

Article

Assessment of Drinking Water Quality in School Tanks in the Holy Governorate of Karbala, Iraq

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Abstract: This research was conducted to assess the water quality of school tanks. A total of 240 water samples were collected, distributed in 16 sites divided into four districts of the Holy Karbala Governorate, for a period of five months from October 2025 to February 2026. Physical and chemical tests of water samples were conducted according to standard methods approved for water testing. The results showed that the temperatures were within the permissible levels for drinking water. While turbidity recorded relatively low values, this indicates a low content of suspended materials and pollution-causing organisms. The electrical conductivity and total dissolved solids also showed a relative increase in some locations and months, especially during the rainy season. As for the suspended solids, they remained within the permissible limits. The pH values showed relatively stability within the acceptable range. The total hardness recorded an increase that exceeded the standard limits in some locations, while chloride concentrations remained within permissible limits. The results of dissolved oxygen also showed a slight increase during the winter as a result of lower temperatures and increased oxygen solubility, while Biological Oxygen Demand recorded relatively low values. The study found that the water quality at the study sites was relatively acceptable, except for some parameters that exceeded the permissible limits. Therefore, periodic treatment procedures should be applied to maintain the level of physical and chemical properties within the safe limits for drinking water in schools.

Keywords: Water quality, Physical parameters, Chemical parameters, school water Tanks.

Introduction

Water pollution poses a global threat to biodiversity and human health, Urbanization and industrialization have led to increased use of chemical pesticides, mining, and other activities carried out by humans with the aim of enhancing global food security, these activities lead to the deterioration of aquatic ecosystems and higher rates of disease [1] [2] Water pollution, in general, is characterized by a change in biological, physical, and chemical properties that leads to a change in the basic properties of water, such as colour, smell, and taste, which negatively affects human health [3]. Water pollution causes many environmental risks, the most important of which is drinking water pollution, which is caused by pathogenic organisms, such as fish that humans feed on, as a result of exposure to biological

toxins and their accumulation in their bodies. Among these diseases are typhoid, cholera, amoebic dysentery, and others [4].

Water plays a vital role in human life, as water quality is closely related to human health. According to the World Health Organization, providing safe drinking water brings great health benefits and contributes to the prevention of many diseases [5]. Good quality water is defined as water that possesses acceptable chemical, physical, biological, and radiological properties, based on widely accepted local and international standards, such as those of the World Health Organization. Water quality deterioration can be attributed to contamination at various points within the water supply system, including distribution and storage [6][7]. Although many local and international organizations are making strenuous efforts to improve water quality, water pollution remains widespread, and pollution, whether direct or indirect, by human or animal waste, especially feces, is the most common and widespread health risk associated with drinking water [8][9].

Water quality assessment has received widespread global attention because the majority of diseases that cause morbidity and death are related to water [10]. Over the past two decades at least, concern about the quality of tap water has increased due to pollution and its undesirable taste and smell [11][12]. Tap water contamination can originate from multiple sources, including contamination from water pipes and storage tanks [13]. Furthermore, in the absence of regular and proper maintenance, byproducts of disinfectants produced during water treatment with ozone and chlorine may form [14][15]. Therefore, for safety and quality reasons, people are switching from tap water to bottled water.

To assess water quality, the results are compared with standard limits of drinking water. Physical, chemical, and biological factors should be continuously examined to gather information about the water, establish guidelines for its intended use, and determine its suitability for a given purpose. Therefore, the main objective of this research was to study the current status of physical and chemical parameters of school water and assess its suitability for drinking.

Materials and Methods

Study area

Water samples were collected from government schools in the holy province of Karbala, located in south-central Iraq, between latitudes (32°10' and 32°50') north and longitudes (43°10' and 44°12') east, It is about 30 meters above sea level. The study was distributed over four districts (Karbala Center, Al-Hur, Al-Husayniyah, Al-Hindiya) and four schools from each district, as shown in Table (1).

