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Investigation of Agricultural Water Quality of Bursa-Nilüfer Hasanağa Dam Pond and Kütahya-Tavşanlı Adranos Stream

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Abstract

In terms of sectoral distribution of water used in Turkey, approximately 75% is used for irrigation purposes. Irrigation planning varies depending on water quality. In particular, the usage of poor quality water through surface irrigation increases the damage. Quality criteria and classification systems were developed for the evaluation of irrigation waters. By using of these criteria and classification systems, monitoring the water quality of Hasanağa Pond and Adranos Stream, it will be useful for regional farmers to identify problems in agricultural productivity and to take precautions against pollution. In the results of the study, in winter in Adranos Stream, cations are aligned as Mg>Ca>Na>K>B, and anions are aligned as SO4>CO3>HCO3>Cl. In summer, cations are aligned as Na>K> Mg>Ca=B, and anions are aligned as SO4>HCO3>CO3>Cl. In Hasanağa Pond in winter, cations are aligned as Ca>K>Na>Mg=B, and anions are aligned as CO3>Cl>HCO3>SO4. In summer, cations are aligned as Na>K> Mg>Ca=B, and anions are aligned as SO4>CO3>HCO3>Cl. When the results regarding water quality classification were examined, it was determined that the usage of Adranos Stream and Hasanağa Pond in agricultural irrigation poses a problem in terms of salinity. During summer and winter periods, compared to Hasanağa pond, the EC value of Adranos Stream is approximately 2 times higher. When SAR values are compared to each other, it was understood that Adranos Stream may cause problems for agricultural irrigation, especially in summer. It was understood that Hasanağa pond has more suitable and higher quality water for agricultural irrigation compared to Adranos Stream.

Keywords: Adranos Stream, Agricultural Water Quality, Hasanağa Pond, Sodium Adsorption Rate

1. INTRODUCTION

Water has an important place in the survival of living things. If precautions are not taken for the coming years without considering various reasons such as climate change and environmental pollution, many difficulties may be encountered in the supply of drinking and irrigation water (Coşkun, 2022).

Global freshwater scarcity is caused by the increasing demand for water for agricultural production, industrial use and human consumption (Hoekstra et al., 2012). Therefore, approximately 80% of the world's income is exposed to high-level threats to water security (Vörösmarty et al., 2010).

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Irrigation water quality can directly affect to crop yield, physical soil conditions and the performance of irrigation systems (Bauder et al. 2011). The use of dirty water affects the agro-ecosystems and socio-economic activity in a basin (Yurtseven and Randhir 2020). Water quality affects crop production and soil quality through salinity hazard, infiltration and permeability problems and specific ion toxicity (Ayers and Westcot, 1985).

Irrigation water quality affects plant yield, plant and soil physical properties. The selection and planning of irrigation methods vary according to water quality. The quality of water used in agricultural irrigation might negatively affects plant and soil properties. Water resources are in danger of depletion and pollution. Therefore, it is important to prepare plans and programs for sustainable water usage (Kapdı and Aşık, 2021). Therefore, the main purpose of this study is to help protect water resources and achieve sustainable agriculture.

The Hasanağa Pond Dam in Bursa is exposed to pollutants and organized industrial wastes in agricultural areas. Therefore, this research will be useful in terms of classifying and monitoring possible pollution in terms of agriculture, identifying problems and taking precautions against pollution. In addition, it can be said that the Hasanağa Dam Pond is quite suitable in terms of drinking water quality. The usage of wastewater, which is necessary for the provision and protection of a livable environment, is very valuable. Thanks to the Wastewater Treatment Plant by HOSAB, the water taken from the dam has become usable as drinking water.

Tavşanlı County, located in the northwest of Kütahya, is at the junction of the Marmara and Aegean Regions. Adranos Stream follows the Tavşanlı-Kayaarası-Tunçbilek-Hamitabat-Güney-Kızılçukur route, enters the Bursa Province borders from the Çayören (Hereke) village borders of Keles, and reaches the Marmara Sea from the Orhaneli-Mustafakemalpaşa route. The pollution in these regions significantly affects mining activities and the geological structure of the basin.

