Chapter

Investigating Issues and Problems of Using Sewage Effluent in Agriculture

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Abstract

The ever-increasing growth of the population and the rapid development of industries are important factors that have caused an increase in water consumption and wastewater production in communities. On the other hand, in countries located in arid and semiarid regions, available water resources are limited. Therefore, the use of non-conventional water resources (sewage) in these countries is becoming more important day by day. The use of wastewater as a permanent source of water in agriculture, in addition to providing a part of water needs, also saves and sustains water resources. In this research, the effluent of the wastewater treatment plant of Arak city in the central province of Iran was studied in order to check its quality and usability in agriculture. The quality of the effluent was compared with the standards. The results of the research showed that the above wastewater has no restrictions for use in agriculture according to the investigated parameters. This text is compiled based on the results of various research studies conducted in different parts of the world. Finally, the challenges and opportunities of using wastewater in agriculture and providing suitable solutions to reduce the problems have been discussed.

Keywords: irrigation, sewage, sewage treatment plant, soil pollution, water quality

1. Introduction

1.1 What is sewage?

Wastewater is water used for specific consumption that cannot be reused. Because this water is often impure and has an unpleasant smell, it is also called sewage.

Wastewater composition: Wastewater consists of approximately 9.99% water and other solid materials, some of which are organic materials and the other part are solid minerals dissolved or suspended in water. The bad smell of sewage is often due to organic substances in it. The source of wastewater may be domestic, industrial, agricultural, or combined. In terms of physical, chemical, biological, and polluting properties, it has four states: weak, medium, strong, and very strong. In this article, emphasis is placed on the most common type of treated wastewater, which originates from urban wastewater. This wastewater is water that contains human body waste (excrement and urine) and wastewater resulting from sanitary measures such as bathing, washing clothes, cooking, and other kitchen uses.

Today, the problem of water shortage and environmental destruction is considered as one of the biggest problems of human societies. In the last century, due to the increase in population growth and the development of the range of human activities in different sectors, the per capita consumption of water has increased greatly. The increase in per capita consumption as well as indiscriminate use of water resources has caused the quantitative and qualitative crisis of water resources to appear in many regions of the world, especially in places that naturally face unfavorable climate and limited water resources. Effluent from urban sewage treatment plants is a great source of water that can be used in agriculture and green space. In this situation, wastewater treatment and recirculation are the most important solution in the development of water resources management, which can play an important role in water scarcity problems [1]. The use of wastewater in agriculture is common in many countries of the world, including the United States of America, Canada, France, Germany, Mexico, Brazil, Egypt, Morocco, Jordan, Saudi Arabia, Qatar, China, etc. [2–8]. In the country of Iran, in recent years, due to the limitation of water resources, population growth, development of urbanization, industries, and agriculture, as well as the development and implementation of numerous plans for the collection and treatment of wastewater, the use of wastewater in agricultural lands has become particularly important and is in the priorities of the program. A study was conducted to identify the state of sewage treatment and the quality of production effluents in Kish Island. The results of this study showed that the quality of wastewater in Kish Island was consistent with the reuse standards of the Environmental Protection Organization for irrigation in all parameters except the total number of coliforms and fecal coliforms. Compared to the standards of the World Health Organization, the said effluent is suitable for drip irrigation and tree irrigation, and it was not found suitable for watering sports fields and green spaces of hotels. Amjad et al. (2006) by examining the facilities and capabilities of reusing urban wastewater in Yazd showed that the quality of the wastewater compared to the standards of the Environmental Protection Organization for reuse in agriculture and irrigation is suitable for irrigation and agriculture [9]. Alaton et al. (2007) studied the effluents of four selected refineries in Turkey and showed that the results are appropriate in terms of common control parameters and heavy metal concentrations. However, the wastewater of selected treatment plants has not been satisfactory in terms of microbes, especially fecal coliforms [1]. Hong Yong and Abbaspour (2007) analyzed the potential of reuse in Beijing city by applying linear programming model. The results of this study evaluated the effective and key factors of reuse potential and provided the basic foundations of this evaluation in other Chinese cities as well [10]. Almas et al. (2006) investigated the performance of sewage stabilization ponds (WSP) in Aden city with experiments on effluents and showed that it is possible to use effluents for limited irrigation [11]. Due to the differences in climatic, plant, social, cultural conditions, soil quality, and the variability of wastewater characteristics from one region to another and even over time in one place, it is wrong to only rely on the application of the instructions provided in other regions of the world, and in the long term, it causes irreparable damage to soil and water resources [12]. Although the use of wastewater in the agricultural sector has many advantages, it is because such waters contain substances such as salts, sodium, chlorine, boron, pathogenic microorganisms, and in some cases, heavy metals or organic and inorganic compounds. Another disadvantage is that their unplanned use can cause very adverse environmental consequences, many of which will not be possible to compensate for, at least in the short term. Salinization of soils, destruction of soil structure, poisoning of plants, and reduction of their performance, pollution of surface and underground water sources, and spread of diseases are prominent examples of these effects. For this reason, in order to prevent short-term and long-term adverse effects of wastewater use, special plans and provisions should be considered. In this article, mainly the challenges associated with the application of wastewater in agriculture are examined and the points that are necessary to be followed in the planning and management of wastewater application plans are discussed, and not paying attention to them will prevent the achievement of the goals of the sustainable development program of agriculture. It creates ambiguity. The general purpose of reuse of wastewater in agriculture is to optimize and preserve the availability of water resources by returning the wastewater flows to the ground and rational use of freshwater resources. Experience has shown that the presence of significant amounts of substances such as phosphate, potassium, and nitrogen in wastewater, which all play a valuable role in the fertility of agricultural land, has been effective in increasing the amount of crops. On the other hand, due to the provision of water for agriculture, new lands can be cultivated, and this will play a key role in controlling the migration of villagers to cities.

2. Location of the area

The location of Iran in a dry and semiarid climate and severe pressures on renewable water sources as a result of recent droughts and the increasing development of urbanization, today the optimal use of available non-conventional water such as urban sewage and Home has been taken into consideration. The reuse of wastewater in the study area of this research is considered important in order to meet the increasing needs of water. At the time of conducting this research, the effluent of Arak sewage treatment plant was randomly used by downstream farmers after being discharged to Mighan desert. Therefore, in order to prevent threats to public health, soil contamination, the entry of pollutants into water sources, and the contamination of agricultural products, it is necessary to reuse it consciously and with the necessary investigation along with the quality control of the effluent at the source. In this research, the wastewater treatment plant of Arak city was studied in order to check its quality and usability in agriculture. The present research is cross-sectional descriptive and sampling of wastewater and conducting tests to determine the quality of wastewater and compare it with the standards.

Arak is one of the cities of Central Province in Iran. The study area of North Arak is an agricultural pole. The water used and needed by different departments is provided exclusively from underground water. Therefore, the limitation of water resources in agriculture and the increasing need for water in the industrial sector have become the concern of the provincial officials. Arak sewage treatment plant is located 10 kilometers north-east of the city (**Figure 1**). This treatment plant with the capacity to treat the wastewater of 105,000 people and receiving wastewater from a number of industries has about 75,000 cubic meters of treated wastewater per day, which is released into the environment and finally flows into the Meghan desert lake. Many lands in the villages around the refinery are barren, and cultivating them can be an effective help in creating employment.

