Journal of Tekirdag Agricultural Faculty
Tekirdağ Ziraat Fakültesi Dergisi

Eylül/September 2024, 21(4)
**Başvuru/Received:** 05/03/24
**Kabul/Accepted:** 27/06/24
**DOI:** 10.33462/jotaf.1446757

http://dergipark.gov.tr/jotaf
http://jotaf.nku.edu.tr/

**ARAŞTIRMA MAKALESİ** **RESEARCH ARTICLE**

# Environmental Valuation of Wastewater Used in Agricultural Production*

Tarımsal Üretimde Kullanılan Atık Suyun Çevresel Değerlemesi

**Zuhal KARAKAYACI[1*], Ebru AYDIN[2]**

## Abstract

In recent years, problems related to the adequacy of existing water resources have arisen due to issues such as population growth, rapid urbanization, industrialization, and climate change. Especially in agricultural production where water is used the most, the use of wastewater has become widespread as a solution to this problem. Considering that wastewater may harm the environment due to the substances it contains, it is aimed to make an environmental valuation in this study. In this context, by using the travel cost method used in the valuation of goods without a market, a different approach was brought to this method, as agricultural production is concerned, and an evaluation was made based on producer surplus. In the study, by comparing the agricultural productions with wastewater and well water, 2 hypotheses have been developed about the environmental valuation of wastewater; First, if the producer surplus of agricultural production with wastewater is lower than that of production with well water, there is environmental pollution, and its value is the difference between the two rents. The second hypothesis is that if the producer's surplus with wastewater is high, positive externality will occur as a hypothesis against the negative effects of environmental pollution. By conducting a survey with 125 producers in the research area, the data of 314 parcels in total were included in the analysis, and the producer surplus was calculated by creating the supply function with the regression analysis. As a result of the research, the producer surplus (584.40$) obtained from the agricultural production made by irrigating with wastewater was found to be higher than the producer surplus (553.44$) of the production made by irrigating with well water. In this case, it was concluded that the wastewater irrigated did not affect the environmental pollution, but the positive externality. Although the use of wastewater in agricultural production has made a positive contribution to the economy, it will be beneficial to use it after the necessary treatment processes, considering its harmful effects on human health.

**Keywords:** Wastewater, Environmental valuation, Agricultural production, Producer surplus

[1]***Sorumlu Yazar/Corresponding Author:** Zuhal Karakayaci, Selcuk University Agricultural Faculty Department of Agricultural Economics, Konya Türkiye. E-mail: zuhalunal@selcuk.edu.tr OrcID: 0000-0003-2933-5608

[2]Ebru Aydın, State Hydraulic Works, Bursa Regional Directorate, Bursa, Türkiye. E-mail: ebruaydinea03@gmail.com OrcID: 0000-0002-9383-3954
**Atıf:** Karakayacı Z., Aydın E. (2024). Tarımsal üretimde kullanılan atık suyun çevresel değerlemesi. *Tekirdağ Ziraat Fakültesi Dergisi,* 21(4): 1058-1068.
**Citation:** Karakayacı Z., Aydın E. (2024). Environmental valuation of wastewater used in agricultural production. *Journal of Tekirdag Agricultural Faculty,* 21(4): 1058-1068.

*This study was summarized from the Ebru Aydın's MSc thesis.

# Öz

Son yıllarda tüm dünyada nüfus artışı, hızlı kentleşme, sanayileşme ve iklim değişikliği gibi konular nedeniyle mevcut su kaynaklarının yeterliliği ile ilgili sorunlar ortaya çıkmıştır. Özellikle suyun en çok kullanıldığı tarımsal üretimde bu soruna çözüm olarak atık su kullanımı yaygınlaşmıştır. Atık suların içeriğinde bulunan maddeler nedeniyle çevreye zarar verebileceği göz önünde bulundurularak bu çalışmada çevresel bir değerleme yapılması amaçlanmıştır. Bu kapsamda, piyasası olmayan malların değerlemesinde kullanılan seyahat maliyeti yöntemi kullanılarak, tarımsal üretim söz konusu olduğundan bu yönteme farklı bir yaklaşım getirilmiş ve üretici rantına dayalı bir değerlendirme yapılmıştır. Çalışmada, atık su ve kuyu suyu ile yapılan tarımsal üretimler karşılaştırılarak, atık suyun çevresel değerlemesi hakkında 2 hipotez geliştirilmiştir; Birinci hipotez atık su ile yapılan tarımsal üretimin üretici rantı kuyu suyu ile yapılan üretimden daha düşük ise çevresel kirlilik vardır ve değeri iki rant arasındaki farktır. İkinci hipotez ise üreticinin atık su ile elde ettiği rantın yüksek olması durumunda, çevre kirliliğinin olumsuz etkilerine karşı bir hipotez olarak pozitif dışsallık oluşacağıdır. Araştırma alanında 125 üretici ile anket yapılarak toplam 314 parselin verileri analize dahil edilmiş ve regresyon analizi ile arz fonksiyonu oluşturularak üretici rantı hesaplanmıştır. Araştırma bulguları sonucunda atık su ile sulama yapılarak gerçekleştirilen tarımsal üretimden elde edilen üretici rantı (584.40$), kuyu suyu ile sulama yapılarak yapılan üretimin üretici rantından (553.44$) daha yüksek bulunmuştur. Bu durumda, sulanan atık suyun çevre kirliliğine değil, pozitif dışsallığa etki ettiği sonucuna varılmıştır. Atık suyun tarımsal üretimde kullanılması ekonomiye olumlu katkı sağlamış olsa da insan sağlığı üzerindeki zararlı etkileri göz önünde bulundurularak gerekli arıtma işlemlerinden sonra kullanılması faydalı olacaktır.