School name and location	Sample number	Coordinates	
		Latitude (N)	Longitude (E)
Al Nahda	St1	32°40'42.9	44°12'07.1
Al-Husayniyah District shahid Al-Mihrab	St2	32°39'02.5	44°06'34.1
Al-Husayniyah District Al-Mada	St3	32°43'07.2	44°12'29.8
Al-Husayniyah District albusat Al-Akhdar	St4	32°41'54.7	44°08'41.6
Al-Mutafawiqin	St5	32°32'37.9	44°13'44.3
Al-Hindiya District AL-Wala	St6	32°32'30.7	44°16'03.4
Al-Hindiya District Hajar Bin Adi	St7	32°30'33.5	44°14'29.3
Al-Hindiya District Al-Hadar	St8	32°28'22.5	44°13'08.2

Alshahid Abu Al-Maali Karbala Center	St9	32°35'50.2	44°00'41.0
The second mutafawiqin Karbala Center	St10	32°37'26.8	43°59'38.3
Al-Thura Karbala Center	St11	32°34'43.0	44°00'22.8
Karbala Preparatory Karbala Center	St12	32°36'16.4	44°01'55.3
Al-Hur Al-Riyahi Al-Hur District	St13	32°39'03.4	43°58'33.9
Umm Habiba Al-Hur District	St14	32°38'17.1	43°59'19.9
Yawm Al-Ghadir Al-Hur District	St15	32°42'20.5	44°01'07.1
Sharia Al-Hur District	St16	32°41'24.2	32°41'24.2

Sample collection

The collection of samples from school water tanks began in the mornings during official working days from eight in the morning until twelve noon from October 2025 until February 2026, with three replicates for each sample. Water samples were collected for physical and chemical testing using clean 2-liter polyethylene containers. Water samples were collected using 250 ml transparent Winkler bottles for dissolved oxygen (DO) estimation and 250 ml opaque Winkler bottles for biological oxygen demand (BOD5) estimation. The samples were then transported directly to the laboratories of the Holy Karbala Water Directorate for laboratory testing.

Physical parameters

Several physical tests were performed at each site, including temperature, which was measured using a mercury thermometer; electrical conductivity (EC); total dissolved solids (TDS) using a HANNA multimeter; and turbidity using a WTW turbidity meter. Total Suspended Solids (TSS) were measured according to the method described by the American Public Health Association [16].

Chemical parameters

To estimate dissolved oxygen values and biological oxygen demand, the Azide modification method of Winkler's method was used, and the result was expressed in mg/L units. pH was measured using a multimeter of type (HANNA), total hardness by titration with EDTA-2Na solution (0.01 N) using Eriochrome Black T (EBT) as an indicator and the result was expressed in mg/L units, and chloride by titration with nitrate [16].

Results

Table 2 shows the results of the physical and chemical tests of 240 water samples collected from 16 schools over five months. The data included the average, minimum and maximum physical and chemical properties and their comparison with the standard limits of the World Health Organization.

Physical parameters

The results in Table 2 show that the temperature values at the study sites ranged between 17.60–20.40 °C and varied during the study months Figure 1, reaching a minimum of 14.96 °C in January and a maximum of 21.88 °C in October. These values are within the standard limits of the World Health Organization. Turbidity values at the study sites Table 2 ranged between 2.24 and 5.80 turbidity units, with the highest value recorded at study site St12. Turbidity showed variation during the study months (Figure 1), with the lowest average being 2.66 turbidity units during February and the highest average being 4.47 turbidity units during October. The electrical conductivity values reached 1443.93–1599.20 µs/cm at the study sites (Table 2). The lowest value of 1429.83 µs/cm was recorded during February, and the highest value of 1676.79 µs/cm was recorded during January (Figure 1). In the current study, values of Total dissolved solids (TDS) at the study sites ranged from 922.93 to 1052.27 mg/L (Table 2),

and monthly Monthly variations (Figure 1) reached a minimum of 912.83 mg/L during October and a maximum of 1067.10 mg/L during December. The values Total Suspended Solids at the study sites ranged from 3.00-6.00 mg/L (Table 2). The changes in values during the months (Figure 1) ranged from a minimum of 3.13 mg/L during February to 5.63 mg/L during December.

