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Araştırma Makalesi - Research Article

Irrigation Water Quality in Selected Water Bodies of East Mediterranean Basin of Turkey

Türkiye Doğu Akdeniz Havzasının Seçilmiş Su Kütlelerinde Sulama Suyu Kalitesi

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ABSTRACT

Turkey is a country that has available climate conditions and water sources utilizable for agriculture. Most surface waters in the country can be applicable for irrigation purposes. Electrical conductivity (EC) is a measure of the salinity of the irrigation water, while salinity can also be directly measured in ppm. High salinity water prevents the water supply of the plant roots due to the high osmotic pressure, in other words reduces the availability of irrigation water. Sodium adsorption ratio (SAR) is an indicator of the quality of the irrigation water that is a measure of the sodium amount relative to calcium and magnesium amounts. High SAR values in the irrigation water result in impermeability in the soil meanly infiltration problems following a decrease in the water supply by the crop. In this study, four selected surface waters from the East Mediterranean Basin were chosen to evaluate their availability for the purpose of irrigation. Since the East Mediterranean Basin is a productive land due to its climatic conditions, monitoring the quality of the irrigation water of the basin becomes crucial. The selected surface water bodies were analyzed at three-month intervals between 2015 and 2019. The salinity and alkalinity classes were found to be C2-S1 which corresponds to good irrigation water quality and can be used to irrigate all types of plants.

Keywords- East Mediterranean Basin, Irrigation Water, Salinity

ÖZ

Türkiye, elverişli iklim koşullarına ve tarım için kullanılabilecek su kaynaklarına sahip bir ülkedir. Ülkedeki yüzey sularının çoğu sulama amaçlı kullanılabilir. Elektrik iletkenliği (EC), sulama suyunun tuzluluğunun bir ölçüsüdür, tuzluluk da doğrudan ppm cinsinden ölçülebilir. Yüksek tuzlu su, yüksek ozmotik basınç nedeniyle bitki köklerinin su beslemesini engellemekte, bu da sulama suyunun etkinliğini azaltmaktadır. Kalsiyum ve magnezyum miktarlarına göre sodyum miktarının bir ölçüsü olan Sodyum adsorpsiyon oranı (SAR), sulama suyunun kalitesinin bir göstergesidir. Sulama suyundaki yüksek SAR değerleri, infiltrasyon diye bilinen toprakta geçirimsizlik sorununa ve ürünün su alımında azalma oluşmasına yol açar. Bu çalışmada, Doğu Akdeniz Havzasından seçilen dört yüzey suyu, sulama amacıyla kullanılabilirliklerini değerlendirmek için seçilmiştir. Doğu Akdeniz Havzası, iklim koşulları nedeniyle verimli bir arazi olduğundan, havzanın sulama suyunun kalitesinin izlenmesi büyük önem taşımaktadır. Seçilen yüzey suyu kütleleri 2015 ile 2019 yılları arasında üç aylık aralıklarla analiz edilmiştir. Tuzluluk ve alkalinite sınıfları, iyi sulama suyu kalitesine karşılık gelen ve her tür bitkiyi sulamak için kullanılabilen C2-S1 olarak bulunmuştur.

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I. INTRODUCTION

East Mediterranean Basin of Turkey is the location for agriculture of various plants, and it supplies a significant percentage of the country's food store [1]. The climate of the basin is suitable for long-term agriculture and gives way to planting a variety of products [2,3]. Despite the available precipitation amounts but due to the excessive evaporation because of the hot weather, the irrigation water in the basin should be forethoughtfully and wisely used. The scarcity of water worldwide is reaching up to higher levels day by day.

