An-Najah University Journal for Research – A

Natural Sciences

Assessment of Water Quality in Euphrates River: Haditha Dam Reservoir as a Case Study, Anbar Province, Iraq

Sari Aymen Alrawi[1,*], Arkan Dhari Jalal[2] & Uday Hatem Abdulhameed[2]

Received 16th Dec. 2024, Accepted: 4th Mar. 2025, Published: ××××, DOI: https://doi.org/10.xxxx

Accepted Manuscript, In Press

Abstract: Natural water contamination is one of the world's most significant environmental issues. Urbanization-induced increases in freshwater demand with population growth, water shortages in arid and semi-arid areas, and industrial and agricultural processes are primarily responsible for of this. The purpose of the current study is to assess Haditha Dam's water quality adequacy. The water quality of the reservoir at Haditha Dam was evaluated in this study using nine parameters: pH, electrical conductivity(CE), Total Suspended Solids (TSS), Chloride (Cl-), Calcium (Ca), Sulfate (SO4-2), Sodium (Na) Potassium (K), and Magnesium (Mg). SPSS software was used to analyze the data and assess its quality. Two years' worth of data was gathered from 46 samples, and parameters were evaluated using accepted methods. Except for pH, which had moderate values, the results showed low average concentrations for every parameter. The outcomes were contrasted with WHO and Iraqi water quality guidelines. This study offers guidance for efficient Water resource management and planning, including their appropriateness for drinking and irrigation. The findings indicate that while the river's water is suitable for irrigation, it is not fit for human consumption.

Keywords: Water Quality, Pollution, Sustainability, Environment, Haditha Dam Reservoir.

Introduction

Both the amount and quality of water are essential for a sustainable ecosystem (1), which explains why it is so crucial. Numerous environmental elements, including precipitation, soil erosion, and weather, affect the quality of surface water. The demand for water resources, along with more unusual actions like industrialization, Runoff from farms, urbanization, and the generation of municipal wastewater, all affect the quality of surface water (2). The cause of about 80% of human ailments is contaminated water (3). The community's access to a suitable water supply must thus be strengthened. But what has to be evaluated the most is the quality of the water. Known as Iraq's two main water sources, the Tigris and Euphrates rivers have lately started to deteriorate in terms of quality on a rapid and increasing rate, The (UNESCWA-BGR) (4). Measured 15.5 billion cubic meters of the river Euphrates' flow at Hussaybah, the river's site entrance in Iraq, between 1999 and 2010, discovering a decrease (5). There are now two different kinds of problems with water quality in Iraq. The amount of pollutants that are added to freshwater sources by commercial, industrial, and governmental activities is the second factor, after salinity (6).

The Tigris, Euphrates, and other Iraqi rivers are becoming more salinized as a result of the expansion of agriculture along the basins of these rivers, both inside and outside of the country. Additional reasons that are being explored to explain increasing loads include population and economic expansion. of various contaminants. Droughts are the primary cause of agricultural regions being decertified and exacerbate the degradation of water quality (7). Due to the building of large dams in Syria and Turkey (GAP project), the annual water flows into the Euphrates River have been gradually declining. Water is primarily affected by TDS, TH, pH, DO, nitrate, and phosphate quality, as stated by Al-Shujairi (5). The primary water source for the southern region of Anbar Province regions of Iraq is the Euphrates River. Numerous studies were conducted to assess the Tigris and Euphrates rivers' water quality.

Examination of the degradation and water quality of the Tigris River levels for a number of contaminants, such as water flow, electrical conductivity, temperature, salinity, dissolved oxygen\, total dissolved solids, biological oxygen demand and, total nitrogen, and total phosphorus, among other contaminants, were used to analyze the water quality and pollution. The analysis showed that the river's water quality varies from mediocre to bad due to the many negative effects of pollution on the river (8). Said that the Euphrates River's (the Hilla River's) branch water quality was just passable. Bicarbonate overabundance in irrigation water is one of the most prevalent issues (9). In addition to its impact on potassium and chloride ion concentrations, the increase in water levels also considerably improves water quality by lowering sedimentation and electrical conductivity (10).

1 MSC student, Dams and Water Resources Department Engineering, College of Engineering, University of Anbar, 31001 Ramadi, Anbar province, Iraq.