**Anahtar Kelimeler:** Atık su, Çevresel değerleme, Tarımsal üretim, Üretici rantı

## 1. Introduction

The needs of humans, animals and all living creatures in the world and all kinds of economic activities necessary to meet these needs; that is, the most basic resource required for the natural cycle of life to function in a certain order is water. The fact that water is the main resource at all stages of the natural cycle shows its importance more and more as the population increases day by day.

The sector in which water resources are used the most in Türkiye and in the world is agriculture. 71% of the water used in the world and 85% in Turkey is used in the agricultural sector (World Bank, 2022). When selecting irrigation systems for agricultural purposes, it is advisable to choose those that conserve water, increase yield and quality per unit area, and reduce the need for labour. Although irrigation systems are preferred for their ability to diversify products and cover large areas of land, it is important to consider the investment cost and economic life of the system (Ağızan and Bayramoğlu, 2021). In this context, due to the decrease in water availability with the effect of climate change experienced in recent years, solutions are tried to be produced regarding water use. One of these solutions is the use of wastewater in agricultural activities.

The safe use of wastewater as an alternative source of irrigation is an accepted strategy for the prevention and efficient use of water pollution with increasing water scarcity (Khan et al., 2013). The use of wastewater in agricultural lands, especially in those close to the central provinces, is economically very important. Because the insufficient underground water in arid lands is replaced by wastewater and the need for natural water resources is reduced; contributes to the formation of a sustainable resource management (Jaramillo and Restrepo, 2017; Direk et al., 2022). The use of wastewater in agriculture not only saves water by reducing the demand for fresh water, but also reduces the fertilizer need of plants thanks to the elements such as nitrogen and phosphorus in its content (Adalı and Kılıç, 2020). Wastewater, even if treated, is rich in organic matter, macronutrients (N, P, K) and has a higher content of numerous micronutrients such as Fe, Zn, Mn and Cu than a synthetic fertilizer (Çakmakcı and Şahin, 2020). USA, Australia and Western European countries consider treated wastewater as an alternative source (Yurtseven et al., 2010). Treatment facilities have been widely used in Turkey and all over the world in order to contribute to sustainable water management by purifying wastewater.

There are risks and advantages that occur or may occur in the use of wastewater as a source of agricultural irrigation. These are given in *Table 1* as follows;

***Table 1. Advantages and Risks that May Occur Due to the Use of Wastewater***

| Advantages | Risks |
|---|---|
| Due to the nitrogen and phosphorus contained in the wastewater, savings can be made in the use of fertilizers, and it can also benefit both crop and soil fertility. | If the use of wastewater is not controlled, heavy metals, various minerals and organic substances in its content can damage groundwater. |
| It can be a solution to water scarcity as it is an alternative source. | With the uncontrolled use of wastewater, it can be dangerous to human health, especially in raw vegetables or with pathogens that can be transmitted through wastewater. |
| Wastewater is continuous because it is the result of a cycle and can be a ready source for irrigation in seasons and periods when water resources are scarce. | Uncontrolled and intensive use of wastewater and the accumulation of its contents in the soil can cause damage to the soil. |
| If the wastewater is treated in accordance with the requirements apart from agricultural irrigation, it can also provide benefits in different areas as drinking and using. | |
| As a result of the researches, it was observed that the metabolic activities of beneficial microorganisms in plant cultivation increased with the use of wastewater in irrigation. | |

Reference: (Saracoğlu 2014)

The use of treated wastewater in agriculture benefits human health, the environment and the economy. This use has been evaluated as an alternative to the water shortage caused by the need for water due to the growth of the urban population in different regions (Becerra, 2015). The use of wastewater in agriculture is considered beneficial for agricultural and economic reasons, but negative health and environmental effects should be minimized (Alobaidy et al., 2010). For this reason, it is necessary to carry out an effective wastewater management.