Besides the limitations in the amount of the irrigation water, the irrigation qualities of the waters in the basin are crucial to be inspected to determine the applicability of the irrigation water for the intended plantings [4]. Because of the incorrect irrigation water usage, farmers face a lack of efficiency or plant decays besides time and economic losses, and targeted planting cannot be achieved [5-7]. To prevent these losses, classification of the irrigation waters for intended purpose becomes valuable [8]. Irrigation waters are identified and classified basically according to the salinity and sodium contents [6]. Salinity is expressed by electrical conductivity and increases by the scarcity of precipitation and the increase in evaporation. Quality classes concerning salinity begin from the low hazard, and by the increase of the conductivity, it reaches medium, high, and very high hazard levels. In the case of using high salinity water for salt-nonresistant plants, yield reductions are detected.

Sodium contents are expressed by sodium adsorption ratio and dissolved sodium ions relative to dissolved calcium and magnesium ions [9]. Quality classes with respect to sodium adsorption ratio begin from the low hazard, and by the increase of the sodium concentrations, it reaches medium, high, and very high hazard levels. High sodium contents in the irrigation water have an indirect effect on the plant by primarily causing soil problems [10].

While low hazardous waters can be used to irrigate all types of plants, medium, and high hazardous waters should be used for resistible plants. Highly hazardous waters are not suggested for any types of plants. In the case of having no other irrigation-safe water in hand, very high hazardous waters may be used by applying some precautions just like blending with safe water, planting tolerant crops, blending with safe water or treatment of soil with gypsum or elemental sulphur [11,12].

In this study, four surface water sources that are commonly used for the agriculture of cherry, grapes, apple, olive, and nuts in the East Mediterranean Basin were monitored once per every three months between 2015 and 2019 as long as climate conditions were available or accessible waters were found despite the drought. Since a balanced diet is fundamental for a healthy body, beneficial planting becomes essential. The planting efficiency is principally based on the correct irrigation water quality besides the soil characteristics and the climatic conditions. Several studies concerning the chemical analysis of waters for irrigation purposes in different regions can be found in the literature. Still, since East Mediterranean Basin is the basic cultivated area for many parts of Turkey, it should be monitored and evaluated. The investigation results should fill the gaps in the irrigation water quality map of the country.

II. MATERIAL AND METHODS

A. Sampling

Sampling sites for the study were selected to be four surface water bodies from the bridges in the East Mediterranean Basin, whose details are given in Table 1. In this study, 1st sampling point Konya Hadim Bolat Village Bridge, was sampled for 13 times (n=13), 2nd sampling point Konya Hadim Afşar Village Bridge was sampled for 15 times (n=15), 3rd sampling point Karaman Başyayla Serper Bridge was sampled for 20 times (n=20) and 4th sampling point Karaman Bucakkışla Bıçakçı Bridge was sampled for 20 times (n=20), once in every three months between the given 2015-2019 period. The locations of the sampling points are given in Figure 1. The gaps in the samplings were caused because of the unavailable climate conditions or drought. The selected water bodies are used as irrigation water for planting cherry, grapes, apples, olive, and nuts in Konya and Karaman cities of Turkey [13].

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Figure 1. Locations of the sampling points.

B. Experiments

Electrical Conductivity (EC) analyses were made by the electrochemical method according to TS 9748 EN 27888. Calibration and quality control of the conductivity-meter were made by 1413 µS/cm and 1408 µS/cm solutions at 25°C, respectively.

Dissolved sodium, dissolved calcium, and dissolved magnesium ions were analyzed by ion chromatographic method according to TS EN ISO 14911. Calibration by the standards and quality control of the results of the ion chromatography instrument were made using certified calibration and quality control solutions.

C. Classification

Sodium adsorption ratio (SAR) values were calculated using Equation 1, where sodium, calcium, and magnesium concentrations are in mmol/L [14].

$$SAR = \frac{Na}{\sqrt{\frac{Ca^2+Mg^2}{2}}} \quad (1)$$

Salinity and alkalinity classes were determined using Figure 2, in which salinity and sodium contents range from low to very high over 1 to 4. The diagram's electrical conductivities are in µS/cm, and the SAR are calculated by equation 1 and are in mmol/L. EC below 250 µS/cm has low hazards to the plants, EC between 250-750 µS/cm has a medium hazard, EC between 750-2250 µS/cm has a severe danger for the plants, and EC above 2250 µS/cm is very highly hazardous. Likewise, the low sodium hazard is lower than 10 mmol/L SAR, the medium hazard to plant is between 10-18 mmol/L SAR, the high hazard is between 18-26 mmol/L, and above 26 mmol/L SAR is very hazardous to plants.

