# O 12. EVALUATING GROUNDWATER QUALITY FOR IRRIGATION SUITABILITY IN KONYA CITY

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**ABSTRACT:** The estimation of groundwater quality for irrigation suitability in Konya city had been investigated based on different indices such as Sodium Adsorption Ratio (SAR), Soluble Sodium Percent (SSP), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH), Kelly's Ratio (KR) and EC concentration. The Wilcox's, US salinity (USSL) and Piper diagrams had been created in order to the water classification in the study area. The US salinity diagram shows that most of the samples of Konya groundwater fall in the field of C2-S1 and C3-S1 in both seasons, signifying medium and high salinity with low sodium water. Such regions necessitate special be interested to provide sufficient drainage and introduce alternative salt tolerance cropping. Moreover, in accordance with Wilcox's Diagram, the values of the most our samples are classified as excellent to good and good to permissible classes about 94.85% in the winter and 94.35% in summer. Other best-fitted models, such as SAR, Kelly's Index (KI), MH and RSC values indicate that groundwater is between moderate to good for irrigation purposes. The dominant groundwater classified into two water types were (Mg-Ca-$HCO_3$) and (Ca-Mg-$SO_4$-$HCO_3$-Cl) types based on Piper diagram. Generally, estimation of water samples indicated that the most of the water samples are suitable for irrigation purpose, except some samples.

*Keywords: Irrigation Water Quality, Water Classification, Groundwater pollution*

## 1. INTRODUCTION

Agriculture is the most user of water, covers functions related to the production of cultivated plants. In Turkey, the social and economic aspects, plays an important role in the lives of the people. Agriculture accounts for 19% of total national income and 9% of exports. About 51% of the society provides employment opportunities through agricultural functions (Kartal, Değirmenci, & Arslan, 2019; Kılınçer et al., 2002). However, the increase in water use causes very important problems. For example, underground water resources are depleted, other water ecosystems are polluted and degraded; there are also many environmental problems in irrigated agriculture. In fact, water, which is considered as a renewable natural resource, gains a very dangerous feature such as losing this feature in limited areas. As a result of the described situation, the provision and development of new water resources becomes very expensive and even impossible. Worse, the majority of the society is not interested in the fact that water will become a hindrance factor in adequate food production in the future (Pulido, Barrena-González, Alfonso-Torreño, Robina-Ramírez, & Keesstra, 2019; Rosegrant, Cai, & Cline, 2002; Singh, 2019; Wyman & Yao, 2019). One of the most important environmental problems in in-field irrigation is the accumulation of salt in the soil in case of excessive irrigation under inappropriate irrigation management and poor drainage (Ghassemi, Jakeman, & Nix, 1995; Haroon, Ping, Pervez, & Irshad, 2019; Masoumi, Gharaie, & Ahmadzadeh, 2019; Singh, 2019). The different structure of Turkey's agriculture, other physical, economic and socio-cultural characteristics, as well as the agriculture-environment interaction and especially the environmental negative effects of agricultural production are different from many EU countries. These effects, which have not been felt to date, have started to manifest themselves in recent years, especially due to the scarcity of water and pollution in water resources. Intensive agricultural activities in recent years both carry the risk of environmental pollution and increase the pressures on the environment and social life through the use of inappropriate natural resources. For many years, the EU is Turkey's full membership to EU harmonization is particularly vital for the agricultural sector. In this process, where alignment with the acquits has yet to be achieved, agricultural-environmental practices in the EU have not been adopted, but some steps have been taken in this context (Dişbudak & Saklıdır, 2008).

The objective of this study is determining the groundwater quality of Konya city using Inverse Distance Weighting (IDW) method within ArcGIS environment for Irrigation purposes based on different indices such as Sodium Adsorption Ratio, Soluble Sodium Percent (SSP), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH), Kelly's Ratio (KR), piper, Wilcox and US salinity diagrams.