* Corresponding author email: sar23e4003@uoanbar.edu.iq

2 Dams and Water Resources Department Engineering, College of Engineering, University of Anbar, 31001 Ramadi, Anbar province, Iraq

Water Quality

Iraq's water quality is greatly affected by the release of untreated household and industrial waste, which lowers the water's chemical and physical attributes. Another important factor that affects the water is seasonal climate change in rivers similar the Tigris and Euphrates in terms of flow and quality (11).

pH: The concentration of ionized hydrogen in water is indicated by its pH level, which also influences the solubility of certain metals. The pH of water used for agriculture is usually slightly acidic because of the carbon dioxide and bicarbonates. The pH level may have an impact on the toxicity and solubility of specific elements, resulting in a crucial component of water quality evaluation (12).

Sodium (Na): Salinity raises the quantity of sodium in water, and excessive amounts can be harmful to plants. It is a crucial component in assessing the quality of water for farming (13).

Calcium (Ca): In addition to improving soil structure by reducing the negative impacts of calcium and sodium is necessary for plant growth. Increased soil permeability and aeration due to high calcium levels in water can improve plant growth (12).

Magnesium (Mg): Magnesium is found in nature in large quantities and is essential to Photosynthesis in plants. High quantities, however, may result in hard water and impair plants' ability to absorb nutrients (14).

Chloride (Cl-): A naturally occurring ion, chloride, can be harmful to plants in excessive amounts. It has a big role in deciding how clean the water is for farming (15). Elevated amounts of chloride, especially from deicing salts, have been connected to aquatic organism toxicity and declining water quality (16).

Sulfate (SO4-2): Water hardness is influenced by sulfate, which is frequently present in natural waters. Water quality and plant growth may be impacted by the salts it forms with calcium and magnesium (17).

Total Suspended Solids (TSS): High levels of TSS prevent light from penetrating, which interferes with photosynthesis in aquatic plants and phytoplankton, which are essential to the food chain (18).

Electrical Conductivity (EC): In highly conductive water, contaminants like methylene blue degrade less effectively, underscoring the significance of water quality in treatment procedures (19).

Potassium (K) Strong interactions between water molecules and the hydration structure of K ions in water impact the dynamics of solvation and may have an impact on the availability of nutrients in soils (20).

Materials and Methods

Study Area: The largest is Haditha Reservoir and most significant bodies of water on the Euphrates River (21). It is situated eight kilometers to the north of Haditha city in western Iraq (Figures 1). It was created as a result of the 1986 establishment of the Haditha dam. It is now a multi water's intended usage. Between longitudes 42° 26´ and 41° 55´ East and latitudes 34° 40´ and 34° 13´ North is the research region (22). With 10 km of shoreline, the river and reservoir span over (500 km2) at the highest flood water level of (147 m.as.l.) (23).

Figure (1): Haditha Reservoir's location

Samples, Measurements and Analysis: Monthly samples were collected from January 2018 to January 2020. Nine parameters were determined, including pH, Na, K, Ca, Cl-, Mg, SO4-2, TSS, and EC. Every chemical test was carried out in the labs of the Haditha Dam Project. Prior to sample collection, all polyethylene plastic bottles were carefully cleaned, dried, and rinsed with water samples that would be taken on collection day. Following appropriate sample collection, labeling was completed.

Standards for Water Quality: According to Table (1), Iraqi irrigation standards were used to determine the following physical and chemical properties. Furthermore, the current study relied on the Iraqi Guiding Line's drinking purposes guidelines (number 417; revised in 2009), according to Table (2). The suitability of the examined river water for human consumption has been assessed by comparing this with measured data.

Table (1): Iraqi irrigation water standards (24).

Water quality parameters	Unit	Standard
PH	-	4-8.6
Calcium (Ca)	mg/L	450
Total dissolve solid (TDS)	mg/L	2500
Alkalinity	mg/L	200
Electrical conductivity (EC)	mg/L	2250
Sulfate (SO4-2)	mg/L	200
Chloride (Cl-)	mg/L	250
Total suspended solid (TSS)	mg/L	60
Potassium (K)	mg/L	100
Sodium (Na)	mg/L	250
Total hardness	mg/L	300

Table (2): Drinking Water Quality Standards (Iraqi and WHO guidelines, 2009 and 2007, respectively) (25)

