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A Review of the Effects of Using Municipal Treated Wastewater on Some Characteristics of Cotton Plants and Soil of Irrigated Fields

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ABSTRACT

Although the use of wastewater has a relatively long history, today more than ever, urban wastewater is considered as a source of irrigation water. In this study, by examining the effects of using treated effluent on the characteristics of cotton plants such as yield and number of bolls per square meter, leaf index and plant height, as well as cotton boll weight and vegetative growth, suggestions have been made that can help farmers to irrigate fields. Informs about the treated effluent. Also, considering the pattern of accumulation of heavy elements in the soil on their effects on soil quality and cultivated crops, the need for this research is even greater. The results of studies have shown that treating municipal effluent as one of the unconventional water sources for irrigation increases the yield of cotton plants. Also, the use of treated effluent in research has increased the number of bolls per square meter, leaf index and plant height in Irrigation treatments with treated effluent show high significance. The purpose of this article is to investigate the use of irrigation with treated effluent on the yield and yield components of cotton plants as well as its effect on the soil of irrigated fields.

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1. Introduction

In the last century, due to population growth and the expansion of human activity, per capita water consumption has increased significantly; Under these conditions, the excessive use of water resources has caused many areas that face limited water resources, critical conditions in terms of quantity and quality for water to occur due to the use of unconventional water, including wastewater in agriculture is of particular importance (Ranjbar-Fordoei, 2018).

The use of wastewater in agriculture has many benefits, including providing a cheap source of water, reducing the cost of treating this water, reducing the use of chemical fertilizers and reducing environmental impact. The general goal of reusing treated water in agriculture is to optimize and maintain the existence of water resources by returning wastewater streams to the ground, which is very important in arid areas (Mirdeilami *et al.*, 2019).

The use of municipal wastewater in agriculture in terms of water supply as well as plant nutrition has long been common. The first documented report on the use of wastewater is seen in Germany in the 16th century. In the 1980s, about 60 percent of the effluent produced in the United States was used in agriculture, and in recent years in the United States, approximately 7 million cubic meters of effluent enters agricultural land daily. Other European and Asian countries such as Tunisia, China and Japan are also leaders in this field (Fereyduni *et al.*, 2012).

Cotton is the most widely used natural fiber and the most important dual-purpose industrial plant in the world, which has employed more than millions of people in the fiber and oil industries in 79 countries and is the second-largest oilseed in the world after soybeans. In addition to the stated reasons, the cotton plant was usually selected as a drought-tolerant crop

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among the known crops for this research (de Albuquerque *et al.*, 2006)

Optimize and maintain the availability of water resources by returning wastewater to the land and the rational use of freshwater resources. Experience has shown that significant amounts of materials such as phosphate, potassium, and nitrogen in wastewater, all of which play valuable roles in agricultural fertility, have been effective in increasing crop yields. It should be noted that excessive use of treated wastewater can also increase the risk of contamination of groundwater and soil (Ababsa *et al.*, 2020).

The growing population of the world and the need for more agricultural products is one of the important issues that human beings face today, and among them, water is the main institution of agricultural production, which occupies a significant volume in the agricultural sector. It has become a major challenge and it is predicted that by 2050, 65 countries with a population of over 7 billion people will face water shortages (Christou *et al.*, 2017).

It is reported that food shortages for the growing population of the world, especially for developing countries, have raised serious concerns about food security. In our country, most of the foreign exchange earnings are spent annually on food products from abroad, and due to the rapid population growth and lack of proper use of the country's natural resources, this trend is expected to accelerate in the future. On the other hand, drought is a serious threat to the successful production of crops around the world. Approximately 93% of the arid regions of the world are concentrated in 27 countries, including Iran. Currently, in many arid and dehydrated areas of the world, treated municipal and industrial wastewater is reused in agriculture and industry. Therefore, due to the limited fresh water resources in the country and its increasing limitation and due to the gradual increase of municipal wastewater, replacing the water needed for agriculture with wastewater can reduce the problems of this sector to some extent (Emami *et al.*, 2007). Therefore, effluent is a factor in improving water resources and sustainable use of water resources, especially in arid areas (Paranychianakis *et al.*, 2006).

