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*Research Paper*

# Evaluation of the Irrigation Waters of Çaycuma District in Terms of Certain Water Parameters

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**Abstract:** This study was conducted in the Çaycuma district of the Zonguldak Province, which is the district with the highest density of agricultural activities in the city. Water is the basic resource needed for life and is one of the most important factors that influence yield and quality in agricultural productions. In the present study, five locations were randomly selected amongst the irrigated fields of the district, and the irrigation water samples collected from these fields were analyzed to determine their pH and electrical conductivity, and their anion, cation, and boron contents. The relationships between all the measured properties were tested for statistical relevance with two-tailed Pearson correlation analysis. Boron content is an important parameter for growing the boron-susceptible plant species, and a positive relationship between boron (B) content andpH also pearson correlationcoefficient (r=0,992) was found statistically significant at the level of $p<0.01$. On the other hand, a negative relationship between the electric conductivity and boron content was also determined (r=-0.929) with the level of $p<0.05$. Evaluation of the analysis results reveals that the tested waters are appropriate even for growing the boron-susceptible plants and that it is possible to introduce a wide range of new products as an addition to the ones already grown in the region.

***Keywords:*** *Irrigation water, Çaycuma, agricultural production, water quality, pH*

## Introduction

Due to the rapid increase of the world population, it becomes ever more difficult to provide enough food and water for the humankind. For the agriculturally intense areas, low-quality waters or the lack of ample amounts of water in nature represents a particularly important problem (Gülgün et al., 2013; Yazici et al., 2013; Aşur, 2017) As the natural resources in this regard grow scarce every day and as they become more polluted, the saline content of the soil increases and the waters become unsuitable for agricultural activities, forcing the plant growers to use low-quality waters for their irrigation purposes (Yeter and Yurtseven, 2015; Kıymaz et al., 2016; Sancak et al., 2017).

Even though our country holds a strong position in terms of agriculture and agriculture-based industries, the amounts of harvested products fail to reach the desired levels due to unconscious irrigation, enriching, and pest control methods involved with the agricultural sector in the country (Arslan et al., 2007). The primary objective in agricultural activities is to obtain the highest possible yield per unit area in a sustainable manner. In that regard, water represents one of the most important limiting factors for this goal. When this problem is evaluated with the perspective of future generations, the preservation of water resources become even more important (Howell and Tolk, 2001). Effective use of water is also important for proper and high-quality plant growth (Yudelman, 1994; Şimşek et al., 2017; Gülgün et al., 2015).

The quality of the water source, and its effects on the soil and plant development may show significant variation based on the water's physical and chemical properties. Furthermore, the salinity tolerance of the plants also varies based on the climate properties of the location, the amount of water used, and irrigation period and method. In order to be able to reach the desired levels of production, it is necessary to evaluate these quality properties in the irrigated locations (Rhoades, 1972; Şimşek et al., 2017). In the near future, it is possible that the water presence will become even scarcer and that there will be problems regarding the quality of the existing water (WWAP, 2012). For this reason, it is of utmost importance to identify and monitor the quality components of the water sources used for

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irrigation purposes in order to ensure the sustainability of the water presence and of agricultural activities (Kıymaz et al., 2016).

In Pakistan, used lake for to investigate biological, chemical and physical characteristics of driking and irrigation waters. This study which in Pakistan have show a detailed review of drinking-water quality in the country and the consequent health impacts. The parameters analyzed in irrigation waters are respectively: pH, sulfates (mg/L), faecal coliform, electrical conductivity (mµmhos/ cm) total dissolved solids (mg/L), chlorides (mg/L), suspended solids (mg/L), magnesium (mg/L), dissolved oxygen (mg/L), nitrates (mg/L), biochemical oxygen demand (mg/L), calcium (mg/L), chemical oxygen demand (mg/L).This study have suggested that there is need to launch public awareness for educate people about the importance of safe irrigation water supplies (Aziz, 2005). In the studies Bafra Plain on the quality of groundwater water parameters like EC, pH, $Na^{+}$, $Ca^{+2}$, $K^{+}$, $Mg^{+2}$, $CO_3^{-2}$, $HCO_3^{-}$, Cl and $SO_4^{-2}$ was determined very significant changes and so have suggested that the irrigation should not be done (Arslan et al. 2007).In the study performed in Kırşehir province, samples were collected from 40 regions used in irrigation.n the study, it was observed that the waters had neutral or alkaline properties and was determined the sulphate concentrations varied between 1.49 and 299.7 ppm (Şimşek *et al*., 2017).