Parameter	unit	Iraqi guideline 2009	WHO 2007
PH	-	6.5-8.5	6.5-8.5
Total dissolve solid (TDS)	mg/L	1000	1000
Nitrate (NO3)	mg/L	50	50
Magnesium (Mg)	mg/L	100	125
Chloride (Cl-)	mg/L	350	250
Calcium (Ca)	mg/L	150	75
Potassium (K)	mg/L	12	12
Sulfate (SO4-2)	mg/L	400	250
Cadmium (Cd)	mg/L	0.003	0.003
lead (Pb)	mg/L	0.01	0.01
Copper (Cu)	mg/L	1	1
Sodium (Na)	mg/L	200	200
Irion (Fe)	mg/L	0.3	0.3
Zinc (Zn)	mg/L	3	3
Manganese (Mn)	mg/L	0.1	0.1

Statistical Package for Social Sciences (SPSS): IBM SPSS Statistic version 26 software was used to analyze the samples utilized in this study. Statistical analysis software is one of the most important statistical applications that has gained popularity among researchers for carrying out mathematical computations. The social sciences, engineering, administrative sciences, and agricultural sciences are among the many scientific fields that use it. Through the use of numerous tools and techniques that increase transparency and clarity, SPSS facilitates the visualization of data and the communication of research findings. Users can create a range of graphical representations with it, such as pie graphs, bar charts, and box plots, all of which are essential for effectively summarizing data (26). Additionally, SPSS provides a collection of syntax files that promote transparency in scientific discourse by displaying raw data with summarized results (27). Furthermore, even individuals without any prior statistical knowledge can utilize the program because it enables users to construct tables and graphs (28).

Results and Discussion

The characteristics of the surface water flow's geological components and recharge water quality dictate the types and concentrations of natural contaminants. The water can absorb numerous substances, including fluoride, magnesium, calcium, sodium, nitrate, iron, chloride, and many more, as it flows through soils and sedimentary rocks. This indicates that the kind and concentration of these organic contaminants determine their detrimental effects (29).

Table (3): Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
70.9	87.8	9

Table 3 illustrates the results of Cronbach's Alpha reliability analysis. The overall Cronbach's Alpha value is 70.9, indicating a reliability of 87.8%. A Cronbach's Alpha model exceeding 80% is considered highly reliable and demonstrates high consistency (30).

Table (4): Statistics for Parameter.

		EC	pH	TSS	K	Na	Mg	Ca	Cl-	SO4-2
N	Valid	46	46	46	46	46	46	46	46	46
	Missing	0	0	0	0	0	0	0	0	0

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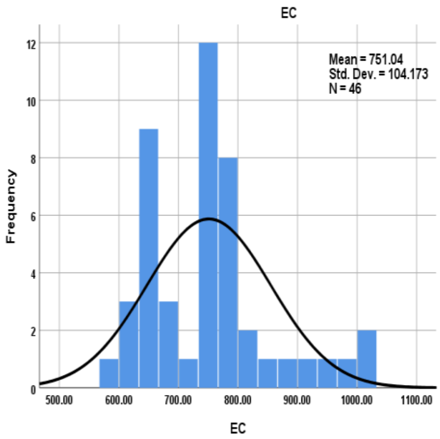