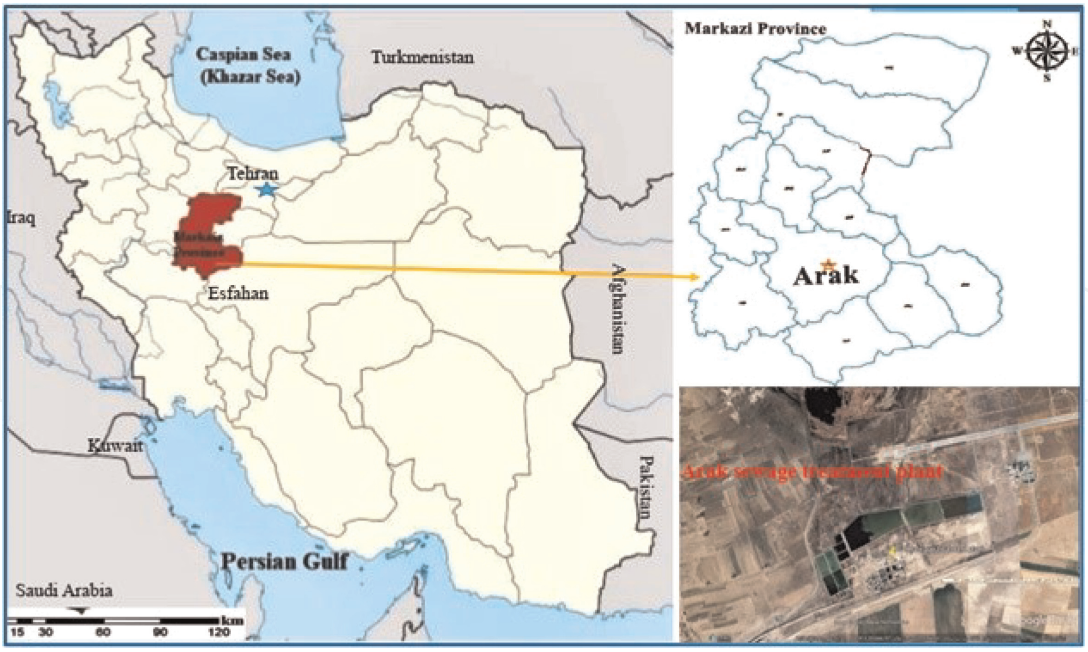

Figure 1.
The location of Markazi Province in Iran.

3. Method of work

This study was a cross-sectional descriptive study. Sampling of wastewater treatment plant effluent in order to determine the required parameters for quality determination in the two cold seasons of autumn and winter 2013 and hot spring and summer 2013 in order to influence the maximum and minimum ambient temperature conditions on the performance of the treatment plant and finally the quality of the effluent. It was done monthly. The samples were prepared in composite form at 6-hour intervals (four times a day) and after the required protection, they were transferred to the laboratory. Samples related to microbial tests were collected in sterile containers and kept at a temperature of four degrees Celsius and transported to the laboratory. The samples related to heavy metal testing were transferred to the laboratory by adding nitric acid and bringing the pH below two. Also, the COD test samples were transferred to the laboratory by adding sulfuric acid and bringing the pH below 2. Some parameters such as dissolved oxygen, temperature, and pH were determined with portable devices on site. All experiments were performed based on the methods recommended in the 2005 standard method book (**Figure 2**). In order to determine health risks, microbial indicators (total coliforms and feces) and heavy metals cadmium, lead, and copper were quantified in terms of their importance. BOD5 and COD parameters were measured to determine the amount of organic substances in the effluent. The analysis of the results was done in the Excel environment, and the statistical indicators including the mean and standard deviation were obtained. It is possible to make a decision about the usability of wastewater in different options based on the results of the tests conducted on the wastewater and comparison with the standards. Various standards for using wastewater in different fields have been provided by international organizations such as EPA, WHO, NAS, and FAO, as well as the quality standards of Jordan for the use of treated domestic wastewater in irrigation. In our country, the standard for the use of wastewater in agriculture and irrigation has been provided by the Environmental Protection Organization. The analysis is based on

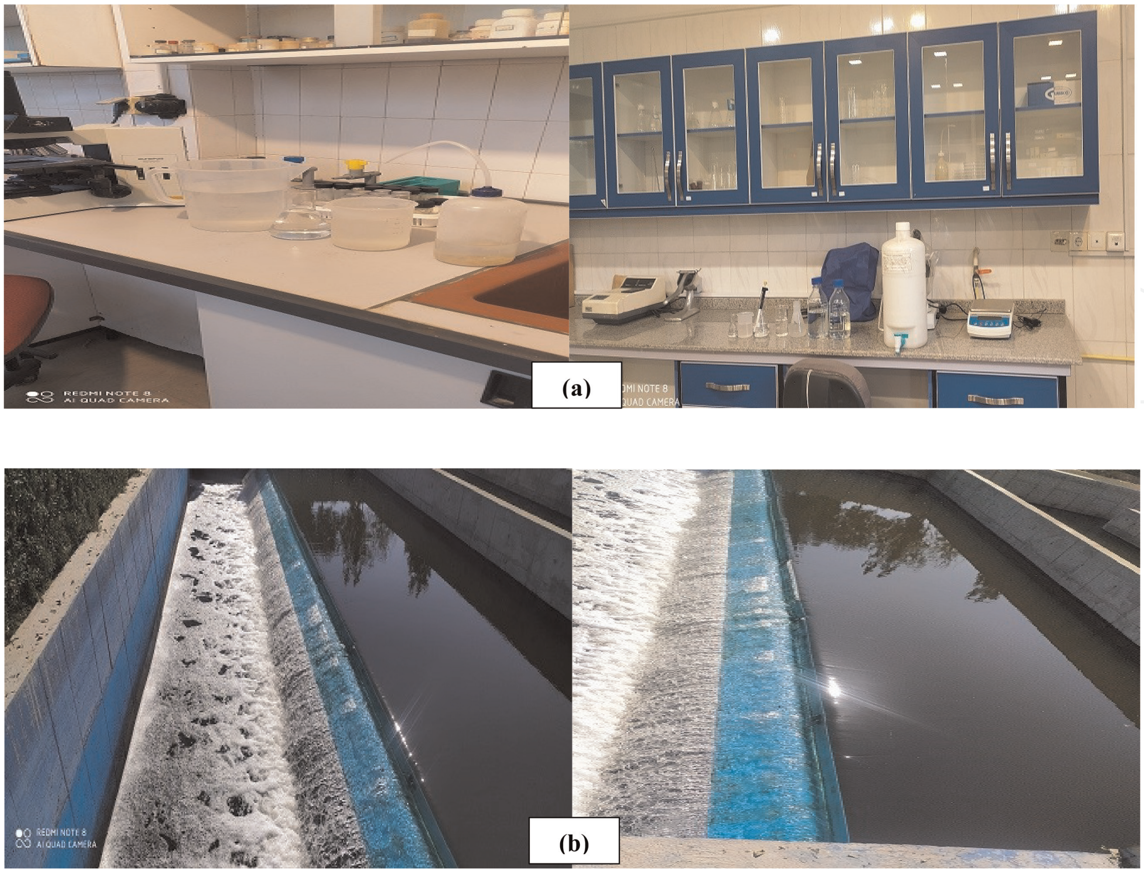

Figure 2.
Sampling and preparation of wastewater samples to send to the laboratory.

existing standards including WHO (World Health Organization), EPA (US Environmental Protection Agency), IRNDOE (Iranian Environmental Protection Organization), NAS (US National Academy of Sciences), FAO (World Food Organization), JORS (Jordanian Environmental Standard), and the vice president of strategic planning and supervision.