The need for drinking and utility water is rapidly increasing due to industrialization and population growth. Therefore, there is a need to protect existing natural resources and build new water resources such as dams and ponds. It was reported that dam ponds differ from natural lakes in terms of parameters such as high flow rate, high suspended solids in water, formation of density currents, effect of released water on nutrient content, short water exchange period and due to the width of the water collection basin, they can be affected by pollution in the basin more than natural lakes (Komarkova and Hejzlar, 1996; Lind, 1990).

Bulut et al. (2011) took water samples from three different stations in Selevir Dam Lake at monthly intervals from the surface, 7 and 14 meters. In the samples taken, the average temperature in the water column was 13.1°C, pH was 8.21, dissolved oxygen was 8.25 mg/L, organic matter was 3.2 mg/L, electrical conductivity was 294 µS cm^{-1}, light transmittance was 2.9 m and total hardness was 14.72 mg/L. The cation order was found as Ca>Mg>Na>K, and the anion order was found as HCO_3>NO_2>Cl>SO_4=>NO_3. When the obtained water quality analysis results were evaluated according to the Water Pollution Control Regulation, it was class I water quality according to the average water temperature, pH, dissolved oxygen, sodium, chloride, sulfate, nitrate, ammonium, organic matter amount values, and class III water quality in terms of nitrite and phosphate. It can be classified as "slightly hard" water in terms of hardness value.

Plants show very different reactions in terms of accumulating sodium in their bodies and leaves or excreting it from their leaves. Besides, studies was conducted with a wide variety of plants in order to reveal the damage caused by Na. For example, in experiments conducted on almonds and avocados, damage occurred in plant leaves due to high Na concentrations in the soil. Another study conducted on alfalfa, barley, cauliflower, cotton, potatoes, sesame, sugar beet, sunflower and tomatoes revealed that as a result of sprinkler irrigation with salty irrigation water, Na adsorption on leaves increased and damage could occur depending on the irrigation intensity and salinity level. In a similar study, it was found that a 15 mol/m^3 Na concentration caused damage to leaves in plums with sprinkler irrigation (URL 1).

The negative effects of high Ca concentrations on plant development vary according to the plant type. Besides, some Ca salts were found to be more toxic. For example, it was showed that $CaCl_2$ salts are more toxic than NaCl salts for soils. Besides, it was observed that Ca salts added to soil solution in orchards had some special effects. Since the added $CaCl_2$ and $CaNO_3$ salts had similar effects, it was stated that the effect was due to the presence of Ca rather than Cl. In experiments conducted on stone fruits, it was observed that even normal levels of $CaCl_2$ salt had a harmful effect because Cl was accumulated in the leaves and damaged the plant (URL 1).

High concentrations of Mg salts can sometimes be toxic. This toxicity can be reduced by relatively high concentrations of Ca. Potassium is rarely found in high concentrations. High K concentrations will be toxic. This toxic effect can be balanced by increasing the Ca concentration, as with Mg. High K concentrations can also cause Mg deficiency and iron chlorosis (URL 1).

Although boron is one of the elements required for the normal development of plants, the amount required is very low. If its concentration exceeds this amount, it can be harmful. Boron requirements and its harmful concentrations vary according to plant species and breeds. Therefore, the amount required for some plants may be harmful to sensitive plants. While some species do not show any symptoms regarding boron damage, burning, chlorosis and necrosis effects are generally seen in plants.

When chloride ions exceed certain concentrations, they cause adverse effects by damaging plant organs. As a result of studies conducted by many researchers, it was shown that Cl has a toxic effect on peach and other stone fruits and that it causes leaf adsorption and leaf burns in plants such as citrus, avocado, grapevine, soybean, alfalfa, barley, cauliflower, cotton, potato, sesame, sugar beet, sunflower, and tomato (URL 1).

Sulfate damage was observed in many plants. The main reason for this damage is that plants cannot take up Ca ions under high SO_4 concentration conditions. With this decrease in Ca ion, the adsorption of Na and K ions increases and thus the harmful effect of high concentration sulfate may be related to the disruption of this cation balance.

The harmful effects of bicarbonate ion vary according to plant species and in some cases, even low concentrations can be harmful. Studies was shown that bicarbonate affects the plant's nutrient uptake and metabolism and that the degree of this effect varies according to the plant species. For example, while beans are very sensitive, beets are relatively less sensitive. In studies conducted in sand culture, beans contained less Ca and more K in conditions where bicarbonate was present in the environment compared to the control subject. In addition, the main effect of bicarbonate was the decrease in Mg content and the increase in Na content (URL 1).