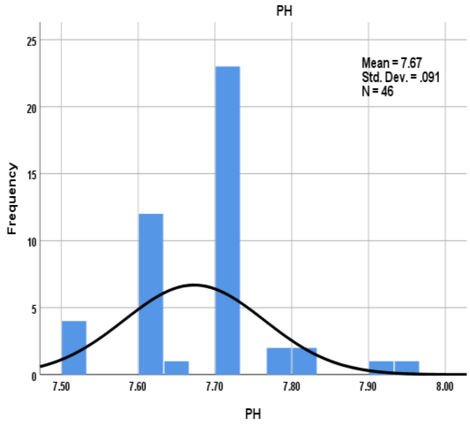

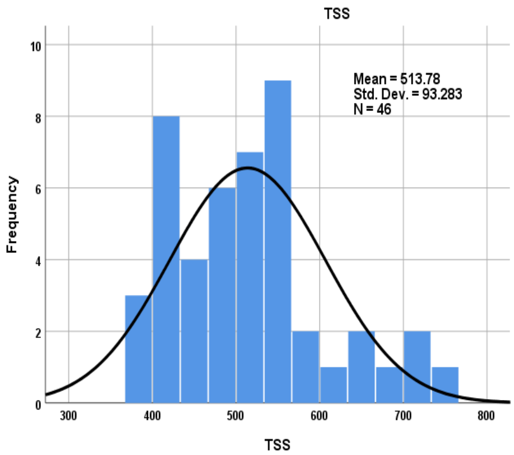

Mean		751.04	7.67	513.78	7.56	31.59	23.63	40.02	59.2	Mg 60.65
Std. Error of Mean		21.91	0.15	13.75	0.21	1.24	0.67	0.795	1.999	4.22
Median		754.50	7.70	517.00	7.60	30.75	24.35	40.50	58.00	162.50
Mode		745.00a	7.70	416 a	6.20 a	25.00 a	26.4	38.00 a	52.00 a	118.0 a
Std. Deviation		104.17	0.91	93.28	1.45	8.44	4.54	5.39	13.56	28.65
Variance		10852.04	0.008	8701.64	2.10	71.20	20.62	29.08	183.75	820.96
Skewness		0.917	0.371	0.670	-0.031	-0.223	-1.164	-0.836	0.510	-0.212
Std. Error of Skewness		0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
Kurtosis		0.783	1.294	0.183	-0.511	1.406	1.937	2.073	0.375	-1.438
Std. Error of Kurtosis		0.688	0.688	0.688	0.688	0.688	0.688	0.688	0.688	0.688
Range		444.00	0.44	369	6.1	41.0	22.2	28.8	59.3	93.0
Minimum		586.00	7.5	369	4.3	8.0	9.5	23.2	33.0	114.0
Maximum		1030.00	7.94	738	10.4	49.0	31.7	52.0	92.3	207.0
Sum		34548.00	352.95	23634	347.7	1453.2	1086.9	1840.7	2724.3	7389.9
Percentiles	25	661.5	7.6	432.00	6.575	27.00	21.90	37.88	51.00	132.75
	50	754.5	7.7	517.00	7.6	30.75	24.35	40.50	58.00	162.50
	75	778.0	7.7	459.75	8.725	35.5	26.425	43.60	68.28	188.25
Multiple modes exist. The smallest value is shown.										

Table 4 illustrates the statistical values used for analysis, which include the number of samples (N), range, minimum, maximum, sum, percentiles, variance, skewness, standard error of skewness, kurtosis, standard error of kurtosis, median, mode, standard deviation, variance, median, and standard error of the mean. Evaluation parameters for output include electrical conductivity EC, pH, TSS, K, Na, Ca, Mg, Cl-, and SO4-2. Additionally, it shows the frequency (f) of a given value, which is the number of times that value appears in the dataset. A variable's distribution is its pattern of frequencies, which includes the set of all possible values and the frequencies that correspond to them. Frequency distributions are shown graphically in graphs or in frequency tables. Values from the variance curve are also given for this data.

