World Journal of Agricultural Sciences 3 (1): 105-110, 2007
ISSN 1817-3047

An Investigation into the Quality of Irrigation Water from Underground Water Sources in the Vicinity of the Coast of Yalova, Turkey

[1]Funda Dökmen and [2]Ahmet Nedim Yüksel

[1]İhsaniye Vocational School, University of Kocaeli, İhsaniye-Gölcük/Kocaeli, Turkey
[2]Department of Agricultural Construction and Irrigation, Faculty of Agriculture,
University of Trakya, Tekirdağ, Turkey

Abstract: The objective of this study was to evaluate the quality of irrigation water of some underground water resources in the towns of Altınova, Çiftlikköy and Taşköprü, which depend on Yalova. Analysis of the anions and cations in five water samples taken during June 1999-August 2000 was performed. Water samples were obtained from Altınova, Çiftlikköy and Taşköprü. The Electrical Conductivity (EC) and sodium absorption (SAR) were analysed. The Boron (B) content and pH of each sample were also investigated. The results indicate that the quantity of soluble solid matter decreases or increases in water because of continual loss or feeding in underground water resources. Electrical conductivity increases due to a reduction in water level, on the contrary, it decreases. The salinity of water rises due to excess withdrawal from underground water resources in the summer season. The samples of the study were evaluated according to the classification of irrigation water of the USA Salinity Laboratory. Following this classification, water from two sources was classified as C_3S_1 (high salinity-less sodium) and water from the other three sources was classified as C_2S_1 (moderate salinity-less sodium).

Key words: Boron · classification of irrigation water · electrical conductivity · salinity · SAR

INTRODUCTION

Irrigation is very important for meeting the food and clothing needs of the world's population. The extent of available water resources and the availability of ground water for irrigation are critical for irrigation projects. The life of an irrigation project depends on the quality of the irrigation water.

All water used on agriculture contains salt to a variable extent. Large quantities of salt are brought into agricultural areas by water of good quality. This salt affects the properties of the soil and the growth of plants. Detailed knowledge of the water provided by irrigation and effects upon the soil and plants can help in solving problems associated with the salt content. Therefore, this study examined the quality of irrigation water from underground sources in the Yalova coast.

This paper reports on research into determination of the quality of irrigation water from under ground water resources in Yalova and the vicinity of its coast to identify whether current levels are a matter of concern.

MATERIALS AND METHODS

The study area included agricultural areas around the towns of Altınova, Çiftlikköy and Taşköprü, depending on Yalova. These towns have Kocaeli in the east and the towns of Orhangazi and Gemlik of Bursa in the south. The Marmara Sea lies to the west and north (Fig. 1). The areas selected were areas of intensive agricultural usage that were being subjected to rapid urbanization. Underground water was commonly used for irrigation and drinking. Deep wells were generally dug for drinking and industrial use. Shallow wells were dug much more for irrigation.

Five water sources near the coastal towns of Altınova, Taşköprü and Çiftlikköy were selected. These towns are located close to each other. All underground water resources were selected as coincidentally on the map of research area. All data relating to underground water resources were obtained from the DSİ (goverment water works office) in Yalova. One sample was taken from each of the sources every month. The samples, 2 litres each, were collected in glass bottles according to the method of the USA Salinity Laboratory[1] and APHA [2].

Corresponding Author: Dr. Funda Dökmen, İhsaniye Vocational School, University of Kocaeli, İhsaniye-Gölcük/Kocaeli, Turkey

Fig. 1: Map of research area in Yalova and its vicinity

Water was pumped for 15 minutes before collection of a sample. Experience has shown that a well must be pumped before a water sample that reflects the ground water quality can be obtained. The sampling was repeated twice in the summer months. Samples were collected during June 1999-August 2000. Analysis of water samples was done according to the methods of Ayyıldız [2-4].

The salt content was classified according to Electrical Conductivity (EC), following the procedure described by the USA Salinity Laboratory [1] and sodium absorption (SAR) classification scheme. The classification of Wilcox and Magistad was used to classify the boron content [5].