In this study, the current water quality status of Kütahya-Tavşanlı Adranos Stream and Bursa Hasanağa Dam was determined. Seasonal (for summer and winter) water quality parameter changes of these water resources were determined. Besides, irrigation water classification was made. Namely, the quality of the water resources examined in the study and their suitability for agriculture were investigated. As a result, the necessary results to be used in determining the agricultural production plan depending on water quality were produced. Farmers will be able to make their production plans according to these results.

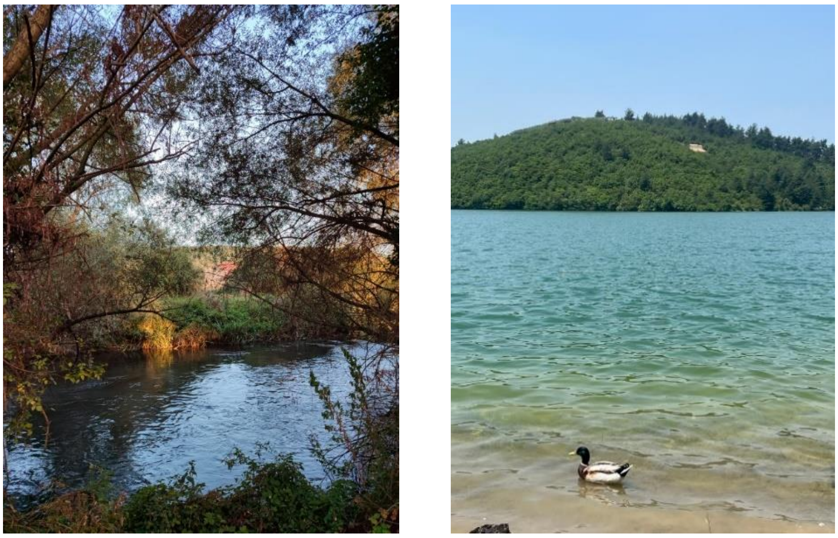
2. MATERIAL AND METHOD

2.1. Material

Hasanağa Dam is a dam built on Hasanağa Creek in Bursa between 1978-1985 for irrigation purposes. The dam, which is a soil and rock body fill type, has a body volume of 873,000 m^3, a height of 37,00 m from the stream bed, a lake volume of 3.71 hm^3 at normal water level, and a lake area of 0,31 km^2 at normal water level. The dam provides irrigation services to an area of 715 hectares. (Ersöz and Çamoğlu, 2020) Dam lakes are artificial lakes built on streams for various purposes such as providing drinking water sources, irrigation and flood protection, and energy production, which accumulate behind a dam structure (Coşkun, 2022).

Adranos Stream in Kütahya follows the route Tavşanlı-Kayaarası-Tunçbilek-Hamitabat-Güney-Kızılçukur, enters Bursa Province borders from Çayören (Hereke) village borders of Keles and reaches Marmara Sea from Orhaneli-Mustafakemalpaşa route. Tavşanlı Stream originates from sources near Esatlar Village. Its length within the provincial borders is 65 km, and its average flow rate is 8 m^3/s. The altitude of the plain in the north of Kütahya is 840 m above sea level. The density of the stream network has caused the eastern part of Tavşanlı Plain to be very indented (Dalkıran et al., 2020).

Pear, apple, quince, plum, peach, oleaster, walnut and cherry production is carried out in Tavşanlı Adranos Stream basin. Tavşanlı is the largest district of Kütahya province, established in a mountainous area in the source region of Adronos Stream (Kocasu), on the southwestern edge of Yaylacık Mountain. Its total population was recorded as 101,460 in 2019. Its surface area is 1804 km^2 and it is only 48 km away from the city center. The pictures of Adranos Stream (a) and Hasanağa Pond (b) are in Figure 1.



(a) **(b)**

Figure 1. Adranos Stream (a) and Hasanağa Pond (b)

2.2.Method

2.2.1. Determination of Quality parameters of irrigation water

Some of the irrigation water quality parameters determined in this study are as follows (Tüzüner, 1990; Ayyıldız, 1990);

Electrical conductivity (dS/m) and pH: They will be measured directly with EC meter and pH meter.

