



Original Article



Providing Water Quality Index for Water use in Agriculture: A Case Study

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Sosan Rezaei,

Email: Sousan_rezaee@yahoo.com**Abstract**

Background: Most countries face water scarcity, population growth, climate change, uneven water distribution, excessive water use, and biological, agricultural, and industrial water pollution. Using wastewater and brackish waterways for cultivation reduces pollution. Polluted water impacts human biology. Thus, they must be adequately studied before irrigating crops.

Methods: This study used the analytical hierarchy process (AHP) to assess the quality of non-conventional agricultural waters from the Karaj and Anbaj wastewater treatment plants in Iran. Water quality was evaluated based on 7 primary criteria and 52 sub-criteria. The Canadian Water Quality Index (CWQI) and the proposed model were developed from the measured parameters of the effluent from both the Anbaj and Karaj treatment plants. The data were analyzed using the Expert Choice software.

Results: In this study, chloride, fecal coliforms, and intestinal parasite eggs received the highest scores, while arsenic (As) and molybdenum (Mo) were assigned the lowest scores. The findings indicated that the effluent from the Anbaj wastewater treatment plant requires extensive treatment before being suitable for agricultural use. In contrast, the effluent from the Karaj wastewater treatment plant was of moderate quality and requires minimal treatment. This study recommends applying the proposed model to evaluate wastewater quality for agricultural purposes.

Conclusion: Researches of soil and wastewater interactions suggests that crops irrigated with wastewater may pose risks to both ecosystems and human health due to physical, chemical, and microbiological factors. These impacts can compromise soil fertility and productivity. Therefore, the use of wastewater in agricultural practices should be implemented with appropriate safeguards.

Keywords: Analytical hierarchy process method, Sewage effluent, Wastewater, Water reuse

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Introduction

Water is increasingly regarded as one of today's "crisis resources," particularly in regions experiencing growing water scarcity.¹ Simultaneously, the discharge of untreated sewage into the environment degrades both surface and groundwater flows, polluting natural ecosystems. Wastewater treatment not only addresses sewage disposal but also facilitates the removal and recycling of used water, thereby protecting the environment.² Globally, approximately 0.4 trillion cubic meters of wastewater are discharged annually, contaminating an estimated 5.5 trillion cubic meters of water. Consequently, the treatment and reuse of such vast amounts of wastewater should be a global priority.³ Previous studies have reported that an annual renewable water supply of at least 2000 m³ per person is essential for maintaining adequate

living conditions. Countries with a yearly renewable water supply of 1000–2000 m³ per person may experience frequent or localized water shortages. It is noteworthy that 1000 m³ per person per year represents the critical threshold for freshwater supply.⁴ In addition, public health and ecological risks, alongside technological, institutional, socio-cultural, and sustainability considerations, are among the most pressing concerns in this context.⁵ One of the key challenges in agricultural water management is the scarcity of freshwater resources, exacerbated by population growth and declining water quality.⁶ Maintaining a reliable supply of agricultural water is further complicated by severe droughts induced by climate change and the expansion of protected farming.⁷ In recent years, wastewater reuse for agriculture has gained increasing attention as an alternative water source



on a global scale.⁸ Moreover, recycling wastewater offers countries and regions with limited freshwater supplies the opportunity to substitute recycled water for non-potable uses.⁹ While the use of wastewater is an established practice, it has not always been adequately regulated or managed according to usage-specific quality standards.¹⁰ Globally, the depletion of freshwater resources in agriculture has driven the use of significant volumes of sewage for irrigating agricultural fields. Currently, 50 nations utilize sewage to irrigate approximately 2.0×10^6 km² of farmland.¹¹ In some developed countries, methods for treating and reusing sewage have successfully met the goals of water conservation and pollution control.¹² However, untreated sewage contains a variety of pathogens and must undergo proper filtration before being repurposed for various applications. To safeguard human health and the environment, organizations such as the World Health Organization (WHO), the European Union, the Iranian Environmental Protection Agency, and others have established regulations and guidelines for wastewater reuse.¹³

Research on the reuse of non-conventional water is crucial for mitigating risks to public health and preventing environmental damage, such as soil contamination, infiltration of pollutants into groundwater, and surface water pollution. However, a targeted management approach is essential in this domain. The reuse of non-conventional water, particularly wastewater, offers an effective alternative for waste disposal and enhancing the agricultural water supply. The objective of this study is to establish standards for the use of unconventional saline and brackish waters in Iranian agriculture, as well as to evaluate the qualitative characteristics of the water sources studied.