RESULTS AND DISCUSSION

The underground water sources that were examined were wells in the towns of Altınova, Çiftlikköy and Taşköprü. Agricultural activity was intensive at these places. The water samples were analysed for anions and cations. The results were used to determine the EC and SAR. Graphs were drawn of the variation of these parameters over the 15-month period. The boron content and pH value were also taken into consideration.

Variation of EC: The EC value was maximum, 1.0-1.1 dS m^{-1}, in the autumn and spring months in the first well. It became 0.3 dS m^{-1} in December 1999 and 0.6 dS m^{-1} in March 2000 in the same well. In the second source, a value of 1.3 dS m^{-1} was noted from October 1999 to June 2000. It reached a maximum level of 1.4 dS m^{-1} in June 2000. The EC was constant at 0.7-1.0 dS m^{-1} between June 1999 and October 1999 in the third source. After March 2000, it had a constant value of 1.0 dS m^{-1}. It reached a minimum value of 0.3 dS m^{-1} in November 1999. In the fourth source, the value varied between 0.6 and 1.0 dS m^{-1} in the summer and spring months. It was between 0.8 and 1.0 dS m^{-1} in November 1999-January 2000 and it became 0.2 dS m^{-1} in January. In the fifth source, the EC varied between 0.7 and 0.9 dS m^{-1} in June 1999-December 1999. After March 2000, it became 1.0-1.2 dS m^{-1}. These are data showing that EC values are low in winter. This could reflect rain water percolating down to shallow ground water and it could also reflect surface runoff from rainfall collecting around a well and flowing down outside the well casing (Fig. 2).

Variation of SAR: When we examined the changes in SAR value over the 15-month period, we saw that the SAR value is minimum in March and maximum in April in the first well. In the second well, the SAR reached values of 0.8 and 1.4 in summer and autumn, 0.6 in March 2000 and 1.9, the maximum in April 2000. In the third source, the SAR reached a maximum value of 1.2 in April 2000 and in the other months it varied in the range 0.6-1.0. In the fourth well, the SAR value ranged between 0.4 and 0.8 in June 1999-January 2000; it lay in the range of 0.4-0.6 in January-March 2000. It reached the maximum value of 1.4 in April 2000; after this, it took values in the range 0.6-0.8.

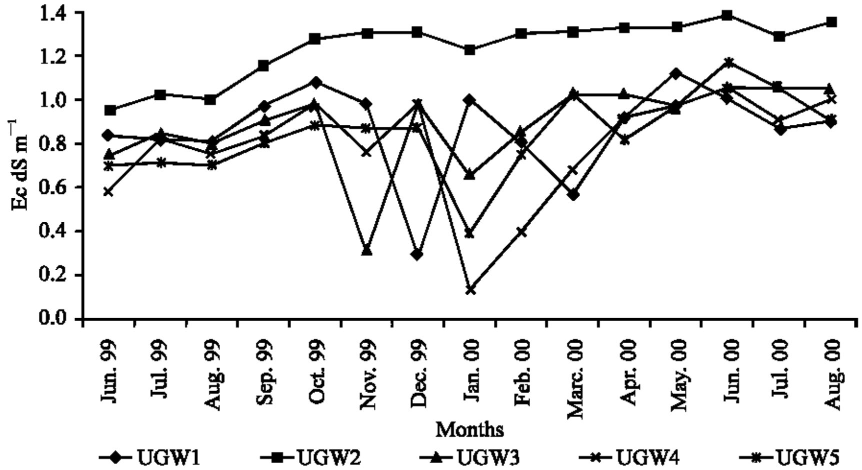

Fig. 2: Amounts of EC in the underground water resources in Yalova and surrounding towns a 15 month period in June 1999-August 2000