Calcium (Ca) and Magnesium (Mg) (me/L): They will be determined by EDTA titration method. The values found with the titration will be used in equation 1 and 2.

$$\text{Ca+Mg (me/l)} = [(A\text{-}B)*N*1000]/a \tag{1}$$

In the equation;
A: In the water sample, the amount of EDTA spent in the titration (ml)
B: In the blank, the amount of EDTA spent in the titration (ml)
N: Normality of EDTA (0.01)

$$\text{Ca (me/l)} = [(A\text{-}B)*N*1000]/a \tag{2}$$

In the equation;
A: In the water sample, the amount of EDTA spent in the titration (ml)
B: In the blank, the amount of EDTA spent in the titration (ml)
N: Normality of EDTA (0.01)
a: Water sample volume (ml)

Carbonate (CO_3) and Bicarbonate (HCO_3) (me/L):
They will be determined by Sulfuric Acid titration method. The values found with the titration will be used in equation 3 and 4.

$$CO_3 \text{ (me/l)} = (2*Y*N)/a \tag{3}$$

$$HCO_3 \text{ (me/l)} = [(Z\text{-}2Y) *N*1000)]/a \tag{4}$$

Y = Amount of sulfuric acid used for CO_3 titration (ml)
Z = Amount of sulfuric acid used for CO_3 + HCO_3 titration (ml)
N = Normality of sulfuric acid
a = Water sample volume (ml)

Chlorine (Cl) (me/L): It will be determined by silver nitrate titration method. The values found with the titration will be used in equation 5.

$$\text{Cl (me/l)} = [(A\text{-}B) *N*1000)]/a \tag{5}$$

A = Amount of $AgNO_3$ solution used in sample titration (ml).
B = Amount of $AgNO_3$ solution used in blank titration (ml).
N = Normality of silver nitrate solution.
a = Water sample volume (ml)

Sulfate (SO_4) (me/L): Sulfate concentration will be determined with the help of the following equation. The results of EC, CO_3, HCO_3 and Cl will be used in equation 6.

$$SO_4 \text{ (me/l)} = ([EC\times10^6]/100) - (CO_3+HCO_3+Cl) \tag{6}$$

In the equation;
EC= Electrical conductivity in "micromhos/cm" at 25 °C

Sodium (Na) and Potassium (K) (me/L): They will be determined with a flame photometer.

Boron (B) mg/L: It will be determined spectrophotometrically by the Carmine method.

Sodium Adsorption Rate (SAR): It will be determined by calculation. The results of Na, Ca and Mg will be used in equation 7.

$$\text{SAR}=Na/\sqrt{((Ca+Mg)/2)} \tag{7}$$

Waters with a SAR value less than 10 are in class A1, and waters greater than 26 are in class A4 (Table 1).

Table 1. Classification of irrigation waters according to SAR value

SAR	Class
0-10	A1
10-18	A2
18-26	A3
>26	A4

(A1) is low sodium water, (A2) is mid sodium water, (A3) is high sodium water, (A4) is very high sodium water in table 1.

2.2.2. Determination of Quality classification system of irrigation water

Some of the classification systems of irrigation water quality determined in this study are as follows;

1. Schofield (1933) system (EC and %Na)
2. Schofield (1935) system (EC, %Na, Cl, SO_4)
3. Wilcox and Magistad (1943) system (EC, %Na, Cl, B)
4. Wilcox (1948) graph system (EC and %Na)
5. Thorne and Thorne (1951) graph system (EC and %Na)
6. USSL (USA Salinity Laboratory) (1954) classification system (EC and SAR)

3. RESULTS

It was seen that pH and Ca values in both Adranos Stream and Hasanağa Pond are very close to each other in summer and winter. In summer and winter periods, EC value of Adranos Stream is approximately 2 times higher compared to Hasanağa Pond. When SAR values are compared, it is understood that Adranos Stream can create problems for agricultural irrigation especially in summer. When %Na values are compared, Hasanağa Pond has better quality water in winter and Adranos Stream in summer. When RSC values are compared, Adranos Stream has better quality water in winter and Hasanağa Pond in summer. Compared to Adranos Stream, it is understood that Hasanağa Pond has better quality water and is more suitable for agricultural irrigation. Hasanağa Pond and Adranos Stream generally have better quality water in winter compared to summer. In Adranos Stream in winter, cations are listed Mg>Ca>Na>K>B, anions are listed as SO_4>CO_3>HCO_3>Cl. In summer, cations are listed as Na>K>Mg>Ca=B, anions are listed as SO_4>HCO_3>CO_3>Cl. In Hasanağa Pond in winter, cations are listed as Ca>K>Na>Mg=B, anions are listed as CO_3>Cl>HCO_3> SO_4. In summer, cations are listed as Na>K> Mg>Ca=B, anions are listed as SO_4>CO_3>HCO_3>Cl (Table 2).