Methods and Materials

The classification of water quality indicators into seven categories—physical, chemical, biological, heavy metals, anions, cations, and disinfectants—serves as a tool for assessing the quality index of sewage effluent for agricultural irrigation. For this purpose, samples of incoming and outgoing effluents from the Anbaj and Karaj treatment plants were obtained from the Ministry of Energy for the year 2013. Subsequently, a hierarchical analytic method (weighting of qualitative criteria) was applied to evaluate wastewater quality, utilizing seven criteria and 52 sub-criteria related to water quality parameters. To enhance the accuracy of the final weights assigned to each parameter, a scoring range from 1 to 3 was established using the Delphi approach (where a low value of the parameter equals 3, an average value equals 2, and the maximum value of the standard limit equals 1). The product of each parameter's weight was then calculated to generate a weighted score for each parameter. Ultimately, the overall weighted score for each type of unconventional water (wastewater) determined its quality. Specifically, a total weighted score within the

ranges of 0-10, 10-20, and greater than 20 was classified as unacceptable, acceptable, and good for agricultural use, respectively. The weights of the criteria and sub-criteria were determined through the completion of the analytical hierarchy process (AHP) questionnaire using Expert Choice software and performing pairwise comparisons, with scores ranging from 1 (the lowest) to 9 (the highest).¹⁴

To investigate the effectiveness of various parameters influencing the use of unconventional waters in Iran—such as awareness, strategy, evaluation of selection, and utilization—two questionnaires were developed. These questionnaires were randomly distributed among specialists and experts at the Ministry of Energy, who subsequently completed them. The data collected from the completed questionnaires were entered into the fuzzy decision-making (FDM) software for analysis. The response options included “agree,” “completely agree,” “neutral,” and “disagree,” corresponding to point values of 4, 3, 2, and 1, respectively, within the FDM software. Due to the limited number of parameters, scores of 0, 50, and 100 were generated (Table 1).

Results and Discussion

The study examined the potential use of wastewater from two treatment plants, located in Karaj and Anbaj, Iran, for agricultural irrigation, and it was conducted in two distinct phases. In the first phase, the AHP approach was employed to assess and quantify key water quality indicators relevant to agricultural use. Specifically, the water quality parameters of these treatment plants were evaluated. The results indicated that chloride, fecal coliforms, and intestinal parasite eggs received the highest scores in terms of significance, while arsenic (As) and molybdenum (Mo) were assigned the lowest scores.

In the second phase, a customized model for Iran, termed the Iranian Agricultural Water Quality (IAWQ) model, was developed. This model was based on established methods for determining the suitability of treated wastewater for irrigation purposes. To validate the proposed model, the Canadian Water Quality Index (CWQI) was applied. Additionally, using the FDM software, several conflicting factors were analyzed to evaluate the influence of water quality parameters on the application of non-conventional water standards. The findings revealed that, among biological parameters, total coliforms held the highest rank in the wastewater quality assessment for agricultural use, whereas temperature, a physical parameter, exerted the least influence.

Evaluation of Water Quality Parameters

As presented in Table 2, chloride received the highest rating in terms of the overall objective. The general parameters of fecal coliforms and intestinal parasite (nematode) eggs followed in subsequent rankings. In contrast, the lowest rankings were assigned to the parameters of As and Mo, respectively.