There have been many studies showing the advantages and disadvantages of wastewater use. There are studies proving the benefits of wastewater such as increasing in crop yield (Rosemarin, 2004; Keraita et al., 2008) and producer income (Danso et al., 2002; Huibers et al., 2004; Rosemarin, 2004), increased crop diversity (Raschid-Sally et al., 2005), providing balanced nutrition for the plant (Koottatep et al., 2006), and urban livestock production by providing feed production with wastewater (Drechsel et al., 2010). On the other hand, soil salinization (Walker and Lin, 2008), decreased soil porosity (Wang et al., 2003), heavy metal pollution (Ashraf et al., 2013), water impermeability (Wallach et al., 2005) and underground It has been determined that it causes negative effects such as pollution of water (Mahmood and Maqbool, 2006). Wastewater can be beneficial to the environment and human health, as well as be harmful with unconscious and uncontrolled use. Therefore, in this study, the environmental impact of the wastewater used in agricultural production has been made and its economic impact has been revealed.

Wastewater reuse is an important component of sustainable water resources management; Reusing water from various wastewater sources after removing pollutants, nutrients and pathogens offers an alternative for water security (Grant, 2011; Matheyarasu et al., 2016). The current scarcity of resources and the inability to meet the need in terms of quality or the increased pressure on water with unconscious use emphasize the importance of wastewater. Needs will be met with this alternative source, which will provide benefits both environmentally and economically.

Environmental valuation methods are used to determine the benefits and costs associated with the use of environmental products, the improvement of their conditions or the elimination of environmental damage (Lindberg and Lindberg, 1991). Environmental valuation refers to the monetary measurement of the benefit or cost to the life of society of the consequences of environmental improvement interventions and environmental degradation (Christie et al., 2012). In this study, it is aimed to make an environmental valuation for the waste form of water, which is one of the most important natural resources, and to reveal whether it contains benefits or costs for agricultural production.

## 2. Materials and Methods

In order to obtain the data in the research, 5 neighbourhoods (Acıdort, Çengilti, Divanlar, Göçü, Karakaya) located in the Karatay district of Konya province, which are the research area, and which carry out agricultural irrigation with wastewater, were chosen for the purpose; A total of 742 agricultural enterprises were identified as the main population and the number of samples was determined as 125 according to the stratified random sampling method. However, due to the lack of sufficient producers during the field studies, a total of 114 producers were interviewed.

Konya province is the city with the most agricultural area in Turkey, and Karatay district, which is the research area, is the district with the highest agricultural area in Konya. Karatay district has 178 154.7 ha of agricultural land, 50% of which is dry agricultural land. The fact that Karatay district is the central district of Konya is more exposed to environmental pollution than rural districts, and it is used as an agricultural irrigation alternative due to its proximity to the wastewater source.

There are some environmental valuation methods at the point of determining the pollution with monetary values. Since environmental pollution is associated with externality, it is mostly done by considering methods that have no market value (Gündoğmuş and Kalfa, 2016). Travel cost and contingent valuation methods are mostly used in the studies. In this context, studies in which the travel cost method is used are generally associated with the consumer, and people who benefit from a certain area are used in the calculations. When calculating with the travel cost method for any recreation area, the value of this area, which is valued using consumer surplus, is determined by the number of visitors. Consumer surplus is estimated with the help of the demand function created between the travel cost and the number of visits (Çay et al., 2020). By using travel costs instead of price when deriving the demand curve, these travel costs are considered to reflect people's propensity to pay for recreation services (Kaya, 2002). In this study, since the effect of agricultural lands and land value on environmental pollution is taken into account, the producer surplus has been calculated over the supply function.

Producers may be willing to sell their product at a price below the equilibrium price in order to sell a good. The difference between the equilibrium price and the price that is below the equilibrium price agreed by the producer is the producer's surplus, and in the study, the producer's surplus is calculated and the income obtained in return for the factors of production used is determined. As a matter of fact, price is equal to cost in a free market. Since the aim of the study is to determine the environmental valuation of the wastewater in the research area, the prices of the production factors are discussed by keeping the other variables constant in the supply function.

$$S = f(Se + Fe + W + P + L + Fu) \quad \text{(Eq.1)}$$

In the function, S = quantity of supply, Se = price of seed, Fe = price of fertilizer, W = price of water, P = price of pesticide, L = price of labour, Fu = price of fuel. Producer surplus was calculated by integrating the function with the following formula (Cinemre et al., 2008).

$$PS = Q.P - \int_0^Q f(Q)dQ \quad \text{(Eq.2)}$$

PS = Producer Surplus, Q = Equilibrium Quantity, P = Equilibrium Price.