Also, the use of treated wastewater and other non-conventional water could have benefits such as providing a cheap and permanent water source, reducing the treatment costs, releasing part of good quality water for other uses instead of irrigation, reducing the environmental effects of chemical fertilizers, and pesticides and reducing the environmental effects of wastewater disposal from water resources, but it may also have negative biological and ecological effects due to the quantity, composition, and reactivity of the wastewater (Elgallal *et al.*, 2016).

The purpose of this article is to study and review past research to provide suggestions to farmers to increase the yield of cotton as well as increase water use efficiency and prevent contamination of irrigated soils with treated effluent.

1.1. Importance and necessity of conducting research

Due to the droughts of the past few years in Iran, as well as population growth and increasing demand for agricultural products, as well as to deal with the crisis of water shortage and availability of water for farmers and the need to use unconventional water to increase productivity water, the use of treated wastewater to increase performance per unit area to meet the needs of society, the proper use of unconventional water resources. The present study was conducted to inform farmers about the benefits and harms of using treated effluent on cotton plants and by studying and reviewing previous research, suggestions to increase the yield of cotton plants and also increase water use efficiency and prevent contamination.

2. Materials and methods

In this study, we have tried to review the effects of previous research on cotton plants and irrigation with treated effluent on the yield and some performance of cotton yield as well as on the soil under irrigation in the field and what effects it has had. Let's examine the researchers. In the following, the research records and how to perform the experiments of different researchers who studied the effects of the effluent on the cotton plant are presented. Finally, the results of this research are compared and the summarized results are generalized. In the present study, comparisons were made between previous research on the cotton plant affected by irrigation with treated effluent, and we found out what the researchers who did the work in this regard reported in the end. Then compare the results in the form of a comprehensive scientific report and compare the results of cotton plant cultivation and yield

and yield components of the cotton plant under irrigation tire with treated effluent in the form of tables and graphs that are analyzed in Excel and using ASA software. We reported and finally compared the results and presented the suggestions made by previous researchers to reduce the negative effects of irrigation with treated effluent in cotton fields and suggested the best result to produce high yield and pollution, we have the least and the least negative impact on the crop and the farm soil.

Table 1. Mean quality parameters of cotton plant fibers in different treatments.

Parameter	F	W	WWF	W 66% F 33%	WF	W 50% F 50%	FFW	W 33% F 66%
Fiber (%)	38.0	38.40	38.5	37.6	39.2	37.4	38.5	37.6
Effective length (mm)	27.6	28.70	28.0	28.1	27.9	27.9	27.5	28.9
Attraction (%)	6.7	6.50	6.4	6.5	6.2	6.3	6.5	6.5
Delicacy(μgin^{-1})	4.6	4.60	4.6	4.8	4.6	4.6	4.8	4.8
Monotony	79.6	78.80	80.0	79.6	80.9	77.9	82.3	81.0
Resistance(gr m^{-1})	24.1	25.20	23.7	24.2	23.2	23.6	23.2	24.4

Table 2. Mean parameters of cotton plant characteristics in different irrigation treatments.

Parameter	F	W	WWF	W 66% F 33%	WF	W 50% F 50%	FFW	W 33% F 66%
Plant height (cm)	42.4^{b}	52.20^{a}	52.8^{a}	49.00^{ab}	49.50^{ab}	50.10^{a}	42.60^{b}	42.20^{b}
Number of bolls (m^2)	21.0^{e}	5.00^{a}	36.0^{bc}	38.00^{b}	33.00^{cd}	34.00^{bd}	31.00^{d}	32.00^{d}
Bounce weight (gr)	3.8^{c}	4.50^{ab}	4.5 ^{ab}	4.90^{a}	4.80 ^{a}	4.20^{bc}	4.60^{ab}	4.50^{ab}
Intermediate distance(cm)	3.0^{d}	3.60^{a}	3.5^{ab}	3.40^{ac}	3.30^{ad}	3.20^{bd}	3.10^{cd}	3.10^{cd}
LAI	0.4^{c}	0.77^{a}	0.6^{b}	0.47^{c}	0.51^{bc}	0.50^{bc}	0.47^{c}	0.49^{c}

3. Results and discussion

One of the possible problems of using wastewater for irrigation purposes is its possible effect on the chemical and physical properties of the soil as well as creating unfavorable conditions in the plant. If the concentration of some elements in the effluent is higher than the standard, the concentration of these elements in the soil will gradually increase and will exceed the tolerance threshold of the plant. At the same time, they may cause groundwater pollution and environmental problems. Accumulation of salts and salts causes salinization of soils and reduces their fertility. Excessive accumulation of some elements can also cause poisoning for plants. It is important to know the different reactions of plants to the changes that occur as a result of the use of these waters in the physical and chemical properties of the soil (Moftahi, 2011).