Çaycuma district is located within the Zonguldak province, which in turn is located in the Black Sea Region of Turkey. The district is positioned between the two shoulders of the Filyos Valley. Çaycuma has a wide range of agricultural products, and besides the vegetables, fruits, and feed plants produced in the city, ornamental plants are also gaining popularity in the region. The fact that numerous types of agricultural activities are conducted in the province makes the irrigation water quality even a more important property.

Analysis of irrigation water to determine the content beforehand; with this water can be prevented the increase of salinity in the land irrigated with time, with the use of fertilizers can ensure the continuity of soil fertility. The awareness of the need to analyze the irrigation water in our region will increase the efficiency of the fertilizer used, the correct use of water resources, soil fertility.

Zonguldak city is not suitable for agricultural production especially due to have thermal power plants and uneven terrain sourced from the geographical structure of the city center. For this reason, in this study it is aimed to determine chemical properties of irrigation water samples taken from 5 different locations and take required measures at Çaycuma region where agricultural production is dense.

## Materials and Methods

Çaycuma district of Zonguldak is quite prominent in terms of agricultural activities. The fertile plains along the Filyos Valley constitute the agricultural power of the district, which is also its economic cornerstone. The mild climate of the Black Sea Region is predominant in the region, and the annual average precipitation is between 1250 and 1500 kg/m$^2$, most of which occurs during the spring and the fall (Anonymous, 2019; Figure 1).

The samples for the study were collected from 5 different locations in Çaycuma. The selected regions have different environmental impacts and are also areas where agricultural activities are generally concentrated. The water samples analyzed were taken from three different locations which are rivers, taps and wells. Table 1 represents the locations from which the samples were taken, along with each location's distance to district centrum.

**Table 1.** Locations from which the water samples were collected from.

| Sample Locations | GPS coordinates | Distance to center (km) |
|---|---|---|
| Çaycuma River | 41° 25' 43.1112" Northand 32° 4' 37.9416" East gps | 0 |
| Çaycuma Drinking Water | 41° 25' 43.1112" Northand 32° 4' 37.9416" East gps | 0 |
| Perşembe Municipality | 41° 24' 50.8860" Northand 32° 9' 29.6532" East gps | 7 |
| Kayıkçılar Village | 41° 21´ 42.3072" Northand ve 32° 10´ 37.4664" East gps | 5 |
| Kayıkçılar Wells Water | 41° 21´ 42.3072" Northand ve 32° 10´ 37.4664" East gps | 5 |

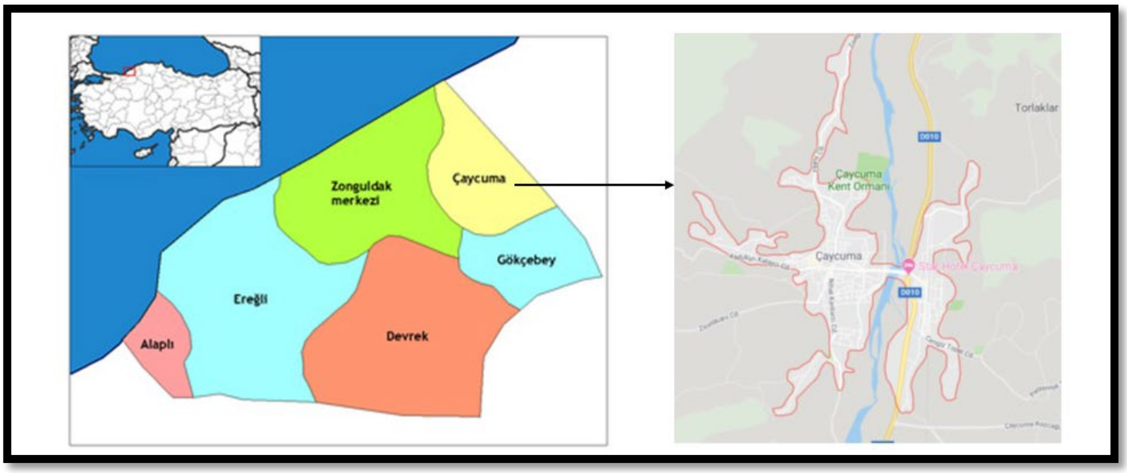


**Figure 1.** Location of the research area

During the sampling, the criterions defined by Ayyıldız (1990) were taken as a basis. When collecting the samples from rivers, the sampling was made from a depth of 30 to 40 cm. Considering the hydrodynamic properties of the water, parameters like temperature, pH, and electrical conductivity were measured in a laboratory right after the collection of the sample. High-densitypolyethene sample jars were used to store the samples. When collecting samples from taps, the water was run for a few minutes first. Furthermore, the vicinity of the tap and the tap itself was cleaned with alcohol before sample collection. When collecting samples from wells, samples were taken into the containers after a certain period of water pumping.