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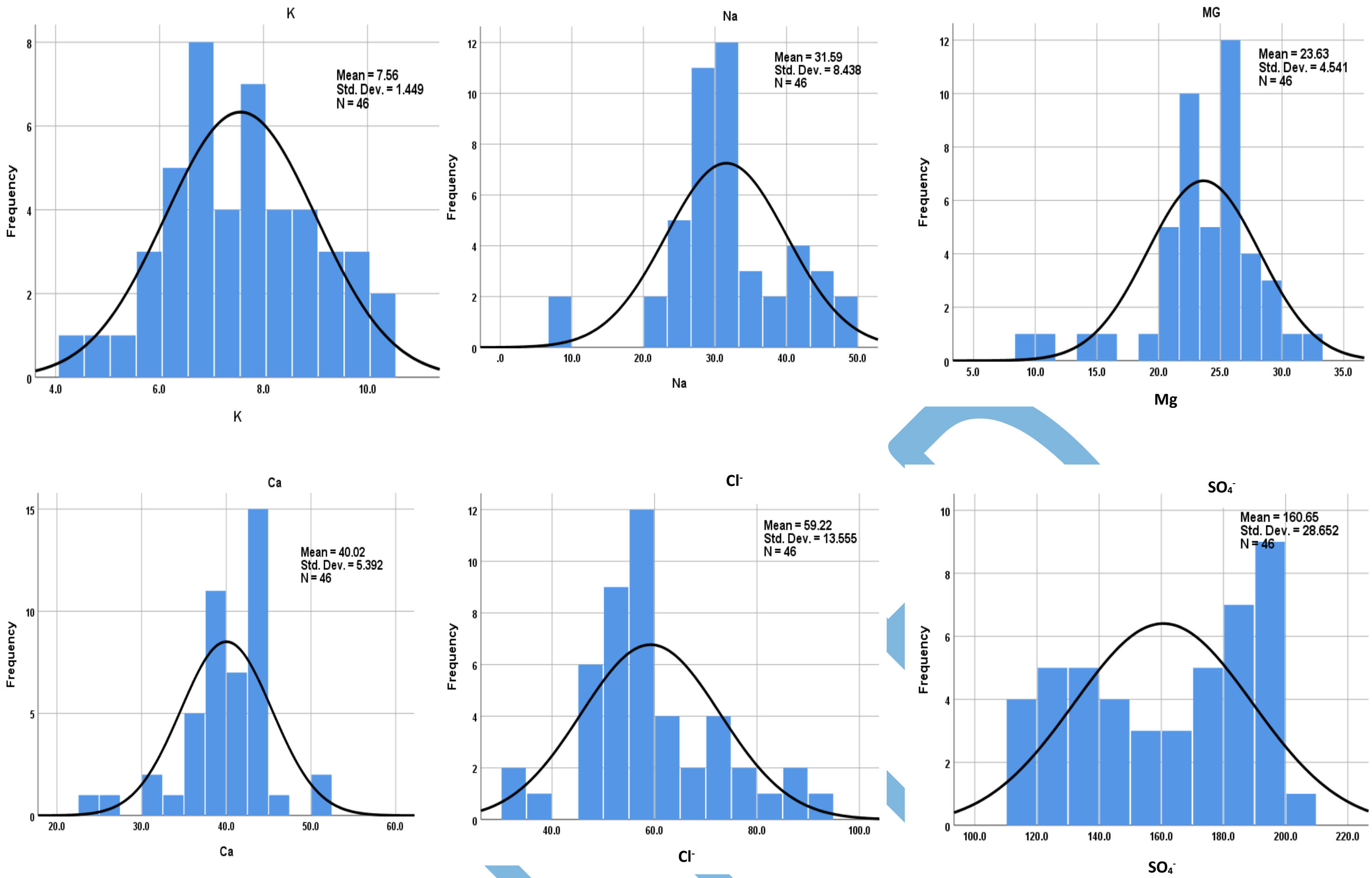

Figure (2): Frequency histogram of water quality parameters

Figure 2 The histogram plot illustrates the lengths referred to in the figures above. It can be observed that the data is skewed due to high values within the range specific to each parameter, while all other values fall under the normal curve. This indicates that the samples follow a normal distribution. Table 5 will be attached to show the direction of data skewness for each parameter and the range of values.

Table 5. Parameters, Skewed, and Range of Value

Parameter	Skewed	Min. To Max. Val
EC	left	586 to 1030
PH	left	7.5 to 7.94
TSS	left	369 to 738
K	left	4.3 to 10.4
Na	left	8 to 49
Mg	right	9.5 to 31.7
Ca	left	23.2 to 52
Cl^-	left	33 to 92.3
SO_4^{-2}	right	114 to 207

Table (6): Correlation between Parameter.

	EC	pH	TSS	K	Na	MG	Ca	Cl^-	SO_4^{-2}
EC		0.101	0.854**	0.696**	0.449**	0.295*	0.703**	0.901**	0.85**
pH			0.81	0.017	-0.233	-0.123	0.016	0.119	-0.055
TSS	**			0.517**	0.475**	0.054	0.746**	0.777**	0.692**
K	**		**		0.462**	0.356*	0.482**	0.718**	0.634**
Na	**		**	**		0.46**	0.761**	0.539**	0.353*
MG	*			*	**		0.362*	0.488**	0.335*

Ca	**		**	**	**	*		0.798**	0.543**	
Cl^-	**		**	**	**	**	**		0.796**	
SO_4^{-2}	**		**	**	*	*	**	**		
**Correlation is significant at the 0.01 level (2-tailed). *Correlation is significant at the 0.05 level (2-tailed).										