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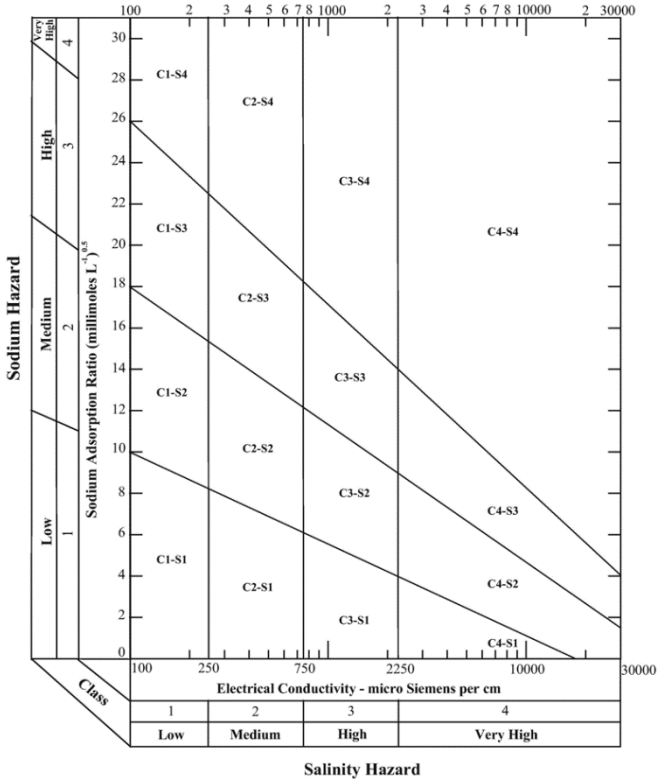

Figure 2. Diagram for the classification of irrigation waters [15]

D. Statistical Analyses

Statistical analyses were performed by Student's t-test using GraphPad Prism 5.0 statistical software package for Windows (La Jolla, CA). All results were expressed as means with their standard deviation (SD). $P<0.05$ was taken as the minimum level of significance.

III. RESULTS AND DISCUSSION

Four water bodies from the East Mediterranean Basin of Turkey were selected, and EC values were determined by electrochemical method besides dissolved sodium, magnesium and calcium concentrations were determined by ion chromatography instrument between 2015 and 2019, which becomes the basis for the evaluation of the waters for salinity and alkalinity classes for the purpose of irrigation.

There are several studies for the determination of irrigation water quality in various regions of Turkey. One of the analyses concerns 21 underground water samples in Biga, the biggest surface area and high capacity agricultural land in Çanakkale. According to the salinity diagram, the underground waters were found to be at C2-S1 and C3-S1 irrigation water quality [16]. Another study for the irrigation water quality was made to determine the irrigation water quality of 18 producers in the Muğla-Dalaman region. At the end of the analysis, the irrigation water quality was commonly as C3-S1 and C2-S1 [17]. The research in 20 wells in the Kütahya-Alayunt region revealed the irrigation water quality to be mostly belonging to C3-S1 and C2-S1 classes [18]. Another study was made for 12 months to determine the effect of industry on the irrigation water quality of Karabük region underground waters. At the end of the study, both in rainy and dry seasons, the underground waters were classified commonly as C3-S1 while some were C2-S1 [19].

Konya Hadim region was studied for drinking water purposes in a research study. Monthly monitoring in the Konya Hadim region was studied between June 2007 and July 2008 in the tap water for drinking water. The chemical analysis was found to be convenient, while bacterial analysis was found to be inconvenient for drinking water purposes. The chemical analysis results of the subject research are in convenience with the chemical analysis results of the present study [20].