The collected samples were transported to Bülent Ecevit Unversity (BEU) Çaycuma Food and Agriculture Vocational High School Chemical Technologies Laboratory for analysis, except for anion and cation measurements, which were performed in BEU Central Laboratories.For anion-cation analysis was used ion chromatography. Carbonate-bicarbonate analysis was determined by titration method by using digital burette. Boron was determined by spectrophotometric method.

## Results and Discussions

### *Correlation Analysis*

The results of the analysis were evaluated in SPSS 22 software. All the relationships between the measured water properties were determined using the two-tailed Pearson correlation analysis and given Table 2. A strong and positive relationship between was determined between the boron content and pH (r= 0.992) with significance level $p<0.01$. On the other hand, a strong negative relationship between the boron content and electric conductivity was also determined (r=- 0.929) with significance level $p<0.05$. Other positive and meaningful relationships were between: Ca and Na content (r=0.925), Ca and Sulphate (r = 0.885), Ca and Mg (r = 0.945), and Na and Chloride (r = 0.912).

**Table 2.** The relationships between the measured water properties.

| | pH | EC | °C | $HCO_3$ | Bor | Klorür | Sülfat | Nitrat | Na | K | Ca | Mg | %Na |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 1 | | | | | | | | | | | | |
| EC | -.874 | 1 | | | | | | | | | | | |
| C | -.785 | .785 | 1 | | | | | | | | | | |
| $HCO_3$ | -.836 | .935* | .588 | 1 | | | | | | | | | |
| Bor | .992** | -.929* | -.805 | -.880* | 1 | | | | | | | | |
| Klorür | .021 | -.176 | -.626 | .047 | .062 | 1 | | | | | | | |
| Suphat | .138 | .171 | -.388 | .227 | .058 | .515 | 1 | | | | | | |
| Nitrat | .360 | -.580 | -.719 | -.263 | .432 | .607 | -.094 | 1 | | | | | |
| Na | .377 | -.382 | -.851 | -.152 | .388 | .912* | .662 | .635 | 1 | | | | |
| K | .706 | -.667 | -.954* | -.400 | .717 | .599 | .376 | .808 | .831 | 1 | | | |
| Ca | .321 | -.149 | -.718 | .040 | .284 | .775 | .885* | .375 | .925* | .729 | 1 | | |
| Mg | .264 | -.063 | -.656 | .193 | .220 | .690 | .797 | .475 | .852 | .765 | .945* | 1 | |
| %Na | .726 | -.960** | -.695 | -.931* | .805 | .242 | -.254 | .534 | .348 | .526 | .060 | -.081 | 1 |

*** values for $p<0.01$(double- tailed), * values for $p<0.05$ (double tailed)*

***The Regression Between the Boron Content and pH***

The boron content of the irrigation water is very influential in product growth and its quality (Brown et al., 2002; Hilal et al., 2011). This study is therefore quite relevant, as the investigation of the toxicity of the boron content is quite important for the Çaycuma district in which vegetables and fruits are the products grown the most. As the boron content of the water increases, the plants' capability of performing photosynthesis drops, slowing down the plants' growth and shortening their lives (Wei et al., 2001; Parks and Edwards, 2005). A regression analysis of boron content was performed in the present study and it shows high correlation with pH, and the regression equation and the corresponding graph is presented in Figure 2.