4. Results and discussion

Tables 1 and **2** show the comparison of the effluent quality of Arak sewage treatment plant with the standard of Iran Environmental Organization regarding reuse in agriculture. According to **Tables 1** and **2**, the average total and fecal coliforms were 878.9 and 379.6 per 100 ml, respectively, with a standard deviation of 17.2 and 11.4. The average parameters of COD and BOD5 were 49.6 and 23.3 mg/liter, respectively, and the standard deviation was 6.12 and 2.19. Therefore, it is below the recommended limits of 1000 total coliforms and 400 fecal coliforms per 100 ml. Parasite eggs in the samples taken from the sewage are less than the standard with an average of 0.5 and a standard deviation of 0.1134. The average of heavy metals cadmium, copper, and lead were 0.0564, 0.08, and 0.513 mg/liter, respectively, and the standard deviation was 0.0147, 0.0361, and 0.0921. It complies with the standard of the environmental organization in this field. The average values of pH, turbidity, and dissolved oxygen parameters in wastewater were 7.55, 21.31 NTU and 5.14 mg/L with standard deviation of 0.304, 10.3, and 1.2, respectively, which are all in

Parameter	Unit	Standard	Average cold season	Standard deviation cold season	Average warm season	Standard deviation of the hot season	Average for the whole year	Standard deviation of the whole year
COD	(mg/L)	200	48.41	5.20	52.6	7.44	49.6	6.12
BOD5	(mg/L)	100	22.79	2.10	24.4	2.12	23.3	2.2
PH	0	6-8.5	7.63	0.24	7.4	0.36	7.5	0.30
DO	(mg/L)	2	1.94	0.12	1.9	0.16	1.9	0.13
Total coliform	Amount per 100 m	1000	880.58	17.1	874.8	17.60	878.9	17.2
Fecal coliform	Amount per 100 m	400	375.33	9.49	389.7	8.957	379.558	11.3
parasite eggs	Number per liter	<1	0.508	0.121	0.06	0.086	0.524	0.11
Pb	(mg/L)	1	0.5	0.093	0.54	0.086	0.513	0.09
cu	(mg/L)	0.2	0.068	0.02	0.11	0.05	0.08	0.04
Cadmium	(mg/L)	0.05	0.058	0.014	0.05	0.017	0.056	0.015

Table 1.
Comparison of the quality of Arak wastewater treatment plant effluent with the standard of Iran Environmental Organization.

accordance with the standard of the Environment Organization. Life has been consistent in these areas. According to **Table 2**, the values of bar, chromium, and oil in the laboratory samples are lower than the standards, and in terms of these parameters, there is no problem in different uses. Also, the average values of the elements in the treated wastewater have been compared with the existing standards (**Figure 3**). The results show that there is no problem in terms of use for agriculture. In **Figure 4**, the comparison between the average values of heavy elements in treated wastewater in two hot and cold seasons has been done, the results show that cold and heat do not have a great effect on the elements. **Figure 5** compares the average values of the elements in the treated wastewater in different seasons. The results show that the average values of the above eight parameters have the least amount of change in the whole year. The same results can be seen in the two parameters of total coliform and fecal coliform. **Figure 6** shows the comparison of the average values of elements in treated wastewater in different months of the year. Except for cadmium, DO, and pH elements, the results show the highest value in July and the lowest value in February. Of course, in the case of the COD parameter, the highest value happened in September.

5. Discussion

According to **Tables 1, 2** and **Figure 3**, the factors in the effluent are within the appropriate range compared to the existing standards. Therefore, from the chemical point of view, the use of wastewater in agriculture has no special limitations. From the microbial point of view, considering that the products that will be irrigated with wastewater are fodder products or products that cannot be consumed raw by humans,

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Standard limit											**Observation rate**	**Parameter mg/L**	**Row**
Planning deputy				**Agriculture**									
Industrial use	**Aquifer nutrition.**	**Back to surface water.**	**Green space and recreational area**	**agriculture**	**JS**	**FAO**	**NAS**	**IRNDOE**	**EPA**	**WHO**			
0	1	2	0.7	1	1	0.7	0	1	1	0.7	0	(B)	1
10	10	10	0	10	0	0	0	10	0	0	<1	(Oil)	2
0	1	0.5	0	1	0.1	0.1	0.1	1	0.1	0.1	<0.1	(Cr)	3

Table 2.
Comparison of observed values of quality parameters of wastewater with existing standards.

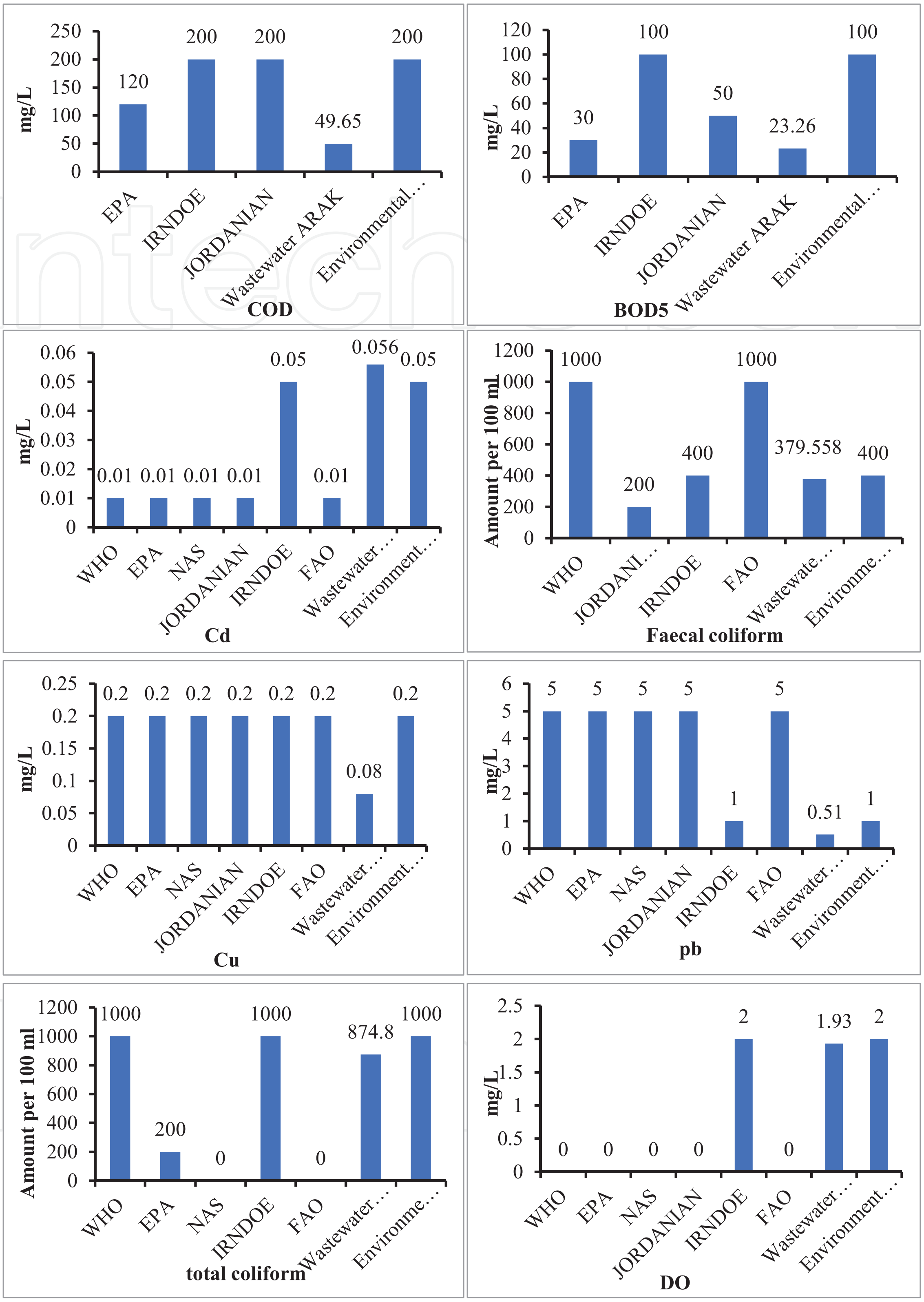

Figure 3.
Comparison of the average values of the elements in the treated wastewater with the existing standards.