3.1. Results of Irrigation Water Quality Parameters for the 1st Term (Winter)

In the 1st period (winter) studies, the water sample taken from Adranos Stream and Hasanağa Pond on 10.12.2023 was analyzed on 19.12.2023. In both Adranos Stream and Hasanağa Pond, pH, Ca, K, B, Cl values were very close to each other for the winter period (Table 2).

3.2. Results of Irrigation Water Quality Parameters for the 2st Term (Summer)

In the 2nd term (summer) studies, water samples taken from Adranos Stream on 08.05.2024 and from Hasanağa Pond on 20.05.2024 were analyzed on 28.05.2024. In both Adranos Stream and Hasanağa Pond, pH, Ca, CO_3 values were very close to each other for the summer period (Table 2).

3.3. Results on Irrigation Water Classification Systems

Various methods have been put forward by many researchers for the classification of irrigation waters. The criteria that these methods take into consideration differ from each other. While some of these methods only consider salinity and sodium parameters, some examine more parameters within the same system. Naturally, systems that include a large number of parameters provide more accurate and sensitive results, while their usage requires knowledge and more time. On the other hand, systems that provide results with a small number of parameters are more practical and easy to use. However, it should not be forgotten that all these systems give the best results for the area and regional conditions in which they are tested. Different interpretations may be required as a result of their usage in other regions and climates. Some of the systems developed for the evaluation of the quality of irrigation waters are given below.

3.3.1.Classification Results of Schofield (1933) System

It is one of the first classification systems put forward for the classification of irrigation waters. In this system, waters are collected under 5 classes according to electrical conductivity (EC) and %Na values. According to Schofield (1933) classification system:

In Adranos Stream, EC parameter is not suitable and %Na parameter is perfect in the winter period. EC parameter and %Na parameter are 2nd Class (good) in the summer period. In Hasanağa Dam, EC value is 5th Class (not suitable) in the winter period, %Na value is 1st Class (perfect). EC value is 2nd Class (good), %Na value is 3rd Class (allowable) in the summer period.

3.3.2. Classification Results of Schofield (1935) System

In this classification, Schofield included Cl and SO_4 concentration values in addition to EC and %Na. According to Schofield (1935) classification system:

In winter period, Adranos Stream gave the result of “not suitable” according to EC parameter, %Na value was “excellent”, Cl value was “excellent” and SO_4 value was “excellent”. In summer period, Adranos Stream gave the result of “good” according to EC parameter, %Na value was “good”, Cl value was “excellent” and SO_4 value was “permissible”. In Hasanağa Dam for winter period, EC value was found as Class 5 (not suitable), %Na value was Class 1 (perfect), Cl was Class 1 (perfect) and SO_4 was Class 1 (perfect). In Hasanağa Dam for summer period, EC value was found as Class 2 (good), %Na value was Class 3 (allowable), Cl was Class 1 (excellent) and SO_4 was Class 1 (excellent).

3.3.3. Classification Results of Wilcox and Magistad (1943) System

This system has been widely used in many states of the United States. In this system, irrigation waters are examined under three groups. The classification criteria are EC, %Na, Boron and Cl values. According to the Wilcox and Magistad (1943) system:

In the winter period, the EC parameter of Adranos Stream was found to be ”3rd class”, %Na value was found to be “1st class”, Cl value was found to be ”1st class” and B parameter was found to be ”1st class”. In the summer period, the EC parameter, %Na value, Cl value and B parameter of Adranos Stream was found to be ”1st class”. In the winter period, the EC value of Hasanağa Dam Reservoir was found to be 3rd class, %Na was found to be 1st class, Cl was found to be 1st class and B was found to be 1st class. In the summer period, EC, %Na, Cl and B were found to be 1st class in Hasanağa Dam.