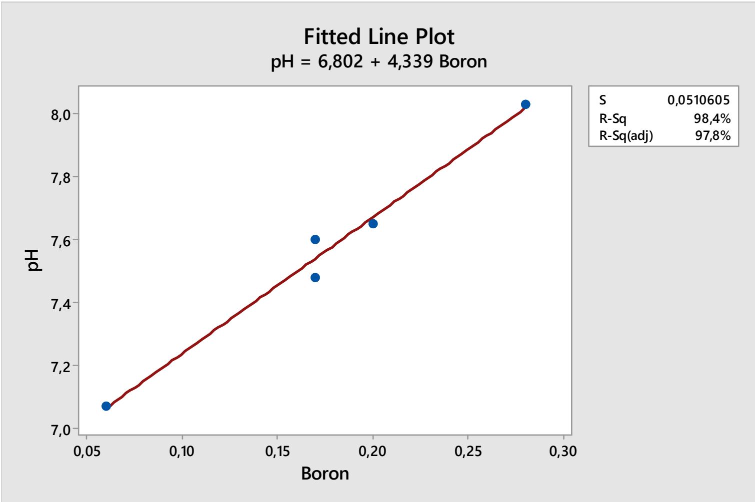


**Figure 2.** The regression graph between the boron versus pH.

Inspection of Figure 2 reveals that as the boron content increases, the pH also increases. At Table 3 given the regression analysis results parameters with F and p values. The results of $R^2$ = 98.4% and $R^2$ linear = 97.8% are clear indicators that the pH value of a given water source can be used to determine if the water can be used for irrigation, considering the boron-accumulation problems.

**Table 3.** The regression analysis results for boron and pH.

| Analysis of Variance | | | | | |
|---|---|---|---|---|---|
| Source | DF | SS | MS | F | p |
| Regression | 1 | 0.0245113 | 0.0245113 | 179.93 | 0.001 |
| Error | 3 | 0.0004087 | 0.0001362 | | |
| Total | 4 | 0.0249200 | | | |

The location-based distribution of boron content in the region is given in Figure 3. As can be seen, Çaycuma River has the most content with 0.28 ppm, while the lowest boron content is in Kayıkçılar Well waters with 0.06 ppm. The boron content is lower than 0.3 ppm in all locations. The boron content limit for the susceptible plants is between 1 and 1.25 ppm. The results clearly indicate that the waters of our district can be used for irrigation of even the boron-susceptible plants.

***Irrigation Water Analysis Results based on Location***

Minitab 15 software was used to prepare the graphical illustrations of analysis results. Figures 4 and 5 represent the anion, cation, pH, electric conductivity, and temperature parameters in matrix graphs. pH values between 6.5 and 8.4 are considered to be normal for irrigation waters, and inspection of Figure 3 reveals that the lowest pH value in our region is in the Kayıkçılar Village with pH 7.07, and highest in the Çaycuma River with pH 8.03. All locations had lower than 145 µmhos/cm electrical conductivity, which meets the "very good quality" criteria of Schofield System that is <145 µmhos/cm.

Inspection of Figure 5 the lowest nitrate, sulphate, chloride, sodium, potassium, and calcium levels were determined to be in the well waters of the Kayıkçılar Village used particularly in greenhouse and field irrigation with 0, 2.57, 0.24, 6.54, 0.13, and 12.57 ppm levels, respectively. Even though sulphate is less toxic than chloride, it is still relevant for irrigation waters as it causes the sedimentation of calcium. The highest sulphate content was observed in the Kayıkçılar village with 223.82 ppm, and the well-water sulphate content of that particular region was found to be 2.57 ppm, which is the lowest observed amongst our samples. For this reason, in order to prevent the soil from getting harmed with sulphate accumulation, the waters of that particular well should be used for the irrigation of the region. Ministry of Forestry and Water Affairs General Directorate of Water Management has determined the limit chloride level as 4 me/l, and the chloride concentration in our region varies between 0.035 - 0.618 me/l.