## 2. METHODOLOGY

The major source for drinking water, industrial and agriculture purposes is groundwater in Konya city that covers about 1050 $km^2$. The sufficient amount of water is necessary for the suitable growth of crops, in addition, the water quality used for irrigation purpose must be well into the allowable limit otherwise it could negatively impact the growth of the plants. This study includes the investigation of chemical properties and some pollution parameters of groundwater wells data had been obtained from Konya city municipality around 123 well in summer 2012 and 96 well in winter 2012 that including electrical conductivity (EC), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), sodium ($Na^+$), chloride ($Cl^-$), potassium (K), bicarbonate ($HCO_3^-$), and carbonate ($CO_3^-$). Groundwater quality in Konya city for irrigation suitability estimation was investigated based on different indicators such as Sodium Adsorption Ratio (SAR), Soluble Sodium Percent (SSP), Residual Sodium Carbonate (RSC), Magnesium Hazard (MH), and Kelly's Ratio (KR). The spatial distribution of the groundwater quality indicators had been produced applying ArcGIS 10.5 software, depending on the IDW interpolation technique. Then the water Classification have been evaluated by drawing Piper, Wilcox and US Salinity Laboratory diagrams. The irrigation indicators were calculated from the equations given in Table 1.

**Table 1**: The summarize of the irrigation indicators and their equations

| The irrigation indicators | equations |
|---|---|
| Sodium Adsorption Ratio (SAR) | $SAR=\frac{Na^+}{\sqrt{\frac{Ca^{++}+Mg^{++}}{2}}}$ |
| Soluble Sodium Percentage (SSP) | $SSP=\frac{(Na+K)\times 100}{Ca+Mg+Na+K}$ |
| Residual Sodium Carbonate (RSC) | RSC= $[HCO_3^- + CO_3^-] - [Ca^{2+} + Mg^{2+}]$ |
| Magnesium Hazard (MH) | $MAR=\frac{Mg^{2+}}{Ca^{2+}+Mg^{2+}}$ |
| Kelly's Ratio (KR) | $KR=\frac{Na^{2+}}{Ca^{2+}+Mg^{2+}}$ |

## 3. RESULTS AND DISCUSSION

The SAR values in the samples of groundwater for the study area in summer 2012 range from 0.0176 to 9.649 and in winter 2012 range from 0.079 to 4.88 as shown in the figure 1, that mean all values were lower than 10, It can be categorized as excellent water for irrigation indicating that all the samples of groundwater based on SAR values are suitable for irrigation purposes. The SSP of the groundwater samples changed from 2.042% to 57.83% with a mean 16.53% in the summer season, while 3.47% to 63.91% with an average of 16.63% in the winter season as shown in the figure 2. The high soluble sodium percentage (SSP or Na%) relating to total cations in irrigation water reasons desolation of soils and weaken permeability of the soil, sodium relates with carbonate can lead to the formation of alkaline soils, whereas saline soils formation when sodium associated with chloride (Nagarajan, Rajmohan, Mahendran, & Senthamilkumar, 2010; Richards, 1954)