Table 2. Seasonal quality parameter values of water resources in the study

	Water resources	**pH**	**EC (µS/cm)**	**Ca (me/l)**	**Mg (me/l)**	**Na (me/l)**	**K (me/l)**	**Bor (ppm)**	**CO_3 (me/l)**	**HCO_3 (me/l)**	**SO_4 (me/l)**	**Cl (me/l)**	**%Na**	**RSC**	**SAR**
1st term (Winter)	Adranos Stream	7.57	8870.86	1.1	1.65	0.235	0.23	0	1.4	1.3	1.68	0.5	77.30	- 0.05	0.23
	Hasanağa Pond	7.67	4763.86	1.4	0	0.043	0.225	0	0.8	0.2	0.168	0.5	22.5	-0.4	0.051
2st term (Summer)	Adranos Stream	7.62	702.73	0	2.5	11.7	3.8	0	1.6	3.7	11.7	1	21.11	2.8	11.7
	Hasanağa Pond	7.74	366.3	0	1	3.2	1.3	0	2	0.5	2.6	0.4	58.2	1.5	4.5

3.3.4. Classification Results of Wilcox (1948) Graphic System

Wilcox (1948) proposed a graphic classification system in his system. EC and %Na values are taken into consideration in this system. Irrigation waters with low EC values are evaluated as "very good" even with high %Na contents in this system. According to the Wilcox (1948) Graphic System:

According to the table taken into consideration, Adranos Stream gave a result of "not suitable" for the winter period, while the result of "very good" for the summer period was reached. According to the graphic, when the EC and %Na values found in the winter period of Hasanağa Dam Reservoir were intersected, it was found as "not suitable". According to the graphic, when the EC and %Na values found in the summer period of Hasanağa Dam Reservoir were intersected, it was found as "very good-good".

3.3.5. Classification Results of Thorne and Thorne (1951) Graphic System

As a result of studies on Utah irrigation water resources, this classification system was put forward. In the system, EC and %Na values were considered as classification criteria and EC values were indicated between 1-5, and %Na values were indicated with letters between A-E. According to Thorne and Thorne (1951) graphic system:

It was seen that both Adranos Stream and Hasanağa Dam Reservoir were in class 1A as a result of the intersection of the parameter results of the summer and winter periods.

3.3.6. Classification System Results of (USSL) USA Salinity Laboratory (1954)

This system, developed by the United States Salinity Laboratory, has been used by many countries since it was introduced. In the system, irrigation waters are evaluated by considering EC and SAR values. Both criteria are grouped under 4 classes and salinity damage is specified between C1-C4, and sodium damage is specified between S1-S4. "C4S1" result was obtained from the graph taken according to the data of the winter period of Adranos Stream. In the summer period, It was "C2S2" medium salt and sodium water. Hasanağa Dam Reservoir was in the "C4S1" class in the winter period. In the summer period, it was "C2S1" medium salt and low sodium water.

4.DISCUSSION AND CONCLUSION

Malakar et al. (2019) said that deterioration of irrigation water quality caused salinity and decrease in crop yield. Yurtseven and Randhir (2020) revealed that bicarbonate ($HCO3^-$), sulfate ($SO4^{2-}$) and boron (B^{3+}) are indicators in the spatial analysis of Uluabat Lake Basin. Salinity, sodium, boron hazard and alkalinity affect both spatial and temporal water quality patterns in the basin. It was observed that the continuous use of low-quality irrigation water negatively affected agriculture and soil health in the basin. Excessive sodium salinity can affects the soil structure and water infiltration. Sodium is often expressed as a sodium sorption ratio (SAR). The ratio of sodium to calcium and magnesium (SAR) is the primary factor controlling the hydraulic conductivity of water in soil (Malakar et al., 2019; Bauder et al., 2007; Singh et al., 2018). The low SAR values of the water resources examined in this study will not negatively affect the soil health, infiltration and hydraulic conductivity properties. Besides, the farmers of Bursa and Kütahya can decidate agricultural planning spatially and temporally according to reults of bicarbonate, sulfate, boron, salinity and sodium.

Johnston et al. (2024) said that the Canadian Water Quality Index (CCME) and the National Sanitation Foundation (NSF) Water Quality Index are very popular in water quality studies. They said that these indexes could provide a mechanism to assess critical contaminants in water (Johnston et al., 2024). SAR, RSC, Na% index are much more reliable for agricultural water quality studies although CCME and NSF index are widely used in general drinking water quality studies. Therefore, these agricultural index results were used in this study.