In this study, the selected samples' EC analyses ranged between 282-644, 346-644, 331-595, and 453-750 µS/cm, respectively, in the sample points (Figures 3-6).

Dissolved sodium analyses of the samples ranged between 3.27-7.19, 2.97-12.50, 1.93-6.28 and 5.99-16.76 mg/L respectively, dissolved magnesium analyses of the samples ranged between 11.32-28.28, 6.04-17.13, 5.42-35.23 and 14.68-37.62 mg/L respectively and dissolved calcium analyses of the samples ranged between 39.61-99.82, 52.83-100.57, 56.48-81.11 and 41.92-102.56 mg/L respectively. The dissolved ions were analyzed by ion chromatographic method in mg/L units and the conversions of the concentrations to mmol/L was required for the calculations of SARs. The samples' SAR values for the corresponding sampling dates were calculated according to Equation 1 and graphed in Figures 3-6 for each sampling point.

The seasonal effects on the EC and the SAR values were found to be acceptable according to the classification of Figure 2, although a detailed investigation is required for a few sampling dates. In February 2015, the EC of the 1st sampling point was low when compared with the others. In November 2016, the EC of the 2nd sampling point was a little high compared with the others, both of which can be neglected due to their outlying characteristics. The SAR values of all sampling points in all sampling dates were similar and showed no definite change, even though the seasonal effects. The sampling points are originated from different water bodies. First, second, third and fourth sampling points are originated from Taşpınar stream, Çataltaş stream, Kuşla stream and Göksu river respectively. But due to the common climatic conditions of the locations, there was not a definite fluctuation from the common characteristics.

The average EC and SAR values for each sampling point were given in Table 1. The corresponding irrigation water classes were evaluated using Figure 2 and displayed in Table 1. All irrigation water samples were found to be belonging to the C2-S1 class in all sampling dates, further to removing the outliers, which presents a character that can be used for every type of plant, including the crops commonly planted in the subject region.

In some situations, in the case of having no irrigation safe water in hand, discharges from the wastewater treatment plants can be used for irrigation purpose. In one of the studies, the effect of wastewater treatment system discharge on the quality of irrigation water in Nilüfer, the irrigation water source of Bursa, was studied. The analysis performed between August 2013 and May 2014 resulted in irrigation water quality between C2-S1 and C4-S4 [21].

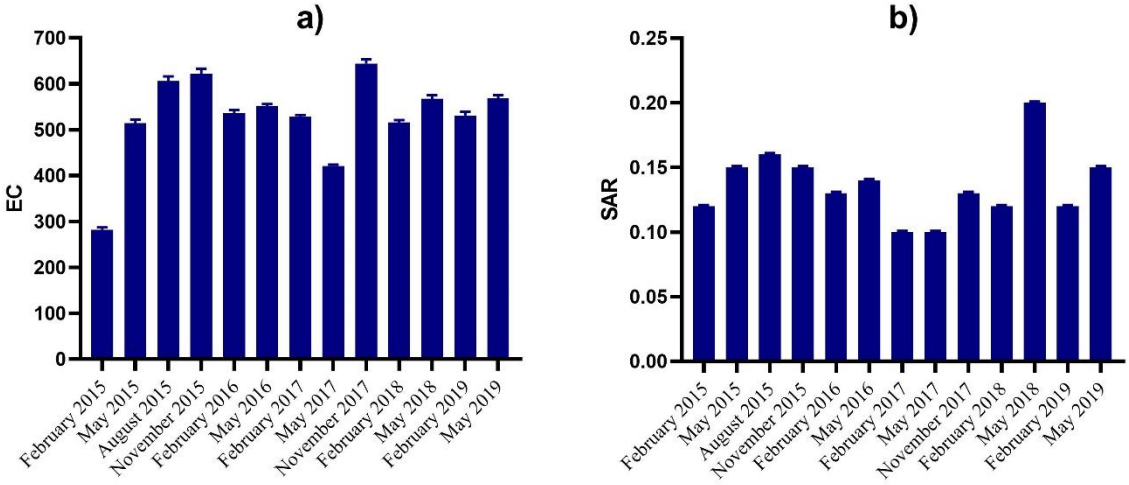

Figure 3. EC and SAR variations by the months for the 1st sampling point between 2015 and 2019