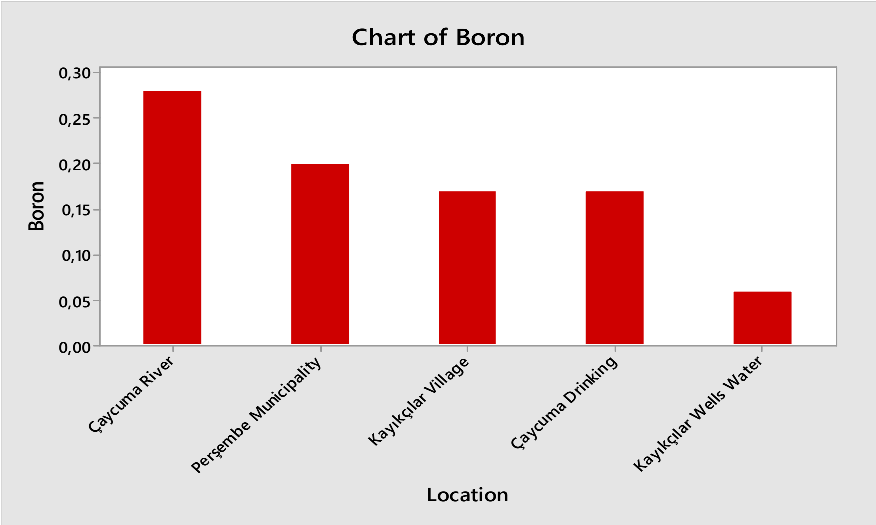


**Figure 3.** Distribution of boron content

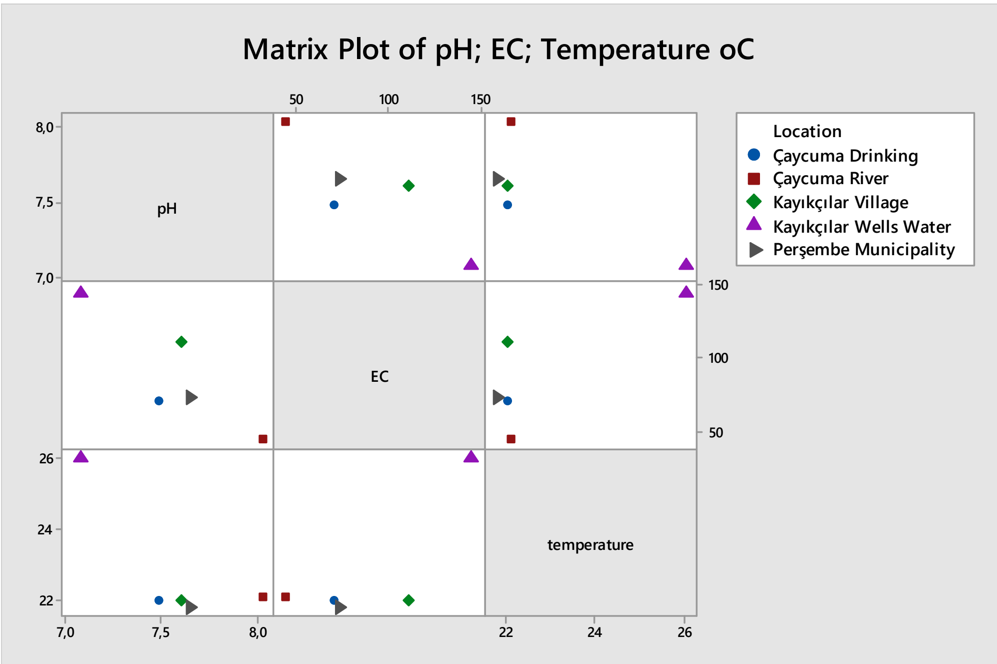


**Figure 4.** Matrix-graph of pH, electrical conductivity, and temperature parameters

Waters with bio-carbonate content can increase the sodium level variable of the agricultural soils. The carbonate concentration in all locations in our region is 0, while the lowest bio-carbonate levels were determined in the Çaycuma river with 3.72 ppm, and the highest in Kayıkçılar village well water with 9.77 ppm (Figure 6). These values are ideal for all kinds of irrigations.