It is aimed to compare the difference between the lands irrigated with wastewater and the lands irrigated with well water within the total population by using the producer surplus. Two hypotheses have been developed for this purpose;

- If the producer surplus is high in the lands irrigated with wastewater, positive externality will be seen as a hypothesis against the negative effects of environmental pollution and a different approach will be gained to environmental valuation.

- If the producer surplus is high in the lands irrigated with well water, the difference between the producer's surplus of the lands irrigated with wastewater will be considered as the environmental pollution value.

Regression and t-test analyses were conducted to determine if there is a cost difference between irrigation with wastewater and well water.

## 3. Results and Discussion

It is seen that the ratios of female and male population in the examined enterprises are at equal levels in all age groups. It has been determined that the rate of 50 years and over is 33.99%; 8.06% of the population aged 0-6; 9.15% between the ages of 7-14; 48.80% between the ages of 15-49. With this result, it is seen that the ratio of the working population, which is the active population, is the highest. Therefore, it is concluded that the workforce potential of the examined enterprises is good. While the age group of 15-49 constitutes 64% of the family workforce, 35.71% is the group aged 50 and over. In the examined enterprises, 12% of the population is illiterate; 51% of them are primary school; 23% of them are secondary school; It was determined that 7.44% were high school graduates and 5.69% were university graduates. It has been observed that the education level with the highest number of people is primary school. In addition, it was determined that 51% of the examined enterprises used wastewater, 23% groundwater and 26% both irrigation sources in agricultural production.

### *3.1. Calculation of Producer Surplus*

Producer surplus is expressed as a producer who is willing to sell her product at a price below the equilibrium price in a perfectly competitive market, making some gains (Dinler, 2016). In this study, a different approach was brought to the consumer surplus in the travel cost method used in the valuation of environmental goods, and it was calculated to determine the rent provided by the producers from the wastewater by adapting it to the agricultural production, which is the subject of the study. The supply function was used to calculate the producer surplus, while keeping the other variables constant, only input costs and production amount were considered and given in *Table 2*.

***Table 2. Average Operating Input Costs and Production Quantities of the Products Irrigated with Wastewater ($/decare)***

| Products | Costs | | | | | | Production |
|---|---|---|---|---|---|---|---|
| | Seed | Fertilizer | Pesticide | Water | Fuel | Labour | Quantities |
| Wheat | 5.39 | 4.88 | 0.91 | - | 5.90 | 7.98 | 1.533 |
| Barley | 7.52 | 7.59 | 1.65 | - | 6.16 | 8.23 | 1.140 |
| Sugar Beet | 12.48 | 10.73 | 5.03 | - | 6.80 | 9.73 | 2.231 |
| Corn | 19.52 | 11.19 | 3.77 | - | 5.92 | 8.81 | 161 |
| Fodder Corn | 46.78 | - | 3.51 | - | 4.79 | 8.55 | 2.640 |
| Sunflower | 11.49 | 6.08 | 2.35 | - | 7.00 | 7.52 | 1.524 |
| Alfa alfa | 2.46 | 4.71 | 8.55 | - | 3.09 | 5.05 | 1.464 |
| Vetch | 3.51 | - | | - | 5.93 | 5.85 | 600 |

* 1 $ = 8,55 Turkish Liras at study time (July-2021)

Seeds, fertilizers, pesticides, water, fuel and labour costs, which are the basic expenses in the herbal production process, are minimum in order to be an optimum production process; efficiency should be maximum. At this point, the use of wastewater has a positive effect on production costs. As a matter of fact, the most expense in plant production is irrigation and fertilization costs. Therefore, while there is no cost for water in productions where irrigation is done with wastewater during the production process, it is seen as a result of the research that the use of fertilizers is reduced thanks to many minerals such as nitrogen, phosphorus and salt in the wastewater.

