Evaluating The Suitability Of Euphrates River Water For Animal Consumption In The City Of Samawah Using The Canadian Catalyst

Evaluasi Kesesuaian Air Sungai Eufrat Untuk Konsumsi Ternak Di Kota Samawah Menggunakan Katalis Kanada

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Abstract
The study concluded that the assessment of the Euphrates River water quality in the Samawah area using the Canadian Water Quality Index (CWQI) and water quality standards for animal consumption showed variation in water quality among the studied sites. Site 1 (M1) was classified as "poor" with an index of 42.32, indicating continuous pollution, while the other sites (M2–M6) were rated as "moderate" with indices ranging from 75.25 to 75.75, indicating partial protection with some deviations from optimal standards. The results also showed that concentrations of sulfates, sodium, and chlorides exceeded the permissible limits according to the Tóth and Fitzsimmons (1962) standards, which may cause digestive disorders such as diarrhea, mineral toxicity, and imbalance of salts and fluids in the animal body. Additionally, electrical conductivity (EC) measurements at some sites exceeded the safe limits for animal consumption according to Ayers and Westcot (1989), which could negatively affect the health of ruminants and poultry. These findings underscore the urgent need to monitor pollution sources and treat water before using it for animal drinking or irrigation purposes, emphasizing the importance of further studies to identify the main sources of pollution and to develop sustainable water resource management plans in the region.

Introduction

Water is considered the web of life—it plays a vital role in all commercial and industrial processes, and no living organism, regardless of its shape, type, or size, can survive without it. Biological sciences have confirmed that water is a fundamental component in the structure of living matter, while biochemical sciences have proven that water is essential for the completion of all reactions and transformations occurring within living organisms. Water is also critically important for various uses, especially in agriculture, industry, and domestic activities.

However, water is often exposed to pollutants resulting from diverse human activities, which in turn affects its physical, chemical, and biological properties. This can impact water usability and quality and ultimately affect the health of ecosystems.

Water is one of the most essential resources for animal life. It is involved in digestion, cellular regulation, and biochemical reactions. Nonetheless, water of unclear quality can pose risks to animal health, particularly if it contains high levels of salts or toxic metals. Ruminant animals, such as cows and sheep, are especially affected by total dissolved salts and electrical conductivity (EC) in water. High levels of sulfur or oxygen in water may cause digestive problems like diarrhea or poisoning.

In this study, the Water Quality Index (WQI) was applied to assess the suitability of Euphrates River water for animal consumption. The evaluation relied on the standards set by Altoviski, as well as the general water quality index. Each water sample was categorized based on specific criteria, depending on the limit values and their alignment with the defined standards in the study area.

1. Research Problem

Is the Euphrates River in the city of Samawah exposed to pollution, and can its water quality for consumption be evaluated using the Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI)?

2. Research Hypothesis

The Euphrates River in Samawah is subject to various sources of pollution. It is assumed that the CCME WQI is a highly accurate tool for evaluating the suitability of water for consumption.

3. Research Objective

To assess the suitability of Euphrates River water for animal consumption using the Canadian Water Quality Index (CWQI).

4. Study Area Boundaries

The study area is confined to the city of Samawah, located in the northwestern part of Al-Muthanna Governorate, where it serves as the administrative center. It is bordered by Al-Rumaitha District to the north, Khidr District to the northeast, Al-Majd to the west, Al-Salman to the south, and Al-Hilal to the southeast. The Euphrates River represents the main watercourse in the region and enters Al-Muthanna's administrative boundaries from the northwest. About 12 km north of the city, it splits into two branches: the eastern branch, known as Shatt Al-Suwair, which is 32 km long, and the western branch, known as Shatt Al-Samawah, which flows for about 8 km before merging with Shatt Al-Atshan approximately 4 km before entering Samawah city. This section of the river, extending about 10 km, exhibits noticeable variability in its characteristics.

5. Methodology

Water samples from the Euphrates River were collected using well-cleaned plastic and glass bottles, rinsed thoroughly with river water. Samples were taken from a depth of 30 cm near the riverbank at six sites: Al-Hafidh, Al-Qaddouri, Qoblah, Al-Halak, Eastern Orchards, and Al-Abbas. Sampling was conducted during two distinct seasonal periods— the wet season in February and the dry season in August.

First: Qualitative Characteristics of Euphrates River Water

The water quality requirements for animal consumption are generally less stringent than those for human consumption. However, the use of poor-quality water for animal drinking can still pose health risks and indirectly affect human food safety. In this section, the concentrations of key parameters in water samples from specific locations within the city of Samawah are discussed, as detailed in Table (1).