Table 2. Physical parameters of water samples for study sites $\pm$ standard deviation.

Station	Physical parameters				
	Temperature ($^{\circ}\text{C}$)	Turbidity (NTU)	EC ($\mu\text{s}/\text{cm}$)	TDS (mg/L)	TSS (mg/L)
St1	17.60 $\pm$	4.00 $\pm$	1460.07 $\pm$	932.13 $\pm$	4.00 $\pm$
	1.92	1.31	97.87	61.27	1.32
St2	17.80 $\pm$	2.26 $\pm$	1482.00 $\pm$	933.80 $\pm$	4.00 $\pm$
	2.65	0.88	101.82	96.42	2.27
St3	19.40 $\pm$	2.80 $\pm$	1514.00 $\pm$	966.73 $\pm$	4.00 $\pm$
	3.38	1.21	183.27	115.99	2.27
St4	20.40 $\pm$	2.45 $\pm$	1533.67 $\pm$	980.00 $\pm$	3.60 $\pm$
	2.50	0.53	196.25	127.91	2.42
St5	19.73 $\pm$	2.44 $\pm$	1591.40 $\pm$	1018.07 $\pm$	3.00 $\pm$
	3.77	0.62	117.41	76.74	0.93
St6	20.00 $\pm$	4.80 $\pm$	1480.47 $\pm$	931.73 $\pm$	5.20 $\pm$
	3.14	0.41	134.05	68.86	1.21
St7	19.80 $\pm$	4.00 $\pm$	1443.93 $\pm$	922.93 $\pm$	3.40 $\pm$
	2.40	1.85	109.78	68.69	1.80
St8	19.00 $\pm$	2.24 $\pm$	1590.07 $\pm$	1017.93 $\pm$	4.80 $\pm$
	3.40	1.49	126.40	81.35	2.81
St9	19.00 $\pm$	4.20 $\pm$	1572.20 $\pm$	1004.40 $\pm$	4.40 $\pm$
	2.78	1.01	110.12	68.12	2.03
St10	18.80 $\pm$	4.14 $\pm$	1599.20 $\pm$	1018.73 $\pm$	4.40 $\pm$
	2.23	0.58	124.09	79.26	2.03
St11	20.00 $\pm$	4.90 $\pm$	1588.07	1011.20 $\pm$	5.00 $\pm$
	2.93	1.29	129.17	81.46	1.31
St12	19.60 $\pm$	5.80 $\pm$	1588.67 $\pm$	1052.27 $\pm$	6.00 $\pm$
	3.18	0.77	138.96	199.46	1.31
St13	18.60 $\pm$	4.20 $\pm$	1539.53 $\pm$	982.00 $\pm$	4.00 $\pm$
	2.32	0.77	174.68	107.77	2.27
St14	19.00 $\pm$	2.43 $\pm$	1572.60 $\pm$	1003.13 $\pm$	3.20 $\pm$
	2.17	1.15	120.36	75.50	1.01
St15	18.40 $\pm$	2.94 $\pm$	1584.67 $\pm$	1015.20 $\pm$	4.00 $\pm$
	2.32	1.14	224.54	141.52	2.27
St16	17.60 $\pm$	3.60 $\pm$	1562.07 $\pm$	985.73 $\pm$	4.40 $\pm$
	1.92	0.83	174.14	121.73	2.41
WHO Limit	25	5	1500	1000	-