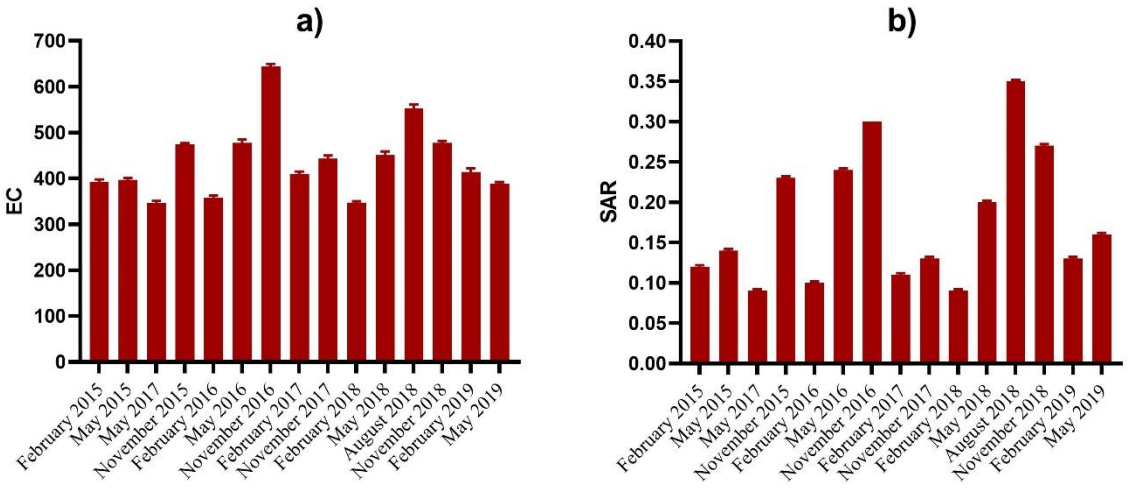

Figure 4. EC and SAR variations by the months for the 2nd sampling point between 2015 and 2019

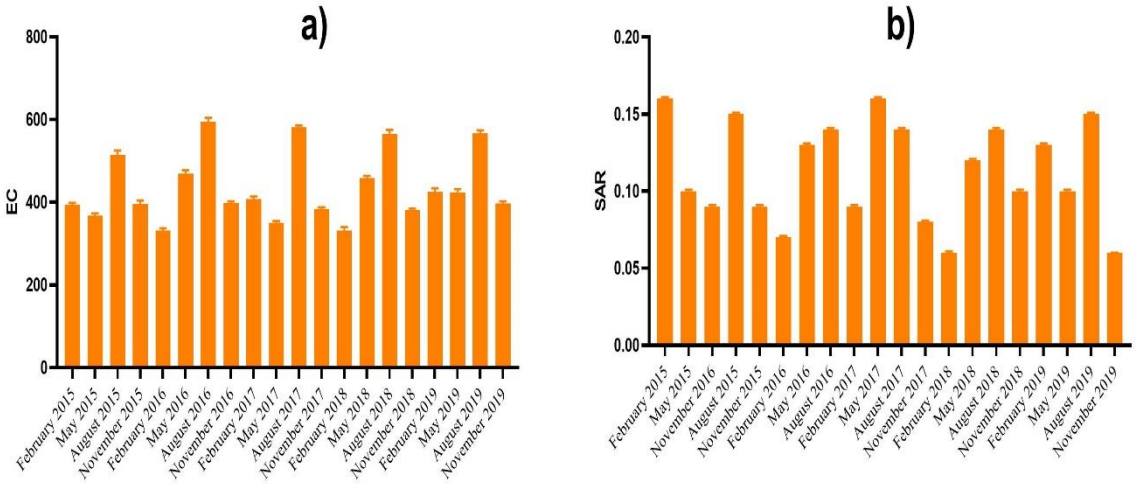

Figure 5. EC and SAR variations by the months for the 3rd sampling point between 2015 and 2019