Table 6 shows the correlation between the factors. The correlation between water quality parameters in Haditha Dam Reservoir: the red and blue colors indicate negative and positive correlations between functional traits, respectively. The lighter the color, the weaker the correlation. Symbols (*, **) indicate a significant correlation at probability levels of P > 0.05, P < 0.01, respectively. When it comes to:

– EC: the highest coefficient is (0.901**), and the lowest is (0.101).
– PH: fluctuation falls between (0.81) and (0.016).
– TSS: value is at its lowest at (0.054) and at its greatest at (0.854**).
– Potassium: (0.718**) is the highest reading, and (0.017) is the lowest.
– Sodium: readings is (0.761**) to (-0.233).
– Magnesium: rises to (0.488**) after reaching its lowest point at (0.054).
– Calcium: The highest coefficient for is (0.798**) while the lowest is (0.016).
– Chloride: The highest degree of connection with is (0.901**), while the lowest is (0.119).
– Sulfate: The range of readings is (0.85**) to (-0.055).

An examination of correlations is presented in this table, highlighting the statistical connections and importance of various factors. A negative sign indicates that the value has statistical significance and that the coefficient represents an inverse relationship. Conversely, a positive sign indicates a direct relationship.

Overall, the levels of potassium (K) and sodium (Na) were low at both sites in contrast to the high quantities of other chemical components, such as magnesium (Mg), calcium (Ca), and chloride (Cl-). The hardness of the water can be used to assess how much calcium and magnesium are present. Parts per million (ppm) of calcium and magnesium by weight are necessary for plant growth. The optimal concentrations of calcium and magnesium for irrigation water are (40–100) ppm and (30–50 ppm), respectively. Based on the findings, the amounts of calcium and magnesium were (23.63–40.02 ppm) respectively, making them appropriate for irrigation (31). Excessive calcium and magnesium leakage from growing media can result from high sodium levels that inhibit plants' ability to absorb calcium. Additionally, the leaves may absorb salt, which could result in leaf burn. The danger of high foliar absorption from chloride in vulnerable plants is due to high root absorption or under overhead irrigation. The danger of excessive foliar absorption does not exist if Cl- values are less than 100 ppm. There is no possibility of poisoning from root uptake if Cl- concentrations are less than 150 ppm. It is not recommended to increase The quantity or frequency of fertilizer that dissolves in water as a solution to these issues because doing so will only increase the total EC and exacerbate the problem (31).

For plants, Na and Cl- levels should typically be maintained below (50 ppm) and (140 ppm), in turn. Higher levels, however, can be accepted based on the crop's sensitivity. Sodium concentrations of 50 ppm or less are considered suitable for overhead irrigation. based on According to the study's findings, the highest levels of Na and Cl- were roughly 50 and 90 mg/l, respectively., indicating that they were at acceptable ranges. Incredibly high quantities of sulfate compounds (114 - 207 mg/L) were detected. The dissolution of several minerals, such as calcium sulfate, was probably the cause of these increased amounts. On the other hand, total suspended solids were found at high concentrations, ranging from (369 - 738 mg/L). The water's calcium and bicarbonate can combine to form lime deposits, clogging drip irrigation emitters. The blockage is most likely to happen when the bicarbonate concentration is more significant than (120 ppm) and the pH of the water is higher than (7.5). When temperatures rise, bicarbonate reacts with calcium to produce calcium carbonate, which is insoluble more rapidly. This explains the faster development of a white crust on your hot water faucet compared to your cold water faucet.

Table (7): The comparison between drinking water and irrigation water.

Parameter	Mean Value in Water	Iraqi Irrigation Standards	Iraqi Drinking Water Standards (2009)	WHO Drinking Water Standards (2007)	Comments
pH	7.67	4 - 8.6	6.5 - 8.5	6.5 - 8.5	Suitable for both irrigation and drinking
EC (µs/cm)	751.04	≤ 2250	-	-	Suitable for irrigation, unsuitable for drinking
TSS (mg/L)	513.78	≤ 60	-	-	Unsuitable for both irrigation and drinking
Ca (mg/L)	40.02	≤ 450	150	75	Suitable for irrigation, unsuitable for drinking
Cl- (mg/L)	59.22	≤ 250	350	250	Suitable for irrigation, unsuitable for drinking

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SO4-2 (mg/L)	160.65	≤ 200	400	250	Suitable for irrigation, unsuitable for drinking
K (mg/L)	7.56	≤ 100	12	12	Suitable for irrigation, unsuitable for drinking
Na (mg/L)	31.59	≤ 250	200	200	Suitable for irrigation, unsuitable for drinking