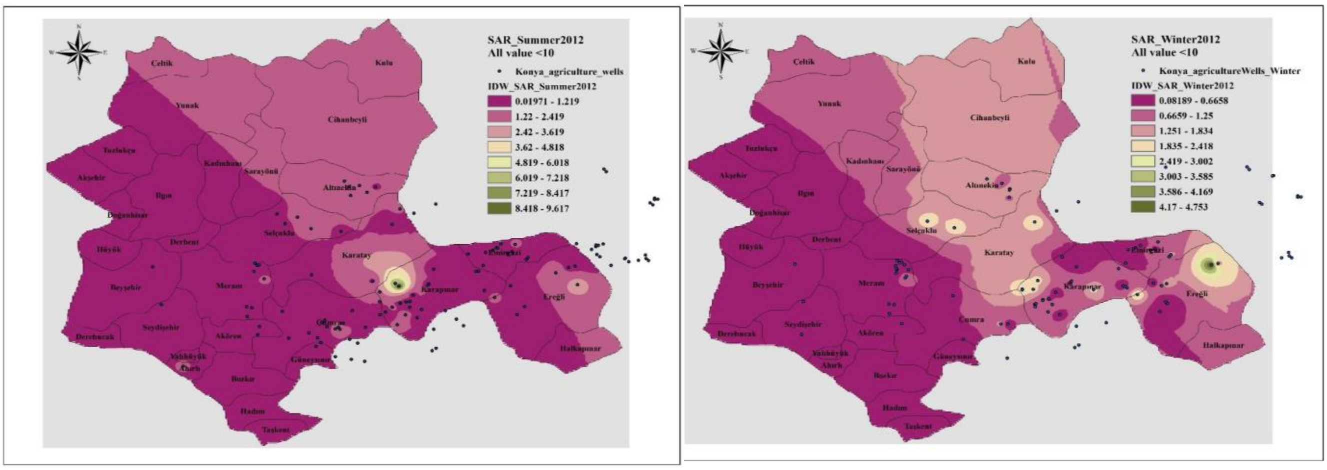


**Figure 1.** The spatial distribution of SAR values for Konya city in summer and winter 2012

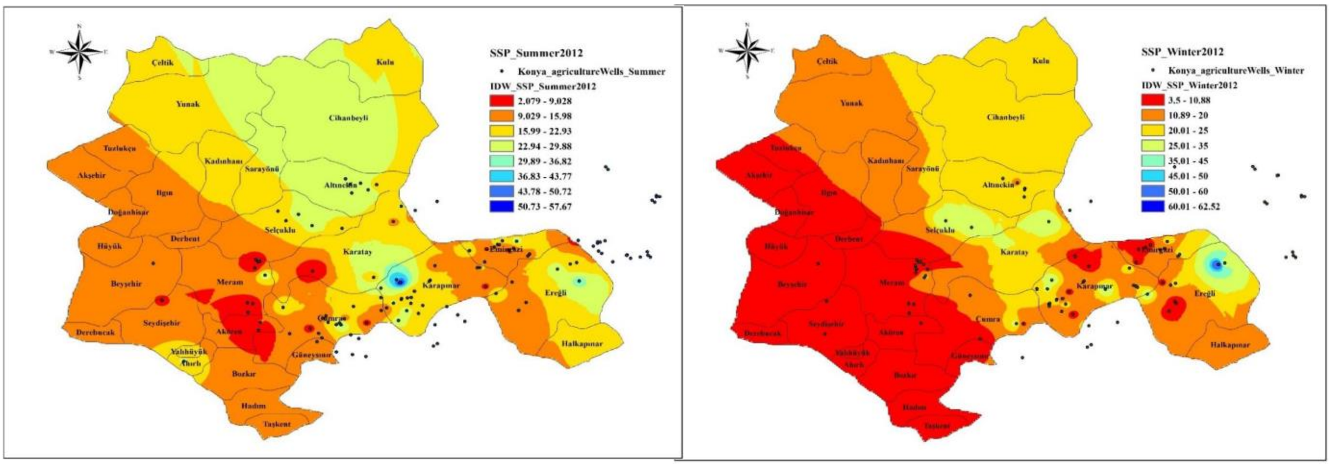


**Figure 2.** The spatial distribution of SSP values for Konya city in summer and winter 2012

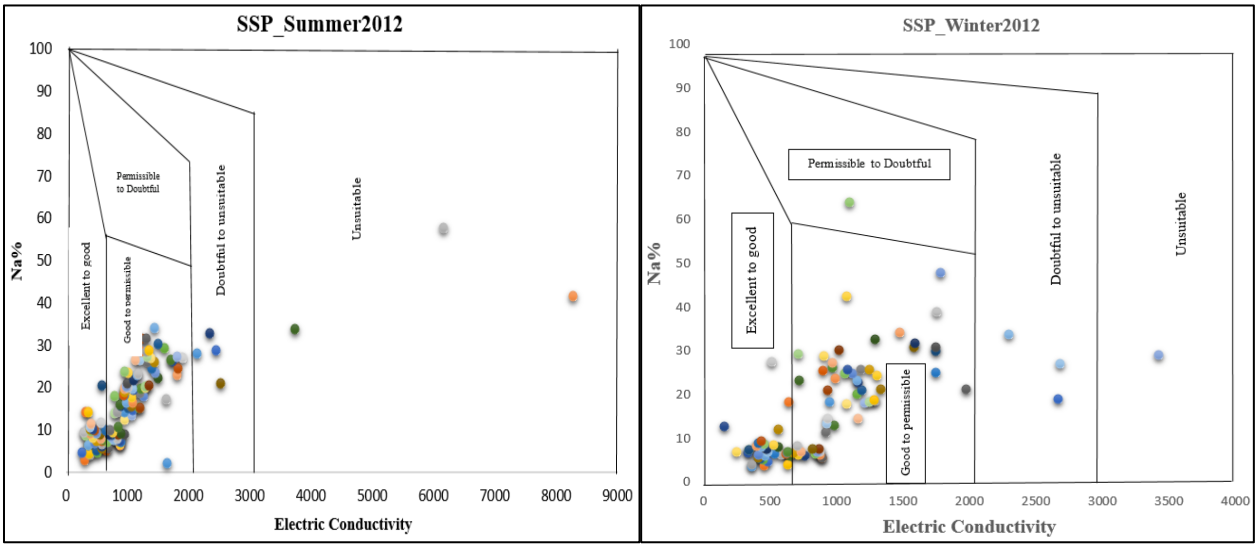


**Figure 3.** Sodium percent against electrical conductivity (Wilcox diagram) in summer and winter 2012

Wilcox (1995) has classified the water in accordance with some parameters (e.g., Na% and EC), and in accordance with his classification diagrams (Wilcox's Diagram). According to Wilcox's diagram about 94.35% and 94.85% of groundwater samples in summer and winter 2012, respectively, can be securely used for purposes of irrigation and some samples are unsuitable for purposes of irrigation within the doubtful to unsuitable classes as shown in figure 3. About 96.75% and 96.88% of the groundwater samples in summer and winter 2012 appeared a magnesium ratio below 50%, signifying their suitability, whereas only 3.25% and 3.12 % in summer and winter, respectively, fall in the unsuitable class with an MH of more than 50%, indicating their possible adverse influence on the crop yield that shown in figure 4.

