.00	0.01	0.71	-	C_3S_1
43	6.59	2.200	20.10	3.00	0.27	23.37	0.70	8.03	14.40	-	23.13	0.23	0.95	-	C_3S_1
44	6.60	2.770	26.50	3.39	0.23	30.12	1.10	9.23	19.70	-	30.03	0.45	0.94	-	C_4S_1
45	6.73	2.460	21.60	5.00	0.28	26.88	1.10	12.02	13.40	-	26.52	0.95	1.52	-	C_4S_1
46	8.28	1.650	14.50	2.83	0.41	17.74	0.80	4.22	11.70	-	16.82	0.01	1.05	-	C_3S_1
47	7.18	0.870	8.80	1.00	0.23	10.03	0.20	1.03	8.60	-	9.83	0.20	0.48	-	C_3S_1
48	6.34	1.393	11.40	4.90	0.28	15.77	2.70	3.21	9.70	-	15.67	0.01	1.71	-	C_3S_1
49	6.63	2.200	20.90	5.43	0.33	26.66	1.90	12.92	11.70	-	26.52	0.47	1.68	-	C_3S_1
50	6.92	1.013	8.45	0.94	0.26	9.65	0.40	1.22	8.70	-	10.02	0.01	0.48	0.25	C_3S_1
51	7.13	1.100	10.35	1.52	0.23	12.10	1.25	2.10	8.70	-	12.05	1.30	0.67	-	C_3S_1
52	7.52	0.692	5.80	1.26	0.13	7.19	0.60	0.23	6.40	-	7.23	0.50	0.74	0.60	C_2S_1
53	7.50	0.600	5.80	0.74	0.23	6.77	0.70	1.43	4.60	-	6.73	0.01	0.43	-	C_2S_1
54	7.43	0.800	6.80	2.13	0.18	9.11	0.70	2.42	5.80	-	8.92	0.01	1.16	-	C_2S_1
55	7.40	0.702	4.20	3.44	0.14	7.78	0.70	1.10	5.80	-	7.60	0.20	2.37	1.60	C_2S_1
56	6.85	1.225	11.80	1.91	0.46	14.17	1.50	3.21	9.20	-	13.91	0.95	0.79	-	C_3S_1
57	6.59	3.803	24.10	15.22	0.26	39.68	3.80	19.60	15.20	-	38.60	0.25	4.39	-	C_4S_2
58	6.45	1.191	12.10	2.48	0.24	14.82	0.40	0.30	14.30	-	15.00	1.35	1.01	2.20	C_3S_1
59	6.59	0.885	4.35	3.96	0.23	8.54	0.40	0.20	8.70	-	9.30	2.70	2.69	4.50	C_3S_1
60	7.54	0.611	5.80	0.65	0.17	8.62	0.40	1.72	4.50	-	6.62	0.01	0.38	-	C_2S_1
Mean	6.98	1.446	10.82	4.82	0.29	15.90	1.53	3.74	10.15	0.17	15.63	0.46	2.04	0.94	
MİN.	5.92	0.391	2.70	0.65	0.14	4.40	0.20	0.20	0.30	0.60	4.30	0.01	0.38	0.25	
MAX.	8.28	3.800	26.50	17.17	0.62	39.68	6.10	19.60	27.10	4.40	38.60	2.70	6.61	6.50	

C_4S_1: very high salinity low Na^+ damage C_3S_1: high salinity low Na^+damage

C_2S_1: medium salinity low Na^+ damage C_4S_2: very high salinity medium Na^+ damage

Table 3: The evaluation in respect of the rate of the electrical conductivity of district waters and the rate of sodium adsorption

ECw (ds m^{-1})	Sample Number	%	SAR	Sample Number	%
< 1.000 (no problem)	19	31.67	< 6 (no problem)	58	96.67
1.000-2.000 (a increase of problem)	34	56.67	6-9 (a increase of problem)	2	3.33
> 2.700 (heavy problem)	7	11.66	> 9 (heavy problem)	-	-

When waters are examined in terms of this parameter, according to the classification made by the U.S.A. Riverside Salinity Lab., it is seen that the water samples in R.S.C values are less than 1.25 me L^{-1} in 71.67% and are included in the first class, that they are between 1.25-2.50 me L^{-1} in 15% and are included in the second class and finally they are over 2.50 me L^{-1} in 13.13% and are included in the third class (Anonymous, 1954; Wilcox, 1955 and Tuncay, 1994).