Table 1. The Results of the Questionnaire, the Degree of Flexibility, and the Wide Scope of Expansion of the Use of Non-conventional Waters

Consciousness	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7	Participant 8	Participant 9	Participant 10	Participant 11	Participant 12	Mean
Is there any level of awareness in the academic and technical community in the field of unconventional waters?	0	100	100	100	100	100	0	0	50	100	0	100	62.5
Is there any research in this field?	100	100	0	100	100	100	100	100	100	100	100	0	83.33
Is there any necessary competence regarding the standard?	0	100	0	50	100	100	0	0	50	0	100	0	41.66
Is there a national standard of competence?	0	0	0	50	100	100	0	0	100	0	100	0	37.5
Strategy													
Is there a sufficient methodology for national standards?	100	100	100	100	100	100	100	100	100	100	100	100	100
Selection Evaluation													
Is there a suitable technology for using this method?	100	0	100	0	100	100	0	100	0	100	100	0	58.33
Is there suitable training for using this method?	0	0	100	0	100	100	100	100	100	100	0	50	62.5
Is it possible to use foreign technology?	0	100	100	100	100	100	0	100	100	100	100	100	83.33
Application Evaluation													
Do you agree with the use of unconventional waters in agriculture?	100	100	100	100	100	100	100	100	100	100	0	100	91.66
Is the use of unconventional waters effective?	100	100	0	0	100	100	100	100	100	100	100	100	83.33

Effect of Sewage-Irrigation on Soil Characteristics

Soil plays a pivotal role in agricultural production, serving as the foundation for a wide array of agricultural activities. It is intricately involved in numerous physical, chemical, and biochemical processes, making it a critical component in the cycling of materials and the exchange of energy. Positioned at the intersection of the atmosphere, lithosphere, hydrosphere, and biosphere, soil provides a stable environment that supports the growth and reproduction of both above-ground vegetation and subsurface microorganisms. For instance, in China, untreated sewage is frequently used for direct irrigation in agricultural practices, supporting crop development.¹²

Once chemicals dissolved in sewage migrate into the soil profile, their transference occurs primarily through four key mechanisms.¹⁵ As outlined by Keesstra et al,¹⁶ some of these chemicals are gradually reduced through the soil’s natural self-purification processes, while others are adsorbed and retained within the soil layers. A portion of these chemicals may also be absorbed by crops, with the remainder percolating through the soil to reach aquifers as water infiltrates deeper layers.

Although soil possesses a natural ability to degrade

and metabolize contaminants through various processes, including nutrient cycling and transformation, prolonged irrigation with sewage that fails to meet water quality standards can lead to the accumulation of organic pollutants, heavy metals, suspended solids (SS), and pathogenic organisms in the soil.¹⁷ The introduction of these contaminants often exceeds the soil’s capacity for self-purification, resulting in severe pollution and significant alterations to the soil’s physical, chemical, and biological properties.¹²

Research suggests that the liquid portion of wastewater comprises a complex mixture of minerals and organic matter in various forms, including large and small particles, floating suspensions, and colloidal substances. Toxic compounds commonly found in wastewater include As, cadmium (Cd), chromium (Cr), lead (Pb), copper (Cu), zinc (Zn), and mercury (Hg), among others.¹⁸ Additionally, wastewater contains a range of organic compounds, such as pesticides, nitrogenous organic matter, carbohydrates, lipids, proteins, synthetic detergents, and pharmaceuticals.^{19,20} These toxic substances pose significant risks to human health²⁰ and are often inadequately removed by conventional

Table 2. The Weight of Criteria and Indicators to Select the Most Important Quality Parameter of Water for Use in Agriculture