it can be said that the transmission of pathogenic bacteria is very weak and there is a limit for the use of wastewater in agriculture, green space, and artificial feeding of underground aquifers does not. Considering that the daily flow rate of the effluent from the treatment plant is 1000 liters per second, and the average hydromodulus of

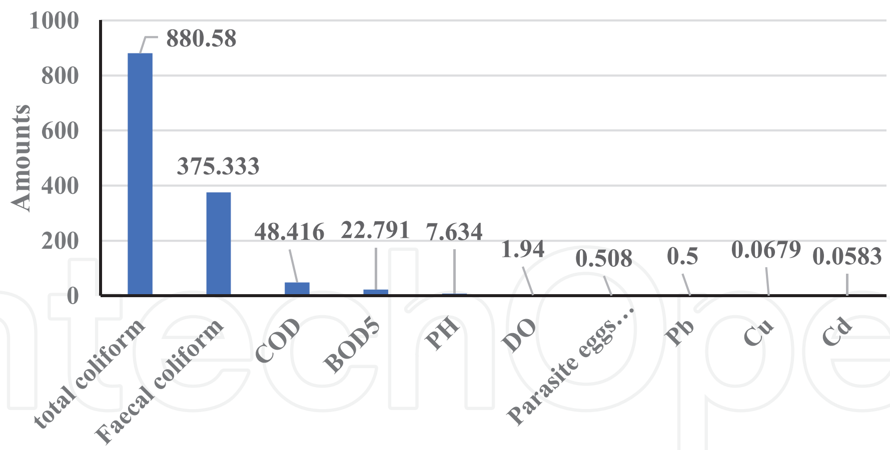

Figure 4.
Comparison of the average values of the elements in the treated wastewater in two hot and cold seasons.

crops in the region is 1.4 liters per second per hectare in the month of August, it is possible to use this water in the cropping season for about 714 hectares of land. He allocated the lands that are barren due to lack of water in the villages around the treatment plant to agriculture and green spaces, and in the non-agricultural season, he used this water for the artificial feeding of the underground aquifers or to the Miqan desert. By artificially feeding the underground aquifers around the desert, the advance of salty water to the underground aquifers of the surrounding villages is prevented. If the effluent is allocated to the irrigation of only one crop, with about 86,400 cubic meters of treated wastewater per day, according to **Table 3**, approximately 4198 hectares of wheat or 1998 hectares of alfalfa or 3679 hectares of clover or He irrigated 16,898 hectares of fodder corn or 18,814 hectares of sunflowers or 30,115 hectares of spruce or 30,586 hectares of walnut trees.

In the application of wastewater for agriculture, the selection of plants should be in accordance with the principles that do not cause contamination of the irrigated crops with pathogenic agents and transfer to the consumer. Therefore, according to the information obtained from the quality of wastewater, compared to the standards of the World Health Organization, the said wastewater is suitable for drip irrigation and tree irrigation, but not suitable for watering sports fields and green spaces of hotels. Also, watering vegetables and products that are consumed raw are not recommended at all. Irrigation of root crops such as potatoes and sugar beets is also not recommended due to direct soil contact. Due to the fact that wheat, barley, and legumes are not consumed directly, they can be cultivated with the effluent of this refinery. It is important that in all cases of application, irrigation with wastewater should be stopped at least 2 weeks before harvest (WHO publication, 2006) [13]. Irrigation of fruit gardens is recommended, but irrigation of fruits that are consumed fresh is not recommended due to the possibility of soil contamination. Trees whose products are consumed as dry fruits such as walnuts and almonds can be suggested. Timber trees such as cypress, pine, elm, and fir can be irrigated with wastewater without restrictions. Also, irrigation of industrial crops such as cotton has no restrictions. Although in this study, the concentration of heavy metals was lower than the recommended standards of the Environmental Protection Organization, but due to the cumulative effect of these elements, the first priority is to irrigate non-edible industrial plants such as cotton and wood trees (WHO publication, 1989) [14].