***Table 3. Average Operating Input Costs and Production Quantities of the Products Irrigated with Well Water ($/decare)***

| Products | Costs | | | | | | Production |
|---|---|---|---|---|---|---|---|
| | Seed | Fertilizer | Pesticide | Water | Fuel | Labour | Quantities |
| Wheat | 8.33 | 7.57 | 1.25 | 2.51 | 7.93 | 9.69 | 1 354 |
| Barley | 7.83 | 7.16 | 1.20 | 17.26 | 7.19 | 9.67 | 1 078 |
| Sugar Beet | 11.70 | 11.74 | 6.43 | 57.08 | 6.69 | 8.51 | 2 555 |
| Corn | 17.56 | 14.15 | 4.39 | 76.34 | 6.81 | 10.47 | 3 396 |
| Fodder Corn | 32.75 | 11.61 | 3.51 | 58.48 | 7.03 | 10.53 | 2 500 |
| Sunflower | 14.23 | 7.33 | 2.88 | 48.30 | 7.02 | 8.56 | 1 369 |
| Alfa alfa | 4.68 | 6.81 | 7.02 | 23.39 | 3.42 | 6.67 | 1 340 |
| Vetch | 4.21 | 6.43 | 0.00 | 21.05 | 6.46 | 10.38 | 800 |

* 1 $ = 8,55 Turkish Liras at study time (July-2021)

According to the research, the specific input costs of the producers using wastewater and well water were compared, and as seen in *Tables 2* and *3*, it was concluded that the input costs of the producers irrigating with well water in general were higher than the producers irrigating with wastewater. As a matter of fact, there are certain differences in the costs of seeds, fertilizers, pesticides, fuel and labour per product.

Independent t-test was applied to determine whether two different irrigation sources are effective on production cost items in agricultural production activities irrigated with wastewater and well water.

$H_0$ = There is no difference in production costs between irrigation with wastewater and irrigation with well water.

$H_1$ = There is a difference in production costs between irrigation with wastewater and irrigation with well water.

According to the purpose of the research, the rejection of the $H_0$ hypothesis was accepted below the 5% significance level. As a result of the analysis made, it was determined that there was no difference in seed cost (t=1.345), pesticide cost (t=0.331) and fuel cost (t=1.469) according to irrigation source in *Table 4*. It was determined that there was a difference in fertilizer cost (t=5.101), water cost (t=23.215), labour cost (t=5.573) and production amount (t=3.346). The decrease in the use of fertilizers in irrigation with wastewater and the decrease in the use of labour in irrigation and fertilization activities confirm these analyses. As a result of this analysis, assuming that there will be differences in the rents of the producers according to the two different irrigation sources, the producer's rents were calculated in order to reveal which irrigation source will generate more producer surplus and to determine whether the wastewater and irrigation will cause environmental pollution.

***Table 4. Independent T-Test of Production Costs by Irrigation Source***

| | Code* | N | Average | Standard Deviation | t | Significance Level |
|---|---|---|---|---|---|---|
| Seed | 1.00 | 216 | 82.9176 | 51.22802 | -1.345 | .179 |
| | 2.00 | 98 | 91.7357 | 59.14489 | -1.275 | .204 |
| Fertilizer | 1.00 | 216 | 43.5935 | 29.22241 | -5.101 | .000 |
| | 2.00 | 98 | 64.1541 | 40.37807 | -4.531 | .000 |
| Pesticide | 1.00 | 208 | 15.0529 | 20.99625 | -0.331 | .741 |
| | 2.00 | 98 | 15.8673 | 17.95219 | -0.350 | .727 |
| Water | 1.00 | 216 | 11.3935 | 11.52622 | -23.215 | .000 |
| | 2.00 | 98 | 305.3061 | 185.64018 | -15.660 | .000 |
| Fuel | 1.00 | 216 | 53.1022 | 28.39243 | -1.469 | .143 |
| | 2.00 | 98 | 57.6949 | 18.26949 | -1.719 | .087 |
| Labour | 1.00 | 216 | 67.0851 | 17.57427 | -5.573 | .000 |
| | 2.00 | 98 | 79.0829 | 17.90394 | -5.534 | .000 |
| Production Quantity | 1.00 | 216 | 618.1065 | 1022.85750 | -3.346 | .001 |
| | 2.00 | 98 | 1173.5000 | 1912.06478 | -2.705 | .008 |

*Code 1.00=Wastewater, Code 2.00=Well water

It is aimed to compare the difference between lands irrigated with wastewater and lands irrigated with well water within the total population by using producer surplus. In order to calculate the producer surplus, firstly, the costs of the factors of production and the supply function were formed by keeping the other variables constant. Since the products irrigated with wastewater will be compared with the products irrigated with irrigation water, two different models have been established: for enterprises irrigating with wastewater and for enterprises irrigating with well water. While the production quantity as the dependent variable and the prices of the factors of production as the independent variable in the supply function, since the purpose of the research is the irrigation cost, the Gross Production Value per decare (GPV) as the dependent variable in the model, the seed cost per decare (S), the fertilizer cost (Fe), pesticide cost (P), water cost (W), fuel cost (Fu), labour cost (L), the price of the product one year ago (Pr) and the production quantity (PQ) are discussed. According to the analysis made in the study, the supply function for agricultural production irrigated with wastewater is as follows;

$$GPV_A = 1238.447 + 0.311S_A + 2.917Fe_A - 2.213Pe_A + 2.517W_A - 1.627Fu_A - 3.727L_A + 285.295PrA + 0.321PQ \quad \text{(Eq.3)}$$