Main criteria				Sub-criteria	Weight	%	Score	Weighted Score
Physical				Settling subjects (SS)	0.221	22.1	1	0.221
				Oil	0.211	21.1	1	0.211
				Total suspended solids (TSS)	0.181	18.1	1	0.181
				Total dissolved solids (TDS)	0.156	15.6	1	0.156
Weight	%	Score	Weighted score	Dissolved oxygen (DO)	0.125	12.5	1	0.125
0.28	28	1	0.28	Turbidity	0.107	10.7	1	0.107
Chemical				Cholera	0.184	18.4	1	0.184
				Detergent	0.144	14.4	1	0.144
				Electrical conductivity (EC)	0.14	14	1	0.14
				Phenol	0.139	13.9	1	0.139
				pH	0.9	9	1	0.9
				Sodium adsorption ratio (SAR)	0.76	7.6	1	0.76
Weight	%	Score	Weighted score	Biological oxygen demand (BOD)	0.75	7.5	1	0.75
0.244	24.4	1	0.244	Chemical oxygen demand (COD)	0.64	6.4	1	0.64
				Radioactive	0.6	6	1	0.6
				Disinfecting	0.32	3.2	1	0.32
				Fluorine (F)	0.204	20.4	1	0.204
Anion of water				Chloride	0.168	16.8	1	0.168
				Sulfate	0.151	15.1	1	0.151
				Sulfide	0.15	15	1	0.15
				Nitrate	0.142	14.2	1	0.142
				Cyanuric	0.94	9.4	1	0.94
Weight	%	Score	Weighted score	Bicarbonate	0.7	7	1	0.7
0.118	11.8	1	0.118	Phosphate	0.21	2.1	1	0.21
Heavy metals				Zinc (Zn)	0.105	10.5	1	0.105
				Aluminum (Al)	0.1	10	1	0.1
				Copper (Cu)	0.9	9	1	0.9
				Cobalt (Co)	0.91	9.1	1	0.91
				Barium (Ba)	0.81	8.1	1	0.81
				Cadmium (Cd)	0.67	6.7	1	0.67
Weight	%	Score	Weighted score	Mercury (Hg)	0.59	5.9	1	0.59
0.113	11.3	1	0.113	Silver (Ag)	0.59	9.5	1	0.59
				Lead (Pb)	0.52	5.2	1	0.52
				Hexavalent Chromium (Cr ⁶⁺)	0.51	5.1	1	0.51
				Nickel (Ni)	0.49	4.9	1	0.49
				Boron (B)	0.46	4.6	1	0.46
				Trivalent chromium (Cr ³⁺)	0.4	4	1	0.4
				Molybdenum (Mo)	0.3	3	1	0.3
				Vanadium (V)	0.31	3.1	1	0.31
				Arsenic (As)	0.3	3	1	0.3
				Selenium (Se)	0.28	2.8	1	0.28
				Cation of water				Sodium (Na)
Calcium (Ca)	0.32	32	2					0.64
Magnesium (Mg)	0.276	27.6	2					0.552
Manganese (Mn)	0.6	6	1					0.6
Weight	%	Score	Weighted score	Iron (Fe)	0.4	4	1	0.4
0.109	10.9	1	0.109	Ammoniac	0.14	1.4	1	0.14

Table 2. Continued.

Main criteria				Sub-criteria	Weight	%	Score	Weighted Score
Biological parameters				Coliform gastrointestinal	0.24	24	2	0.48
				Parasites (intestinal Nematode)	0.23	23	1	0.23
Weight	%	Score	Weighted score					
0.098	9.8	1	0.098	Total coliform	0.19	19	1	0.19
Water disinfectant				Formaldehyde	0.18	18	1	0.18
Weight	%	Score	Weighted score					
0.037	3.7	1	0.037	Chloride	0.16	16	1	0.16

activated sludge-based wastewater treatment processes. Consequently, many of these contaminants are later detected in soils irrigated with treated wastewater.²¹ For instance, Nazari et al²² found that the Dez River, based on data collected from several stations along the Dez, Karkheh, Karun, Marun, and Zohra rivers, exhibited industrial corrosivity. Despite being of better quality than other rivers in terms of drinking water, the Dez River had elevated levels of magnesium, hardness, and Hexavalent Chromium, as determined using the Schuler diagram. Nazari and colleagues' study utilized Iran's national standards, as well as guidelines from the WHO, Environment Canada, and the Schuler and Wilcox diagrams, for comparison with our findings. The Iranian River Water Quality Index (IRWQIsc) and the National Sanitation Foundation Water Quality Index (NSFWQI) were also employed to assess the water quality of these rivers. In another study conducted in Iran to assess the impacts of rural wastewater in the Dena Protected Area, it was found that agricultural wastewater accounted for 53% of the rural wastewater, followed by domestic wastewater (28%) and industrial wastewater (11%).²³