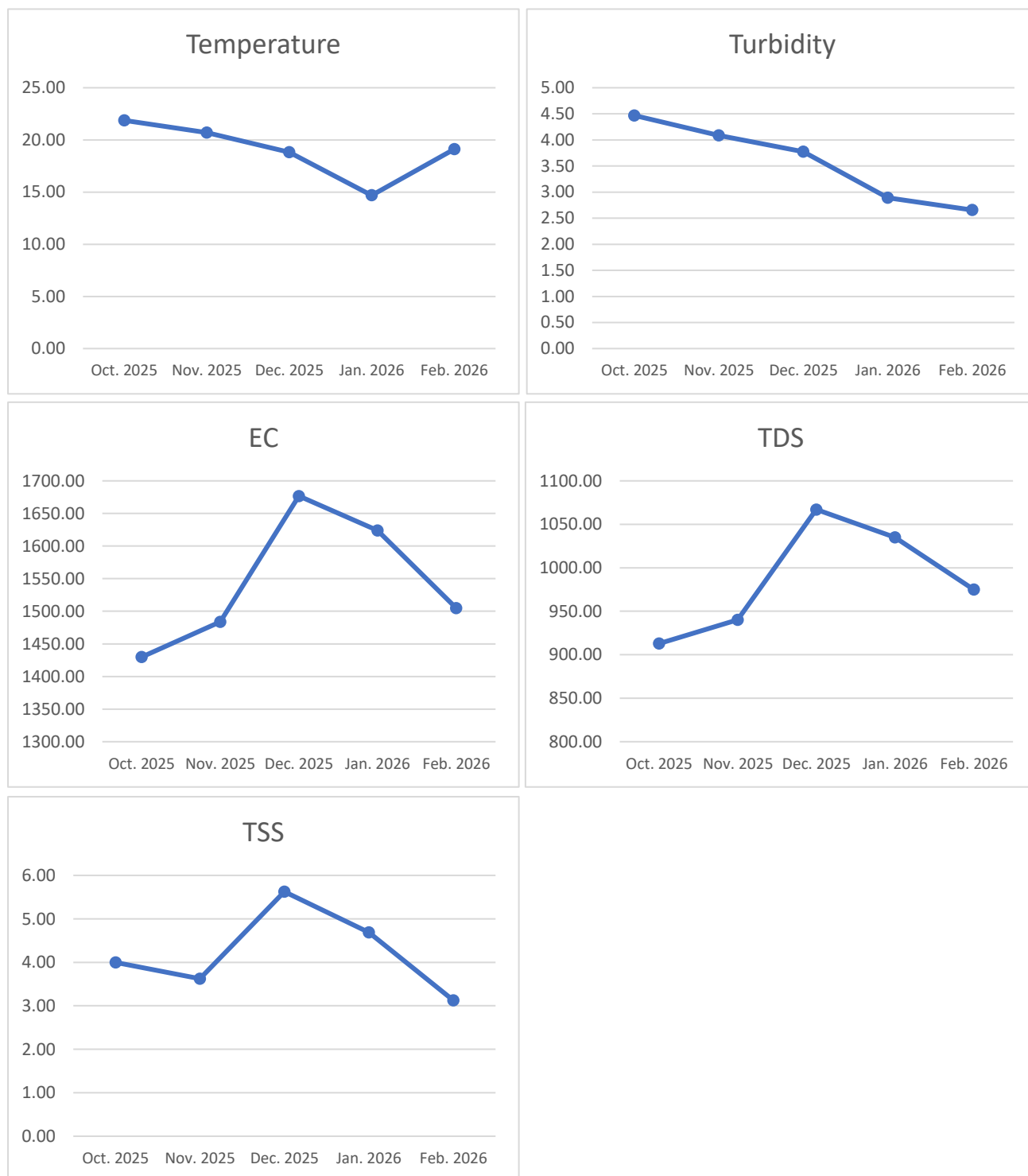


Figure 1. Monthly variations in the Physical parameters of water samples at study site.

Chemical parameters

Regarding pH, the minimum and maximum values for the study sites were 7.26 and 7.71 respectively (Table 3), and the changes during the months (Figure 2) reached their lowest level of 7.41 during November and their highest level of 7.53 during October, which are within the standard limits. Total hardness values at the study sites ranged from 480.07 to 529.07 mg/L (Table 3), and the monthly variations in minimum and maximum values were 452.42 and 561.54 mg/L, respectively (Figure 2).