Analysis was made by considering the data of 216 parcels that were irrigated with wastewater. Since products that differ from each other in terms of yield and input such as wheat, barley, sugar beet, sunflower, corn, and alfalfa are included in the analysis, when the importance levels of the variables are examined, it is seen that variables such as labour, medicine, fuel are not significant. For the purpose of the research, the importance levels of other variables were not taken into account due to the variety of products included in the analysis, since it was examined whether the water used in production was waste or not.

When the average values of the variables other than water cost are included in the function and the model is reconstructed in terms of production quantity (Q), the equation is obtained.

$$WA = 0.3973GPVA - 599.0877 \quad \text{(Eq.4)}$$

In order to calculate the producer surplus, the function is integrated and subtracted from the product of the equilibrium quantity and price (P.Q) in the research area in 2021, which is the research period. Since GPV is taken as the dependent variable in the model, price is taken as the limitation in the integral.

$$PS = (P)(Q) - \int_0^P (0.3973P - 599.0877) \quad (Eq.5)$$

PS = (0.23) (1900) – (0.3973$P^2$ – 599.0877P)

PS = **584.40 $**

***Table 5. Regression Analysis for Enterprises Irrigation with Wastewater***

| Variables | Coefficients | Standard Error | t | Significance Level | VIF |
|---|---|---|---|---|---|
| Constant | 1.238.447 | 190.773 | 6.492 | .000 | - |
| Seed (S) | .311 | .824 | .378 | .706 | 1.145 |
| Fertilizer (Fe) | 2.917 | 1.709 | 1.707 | .089 | 1.600 |
| Pesticide (Pe) | -2.213 | 1.960 | -1.129 | .260 | 1.066 |
| Water (W) | 2.517 | 3.646 | .690 | .491 | 1.134 |
| Fuel (Fu) | -1.627 | 1.474 | -1.104 | .271 | 1.124 |
| Labour (L) | -3.727 | 2.716 | -1.372 | .171 | 1.462 |
| Price (Pr) | 122.474 | 36.947 | 3.315 | .001 | 1.420 |
| Production Quantity (PQ) | .321 | .043 | 7.442 | .000 | 1.357 |

In the study, the data of 98 parcels that irrigate with well water were analysed, and according to the analysis, the supply function obtained for agricultural production with well water is as follows;

$$GPVK = 699.170 + 0.104SK + 4.621FeK - 0.596PeK + 2.784WK - 1.052FuK + 0.280LK - 130.135PrK + 0.51PQk \quad (Eq.6)$$

When the average values of the variables other than water cost are included in the function and the model is reconstructed in terms of production quantity (Q), the equation is obtained.

$$WK = 0.3592GPVK - 467.5498 \quad (Eq.7)$$

$$PS = (P)(Q) - \int_0^P (0.3592P - 517.9842) \quad (Eq.8)$$

PS = (0.23) (1900) – (0.3592$P^2$ – 517.9842P)

PS = **553.44 $**

***Table 6. Regression Analysis for Enterprises Irrigation with Well Water***

| Variables | Coefficients | Standard Error | t | Significance Level | VIF |
|---|---|---|---|---|---|
| Constant | 699.170 | 335.081 | 2.087 | .040 | - |
| Seed (S) | .104 | 1.099 | .094 | .925 | 1.432 |
| Fertilizer (Fe) | 4.621 | 1.944 | 2.377 | .020 | 2.087 |
| Pesticide (Pe) | -.596 | 3.526 | -.169 | .866 | 1.357 |
| Water (W) | 2.784 | .462 | 6.019 | .000 | 2.496 |
| Fuel (Fu) | -1.052 | 3.481 | -.302 | .763 | 1.370 |
| Labour (L) | .280 | 4.316 | .065 | .948 | 2.022 |
| Price (Pr) | -130.135 | 75.628 | -1.721 | .089 | 2.129 |
| Production Quantity (PQ) | .051 | .046 | 1.111 | .270 | 2.370 |

As can be seen in *Table 5* and *Table 6*, producer surplus obtained with irrigation water used in agricultural production were calculated with the analyses made, and it was determined that the producer surplus obtained from irrigation with wastewater was higher. It has been seen that positive externality has been realized as a hypothesis against the negative effects of environmental pollution due to the high producer surplus in the lands irrigated with wastewater, and a different approach has been brought to environmental valuation. It has been concluded that the wastewater used is not harmful to agricultural production and in this case, it is not possible to talk about environmental pollution. In addition, in the examinations made in the research area, it has been determined that irrigation with wastewater has a positive effect on the yield of the product, as well as reducing the cost of irrigation, fertilization, disinfection and labour costs. Due to the fact that the elements in the wastewater act as fertilizer, it has been determined that the fertilization process is much less than the irrigated lands with well water. The fact that the labour force used for fertilization and irrigation operations is less than irrigation with wells has caused this expense item to be lower. This situation reveals that irrigation with wastewater provides a positive externality to agricultural production.