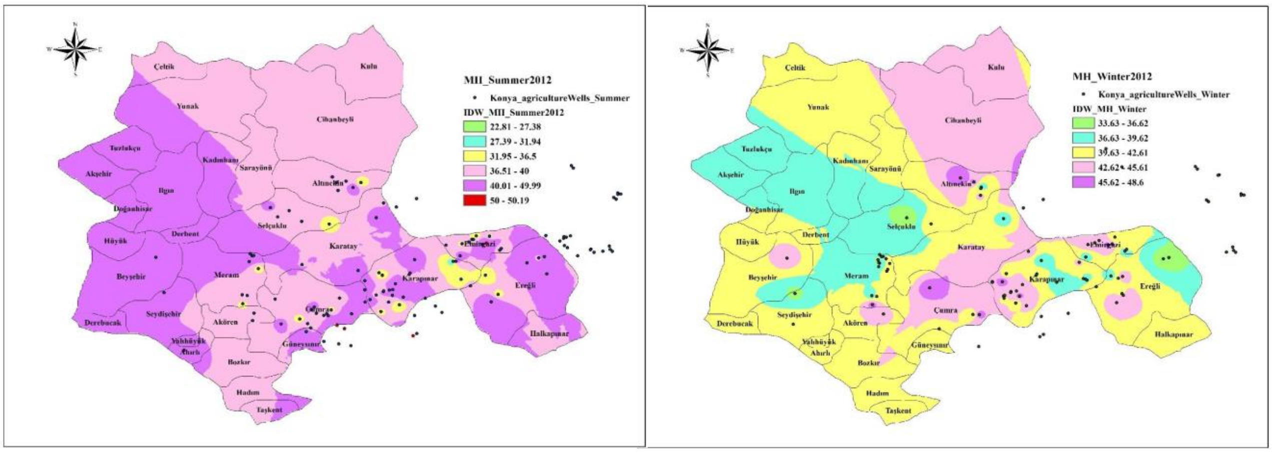


**Figure 4.** The Spatial distribution of MH for Konya city in summer and winter 2012

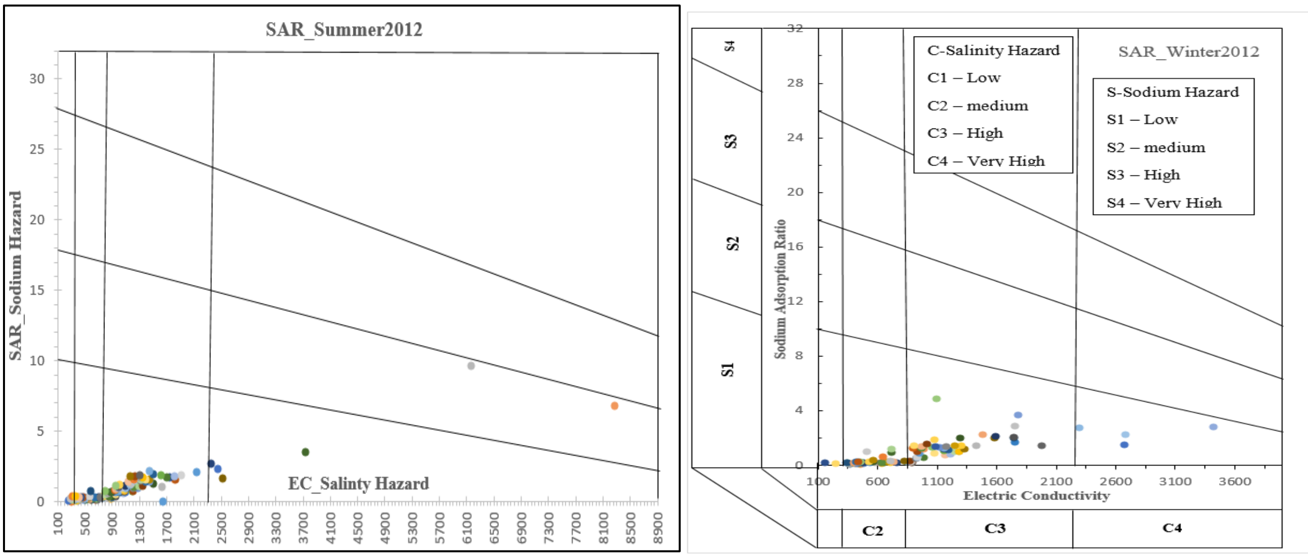


**Figure 5.** USSL diagram of Konya groundwater samples in summer and winter 2012

Based on classification of salinity and alkalinity hazard in summer and winter 2012 that shown in figure 5, most Konya groundwater samples occur with high salinity and low sodium hazard (C3-S1) that cannot be consumed on soils with limited drainage though they have little hazard for the development of harmful levels of exchangeable sodium, even with sufficient drainage, special management for control of salinity may be utilized although plants with good salt tolerance must be chosen for C3-S1, This shows that no alkali hazard is predicted to the yields, while Extra salinity decreases the osmotic activity of crops and consequently overlap with the water absorption and the soil nutrients. Figure 6 shows the spatial distribution of EC values where the highest values of EC found in the Karatay and Karapinar regions. The high amount of residual sodium carbonate (RSC) in water indicates to an excess in sodium absorption on the soil, RSC values of groundwater varied from -18.435 to 2.25 in the winter and from -42.63 to 44.85 in the summer. All the groundwater samples were less than 1.25 (good class) and acceptable for agriculture except one in the winter and another in the summer were greater than 1.25.