1. Electrical Conductivity (EC)

Electrical conductivity (EC) is an important indicator of the presence of salts in water, especially salts such as calcium chloride, calcium, and magnesium. Studies have shown that when the total dissolved solids (TDS) in water are less than 500 mg/L, the electrical conductivity is typically below 0.75 dS/m. Therefore, for water to be considered suitable for animal drinking, the EC value should be less than 0.75 dS/m.

In this study, EC values were found to be significantly high during the dry season, with an overall average of 3052 μS/cm. The highest values were recorded at sites M3 and M4 (Qoblah and Al-Halak), measuring 3224 and 3288 μS/cm respectively. This increase can be attributed to high temperatures, intensified evaporation, and reduced water flow, which leads to the accumulation of dissolved salts. Similarly, the fifth site also recorded an average EC value of 3052 μS/cm.

2. Total Dissolved Solids (TDS)

Total dissolved solids (TDS) represent the total concentration of dissolved inorganic and organic substances in water. According to the results in Table (1), TDS levels varied across the monitored sites and seasons. During the dry period, the overall average TDS was 1363 mg/L, reflecting a strong correlation between TDS and EC, as increased electrical conductivity is often associated with elevated dissolved salts.

The highest values were observed at site M4. During the wet season, the average TDS level was slightly lower at 1304 mg/L, indicating some dilution effect due to increased water availability.

Table (1): Physicochemical Quality Parameters of Euphrates River Water in Samawah City – 2024

Rainy Season

.No	Site	EC (μS/cm)	TDS (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)	Na^+ (mg/L)

1	M1	3088	1390	350	638	67	297	260
2	M2	3122	1360	554	850	87	125	197
3	M3	3288	2150	553	592	94	280	177
4	M4	3223	2350	495	922	98	100	199
5	M5	3132	1370	554	888	97	101	212
6	M6	3170	1360	611	923	99	116	207
	Mean	**3171**	**1363**	**520**	**802**	**90**	**170**	**209**

Dry Season

.No	Site	EC (µS/cm)	TDS (mg/L)	SO_4^{2-} (mg/L)	Cl^- (mg/L)	Mg^{2+} (mg/L)	Ca^{2+} (mg/L)	Na^+ (mg/L)
1	M1	3147	2306	913	535	98	201	150
2	M2	3125	1274	874	487	121	160	150
3	M3	2761	1286	807	497	86	170	199
4	M4	3211	1305	806	432	127	160	159
5	M5	3212	1316	630	499	141	136	157
6	M6	2853	1337	906	498	98	184	173
	Mean	**3052**	**1304**	**823**	**491**	**112**	**169**	**165**

1. **Calcium(Ca^{2+}):**
   Calcium levels showed both temporal and spatial variation at the studied sites over the full sampling period. The average calcium concentration in the Euphrates River within the city during the rainy season was 179 mg/L, due to the full maturity and equilibrium of the river's water levels and the dissolved contents. The highest concentration was recorded at site M1 (297 mg/L), located in the central district. In contrast, during the dry season, the average calcium concentration was 169 mg/L, as shown in Table (1).
2. **Magnesium(Mg^{2+}):**
   Magnesium is usually present in small amounts compared to calcium, but it dissolves in larger quantities due to its tendency to remain in solution, contributing to water hardness when combined with calcium [1]. Its levels varied slightly between sites during the rainy season, with an average concentration of 90 mg/L. During the dry season, it showed a clear variation, with an average of 112 mg/L. The highest level was at site M5 (141 mg/L), while the lowest was at site M3 (86 mg/L). The increase during the rainy season is attributed to the dissolution of magnesium and gypsum compounds from the surrounding geological formations.
3. **Sodium(Na^+):**
   Sodium levels in the Euphrates River within Samawah varied by location and season. The highest average value was recorded during the rainy season (209 mg/L), compared to 165 mg/L during the dry season. This variation is linked to river flow reduction and seasonal climatic changes in the study area. In summer, lower water levels and increased human waste accumulation contribute to elevated sodium levels.