Khasi and Kuchakzadeh (2010) conducted a study to investigate the effect of effluent irrigation on the yield and quality of Mehr fiber in the Ghods town treatment plant in Tehran. In this study, cotton irrigation was done superficially with different mixing amounts and intermittent application of treated wastewater and ordinary in addition to two complete irrigation treatments with treated water and wastewater. The research was conducted in a completely randomized block design with 8 treatments and 3 replications. The results showed that the number of bolls per square meter, leaf index and plant height in treatments irrigated with treated wastewater were significantly higher than the treatment irrigated with water. Also, treated wastewater had no significant effect on the quality of cotton fibers (Khasi and Kuchakzadeh, 2010) Tables 1 and 2.

3.1. The most important reasons for reuse of effluents and mixing with well and aqueduct water

1. Reducing pressure on water resources:

Improper abstraction of available water resources has led to declining groundwater levels in many parts of the world, and this phenomenon will lead to many problems, including landslides and salinization of wells (Peña *et al*., 2020).

2. Reducing the cost of water in agriculture:

In many cases, water production for agriculture requires exorbitant costs to transfer water from remote points, construction of dams and diversion dams or pumping water from the depths of the earth, while the effluent of wastewater treatment plants are located on the ground and from Due to the approximate stability of water flow, it no longer needs to be controlled by dams (Fereyduni *et al*., 2012).

3. Reducing the cost of agricultural fertilizer:

Improving agricultural land and increasing its fertility is one of the current costs of agricultural activities, while the effluent from treatment plants contains nutrients such as nitrogen, phosphorus and potassium in the desired amount. Studies in different parts of the world have shown that products irrigated with wastewater do not need to add chemical or animal fertilizers. Therefore, a lot of savings are made in the cost of agricultural products (Gamito *et al.*, 1999).

4. Increasing product production:

Access to treated effluent as a reliable and permanent source of water and nutrients ensures that agricultural products have sufficient water and nutrients when needed. On the other hand, the amount of effluent salts in many cases is much lower than the amount of salts in water used in agriculture. The use of effluents with less salt and sufficient nutrients can be effective in increasing crop yields (Fereyduni *et al.*, 2012).

5. Reducing the burden of pollution on the environment:

The use of wastewater on the one hand prevents the discharge of wastewater into the environment and on the other hand reducing and stopping the use of organic and chemical fertilizers prevents the destructive effects of chemical fertilizers on the environment (Moftahi, 2011).

The effect of treated wastewater and nitrogen on the chemical properties of soil and cotton plants was investigated. The main treatments include 4 irrigation levels with treated effluent (25, 50, 75 and 10% of available soil water) and four levels of nitrogen (0, 150, 300 and 450 kg/ha) plus treatment with 100% of available soil water and increase of 300 kg/ha Nitrogen was considered as a control. The effect of different levels of nitrogen on all parameters was significant (Sepaskhah *et al.*, 2006). A study was conducted to investigate the economic benefits of using treated effluent as one of the unconventional water sources in cotton irrigation. The results showed that the yield of wastewater treatment without adding fertilizer was not significantly different from the treatment with fertilizer (Blumenthal *et al.*, 2000). Effluents are composed of 99.9% water and 0.1% impurities, which mainly contain suspended solids and colloids. Also, gases and microorganisms constitute a small part of the effluent (Tavakoli and Tabatabai, 1999). Effluents contain the main nutrients (N, P, K) as well as micronutrients that are an advantage in the use of wastewater in agriculture and save on the use of chemical fertilizers (Gideon and DeMalach, 1987).