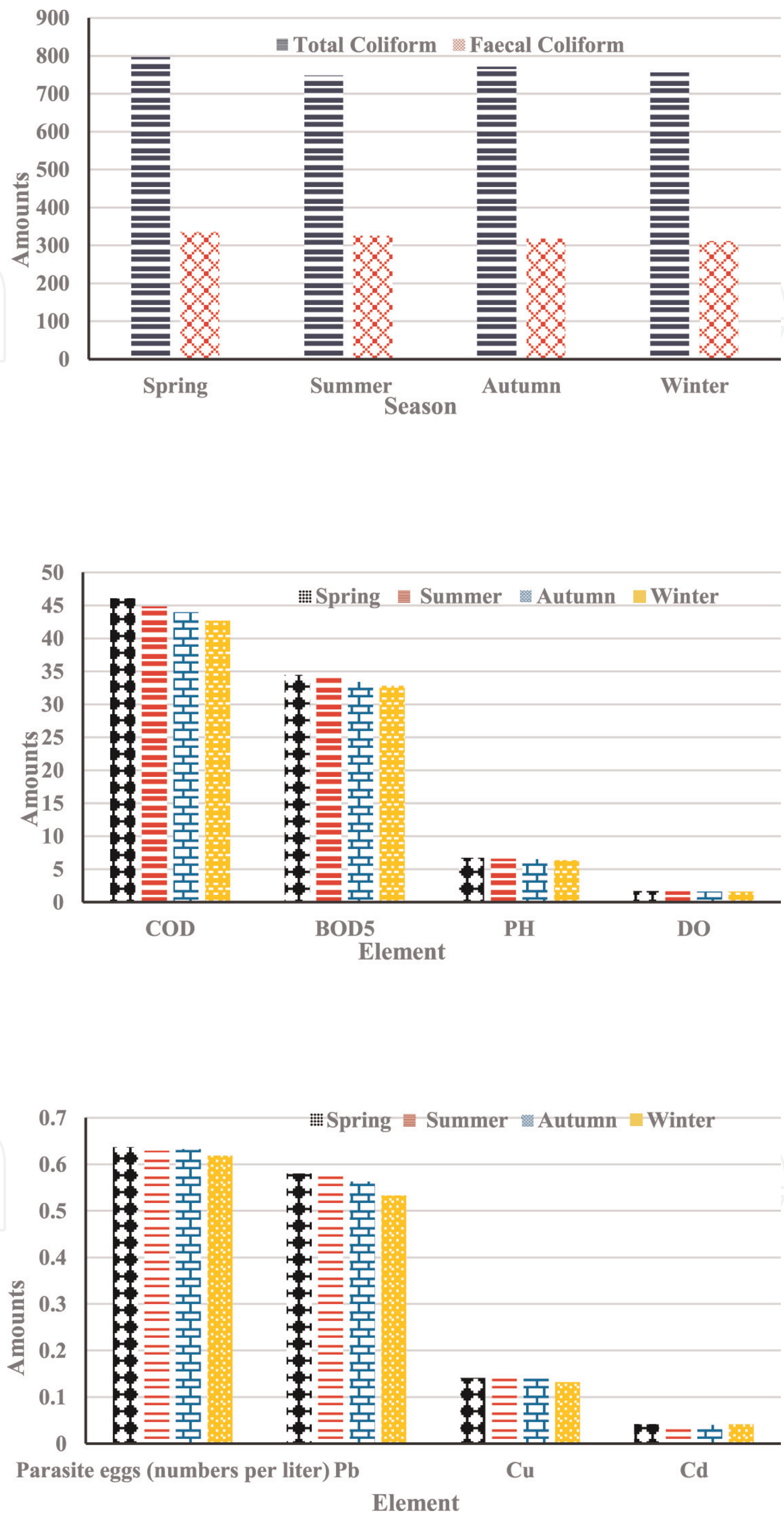

Figure 5.
Comparison of the average values of the elements in the treated wastewater in different seasons.

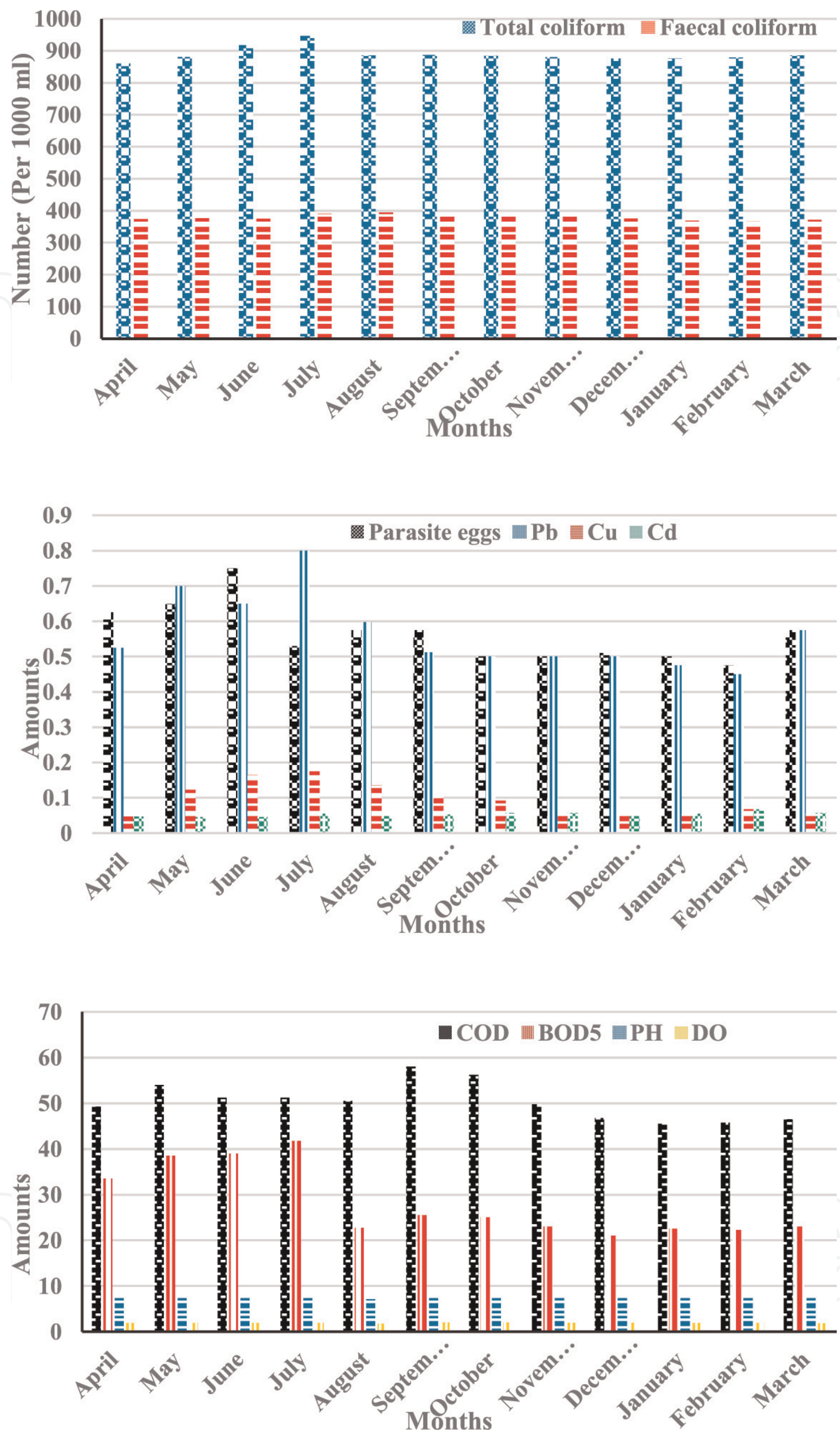

Figure 6.
Comparison of the average values of the elements in the treated wastewater in different months.

5.1 Mixing the wastewater of this treatment plant with primary water

Suitable quality water or primary water can be used directly for product production. On the other hand, raw water mixed with wastewater can be reused. This

Cultivable area (ha)	Pure water required (m^3/ha)	Growth period (Day)	Product name
4198	6520	240	Wheat
1998	13,700	260	Wheat
3679	7440	270	Clover
16,898	6080	110	Fodder corn
18,814	6770	130	Sunflower
30,115	10,830	—	Walnut tree
30,586	11,000	—	Fir tree
714	Average crop yield with hydromodule is 1.3 liters per second per hectare		

Table 3.
Water required for the production of some agricultural products.

combination is possible in two ways: periodic use and mixing. In intermittent use, two water sources are used alternately during the growing season (intra-seasonal intermittent use) or both water sources are used separately during the seasons for different plants (inter-seasonal intermittent use). Choosing a safe option for reuse depends on several important factors, which include: the quality of wastewater, plant resistance to the amount of materials in the wastewater, and the amount of access to freshwater sources. For example, in a place where wastewater is supposed to be used as irrigation water in a cropping season, the important issue is whether the wastewater is used directly or intermittently. The direct use of wastewater is usually done at the farm level without mixing with suitable primary water. The results of the research conducted in India, Pakistan, Central Asia, and Egypt show that surface irrigation with the direct use of wastewater is possible without reducing the yield if the salinity of the wastewater does not exceed the tolerance threshold for the desired plants and the conditions. Drainage should be in good condition. Since plants are more sensitive to salinity in the early stages of growth, according to the research conducted in India, pre-irrigation with water of appropriate quality is of particular importance. In order to obtain a higher yield, it is necessary to pre-irrigate with suitable water and to use wastewater in the subsequent periods of irrigation. Under such conditions, it is possible to use wastewater with a salinity level higher than the plant's tolerance threshold for salinity while preserving the product. Mixing wastewater with water of a suitable quality in such a ratio that the substances in the resulting irrigation water are less than the tolerance threshold of the plant is an acceptable practical method and has been used by many. The option of mixing primary water with wastewater is another management and practical method. It is easy to use because in this method a tank is not needed to mix water from two sources. In addition, many scientists have used good-quality water during the critical stage of plant growth and low-quality water in other growth stages. When the effluent quality is higher than the threshold tolerance value for optimal product production, it can be mixed with other available water sources so that it has an acceptable quality for growing the desired plants. When the mixing operation is carried out at the field level, the water quality can be modified as much as the tolerance limit for the quality of each of the plants. Intermittent use, which is also known as intermittent, is a method that provides the possibility of combined use of suitable wastewater. In this method, wastewater replaces primary water in a predetermined cycle. Intermittent use is used in cases where the effluent quality has exceeded the tolerance of the plant threshold. The intermittent method of using wastewater can be used intra-seasonally and inter-seasonally.