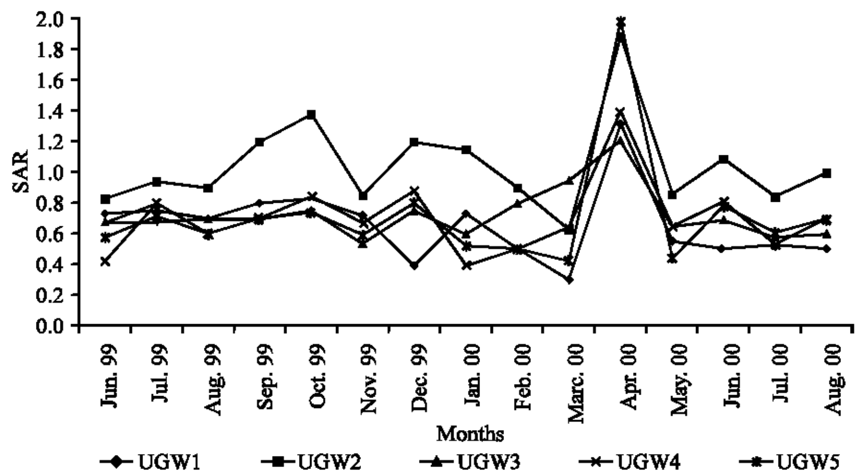

Fig. 3: SAR values from the underground water resources in Yalova and surrounding towns during a 15 month period June 1999-August 2000

In the fifth source, the SAR value ranged between 0.5 and 0.8 overall months, reaching a maximum value of 1.2 in April 2000 (Fig. 3).

Variation of boron: The boron content was 0.0 mg L^{-1} in all sources except wells 2 and 4 over the 15-month period. It had a value of 0.5 mg L^{-1} in June 1999-July 1999 in well number 2. It was 5 mg L^{-1} in June 1999 and 4.9 mg L^{-1} in July 1999 in well number 4 (Fig. 4).

All plants need a small amount of boron for their growth. The difference between the amount of boron needed for growth and that which is toxic is small. According to Ayyıldız [3] irrigation water containing more than 4.0 mg L^{-1} of boron is harmful for all plants. The boron concentration is considered to be first class (very good or good) if it is less than 0.5 mg L^{-1} according to the classification of Wilcox and Magistad [5]. Figure 4 shows that all the underground water sources had water of first class quality in terms of boron content except wells 2 and 4. A boron concentration of 0.5 mg L^{-1} was found in summer 1999 in well 2 and in well 4 in June 1999-July 1999. It is believed that all the sources were affected by natural movement of water. The water level in all the vicinity of all the wells dropped because of an earthquake on August 19, 1999. For this reason, the quality of the samples exhibited variation in terms of some chemical

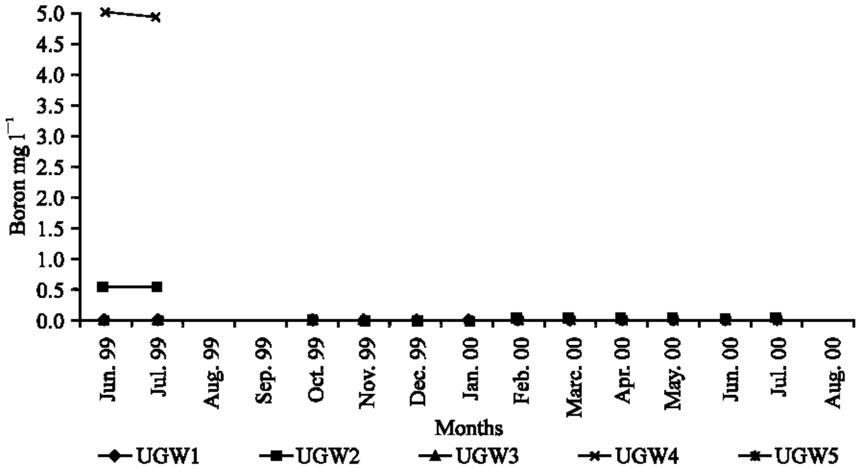

Fig. 4: Amounts of B in the underground water resources in Yalova and surrounding towns a 15 month period in June 1999-August 2000