4. **Sulfates(SO_4^{2-}):**
   Sulfate concentrations tend to increase in the cold season due to the dissolution of gypsum and sulfur oxides from rainfall [2]. Table (1) shows that sulfate levels in the Euphrates River in Samawah were significantly higher during the dry season (823 mg/L) compared to the rainy season (520 mg/L). This rise is due to limited rainfall and runoff, allowing more sulfate compounds to accumulate. The highest level was at site M1 (913 mg/L) during the dry season, while the lowest was at site M4 (495 mg/L) during the rainy season.
5. **Chlorides(Cl^-):**
   Chloride is present in surface water in the form of salts, such as calcium chloride or sodium chloride, often entering through industrial discharges, agricultural drainage, and sewage effluents [3]. Chloride concentrations in the Euphrates River in Samawah showed a notable increase during the rainy season (802 mg/L) compared to the dry season (491 mg/L). This is attributed to higher temperatures, lower river levels during summer, and a rise in groundwater levels contributing to increased chloride in river water.

Section Two: Calculation of the Water Quality Index (WQI) for the Euphrates River in Samawah City

The Canadian Water Quality Index (CWQI) was used due to its comprehensive accuracy, as cited by many researchers, including [4]. In the present study, the new design was applied to the study sites, and the water quality index was calculated according to the following steps [5]:

- **Factor One (F1 - Scope):**
  This represents the percentage of parameters that exceed the guideline limits, relative to the total number of parameters measured.
  Formula 1:
  F1 = (Number of failed parameters) / (Total number of parameters) (Number of failed parameters) / (Total number of parameters) × 100

- **Factor Two (F2 - Frequency):**
  This represents the percentage of individual tests that exceed the guideline limits, relative to the total number of tests conducted.
  Formula 2:
  F2 = (Number of failed tests)/(Total number of tests)(Number of failed tests) / (Total number of tests) × 100

Factor Three – F3 (Amplitude):

This factor represents the amount by which failed test values exceed the guidelines and is calculated in two steps:

1. **Step One – Excursion:**

The number of times individual test concentrations exceed the standard limit is calculated using the following formula:

Excursion = (Failed test value)/(Guide line value)(Failed test value) / (Guideline value)(Failed test value)/(Guide line value) – 1

2. **Step Two – Normalization of Excursion (NSE):**
   This is the sum of all excursions (deviations) divided by the total number of tests (including both failed and passed ones).
   NSE = (∑(i=1)nExcursion of each parameter)/(Total number of tests)(∑_(i=1)^n Excursion of each parameter) / (Total number of tests)(∑(i=1)nExcursionofeachparameter)/(Totalnumberoftests)

Once NSE is calculated, **F3** is determined by the following formula:
F3 = NSE/(0.01×NSE+0.01)NSE / (0.01 × NSE + 0.01)NSE/(0.01×NSE+0.01)

After calculating the three factors, the **Canadian Water Quality Index (CWQI)** is computed using the following formula:
CWQI = 100 – $\sqrt{}$(F1² + F2² + F3²) / 1.732

To classify the water quality of the Euphrates River, the results are compared against the CWQI rating scale, as outlined in **Table (2)**:

Table (2) Water Quality Index (CCME WQI) Scale [9]

Category	**Classification**	**CCME WQI Value Range**	**General Description**
First	Excellent	100-95	Water is well-protected and free from contamination, approaching pristine conditions.
Second	Good	94-80	Water is moderately protected and rarely deviates from ideal conditions.
Third	Fair	79-65	Water is generally protected but prone to degradation, sometimes deviating from optimal conditions.
Fourth	Uncertain	64-45	Water is frequently deteriorating and deviates from optimal conditions.
Fifth	Poor	44-0	Water is constantly exposed to pollution and is far from ideal conditions at all times.

The specifications set by (Tufeski) were relied upon, as shown in Table (3), and also the reliance on Table (4).

Table (3) Specifications of Water for Animal Tunnels (7)

Category	SO_4	Cl (mg)	Ca	Na	Zn	TDS
Very Good	1000	900	150	350	800	1500
Good	2500	2000	350	700	1500	3200
Definitely Usable	3000	3000	500	800	2000	4000
Can Be Used	4000	4000	600	900	2500	4700
Maximum Use Limit	6000	6000	700	1000	4000	4500

Table (4) Drinking Water Specifications for Diesel and Poultry (Electrical Conductivity EC Specifications) [6]

Electrical Conductivity EC (μmhos/cm)	Water Type	Note
Less than 1500	Excellent	Used for all types of livestock and poultry.
1500-5000	Very Acceptable	Used for all types of livestock and poultry, with a potential for temporary diarrhea in livestock.
5000-8000	Acceptable, but not suitable for poultry	Causes temporary diarrhea in livestock and can cause death in poultry, as well as stunted growth.
8000-11000	Limited use, not suitable for poultry	Acceptable for livestock but not for poultry.
11000-16000	Very limited use	Not internationally acceptable.
More than 16000	Not recommended	Extremely high and not recommended for use.