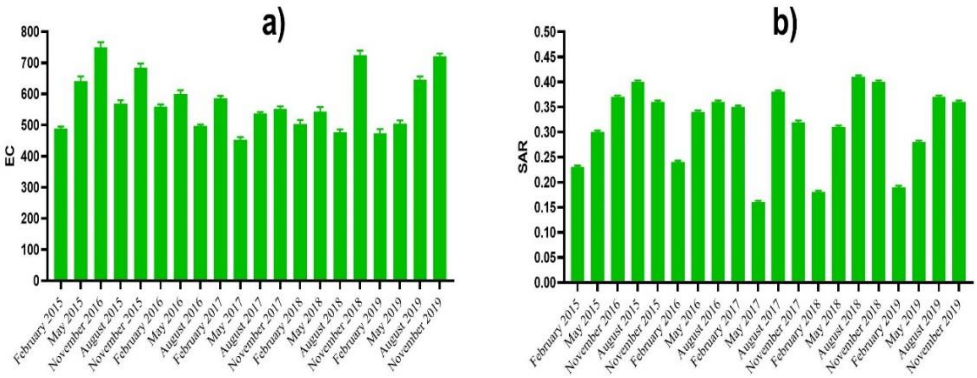

Figure 6. EC and SAR variations by the months for the 4th sampling point between 2015 and 2019

Table 1. Average electrical conductivity (EC), average SAR values and salinity classes of the selected sampling points

	Sampling point	Water body Coordinates X/Y	Average Electrical Conductivity, µS/cm	Average Sodium Adsorption Ratio, SAR	Salinity class
1	Konya Hadim Bolat Village Bridge (n=13)	Taşpınar Stream 447937.6/4103953	530±91.3	0.14±0.03	C2-S1
2	Konya Hadim Afşar Village Bridge (n=15)	Çataltaş Stream 460507.5/4084847	438±79.3	0.18±0.08	C2-S1
3	Karaman Başyayla Serper Bridge (n=20)	Kuşla Stream 479272.5/4061411	437±83.4	0.11±0.03	C2-S1
4	Karaman Bucakkışla Bıçakçı Bridge (n=20)	Göksu River 503484.1/4089231	576±91.2	0.32±0.08	C2-S1

n: number of the samplings

IV. CONCLUSION

The selected water bodies of the East Mediterranean basin executed similar irrigation properties. The electrical conductivities directed the salinity hazard to be at medium level C2 class. Because of the water bodies' medium salinity hazard, it should be careful only in the case of being used for plants that are very sensitive to salinity. Since the region's present agricultural products are not very sensitive to salinity, irrigation water is available for the subject aim. The sodium adsorption ratios were found to be rather low, and evaluation for the irrigation purpose according to the sodium content can be neglected. The selected surface waters were available for use in nearly every type of plants for irrigation purposes. The anthropogenic effect or the negative agricultural effect on the water quality should be established by detailed chemical, residue, and trace metal analysis on the water bodies.

In this study, four water bodies were selected and studied for their availability for irrigation purpose. Since incorrect quality water implementation to the plant causes losses in both the time and the effort, classification of the irrigation water is crucial and economical. The selected surface waters are readily used for the irrigation aim, and the research results support the usage of the surface waters for the intended and applied purpose. Even though these results can fill a gap, to characterize the basin in detail, other sampling points in the basin should be inquired, and an irrigation water quality map of the basin should be drawn.

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