Seiler et al. (2003) investigated the impact of irrigation water on soil and biota pollution in the Western United States. The result of 26 areas showed that deterioration of groundwater quality due to irrigation were a common situation (Seiler et al. 2003; Feltz et al.,1990). When SAR, RSC, Na% values were examined in this study, it was determined that the quality of the irrigation water was good and it would not cause deterioration in groundwater quality.

Yıldız and Karakuş (2020) calculated the sodium adsorption ratio (SAR) and sodium percentage (Na%) in order to assess surface water quality in Sivas Province. The obtained SAR and Na% values changed from 0.10 to 9.43 and from 3.16 to 57.82%, respectively. In this study, the obtained SAR values changed from 0.23 to 11.7 in Kütahya (Adranos Stream) and it changed from 0.051 to 4.5 in Bursa (Hasanağa Pond). The obtained Na% values changed from 21.11 to 77.3 % in Kütahya and it changed from 22.5 to 58.2 % in Bursa. These results meant that Sivas and Kütahya conditions produced similar SAR results. Besides, Bursa and Kütahya conditions produced similar Na% results.

El Bilali and Taleb (2020) used some machine learning methods for predicting of some irrigation water quality parameters. They revealed that the machine learning models were efficient tools for predicting the quality of irrigation water. If the SAR, RSC and Na% indexes are not used as in this study, it may be recommended to use machine learning models, especially in future water quality prediction.

In summer and winter periods, the EC value of Adranos Stream is approximately 2 times higher compared to Hasanağa Reservoir. When the SAR values are compared, it is understood that Adranos Stream can create problems for agricultural irrigation, especially in summer. It is understood that Hasanağa Reservoir has better quality water and is more suitable for agricultural irrigation compared to Adranos Stream. In their studies on Selevir Dam Lake, Bulut et al. (2011) found the cation order as Ca>Mg>Na>K, and the anion order as HCO_3>Cl>SO_4. In this study, in Adranos Stream in winter, cations were ranked as Mg>Ca>Na>K>B, and anions were ranked as SO_4>CO_3>HCO_3>Cl. In summer, cations were ranked as Na>K>Mg>Ca=B, and anions were ranked as SO_4>HCO_3>CO_3>Cl. In Hasanağa Reservoir in winter, cations are listed as Ca>K>Na>Mg=B, anions are listed as CO_3>Cl>HCO_3>SO_4. In summer, cations are listed as Na>K>Mg>Ca=B, anions are listed as SO_4>CO_3>HCO_3>Cl.

According to the results of the classification systems of irrigation waters, in Adranos Stream, EC is unusable and %Na is found in the excellent class according to Schofield (1933) and Schofield (1935) systems for the winter period. According to the analysis results of the summer period, EC and %Na do not pose a danger in terms of agricultural irrigation water with the result of "good" in Schofield (1933) and Schofield (1935) systems. In all the classification systems we have considered in the winter period, %Na value was in 1st class (excellent). In the analyses of the summer period, %Na has proven the suitability of %Na parameter in terms of agricultural irrigability of Adranos Stream with the result of good or medium. Cl, B, RSC, SO_4 and %Na values have proven that there is no danger in terms of irrigability of Adranos Stream in every period by giving usable results according to the water quality classification systems.

While EC gave the result of "not suitable" in all water quality classification systems we considered in the winter period, EC gave the result of "good" in the classifications belonging to the summer period. Based on this result, Adranos Stream used for irrigation in agricultural activities is not suitable in terms of salinity in the winter period but it is suitable in the summer period. Due to the salinity in Adranos Stream, salt-resistant plants should be preferred in the winter period and necessary precautions should be taken regarding salinity.

According to the water quality classification, in the 1st Term (Winter) analyses of Hasanağa Dam Reservoir, it was diagnosed as "Class 1" (Usable) in terms of %Na, Na, Cl and SO_4 in all classification systems and did not pose any problems, while the EC value was not "Usable".

Therefore, by using appropriate irrigation methods and washing with low-salt content water, soil and water salinity should be reduced to levels that will not affect plant yield. In addition, plants resistant to salinity (barley, wheat, tomato, pepper, sunflower, etc.) should be selected and cultivated. In the 2nd Term (Summer) analyses of Hasanağa Dam Reservoir, it was diagnosed as “Class 1” (Usable) in terms of Cl and SO4 in all classification systems but the %Na value was at an acceptable level, and the EC value was “Very good-good”. It is recommended that farmers in the regions make their agricultural plannig according to these results.

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