The amount of Na^+ and Cl^- elements included in the waters are of importance in terms of vineyard as well. The 96.87 % of the analyzed waters of the district contains Cl^- under 4 me L^{-1} and for this respect, it does not constitute any problem. The rate of Cl^- in the 3.37 % of it is between 4-15 me L^{-1}. These waters may cause problems in the long run. However, it may be readily stated that large amount of the waters in the region do not constitute any problem (Anonymous, 1978). When the rate of sodium is under 20 me L^{-1}, any problem does not occur in vineyard (Anonymous, 1978).

The rate of sodium was found under 20 me L^{-1} in all analyzed water samples. The sulphate ions in the irrigation waters lead to the dissolve of calcium and they can be toxic to plants (Anonymous, 1954 and Ayars *et al.,* 1993).

Considering the acceptable limits given by Scofield, it is understood that 6.67 % of waters of the region include $SO_4^=$ between 12-20 me L^{-1} and its use would be in doubt (Anonymous, 1954; Christiansen, 1977 and Ayyildiz, 1990). The content of boron element which is an important criteria in determining the quality of the irrigation water for vineyard was detected in the limits of 0.01-2.70 mg L^{-1} (Table 3). In the 85% of the waters of the district, the rate of boron is less than 1 mg L^{-1} and this causes no problem. However, in the remaining 15%, the rate of boron is between the levels of 1-3 mg L^{-1} which is considered to produce some problems in the long run for vineyard (Anonymous, 1978 and Keren and Bingham 1985).

Based on the findings obtained from another work the plants were classified in accordance with their sensitivities to boron element and the rate of 0.5 mg L^{-1} was given as the limit for the sensitive plants in its vineyards (Bergmann, 1992 and Shorrocks, 1997). Accordingly, in the 26.67% of the analyzed water samples from the district the ratio of boron is above 0.5 mg L^{-1} and this is regarded to be risky for vineyards (Aillery and Gollehon, 1997; Leyshon and Jame, 1993; Keren and Bingham 1985 and Anonymous, 1954). In an other study carried out in the region, since the district of Kavaklidere, referred to as the place where the major trouble is known as bor, is dealt with,it was confirmed that 88.64 % of waters covered boron above 0.5 mg L^{-1} (Konuk and Yener, 1995).

When the classes of the quality of waters are examined, 16.66% is observed to be included in class C_2S_1, 70% in class C_3S_1, 6.67 % in class C_4S_1 and 6.67 % in class C_4S_1 (Aillery and Gollehon, 1997 and Wilcox, 1955). According to these data, it is understood that the analyzed waters of the district definitely have 13.34% of salinity problem and in its 6.67 % on the other hand, they may lead to alkaline problem besides salinity.

Apart from this, 70% of it is included in class C_3S_1 and it is clear that this percentage should be utilized in a careful way in terms of salinity (Ayars *et al.,* 1993). In an other study made in the district, it has been reported the 79.95% of the waters is included in class C_3S_1, 6.82% of it in class C_4S_1 and 13.60% in class C_2S_1 irrigation waters (Konuk and Yener, 1995). As seen, the results of both studies are similar in term of class of irrigation water.

Consequently, the underground irrigation waters in the district of Alaşehir, Manisa where the viniculture is intensively performed in the Aegean region causes certain problems. In the light of the results from obtained, it is clearly understood that the waters of district were problematic in respect of salinity, that in some districts boron element appears to be trouble-some and in minimal amounts problems can occur in respect that alkaline and Residual Sodium Bicarbonate (RSC).

The water facilities and the quality of waters must be taken into consideration in that a new vineyard will be set up. The qualities of underground waters used in the irrigation of present vineyards must be known, the inconvenient waters must not be applied or must be used in a controlled way by analyzing, now and then, the soil and water.

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