Tasadilas and Vakalis by examining the treatments of treated wastewater without adding fertilizer, water by adding fertilizer, treated wastewater by adding part of the plant fertilizer requirement, treated wastewater by adding the complete requirement of plant fertilizer and water without adding fertilizer to as the control treatment on cotton yield, they concluded that the yield of one to four treatments increased by 22.55, 41.16, 36.53 and 44.97%, respectively, compared to the control treatment. Also, in this experiment, the amount of performance of treatments two and four and also treatments two and three were not significant at the level of five percent probability (Tsadilas and Vakalis, 2003).

Bielorai et al. (1984) studied the effect of drip irrigation with treated municipal wastewater on the cotton plant over three years. Treatments included three water levels (350, 440 and 515 mm) and five nitrogen levels (0, 90, 150, 180 and 230 kg/ha) plus one control treatment (irrigation with water without fertilizer). Plant height and vegetative growth of treated irrigated wastewater were higher than water irrigated plants. Also, the yield of the cotton plant under the conditions of using treated wastewater was higher than the treatments irrigated with water, but this difference was not significant in the level of probability of five percent. Amir et al. (2005) examined heavy metals in municipal wastewater waste and stated that heavy metals such as cadmium and lead are significantly present in wastewater waste.

Khalid Bin et al. (1982) in the study of treated wastewater treatment on the cotton plant which includes four treatments of effluent without adding fertilizer, water with added fertilizer, effluent with adding part of plant fertilizer requirement, effluent with adding complete fertilizer requirement and water without adding fertilizer to The title of control treatment on cotton yield showed that the yield of one to four treatments increased by 22.55, 41.16, 36.53 and 44.97, respectively, compared to the control treatment. Also, in this experiment, the yield of two and three treatments increased (not significant at the 5% level). The same results were reported for other plants (Inyinbor *et al.*, 2019; Pedrero *et al.*, 2010).

Gideon and DeMalach (1987) in another study to investigate the effect of drip irrigation with domestic treated wastewater on cotton plants and the results showed that the weight of cotton bolls was not significant in all treatments but the yield was significant. The same results were reported for other plants (Inyinbor *et al.*, 2019).

Another study to investigate the effect of drip irrigation with treated municipal wastewater on cotton plants showed that with increasing the amount of nitrogen received, the yield decreased compared to other treatments and increased vegetative growth (Elgallal *et al.*, 2016).

Also, in wastewater treatment, the amount of cotton grain and fiber yield increased compared to healthy water treatments (Christou *et al.*, 2017).

4. Conclusion

Based on the results of the research and referring to the research records, it can be stated that the treated municipal effluent as one of the sources of unconventional water for irrigation increases the yield in the cotton plant. Also, the use of the treated effluent in the cotton plant in increasing the number of bolls per square meter, leaf index and plant height in treatments irrigated with treated effluent shows a high significance and also has increased the yield of cotton fibers per unit area, due to the positive effect on vegetative growth. Also, yield and reproductive growth in cotton plants can be recommended to the use of treated effluent in irrigation to farmers and its effect on water efficiency is positive, but due to the heavy elements in soils irrigated with treated effluent. It accumulates and destroys the soil texture to some extent and suffers from environmental degradation, so to prevent this, the percentages of mixed effluent with well water can be used, which can have both high performances and up to somewhat prevented the accumulation and toxicity of the soil because full irrigation with the treated effluent causes the accumulation of heavy elements in the soils under cotton cultivation and to prevent this, the mixing percentages of 50% of the effluent and 50% of the well water are used. It has the highest efficiency and the lowest toxicity for the soil and can be prevent soil toxicity.

Promotable findings and practical recommendations:

The treated effluent increases the yield of cotton plants, so it is recommended that in arid and semi-arid regions such as South Khorasan province, this unconventional water source should be used as one of the irrigation methods by farmers, also due to the accumulation of heavy elements in farms. Irrigation bed It is recommended to use the percentages of mixed effluent mixed with well water to prevent soil toxicity.

Conflict of interests

All authors declare no conflict of interest.

Ethics approval and consent to participate

No human or animals were used in the present research.

Consent for publications

All authors read and approved the final manuscript for publication.

Availability of data and material

All the data are embedded in the manuscript.

Authors' contributions

All authors had an equal role in study design, work, statistical analysis and manuscript writing.

Informed consent

The authors declare not to use any patients in this research.

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