6. Challenges of wastewater application

6.1 Adverse effects on soil, plant, and public health

In the reuse of wastewater in agriculture, due to its inherent characteristics and also due to the occurrence of processes such as decomposition of organic substances, ion exchange, oxidation of minerals, sedimentation, filtration, etc., in the soil system, soil properties can be affected and change especially in the long term. Many researchers in different parts of the world have studied and analyzed the effects of wastewater on the physical, chemical, and biological properties of soil. The increase of soil salinity and sodium as a result of irrigation with wastewater, which respectively causes conditions of reduced water availability for plants and destruction of soil structure, has been reported by various researchers [15–17]. Saber during his research on irrigation with wastewater in Cairo showed that with the increase in the years of using wastewater, the amount of dissolved salts in the depth of 0–20 cm of the soil, significantly up to about three times, compared to non-irrigated soils. It has increased [18]. The results of Ebrahimizadeh et al.'s research (1) also indicate that as a result of irrigation with wastewater compared to conventional water, soil salinity in the layers of 20–40 and 40–60 cm and SAR and sodium in the soil at depths of 0–20, 20–40, 40 and 60 cm has had a significant increase [19]. Smart compared the properties of soils in the northern Adelaide area in Australia that were irrigated with water or wastewater, reported that irrigation with wastewater increased the salinity, sodium, and boron content of the soils in the region, although the observed increase was still to a certain extent. It has not affected the performance of agricultural products. But the observed increase in sodium and SAR of the soil is alarming in terms of the destruction of the soil structure and the reduction of its drainage capacity [20]. The study and research conducted on the soils of the Moose Jaw region in the Canadian state of Saskatchewan, which has been irrigated by wastewater in an area of about 1200 hectares since 1982, have shown that the soil salinity has increased significantly so that the average EC Soil has reached from 0.75 to 1.6 in 1997. More salt accumulation is reported in the 1 meter surface layer of the soil. The results of investigations on shallow underground waters in the mentioned area also indicated an increase in sodium, chloride, sulfate, and bicarbonate concentrations. Also, the studies conducted in connection with another big project that started in Swift Current in the same state in 1978 in an area of about 338 hectares indicate that there has been a significant increase in soil salinity in some places. In the recent region, the amount of chlorine, hardness, sodium, sulfate, and manganese in shallow underground water has increased [21]. In his research in Australia, Patterson concluded that the high SAR in the effluent from domestic sewage treatment plants leads to a decrease in the saturated hydraulic conductivity of the soil, so that with the increase of SAR from zero to 3, the hydraulic conductivity The saturation is 50%, and if it increases to 15%, the hydraulic conductivity is reduced by 75% [22]. In Parvan's research report, it has been reported that saturated hydraulic conductivity decreased by 30% in the surface layer of the soil due to long-term irrigation with wastewater [23]. Alizadeh et al. showed in their research that corn irrigation with the treated wastewater of Mashhad city for 2 years resulted in a 156% decrease in the permeability of the soil compared to the time before the beginning of the research [24]. Shadkam and others also observed a significant decrease in the hydraulic conductivity of the studied soils as a result of irrigation with wastewater [25]. Gholamhossein and Al-Saati in the study of the characteristics of production wastes in Saudi Arabia reported that the use of such wastes due to the inappropriate amount of salinity and sodium can increase the salinity of the soil and change the exchangeable sodium percentage of the soil. Therefore, they recommended the use of wastewater only as auxiliary water [26]. Moadad and Hanifeh Lu in the investigation of the quality of the effluent from the wastewater treatment plant west of Ahvaz city for use in agriculture came to the conclusion that in terms of some parameters such as sulfate, chloride, and salinity, the said effluent exceeded the standards of the Environmental Protection Organization of Iran [27]. And especially in terms of salinity, according to Ayers and Westcott irrigation water quality guidelines, it is evaluated as having a very bad outcome. In the reuse of wastewater, the pH of the soil can also be changed. Since the availability of nutrients required by the plant as well as the solubility of many elements and toxic compounds depends on the pH of the soil, changing this parameter can reduce the absorption of the nutrients required by the plant and in this way or by affecting the availability Toxic elements and compounds affect plant growth and performance [28]. The studies of Saber show that the irrigation of the lands of Cairo city with sewage has led to a decrease in the pH of the soil, but in the investigations carried out by Mahida, an increase in the pH in dry and semiarid soils of India due to irrigation with wastewater was reported. Irrigation with wastewater, especially due to the chlorination process in treatment plants, can increase the concentration of this element in the soil and reach the level of toxicity for plants [29]. Agricultural plants and fruit trees are sensitive to chlorine ion, and if the amount of this element in the saturated soil extract reaches about 10, it causes poisoning for many plants [28]. In his research work on the long-term effects of wastewater, Parvan has reported an increase in the amount of chlorine in different depths of the soil. Among the other impurities that are found in the wastewater of treatment plants, especially in industrial areas, stone metals.

7. Standards and guidelines

Standards and guidelines for reuse of wastewater in agriculture are very different in different countries of the world. One of the most important common guidelines regarding the physical and chemical parameters of irrigation water is Ayers and Westcott's guideline, which is summarized in **Table 4**. Because Ayres and Westcott's guidelines are based on many studies and researches and taking into account factors such as leaching percentage, changes in soil permeability due to EC and SAR, plants' tolerable capacity against salinity, sodium, and bar toxicity and other trace elements have been developed, it can be a suitable basis in evaluating the quality of wastewater for use in agriculture [28].

Regarding the microbiological parameters of sewage and effluent due to their importance in public health, guidelines have been provided by various organizations such as WHO and American EPA for use in agriculture, which are shown in **Tables 4–6**, respectively. The purpose of WHO in developing such guidelines is to determine the guiding indicators for design engineers to choose the appropriate technologies for wastewater treatment and for planners to choose the best management options. Comparison of the mentioned tables shows that the American EPA guidelines are more strict than the WHO guidelines [13, 14, 30]. According to the EPA, for the

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The amount of restriction in use			Unit	Irrigation problems
Severe limitation	**Low to medium restriction**	**Unlimited**		
Salinity (affecting the amount of water needed for the plant)				
>3	0.7–3	< 0.7	m/dS	ECw
				or
>2000	450–2000	0.45<	l/mg	TDS
Permeability (the effect on the rate of water penetration into the soil, which is evaluated by considering ECw and SAR)				
< 0.2	0–7.2	>0.7		= ECw 0-3 = and SAR
< 0.3	1–2.3	>1.2		= ECw 3-6= SAR
< 0.5	1–9.5	>1.9		= ECw 6-12= SAR
<1.3	2.1–9.3	>2.9		= ECw 12-20= SAR
<2.9	2–5.9	>5		= ECw 20-40= SAR
Toxicity of certain ions (sensitive plants)				
				Sodium(Na)
>9	3–9	<3	SAR	Surface irrigation
	>3	<3	me/l	Rain irrigation
				Chloror(Cl)
>10	4–10	< 4	me/l	Surface irrigation
	>3	<3	me/l	Rain irrigation
>3	0.3–7	< 0.7	mg/l	Br
Other effects (sensitive plants)				
>30	5–30	<5	mg/l	Nitrogen
				Bicarbonate
>8.5	1.8–5.5	<1.5	me/l	Rain irrigation
	Normal range			pH

Table 4.
Water quality guidelines for irrigation [28].

application of wastewater in the irrigation of plants that are not processed (for example, plants that are eaten raw), no fecal coliforms should be detectable in 100 ml of wastewater samples. Meanwhile, for watering such plants, WHO has considered the total number of fecal forms in 100 ml of wastewater to be less than or equal to 1000.