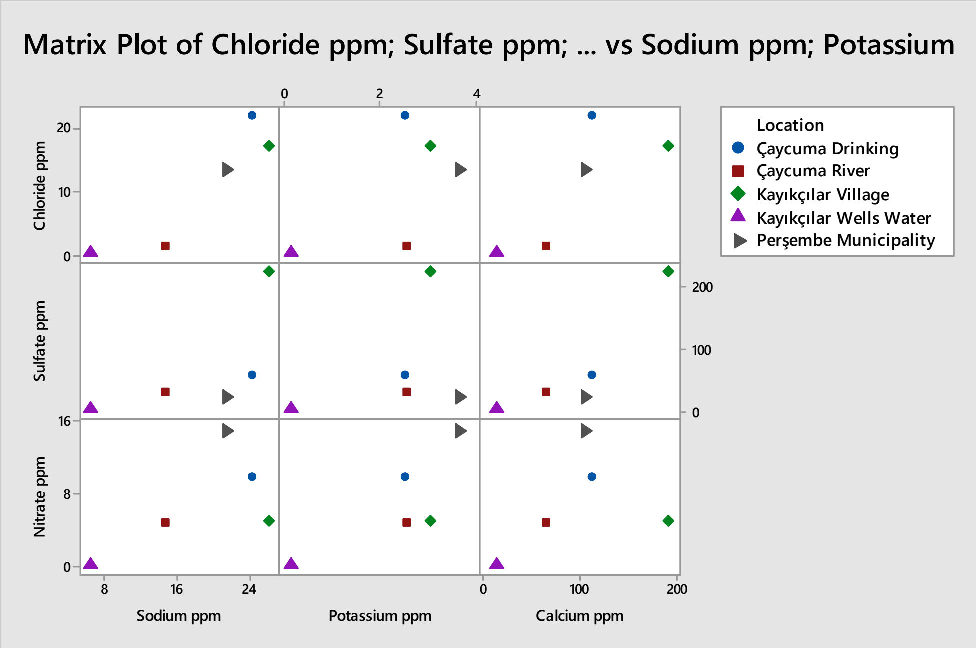


**Figure 5.** Matrix-graph of anion and cation parameters

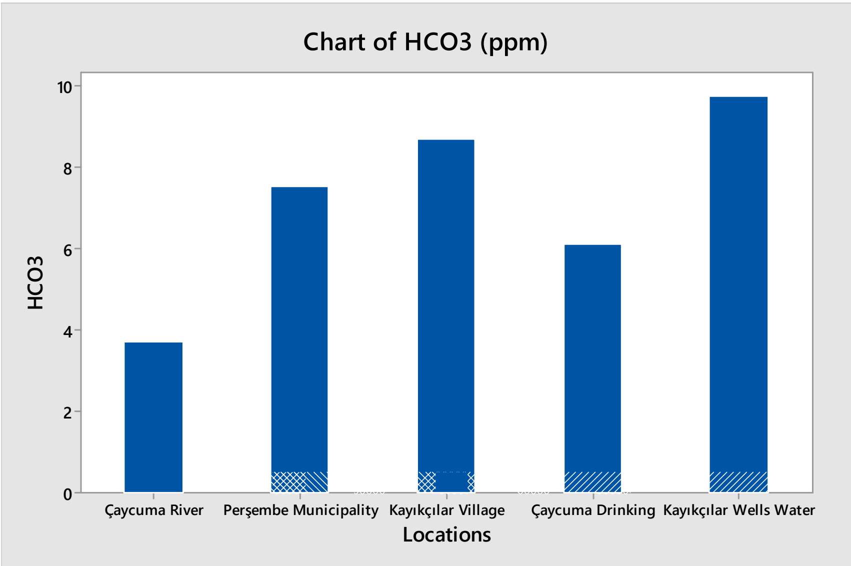


**Figure 6.** Distribution of bio-carbonate levels based on locations

As the sodium concentration increases, the Sodium Adsorption Rate (SAR) also increases. SAR is an important parameter for alkalinity, and if it's between 0 and 10 in a water source, that water can be used for all kinds of irrigation purposes. The SAR values in our region vary between 0.41 and 0.56 and its chance of creating alkalinity is quite low. According to Schofield System, Na% value considered "very good" is <20. As can be seen in Figure 7, the highest Na% level in our region was found to be in Çaycuma River with 13.20 ppm, which meets the <20 requirements. Table 4 represents the salinity and alkalinity classifications for the studied locations. T1 is the low salty and T4 is in very high salt water class. AlsoA1 is located in the class of low sodium and A4 very high sodium water. T3 is the class of high salt water and it can be used in irrigation of salt resistant plants. T2 is a medium-salt water class and can be used to irrigate all plants except saline-sensitive plants.

When Table 4 is examined, the wells water in the Perşembe municipality and Kayıkçılar village is in the high salt water class and the other locations are classified as medium salt water. The alkalinity class has been involved in all classes less sodium salt.