Additionally, the results obtained from the qualitative classification of the Karaj and Anbaj sewage treatment plants using the Iranian Agricultural Water Quality (IAWQ) model in the present study indicated the following concentrations: Total suspended solids (TSS) at 0.181 mg/L, chemical oxygen demand (COD) at 0.64 mg/L, biochemical oxygen demand (BOD) at 0.75 mg/L, and phosphate at 0.122 mg/L. In comparison, Shahandeh's study on the West Ahwaz wastewater treatment plant reported much higher concentrations of TSS (112 mg/L), COD (397.3 mg/L), BOD (213.6 mg/L), and phosphate (10.7 mg/L). After six months of employing the sequencing batch reactor, these values significantly decreased to TSS: 19.04 mg/L, COD: 43.67 mg/L, BOD: 27.76 mg/L, and total phosphorus (TP) at 2.24 mg/L.²⁴ In a separate study, Takdastan et al investigated the impact of implementing an extended aeration system for activated sludge at the Golestan Hospital wastewater treatment plant in Ahvaz. After six months of operation, a substantial reduction in TSS, BOD, and COD values was observed, with recorded levels of 27.49 mg/L, 28.73 mg/L, and 60.85 mg/L, respectively.²⁵

Effects of pH in Agricultural Water

Soil acidity and alkalinity are key indicators of soil fertility and are critical for assessing the impact of sewage irrigation on soil chemical properties. The pH value is the most practical measure for expressing soil acidity or alkalinity.¹⁷ Due to the buffering capacity of soil, pH levels tend to remain relatively stable. However, significant changes in pH can alter the chemical characteristics of the soil, directly affecting nutrient structure, transformation, and availability.¹² According to Wan et al, variations in soil pH are influenced by the type of irrigation water used and the soil classification.²⁶ Research has demonstrated that irrigating yellow clay with wastewater from pig farms leads to a decrease in soil pH with increased irrigation frequency. In contrast, irrigation with effluents from paper-making industries can increase pH levels in moderately degraded saline-alkali soils. Additionally, it has been observed that sewage from animal breeding activities has no significant effect on the pH levels of vegetable fields. Several factors, including the ammonification and nitrification of soil organic matter, anaerobic decomposition of organic matter, the enrichment and release of metal ions, and other processes, may contribute to pH fluctuations.¹²

Comparison of IAWQ and CWQI Water Quality Classifications for Agricultural Usage

The findings of the water quality categorization of sewage treatment facilities in Karaj and Anbaj revealed that the quality of Anbaj wastewater treatment facility effluent for agricultural uses was poor, while the quality of Karaj sewage treatment effluent was ordinary. As a result, the wastewater in the Anbaj treatment facility required complete treatment for use in agriculture and irrigation, and the wastewater in the Karaj treatment plant required some level of treatment. Figures 1 and 2 present the water quality classification of these two treatment plants using the CWQI index.

The average concentrations of total dissolved solids (TDS) and electrical conductivity (EC) in the effluent from the Anbaj treatment plant were 466 mg/L and 0.8 dS/m, respectively. According to FAO standards, the acceptable limits for TDS and EC in agricultural water are less than 450 mg/L and 0.7 dS/m, respectively. Thus, the values obtained for this treatment plant exceed the permissible limits, indicating potential degradation in soil quality and agricultural productivity.