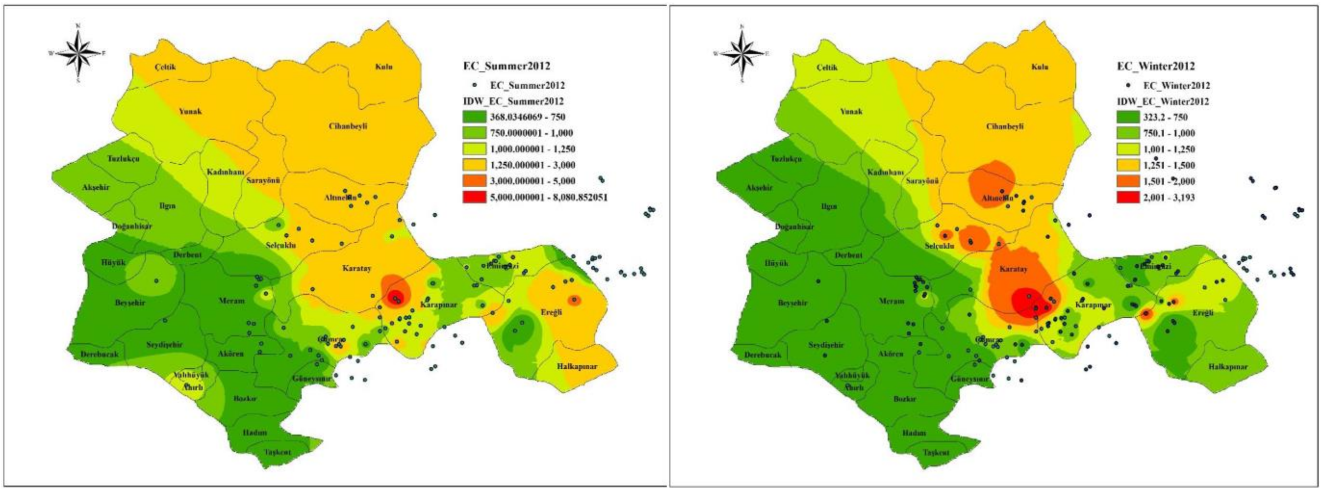


**Figure 6**. Spatial distribution of Electric Conductivity for Konya city in summer and winter 2012

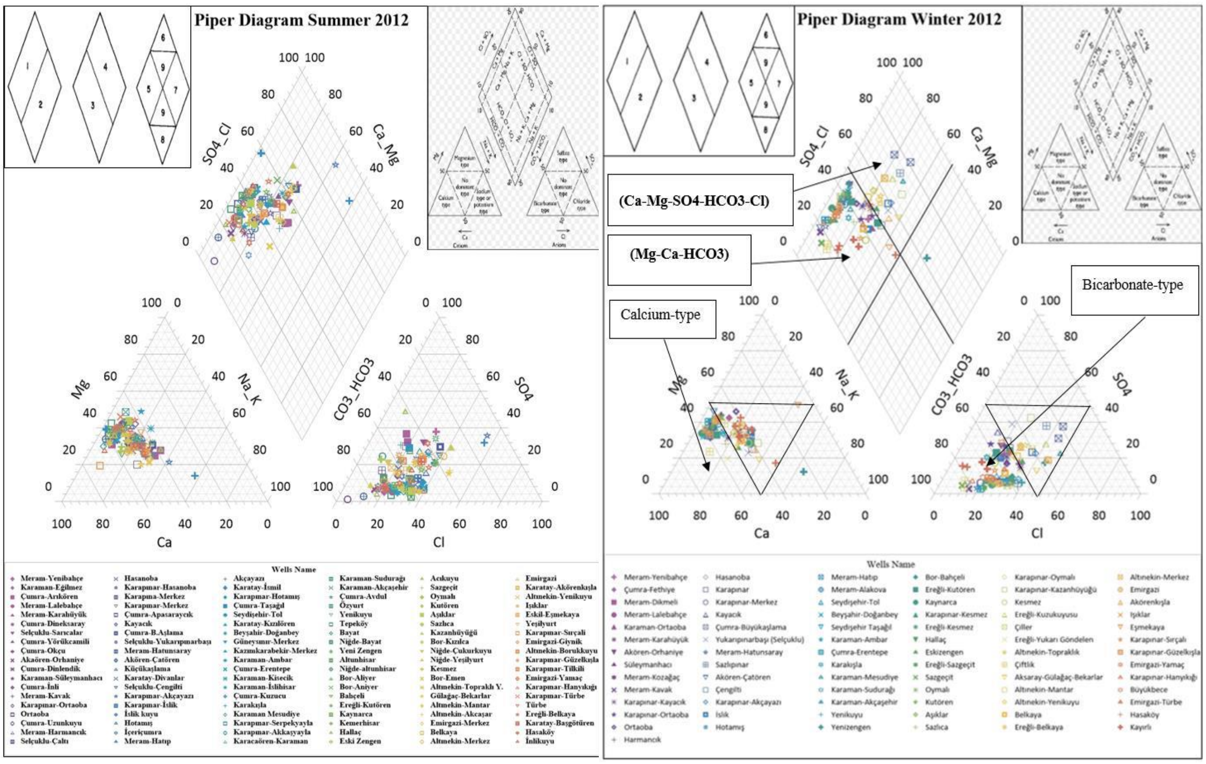


**Figure7.** Piper diagram of the Konya groundwater samples in summer and winter 2012

The groundwater in the Konya city is mainly $CaCO_3$ to $MgCO_3$, and the carbonate hardness is more than 50%. The waters according to the degree of hardness, classified as hard water class. Thus, groundwater in the study area classified as ($Mg$-$Ca$-$HCO_3$) and ($Ca$-$Mg$-$SO_4$-$HCO_3$-$Cl$) types. The analysis in Piper diagram (Piper, 1944) indicates the dominance of alkaline earth ($Ca^{2+}$+$Mg^{2+}$) over alkalis ($Na^+$+ $K^+$) and overwhelming dominance of $HCO_3^-$+ $SO_4^{2-}$ over $Cl^-$ as shown in figure 7.

## 4. CONCLUSION

The using of water for agriculture purposes has become one of the most essential environmental events that are depleting very quickly. Therefore, irrigation with mostly groundwater is the only alternative for the continuation of agricultural activities in arid and semi-arid areas. In this study, the estimation of water samples indicated that the most of the groundwater samples are suitable for irrigation purpose, except some samples, especially in Karatay and Karapinar regions.

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