## 4. Conclusions

With the effect of rapidly increasing urbanization, industrialization and climate change in parallel with the increase in the world population, the difference between the supply and demand of water is gradually increasing. This situation has revealed the necessity of developing alternative strategies for the evaluation of wastewater within the scope of effective water management. Evaluation of wastewater is of great importance, especially for agricultural activities where water is consumed the most.

In the study, it was aimed to make an environmental valuation of the wastewater used in agricultural production, and by calculating the producer surplus with the travel cost method approach, it was concluded that the wastewater had a positive effect on the producers rather than environmental pollution.

In general, wastewater is perceived as a harmful and negative concept; When other studies in the literature and the result of this research are taken into account, it is concluded that with correct and controlled management, it provides benefits for existing resources and reduces environmental pressure. However, the fact that the use of wastewater without treatment can threaten human health should not be ignored. For this reason, first of all, producers should be aware of this issue. In addition, it is recommended to establish facilities where treated water can be used in the research area. In Turkey, it is possible to benefit from the energy subsidies given by the Ministry of Environment, Urbanization and Climate Change for wastewater treatment establishments. In addition, studies such as reducing the environmental pollution effects of wastewater can be carried out to evaluate it as Agricultural Land Footprint.

## Ethical Statement

Since it is an article produced from a master's degree study that used research data before 2022, there is no need to obtain permission from the ethics committee for this study.

## Conflicts of Interest

There is no conflict of interest between the article authors.

## Authorship Contribution Statement

Concept: Karakayacı Z.; Design: Karakayacı Z. X.; Data Collection or Processing: Aydın E.; Statistical Analyses: Karakayacı Z.; Literature Search: Karakayacı Z., Aydın E.; Writing, Review and Editing: Karakayacı Z.

## References


Adalı, S. and Kılıç, M. Y. (2020). The use of treated wastewater in agricultural irrigation: the example of Iznik. *International Journal of Biosystems Engineering*, 1(1): 12-23.

Ağızan S. and Bayramoğlu Z. (2021). Comparative investment analysis of agricultural irrigation systems. *Journal of Tekirdag Agricultural Faculty*, 18(2): 222-233.

Alobaidy A. H. M. J., Al-Sameraiy, M. A., Kadhem, A. J. and Majeed, A. A. (2010). Evaluation of treated municipal wastewater quality for irrigation. *Journal of Environmental Protection*, 2: 629-635.

Ashraf, M., Imtiaz, M., Abid, M., Afzal, M. and Shahzad, S. M. (2013). Reuse of wastewater for irrigating tomato plants (Lycopersicon esculentum L.) through silicon supplementation. *Journal of Water Reuse Desalination*, 3(2): 129-139.

Becerra, C., Lopes, A., Vaz, I., Silva, E., Manaia, C. and Nunes, O. (2015). Wastewater reuse in irrigation: A microbiological perspective on implications in soil fertility and human and environmental health. *Environment International*, 75: 117-135.

Çakmakcı, T. and Şahin, Ü. (2020). The effect of application of treated wastewater with different irrigation methods on macro-micro element and heavy metal accumulation in silage corn. *Journal of Tekirdag Agricultural Faculty*, 17(1): 12-23. (In Turkish)

Çay, R. D., Aşilioğlu, F. and Konyalı Dereli, C. (2020). Determination of recreation value of Edirne urban forest by travel cost method. *Akademia Journal of Nature and Human Sciences*, 6(1): 93-106.

Christie, M., Fazey, I., Cooper, R., Hyde, T. and Kenter, J.O. (2012). An evaluation of monetary and non-monetary techniques for assessing the importance of biodiversity and ecosystem services to people in countries with developing economies. *Ecological Economics*, 83: 67-78.

Cinemre, H. A., Ekberli, İ. and Ceyhan, V. (2008). Using Mathematics in Economic Analysis. Samsun: Ondokuz Mayıs University Faculty of Agriculture Textbook (No: 61) (In Turkish)

Danso, G., Drechsel, P., Wiafe-Antwi, T. and Gyiele, L. (2002). Income of farming systems around Kumasi. *Urban Agriculture Magazine,* 7: 5-6.