Investigations show that heavy metals are the most important harmful pollutants in urban wastewater and irrigation with these wastewaters increases its amount in plants, especially vegetables and soil. Of course, the wastewaters of small and non-industrial cities are less contaminated with heavy metals and chemical compounds. The maximum permissible nitrate concentration that can be present in drinking water is set by the US Environmental Protection Agency as 45 mg/liter. Also, according to the standard of Iran's Environmental Protection Organization, the permissible limit of nitrate for discharging into surface water is 50 mg/liter and for discharging into water

Purification methods expected to meet microbiological guidelines.	Overall fecal forms, geometric mean (number in 100 ml[c]	Intestinal nematode[b] Arithmetic mean (number of eggs per liter)[c]	Vulnerable groups	Reuse conditions	Classification
A series of stabilization sheets designed to achieve microbiological index or their equivalent treatment.	≤1000	≤1	Workers, consumers and the general public	Watering plants that are eaten raw, Sports fields and public parks[d]	A
Storage in stabilization sheets for 8 to 10 days or equivalent methods to remove worms and general fecal forms.	The standard is not recommended.	≤1	Workers	Irrigation of grains, industrial plants, fodder plants, pastures and trees[e]	B
The required pretreatment depends on the irrigation method. Minimum: initial settlement.	Not applicable	Not applicable	None	Irrigation of floor B plants provided that workers and the public are not exposed	C

[a]In special cases, epidemiological, social, cultural conditions, and environmental factors should be considered and the guidelines should be modified based on them.[b]Scaris and Nericoris species and hookworms.[c]During the irrigation period.[d]For public green spaces such as hotels, i.e., where direct public contact is possible, a stricter guideline (less than or equal to 200 coliforms per 100 ml) should be considered.[e]In the case of fruit trees, irrigation should be stopped 2 weeks before fruit picking and no fruit should be collected from the ground. In addition, rain irrigation should not be used.

Table 5.
WHO (1989) Guidelines for the Application of Effluent (Treated Sewage) in Agriculture[a] [14].

Buffer distance	Recommended Monitoring	Wastewater quality	Purification needed	Type of application
300 feet from drinking water sources and 100 feet from publicly accessible areas	• pH - weekly • BOD- weekly • Turbidity- Daily • FC Daily • remaining chlorine - Continuous	• 9-6 = pH • mg/l 30 ≤ BOD • mg/l 30 = SS • ml 100/200 ≤ FC • mg/l 1 = Cl2 Remainder	• Secondary purification • Disinfection	Irrigation: • Food plants that are processed commercially • Orchards and vineyards • pastures • Pastures for dairy cattle • Pastures for livestock
50 feet from drinking water supply wells and 100 feet from publicly accessible areas	• pH - weekly • BOD- weekly • Turbidity- Daily • FC Daily • remaining chlorine - Continuous	• 6-9 = pH • mg/l 30 ≤ BOD • NTU1 ≤ turbidity • ml 100/ (0) = FC • mg/l 1 = Cl2 Remainder	• Secondary purification • filteration • Disinfection	Food plants that are not commercially processed.

Table 6.
USEPA guidelines for wastewater reuse in irrigation [28].

Name of metal	FAO standard	Iranian standard	German standard
Pb	5	1	0.2
Ni	0.2	2	0.033
Hexavalent chromium	—	1	0.2
Fe	5	3	—
cu	0.2	0.2	0.2
Cd	0.01	0.05	0.0033
Zn	2	2	0.5

Table 7.
Allowable concentration standard of some heavy metals for irrigation with wastewater.

absorbent wells, it is 10 mg/liter. **Table 7**. It shows the permissible concentration standard of some heavy metals (mg/liter) for irrigation with wastewater.

8. Sewage pollution intensity

The intensity of sewage pollution is called the power of sewage pollution or its concentration, and the more waste materials in the sewage, the stronger it is. Usually, the strength and weakness of wastewater in terms of organic matter in it are measured according to the following indicators:

A. BOD5 (Biological Oxygen Demand)

BOD5 is the amount of oxygen needed by bacteria to decompose organic matter in wastewater. This standard is the most important tool for measuring biochemically degradable organic substances, which is commonly used in wastewater. The higher the oxygen required, the higher the concentration of organic substances in wastewater that can be oxidized by bacteria. It has been proved by experience that the BOD of a sample is different in hours and even in the early days, and today, at the global level, the value of this index within 5 days (BOD5) has been chosen as the standard. BOD5 relates the reduction of oxygen in the sample (which is consumed by aerobic bacteria in 5 days to decompose organic matter) with the concentration of organic matter that can be decomposed by bacteria, and its unit is mg/liter.

B. COD (Chemical Oxygen Demand)

Chemically required oxygen.

In this method, the amount of oxygen proportional to the chemical decomposition and stabilization of organic materials is called chemically required oxygen. This index is in milligrams per liter.

C. TSS (Total Suspended Solids)

Total suspended solids include materials such as organic particles such as plant roots, soil mineral particles, and plastic particles. Suspended solids are another

Indicators	Chemical composition of untreated urban wastewater			
	Iran (Tehran, Refinement)	Pakistan	America	France
BOD	115–300	193–762	110–400	100–400
COD	125–304	83–103	250–1000	300–1000
TSS	110–790	76–658	100–350	150–500

Table 8.
Range of BOD, COD, and TSS changes in some countries (mg/liter).

sign of wastewater quality. This index is expressed in milligrams per liter. The range of changes of the mentioned three indicators is different depending on the type of wastewater and its characteristics. **Table 8** shows the range of changes in BOD, COD, and TSS (mg/liter) in some countries.

In addition to the above guidelines, different steps have been taken in various countries in order to ensure public health and protect the environment, in the planning of wastewater application in agriculture, an example of which is the development of microbiological standards and guidelines. In terms of developing and applying such standards and guidelines, countries can be divided into several groups: (A) In industrialized and advanced countries such as America and France, standards and guidelines have been developed with a conservative point of view and based on advanced technology and high cost, as well as with low risk tolerance. (B) In some other countries, WHO guidelines, which are based on low technology and low cost, are accepted and form the basis of control [31, 32] and (C) In contrast to the above countries, the third group of countries, which mostly include developing countries, have accepted very strict standards without study and planning. Although these standards are accepted by legal authorities and are very good for having an international image, they are practically unacceptable and unenforceable due to economic and technical reasons. For such countries, perhaps the best solution is the step-by-step development of standards, which, if implemented, can effectively prevent health risks. In relation to the country of Iran, the environmental standards for the use of wastewater are very advanced and include a total of more than 50 physical, chemical, and microbiological parameters, which is ideal if implemented. But according to the existing economic and technical conditions, there are major problems as follows that do not make the implementation of the standards practical:

1. The standards have not been developed based on the economic, social, and epidemiological conditions of the country.

2. Some important qualitative parameters that are very important in terms of agriculture and soil quality, such as: EC, TDS, and SAR, are not included in the current standards.