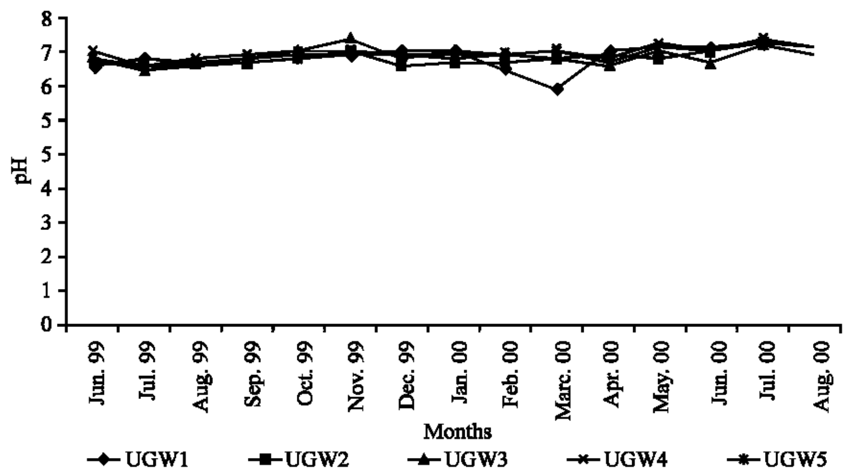

Fig. 5: pH values from the underground water resources in Yalova and surrounding towns during a 15 month period June 1999-August 2000

parameters. All the underground water sources had a boron level of 0.0 mg L^{-1} after August 1999 as a result of the foregoing.

Variation of pH: The pH value was 7.0 in well 1 in all months. It reached a maximum value of 7.4 in July 2000 and in the other months it ranged between 6.8 and 7.0 in the second source. In the third source, the pH reached a minimum value of 6.6 in July 1999 and a maximum of 7.4 in November 1999. It ranged from 6.8 to 7.2 in the other months. In the fourth source, the pH value was 6.7-7.1 between July 1999 and December 1999 and it had a value of 7.0 between December 1999 and January 2000. After May 2000, in summer, it became 7.4. The pH value ranged between 6.7 and 7.1 in July 1999-March 2000. After April, the values were 7.2-7.3 in the fifth source (Fig. 5).

Table 1: Classification according to spinner of irrigation water of USA. Salinity Laboratory of underground water resources

Underground water No.	Situation	Type of underground water	Classification of irrigation water
1	Çiftlikköy	Artesian well	C_3S_1*
2	Ta°köprü	Artesian well	C_3S_1
3	Çiftlikköy	Well	C_2S_1**
4	Altýnova	Well	C_2S_1
5	Çiftlikköy	Artesian well	C_2S_1

*C_3S_1 : High salinity-Less sodium, **C_2S_1 : Moderate salinity-Less sodium

The variation of pH, boron level, EC and SAR over the 15 months in the underground water sources was studied and the sources classified according to scheme of irrigation water of USA Salinity Laboratory (Table 1).

Sources 1 and 2 are classified as C_3S_1 and sources 3, 4 and 5 are classified as C_2S_1.

In underground water resources which examined in the research area comprise food and losses as continue and they caused low or increase quantity of solid matter in the resources. The electrical conductivity increases because of low water levels and decreases when the water level increases. Generally, the underground water level is much higher in April and May. After these months, the water level falls because of intensive pumping. The period of even lower water levels is autumn. The water level rises in the rainy period of winter and spring.

The difference between the periods of low and high water levels in the vicinity of Taşköprü, Çiftlikköy and Altınova [6] is generally between 1 and 2 m. Inflow to underground water resources is mainly from rain and infiltration of subsurface water. Discharge of water from underground resources is through flows into the sea and exploitation for drinking, irrigation and industrial use. Occasionally, the water table drops to more than 2 m because of excessive tapping.