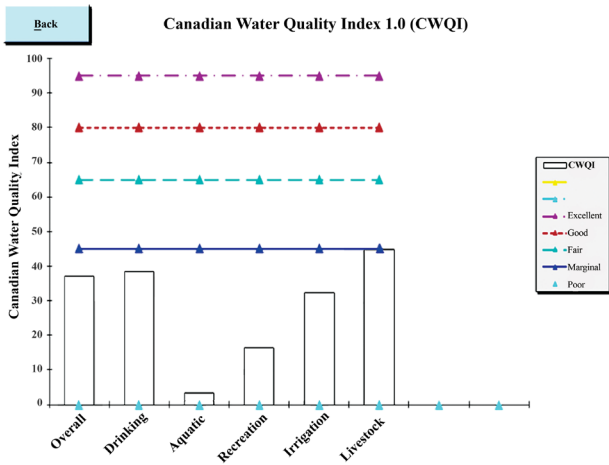


Figure 1. Water Quality Classification of Karaj Treatment Plant Using CWQI Index

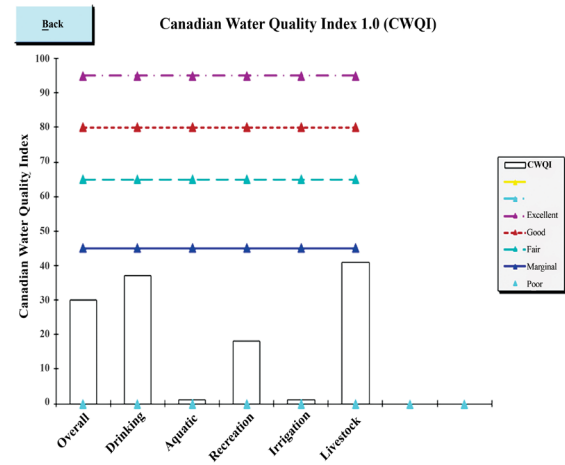


Figure 2. Water Quality Classification of Anbaj Treatment Plant Using CWQI Index

The CWQI indicated that the water quality at the Karaj treatment facility was acceptable concerning its physical and chemical parameters. However, to assess and address potential contamination, fecal coliforms were measured. The results, when compared to standard thresholds, revealed that the microbial quality of the water was suboptimal. The standard permissible limit for total coliforms in effluent discharged into surface waters is approximately 400 MPN/100 mL, whereas the fecal coliform count in the effluent from the Karaj sewage treatment plant was recorded at 920 MPN/100 mL. This value significantly exceeds the regulatory limits. Consequently, discharging wastewater from this treatment facility into surface waters or agricultural fields is not recommended due to non-compliance with effluent standards.

Results of the Fuzzy Software (FDM)

The results indicated that, among the evaluated parameters, total coliforms from the biological parameters ranked highest in the qualitative assessment of wastewater reuse in agriculture. Conversely, the temperature criterion from the physical parameters of water received the lowest impact score. To compare the Fuzzy Delphi Method (FDM) with the AHP model, the percentage derived from the total scores of the completed questionnaires was divided by 100. The final scores are presented in Table 3.

Comparison of the Results of Water Quality Parameters in AHP and FDM Methods

In the AHP method, the highest and lowest scores for water quality parameters were attributed to chloride and Mo, respectively. Overall, among the seven primary parameters, the physical parameter emerged as the most significant. Furthermore, the analysis of both primary and secondary parameters yielded the following insights:

The sub-criteria of SS, oil, TSS, TDS, dissolved oxygen (DO), and turbidity were prioritized as the key physical parameters. Among the chemical parameters of water, the sub-criteria of detergent, EC, toxic organic chemicals

Table 3. Comparison of scores with FDM and AHP method

Main Parameter	Sub-parameter	Total Points	Comparison of Scores With FDM and AHP method
Physical	Temperature	38.46	0.8655
	pH	69.23	0.15571
Chemical	Detergent	69.23	0.6574
	Heavy metal	57.69	0.12975
	EC	50	0.11246
Biological	Total coliform	92.3	0.2076
	Coliform gastrointestinal	30.76	0.6918
Water disinfectant	Disinfectant	76.92	0.17301

(e.g., phenol), pH, chloride, sodium adsorption ratio (SAR), BOD, COD, radioactive substances, and water disinfectants were given higher weights. For the biological parameters, the sub-criteria of fecal coliforms, total coliforms, and intestinal parasite eggs (nematodes) scored the highest. Regarding water anions, the sub-criteria of fluoride, sulfate, sulfide, phosphate, chloride, cyanide, bicarbonate, and nitrite were ranked higher. In the cation group, magnesium, calcium, sodium, ammonium, iron, and manganese were given greater weight. For heavy metals in water, the parameters of Zn, aluminum (Al), Cu, cobalt (Co), barium (Ba), Hg, selenium (Se), silver (Ag), Pb, hexavalent chromium (Cr⁺⁶), nickel (Ni), boron (B), trivalent chromium (Cr⁺³), Cd, vanadium (V), As, and Mo were prioritized. Lastly, in the category of water disinfectants, chloride and formaldehyde were given the highest weights.