3. It is not economically and technically possible to ensure the quality of the effluent quality parameters to meet the developed standards.

4. At present, the quality monitoring of effluents from treatment plants is only based on limited parameters such as BOD, PH, TSS, COD, total forms

and total fecal forms, and other important parameters in agriculture are not measured. Therefore, such statistics cannot be a suitable basis for evaluating the quality of wastewater for use in agriculture. It should be remembered that strict standards and advanced technology do not necessarily mean reducing environmental risks and risks associated with wastewater. Because in many cases, the lack of proper operation of sewage treatment plants, the lack of sufficient funding for the management of treatment plants and the application of appropriate monitoring systems, or the lack of enforcement of laws, cause advanced technology and developed standards to lose their practical meaning. And as a result, environmental risks increase [31, 32].

9. Lack of coordination between relevant bodies and institutions

In relation to the discussion of wastewater treatment and the use of wastewater in agricultural lands, many organizations, institutions, and groups are involved, each of which has specific responsibilities and duties and pursues specific goals. These groups are mainly:

1. Legislative and law-enforcing institutions and bodies

2. Companies and institutions responsible for supplying water for agriculture and other uses

3. Institutions and companies responsible for wastewater treatment

4. Organizations responsible for ensuring community health

5. Organizations responsible for planning for agricultural sectors, forests and pastures

6. Farmers and consumers of agricultural products

Although each of the above groups does its best within the scope of their legal responsibilities and specific goals, unfortunately, in many countries, they do not pay attention to the fact that projects such as the use of wastewater in agriculture are not projects that are only responsible for be the responsibility of a specific organization or body. These types of plans are multi-dimensional and inter-organizational plans, as can be seen from their nature, for which comprehensive planning requires full coordination between all the abovementioned organizations. It is obvious that the success in formulation, implementation, and long-term continuation of such plans, in which all legal, technical, economic, social, environmental, and health aspects of society should be considered, can be accompanied by success and continue the alliance. There should be opinions, unification of goals, and maximum effort to create coordination among the involved and officials of the relevant organizations. The result of such cooperation and coordination is the formulation and correct implementation of comprehensive and principled plans for the use of wastewater in agriculture, which leads to increasing the positive effects and reducing the environmental risks associated with such plans [28–35].

10. Sociocultural aspects

One of the important and fundamental aspects of the success of wastewater utilization programs in agriculture is the acceptance of wastewater as a source of irrigation water by farmers and the acceptance of the general public in buying and consuming products irrigated by this source [35]. To achieve this goal, it is necessary that farmers and people are fully informed about the importance of such plans and how to implement them. Also, if possible, their opinions will be collected and reviewed and used in developing programs. In line with this, education and promotion as well as gaining the public's trust in terms of ensuring their health and guaranteeing the protection of natural resources (soil, surface water, underground water, plants, etc.) can solve many social-cultural problems.

Inadequacy of statistics, information, and research.

Since the climatic conditions, characteristics of production effluents, types of crops, economic, social, technical, cultural, and health conditions of different countries are different from each other, therefore, each country cannot simply use the results of other countries' studies in their planning. Good luck. The continuity and success of long-term plans for the use of wastewater in agriculture depend on the plans being developed based on comprehensive information and results obtained from numerous short-term and long-term research conducted in local conditions. The aforementioned research should cover various topics such as: location, type of crops and cultivation pattern, environmental and health risks, determining the amount of acceptable risks, determining risk points, risk reduction management methods, costs related to different risk reduction options, localization of guidelines and standards, suitable options for training farmers and people, etc. [34, 36]. The truth is that currently in many countries, especially developing countries, regardless of the need to conduct research and obtain the necessary statistics and information, based on the belief that "because other countries have been successful, we will also be successful." Wastewater application plans are compiled and implemented without thinking and delaying, which unfortunately will affect the future generations.

The use of wastewater in agriculture for economic development purposes will only be viable if long-term conservation and preservation of resources as well as public health protection are possible. Examining the challenges associated with the use of wastewater in agriculture shows that many of these challenges can be solved with basic planning and the application of correct management methods. In such methods, an integrated control system (a set of different methods) is used to prevent, reduce, and compensate for environmental and health risks, which results in reducing costs, not requiring strict standards and ensuring the success of planning. In the integrated management system of wastewater application in agriculture, a set of different options are used, the most important of which are:

1. Using appropriate standards and guidelines,

2. Using optimal purification methods,

3. Application of appropriate cultivation patterns,

4. Using proper planting and irrigation methods,

5. Applying the necessary methods to limit the contact and exposure of workers and the public,

6. Compilation and implementation of the necessary instructions (for various relevant groups such as farmers and controlling executive agents).

Creating and implementing accurate and efficient monitoring systems. It is obvious that the selection of a suitable set of the above solutions depends on conditions such as the availability of available resources, the agricultural and social situation of the region, the prevalence of fecal-origin diseases in the region, and the market demand for products irrigated with wastewater, which must be implemented before implementation. The selected collection should be carefully examined and studied.

11. Conclusions and suggestions

According to the results of this study, chemically, the use of Arak wastewater treatment plant effluent in agriculture has no special limitations in terms of the investigated parameters. From a microbial point of view, considering that the products that will be irrigated with wastewater are fodder products or products that cannot be consumed raw by humans, it can be said that the transmission of pathogenic bacteria is very weak. It is recommended to carry out a comprehensive and accurate research on the elements present in the products harvested with sewage and the results should be provided to the users and officials. It is necessary to carry out planned reuse in a prudent manner along with quality control in the wastewater treatment stage. Finally, from the integrated control management system such as: use of appropriate standards and guidelines, use of optimal purification methods, use of appropriate cultivation patterns, use of appropriate planting and irrigation methods, application of necessary methods in order to limit contact and exposure of workers and the public and formulation and implementation of the necessary instructions (for various relevant groups such as farmers and controlling executive agents) creation and implementation of accurate and efficient monitoring systems to prevent, reduce, and compensate for environmental risks. Environmental and sanitary use. The use of wastewater in agriculture for economic development purposes will only be viable if long-term conservation and preservation of resources as well as public health protection are possible. Examining the challenges associated with the use of wastewater in agriculture shows that many of these challenges can be solved with basic planning and the application of correct management methods. In such methods, an integrated control system (a set of different methods) is used to prevent, reduce, and compensate for environmental and health risks, which results in reducing costs, not requiring strict standards and ensuring the success of planning. In the integrated management system of wastewater application in agriculture, a set of different options are used, the most important of which are: The use of appropriate standards and guidelines, the use of optimal purification methods, the use of appropriate cultivation patterns, the use of appropriate planting and irrigation methods, the application of necessary methods in order to limit the contact and exposure of workers and the public, formulation and implementation of necessary instructions (for various relevant groups such as farmers and controlling executive agents), creating and implementing accurate and efficient monitoring systems. It is obvious that the selection of a suitable set of the above solutions depends on conditions such as the availability of available resources, the agricultural and social situation of the region, the prevalence of fecal-origin diseases in the region, and the market demand for products irrigated with wastewater, which must be implemented before implementation. The selected collection should be carefully examined and studied.

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