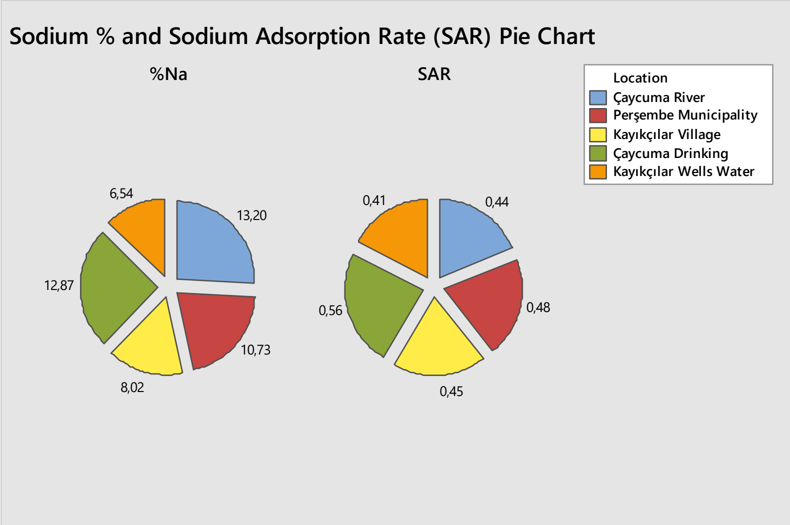


**Figure 7.** Na% and SAR distribution based on locations.

**Table 4.** Classifications of the Irrigation Waters

| Locationlar | Irrigation water class |
|---|---|
| Çaycuma River | T2A1 |
| Çaycuma Drinking Water | T2A1 |
| Perşembe Municipality | T3A1 |
| Kayıkçılar Village | T2A1 |
| Kayıkçılar Wells Water | T3A1 |

*T: Salinity A: Alkalinity*

## Results

The water sample collected from the Kayıkçılar Village Wells water and Perşembe Municipality irrigation system were found to be of high quality and salinity and to have low sodium content. Çaycuma River and tap water samples, and Kayıkçılar Village irrigation waters were found to be of medium salinity and to have low sodium content. From the boron content perspective, all of the water samples were determined to be proper to use in irrigation, even for the growing of boron-susceptible species. pH values of the water samples vary between 7.4 and 8.3, and a statistically relevant positive correlation was determined between the pH value and boron content. The fact that the minimum pH value of our waters was found as 7.4 indicates that our waters are relatively soft, as they can't meet the pH<7 requirements to dissolve minerals like calcium carbonate, magnesium and sulphate. Evaluation of the anion contents reveals that the Kayıkçılar Village is at the limit level in terms of sulphate content.

The highest pH in our region was found in Çaycuma River with 8.03. This pH value is close to the maximum portion of the pH values (6,5-8,4) for the regions where Çaycuma River is used. Since the soil has high buffering capacity, it takes a long time to be affected by irrigation water. However, if the soil is affected, different preventions should be taken instead of trying to correct the pH of the water. In routine measure of pH of irrigation waters, should be add to lime for low pH and add sulfur and other acid based formulations to correct high pH. Awareness should be made about this issue. The routine controls of the pH value in the irrigation water and taking necessary measures will contribute to the economic activities as well.

The most important parameters affecting the intake of boron by plants are irrigation water and soil pH (Bartleta ve Picarelli, 1973; Bennett ve Mathias, 1973; Demirtaş, 2005). High levels of boron in irrigation water or soil can cause product losses. Boron element is usually carried by water in plants makes the boron content of irrigation water important. The regression between boron and pH was found to be statistically significant at $F = 179{,}93$ and $p = 0{,}001$, which enabled the monitoring of the effect of boron mineral, which damages sensitive plants, for our region by pH analysis and to take measures against possible increase. The salinity results of the Perşembe municipality and Kayıkçılar well water were found T3 and the irrigation water of these regions contain a large amount of salt.

In Kayıkçılar village, where the maximum amount of sulphate is 223,82 ppm, have recommended to use well water ortouse it in times of high pH in order not to damage the soil. In general, we suggest that excellent quality parameters of irrigation Water and the availability of favorable, flat lands in Çaycuma allow this region to be used in agricultural tourism activities.

Kayıkçılar village residents generally use the well water in the garden, greenhouse and fields, so that they do not create salinity problems in case they are used continuously, it is necessary to raise awareness about the necessity of applying some washing water together with each irrigation water and the necessity of growing the plant to be salt resistant.

Literature studies have shown that high-quality water allows higher yields when used in good soil and water practices (Şimşek et al., 2017). For this reason, the irrigation water quality of the regions that depend on agriculture to sustain their economies should be determined and monitored in order to help take precautions against changes that may occur in the parameters that influence the yields.

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