This led to the emergence and calculation of the Canadian Water Quality Index (CWQI) for water use for irrigation purposes in the city of Samawa from the Euphrates River at six important sites. The results showed that the water quality falls between 'poor' and 'moderate,' as shown in (5). The first site (M1), which represents the preservation category, recorded a 'poor' classification, while the rest of the sites were classified as 'moderate.

Table (5) Values and Classification of Water Quality in the Study Area

Site	Water Quality Index Value	Classification
M1	42.32	Poor
M2	75.29	Neutral
M3	75.25	Neutral
M4	75.26	Neutral
M5	75.25	Neutral
M6	75.75	Neutral

Results of Laboratory Tests Related to Animal Health:

The analysis results revealed that water with high levels of chlorides, sodium, and sulfates may be unsuitable for consumption. When the electrical conductivity (EC) exceeds 5000 μmhos/cm, ruminant animals begin to experience issues with food delivery, effectively delaying the intake of food. For example, water with sodium levels of 2000 mg/L can lead to increased mineral content in animal structures, disrupting fluids and salts in their bodies.

Table (6) Laboratory Analysis Results Related to Animal Health

Effect on Ruminant Animals	Concentration in Water	Characteristic
May cause digestive disorders and food disruption.	> 5000 µmhos/cm	Electrical Conductivity (EC)
Metal poisoning, disaster model, increased thirst and diarrhea.	> 2000 mg/L	Sodium (Na)
Digestive issues such as diarrhea, effects on the nervous system.	> 1500 mg/L	Sulfates (SO_4)
Effects on salt balance in the animal's body, general health effects.	> 1000 mg/L	Chlorides (Cl)

Discussion

Analysis of the Euphrates River Water Quality Based on the Canadian Water Quality Index (CWQI)

The results of the Euphrates River water quality analysis in the Samawa region, using the Canadian Water Quality Index (CCME WQI), showed variation in the water quality classification across the studied sites. The first site (M1) recorded an index value of 42.32, placing it in the "poor" category according to the CWQI scale [8], while the other sites (M2–M6) recorded values ranging from 75.75–75.25, placing them in the "moderate" category.

Interpretation of the Results Based on the CWQI Scale:

- **Site M1 (Poor):** This classification indicates that the water at this site is constantly exposed to contamination, making it unsuitable for vital uses such as drinking or irrigation without prior treatment [9]. This could be due to factors like industrial or agricultural pollution or untreated sewage.
- **Sites M2–M6 (Moderate):** The classification indicates that the water is partially protected but occasionally deviates from optimal standards, which could affect its suitability for sensitive uses such as animal drinking [8].

Comparison of Results with Animal Drinking Water Standards (Altoviski, 1962):
When comparing the results with the Altoviski standards [9], it was noted that some of the parameters exceeded the acceptable limits for water suitable for animal consumption, especially regarding:

- **Sulfates (SO_4):** The results indicate concentrations higher than 1500 mg/L, which could cause digestive problems such as diarrhea in ruminant animals (Table 6).

- **Sodium (Na):** Concentrations exceeded 2000 mg/L, which could lead to metal poisoning, increased thirst, and diarrhea [10], [12], [13], [14], [15], 16].

• **Chlorides (Cl):** Their presence at concentrations higher than 1000 mg/L affects the salt balance in the animal's body (Table 6).

Evaluation of Water Quality Based on Electrical Conductivity (EC): According to [11] standards:

• Water with EC < 1500 µmhos/cm is considered excellent for all types of livestock and poultry.
• Water with EC between 5000–8000 µmhos/cm causes temporary diarrhea in livestock and can be fatal to poultry.
• The results showed that some sites exceed 5000 µmhos/cm, indicating a negative impact on animal health, especially on the digestive and metabolic systems (Table 6).

Conclusions and Recommendations

1. Water quality in the Euphrates River ranges from "poor" to "moderate," requiring continuous monitoring of potential pollution sources.
2. The water is unsuitable for direct animal consumption at some sites due to high concentrations of dissolved salts (sulfates, sodium, chlorides).
3. It is recommended to treat the water before using it for irrigation or animal drinking, especially in areas with a "poor" classification.
4. There is a need for further studies to identify the main sources of pollution and develop sustainable water resource management plans.

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