The results of the evaluation of quality parameters in the FDM method are as follows:

Among the physical parameters of water, the pH parameter received a higher score of 69.23 compared to the temperature score of 38.46. Within the chemical parameters, detergents achieved the highest score of 69.23, followed by heavy metals at 57.69 and EC at 50. Among the biological parameters, total coliforms scored 92.30, surpassing the score for fecal coliforms, which was 30.76.

Additionally, the parameters related to water disinfection garnered a notable score of 76.92.

In conclusion, the data obtained from both the AHP and FDM methods indicate that the evaluations produced by these two methods differ significantly. For instance, among the physical parameters, the suspended solids (SS) parameter received a higher score in the AHP method, while the pH parameter was rated higher in the FDM evaluation. Both methods, however, identified detergents as a key parameter among the chemical water quality indicators. In terms of biological parameters, the AHP method assigned greater weight to total coliforms, whereas the FDM method recorded a higher score for the same parameter. Regarding the prioritization of main parameters, the FDM method ranked disinfectant, biological, chemical, and physical parameters in that order, while the AHP method prioritized physical, chemical, biological, and disinfectant parameters, respectively. It is important to note that the same individuals were surveyed to complete the questionnaires for both methods of evaluating water quality parameters for agricultural use.

Effects of Heavy Metals in Agricultural Water

As, Cu, Cd, Ni, Mo, Cr, Zn, and Pb are some of the heavy metals commonly found in municipal wastewater. These metals can be effectively removed through appropriate treatment processes, reducing their concentrations to levels similar to freshwater or within permissible limits.²⁷ However, research indicates that trace amounts of heavy metals may persist in treated wastewater and accumulate in soils, posing potential risks, particularly when wastewater originates from industrial sources or is mixed with domestic effluents. Over time, the use of this water for irrigation can lead to the entry of these metals into the food chain.²⁸ To mitigate these risks, diluting treated wastewater with freshwater during the treatment process is a common method to reduce heavy metal concentrations.²⁹ Nonetheless, soils irrigated with treated wastewater for extended periods, such as 20 years, have been shown to exhibit elevated concentrations of heavy metals.³⁰ In a study by Roomiani et al,³¹ Zn and Cd were found to have the highest and lowest accumulation levels, respectively, among aquatic plants in the Dez River. Cu and Pb also demonstrated significant accumulation, with Zn showing the highest concentration in the marginal plant reed roots (300.45 ± 60.22 mg/kg), *Myriophyllum* stems (104.43 ± 20.66 mg/kg), and *Potamogeton* leaves (122.35 ± 21.44 mg/kg). As a result, these three species of plants that have the ability to absorb heavy metals can play an important role in environmental purification.

Impact of Biological Criteria on Agricultural Water

According to California regulations, total *Escherichia coli* levels, measured as a fraction of total coliform counts, should not exceed a 7-day mean of 2.2 cfu/100 mL, with a maximum permissible level of 240 cfu/100 mL. In contrast, the WHO guidelines for unrestricted irrigation, even

under the strictest conditions, recommend a threshold of 1000 cfu/100 mL.²⁹ Additionally, research highlights that one of the promising methods for wastewater treatment involves the use of plants, particularly microalgae, which utilize sunlight to assimilate nutrients from wastewater and convert them into valuable biomass. In a study by Azarm et al,³² the potential of *Chlorella vulgaris* microalgae for removing pollutants from wastewater in Khuzestan Province was explored. The findings demonstrated that *C. vulgaris* effectively adsorbed pollutants in hydrothermal fish breeding ponds by absorbing nitrate, nitrite, and phosphate, alongside reducing BOD and COD. The study concluded that the application of *C. vulgaris* in effluent treatment systems for fish breeding ponds, prior to discharge into the natural environment, could significantly contribute to algal biomass production. Furthermore, fish breeding pond effluent could serve as an alternative culture medium for cultivating *C. vulgaris*, thereby enhancing its role in reducing nitrate and phosphate concentrations and improving wastewater quality.³¹

Quality Comparison of Karaj and Anbaj Wastewater Treatment Plants With CWQI Index and AHP Model

The results from the evaluation of parameters using the data gathered through the questionnaire in Expert Choice software revealed that the final scores for the water quality parameters of the Anbaj (9.227) and Karaj (8.12) wastewater treatment plants were both below 10. According to the CWQI and the IAWQ model, this indicates that the water from these two facilities is classified as unacceptable and unsuitable for agricultural use. Table 4 provides the qualitative classification of the Karaj and Anbaj wastewater treatment plants based on the applied model.