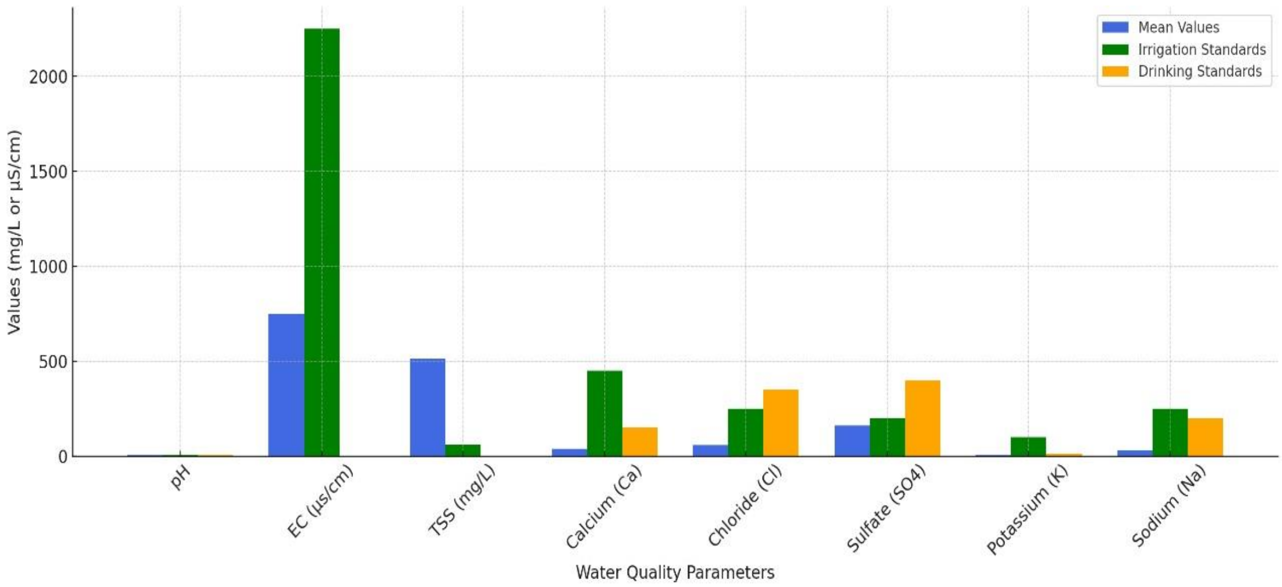

Figure (3): Comparison of Water Quality Parameter for Irrigation and Drinking.

The water is more suited for agriculture than for human consumption, as the bar chart 3 demonstrates, with the majority of water quality parameters meeting irrigation norms but exceeding drinking water limitations, particularly TSS and sulfate levels.

Conclusion

46 samples from different Haditha Dam locations were used in this study to assess the water quality between January 2018 and January 2020. To evaluate compliance, the data were contrasted with Iraqi water quality criteria. Chemical analyses were performed on nine parameters: pH, CE, Na, K, Ca, Cl-, Mg, TSS, and SO4-2. The findings demonstrated that every measure satisfied the requirements, with the wet season showing the highest values. However, due to ecological damage brought on by pollution, it was decided that the river water was unsafe for human consumption, even though it would be suitable for irrigation.

The study emphasized the necessity for consistent water quality codes while highlighting the difficulties in monitoring water quality. Effective water quality assessment is challenging due to the large amount of unintegrated data generated by current water monitoring. Even though they are not good for fishing, rivers are essential to ecosystems and must be protected in order to continue being usable for swimming and fishing.

The results highlight the significance of planning for sustainable water resources, particularly for irrigation and drinking, in order to address issues related to the environment and public health.

Ethics clearance and participation consent

Not Applicable.

Consent for publication

Not Applicable.

Author's contribution

The authors confirm their contributions to the paper as follows:
Study design and conception: Sari Aymen Alrawi, Arkan Dhari Jalal, Uday Hatem Abdulhameed.
Computations and theoretical modeling: Sari Aymen Alrawi.
Data analysis and validation: Sari Aymen Alrawi.
Draft manuscript preparation: Sari Aymen Alrawi, Arkan Dhari Jalal, Uday Hatem Abdulhameed.
All authors reviewed the results and approved the final version of the manuscript.

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Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Funding

No granted funding.

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