Dinler, Z. (2016). Microeconomics. Ekin Press Distribution, 27th Edition, Bursa. (In Turkish)

Direk, M., Güngör, L. and Acar, R. (2022). The importance, value and relationship of wastewater with agriculture. *National Environmental Sciences Research Journal,* 1(5): 8-15. (In Turkish)

Drechsel, P., Scott, C. A., Raschid-Sally, L., Redwood, M. and Bahri, A. (2010). Wastewater Irrigation and Health: Assessing and Mitigating Risks in Low income Countries. London: Earthscan, UK.

Grant, C. A. (2011). Influence of phosphate fertilizer on cadmium in agricultural soils and crops. *Pedologist*, 54:143–155.

Gündoğmuş, M. E. and Kalfa, V. R. (2016). Determining the economic value of non-market assets. *Journal of Life Economics,* 3(4): 177-200. https://doi.org/10.15637/jlecon.163

Huibers, F. P., Moscoso, O., Durân, A. and Van Lier, J. B. (2004). The Use of Wastewater in Cochabama, Bolivia: a Degrading Environment. In: Wastewater Use In Irrigated Agriculture: Confronting the Livelihood and Environmental Realities, 135-142 pp.

Jaramillo, M. F and Restrepo, I. (2017). Wastewater reuse in agriculture: a review about its limitations and benefits. *Sustainability*, 9: 1734. https://doi.org/10.3390/su9101734

Kaya, G. (2002). *Determining the value of forest resources in the framework of non-market products*. (PhD. Thesis) Istanbul University. Institute of Science and Technology, Department of Forestry Engineering. Istanbul.

Keraita, B. N., Jiménez, B. and Drechsel, P. (2008). *Extent and implications of agricultural reuse of untreated, partly treated and diluted wastewater in developing countries*. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources 3:1-15.

Khan, M. J., Jan, M. T. and Khan, K. (2013). Effect of organic and inorganic amendments on the heavy metal content of soil and wheat crop irrigated with wastewater. *Sarhad Journal of Agriculture,* 29(1):49-57.

Koottatep, T., Polprasert, C. and Hadsoi, S. (2006). Integrated faecal sludge treatment and recycling through constructed wetlands and sunflower plant irrigation. *Water Science and Technology*, 54:155-164.

Lindberg, K. and Lindberg, K. (1991). Policies for Maximizing Nature Tourism'S Ecological and Economic Benefits. World Resources Institute: Washington DC. USA.

Mahmood, S. and Maqbool, A. (2006). Impacts of wastewater irrigation on water quality and on the health of local community in Faisalabad. *Pakistan Journal of Water Resources*, 10: 19-22.

Matheyarasu, R., Bolan, N. and Naidu, R. (2016). Abattoir wastewater irrigation increases the availability of nutrients and influences on plant growth and development. *Water, Air & Soil Pollution,* 227- 253.

Raschid-Sally, L., Carr, R. and Buechler, S. (2005). Managing wastewater agriculture to improve livelihoods and environmental quality in poor countries. *Irrigation and Drainage*, 54(1): 11-22.

Rosemarin, A. (2004). The precarious geopolitics of phosphorous. *Down to Earth*, 30(33): 27-34.

Saracoğlu, E. (2014). *Reuse of treated waste water in agricultural irrigation – successful examples from Our Country and the World and application suggestions for Turkey*. (Specialization Thesis) TR Ministry of Environment and Urbanization, General Directorate of Environmental Management, Department of Water and Soil Management, Ankara, Türkiye.

Walker, C. and Lin, H. S. (2008). Soil property changes after four decades of wastewater irrigation: A landscape perspective. *Catena*, 73(1): 63-74.

Wallach, R., Ben-Arie, O. and Graber, E. R. (2005). Soil water repellency induced by long-term irrigation with treated sewage effluent. *Journal of Environmental Quality*, 8: 1910-1920.

Wang, Z., Chang, A. C., Wu, L. and Crowley, D. (2003). Assessing the soil quality of long-term reclaimed wastewater irrigated cropland. *Geoderma,* 114(3-4): 261-278.

World Bank, (2022). World Bank. https://www.worldbank.org/en/topic/water-in-agriculture , Access Date: 15/02/2023

Yurtseven, E., Çakmak, B., Kesmez, D. and Polat, H. E. (2010). Reuse of Agricultural Wastewater in Irrigation, *Agricultural Engineering VII. Technical Congress,* 11-15 January, 135-154, Ankara, Türkiye. (In Turkish)