Eventually, the equation 1 was adopted to calculate the permissible amount of non-conventional water standards in agriculture according to the 11 factors listed in Table 2.

$$C_{max} = C_s \sum (0.734A) + (0.117B) + (0.75C) + (0.143D) + (0.68E) + (0.370F) + (0.107G) + (0.122H) + (0.181i) + (0.74J) + (0.76k) \quad (1)$$

Where, C_{max} is maximum permissible amount of non-conventional water criteria in agriculture and C_s is standard value provided by the Environmental Protection Agency for non-conventional waters.

Limitation and Suggestion

In this study, we introduced a tailored model, referred to as the IAWQ, to assess the effluent quality from treatment plants for its suitability in agricultural irrigation. The model was validated using the CWQI, which is particularly advantageous due to its incorporation of numerous water quality variables in determining the overall quality index. For future research on this topic, it is recommended to utilize more comprehensive survey instruments and

Table 4. A Qualitative Classification of Wastewater Treatment Plants of Karaj and Anbaj Using the IAWQ Model

Parameter	Weight	Amount of Sewage Effluent		Score 3		Score Weight	
Chloride	0.734	Karaj	30	Karaj	3	Karaj	2.202
		Anbaj	88.36	Anbaj	3	Anbaj	2.202
pH	0.117	Karaj	7.67	Karaj	2	Karaj	0.234
		Anbaj	7.76	Anbaj	2	Anbaj	0.234
Biochemical oxygen demand (BOD)	0.75	Karaj	39	Karaj	1	Karaj	0.75
		Anbaj	16.85	Anbaj	3	Anbaj	2.25
Ammonia	0.143	Karaj	4.16	Karaj	1	Karaj	0.143
		Anbaj	8.15	Anbaj	1	Anbaj	0.143
Nitrate	0.68	Karaj	3.3	Karaj	1	Karaj	0.68
		Anbaj	9.377	Anbaj	1	Anbaj	0.68
Faecal coliform	0.37	Karaj	920	Karaj	1	Karaj	0.37
		Anbaj	7.5*10000	Anbaj	1	Anbaj	0.37
Turbidity	0.107	Karaj	38.25	Karaj	2	Karaj	0.214
		Anbaj	14.88	Anbaj	3	Anbaj	0.321
Phosphate	0.122	Karaj	0.39	Karaj	3	Karaj	0.366
		Anbaj	2.5	Anbaj	2	Anbaj	0.244
Total suspended solids (TSS)	0.181	Karaj	130	Karaj	1	Karaj	0.181
		Anbaj	32.85	Anbaj	3	Anbaj	0.543
Chemical oxygen demand (COD)	0.74	Karaj	45	Karaj	3	Karaj	2.22
		Anbaj	37.57	Anbaj	2	Anbaj	1.48
Sodium adsorption ratio (SAR)	0.76	Karaj	80	Karaj	1	Karaj	0.76
		Anbaj	120	Anbaj	1	Anbaj	0.76
Total weighted score						Karaj	8.12
						Anbaj	9.227

explore alternative questionnaire distribution methods, such as the Decision-Making Trial and Evaluation Laboratory (Dimatel) approach. Additionally, replacing the AHP with the Elimination and Choice Translating Reality (ELECTRE) method is advised. The ELECTRE method allows for the identification and evaluation of different alternatives against a set of conflicting criteria while capturing the preferences of decision-makers.

Conclusion

Although wastewater reuse for agricultural irrigation offers several advantages, growing evidence from soil science and wastewater treatment research indicates potential negative impacts on both the environment and human health. These concerns include the risk of diminished soil fertility and reduced crop yields, which calls into question the long-term sustainability of using treated wastewater in agriculture. As a result, appropriate precautionary measures and careful planning must be implemented to mitigate these risks and ensure the responsible application of wastewater in agricultural practices.

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Authors' Contribution

Conceptualization: Sosan Rezaei.

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Competing Interests

The authors declare that there are no conflicts of interest.

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