Underground water resources close to the sea in the northern part of the plains of Taşköprü and Çiftlikköy have been affected by intrusion of sea water. As seen above, sources 1 and 2 are classified as C_3S_1 and their dominant ions are sodium and chlorine. Those sources that have water of high salinity will undergo a great increase in salinity due to excessive pumping during the summer months. The EC value of samples taken from these wells was determined to be 1.4 dS m^{-1}.

High salinity water, such as C_3, can be used for salt resistant plants, but adequate permeability and drainage are necessary to control the salinity. Such water must not be used particularly on soils which do not have a drainage system. The quality of irrigation water, the irrigation system and the adequacy of the drainage system all directly affect the salinity, alkalinity and accumulation of soluble salts in the soil. Soils which do not have salinity problems can be rendered unproductive over time. The salinity and alkalinity of the soils can increase in a short time because of the use of unsuitable irrigation water, inappropriate treatment of the soil and insufficient drainage.

Water from all natural sources contains some salt and so adds salt to irrigated lands. Soluble salts are brought into soils through water movement and are leached from soil by water. Therefore, if the quality of the irrigation water can be varied and the movement of water in soil can be controlled, the salinity of the soil can be controlled as well.

In general, the accumulated salt in the soil is determined by the geological formations and the material of the soil through which subsurface and drainage water move. The main reason for salinity is seawater intrusion near the coast and in low-lying areas as in the study area. The sea water intrusion resulted mainly from excessive withdrawal of water by pumping during the summer months.

The effects of irrigation water on plants are through phytotoxic compounds and the osmotic conditions. Plants are generally much more vulnerable to the effects of soluble compound or salts during germination and seedling stage than during maturity stage.

Well water which take part of inside of sea have got good quality. Water sources 3, 4 and 5, to the south of Çiftlikköy and Altınova, are classified as C_2S_1 and their dominant ions are calcium, magnesium and bicarbonate and the EC value is 1.2 dS m^{-1} (Table 1).

C_2, which is medium salty, can be used for irrigation of all plants except sensitive plants. Special measures for salinity control are not needed when the soil permeability is good or medium.

All the sources, numbers 1 to 5, are classified as S_1, which is 'less sodium' (Table 1). Such water can be used for irrigation for all soil types. Their alkalinity and harmful effects are minimal on the soils. Probably, for sensitive plants alone the alkalinity may result in stone nucleate fruits.

As a result of natural movement, the pH values were 6.8-6.9 and 7-7.3, close to neutral. It has been shown that when the pH is not very high, the sodium content is very high.

CONCLUSIONS

The objective of this study was to determine the water quality of some sources in the study area so as to assess the suitability of the water for irrigation. A variety of factors was considered besides chemical analysis.

Most of the sources are classified as C_2S_1. This water is second class in terms of salinity and can be used for irrigation with appropriate measures to avoid accumulation of salt in the soil. Sufficient washing must be done together with irrigation.

In third class waters (C_3S_1), in terms of salinity, the concentration of carbonate and bicarbonate is higher than the concentration of magnesium and calcium. When such water is used, material must be provided to improve the soil.

When second and third class waters are used for irrigation, suitable drainage, regular washing, supplement of organic matter and special methods of soil cultivation must be used. If necessary, chemicals must be added to the soil.

All the sources investigated in the study area are classified as S_1 or 'less sodium'. Thus, the water from these sources can be used for irrigation and the danger of alkalinity is low. However, alkalinity must be considered when growing sensitive plants.

The alluvial areas near the sea are suitable areas for use of underground water. Due to excessive withdrawal, water in the Taşköprü plains and along the coast has become saline. Wells must not be dug in an uncontrolled fashion and without permission from the DSİ in this plain. Wells must not be dug within 1 km of the coast for the same reasons in Altınova. The danger of increased salinity due to excessive withdrawal in the summer months exists. Using these water sources for irrigation must be limited because of these reasons.

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