Chloride levels ranged from 166.13 to 189.93 mg/L at the study sites (Table 3), and monthly variations (Figure 2) showed a minimum of 162.17 and a maximum of 200.00 mg/L. Dissolved oxygen levels at the study sites ranged from 8.86 to 9.70 mg/L (Table 3). Monthly variations in dissolved oxygen levels (Figure 2) ranged from a minimum of 5.74 to a maximum of 11.78 mg/L. The values of the biological oxygen demand (BOD₅) at the study sites ranged between 1.51 and 1.87 mg/L (Table 3), and the monthly changes in values (Figure 2) ranged from a minimum of 0.95 mg/L during January to a maximum of 3.57 mg/L during October.

Table 2. Chemical parameters of water samples for study sites $\pm$ standard deviation.

Station	Chemical parameters				
	PH	TH (mg/L)	Cl ⁻ (mg/L)	DO (mg/L)	BOD ₅ (mg/L)
St1	7.39 $\pm$	480.40 $\pm$	166.13 $\pm$	8.92 $\pm$	1.59 $\pm$
	0.09	39.45	13.64	2.58	0.75
St2	7.45 $\pm$	494.33 $\pm$	168.93 $\pm$	9.39 $\pm$	1.51 $\pm$
	0.15	33.14	15.06	2.48	0.66
St3	7.51 $\pm$	508.60 $\pm$	171.67 $\pm$	9.21 $\pm$	1.65 $\pm$
	0.23	69.32	27.55	2.72	0.79
St4	7.35 $\pm$	512.00 $\pm$	174.47 $\pm$	9.70 $\pm$	1.73 $\pm$
	0.25	88.98	19.04	1.95	0.87
St5	7.52 $\pm$	517.27 $\pm$	189.40 $\pm$	9.12 $\pm$	1.59 $\pm$
	0.19	50.94	22.70	2.57	0.93
St6	7.46 $\pm$	483.20 $\pm$	168.33 $\pm$	9.39 $\pm$	1.64 $\pm$
	0.12	41.39	16.19	2.36	0.99
St7	7.66 $\pm$	480.07 $\pm$	167.20 $\pm$	9.31 $\pm$	1.69 $\pm$
	0.13	33.05	15.04	2.43	1.01
St8	7.45 $\pm$	522.33 $\pm$	185.20 $\pm$	9.19 $\pm$	1.73 $\pm$
	0.22	47.77	20.07	2.32	1.05
St9	7.38 $\pm$	517.73 $\pm$	189.13 $\pm$	9.17 $\pm$	1.77 $\pm$
	0.16	43.83	16.37	2.29	1.07
St10	7.26 $\pm$	523.93 $\pm$	189.93 $\pm$	8.86 $\pm$	1.80 $\pm$
	0.19	47.14	19.91	2.77	1.04
St11	7.47 $\pm$	526.40 $\pm$	185.73 $\pm$	8.99 $\pm$	1.83 $\pm$
	0.13	59.10	16.45	2.65	1.15
St12	7.40 $\pm$	527.00 $\pm$	185.13 $\pm$	8.91 $\pm$	1.81 $\pm$
	0.11	61.80	22.34	2.53	1.05
St13	7.65 $\pm$	519.00 $\pm$	174.80 $\pm$	8.90 $\pm$	1.87 $\pm$
	0.14	94.57	19.68	2.89	1.12
St14	7.53 $\pm$	529.07 $\pm$	178.40 $\pm$	9.15 $\pm$	1.87 $\pm$
	0.19	64.91	15.43	2.86	1.15
St15	7.42 $\pm$	525.00 $\pm$	182.87 $\pm$	9.20 $\pm$	1.72 $\pm$
	0.25	95.92	24.96	2.69	1.14
St16	7.71 $\pm$	508.80 $\pm$	181.00 $\pm$	9.05 $\pm$	1.82 $\pm$
	0.30	59.88	26.39	2.80	1.19
WHO Limit	6.5-8.5	500	250	>5	-

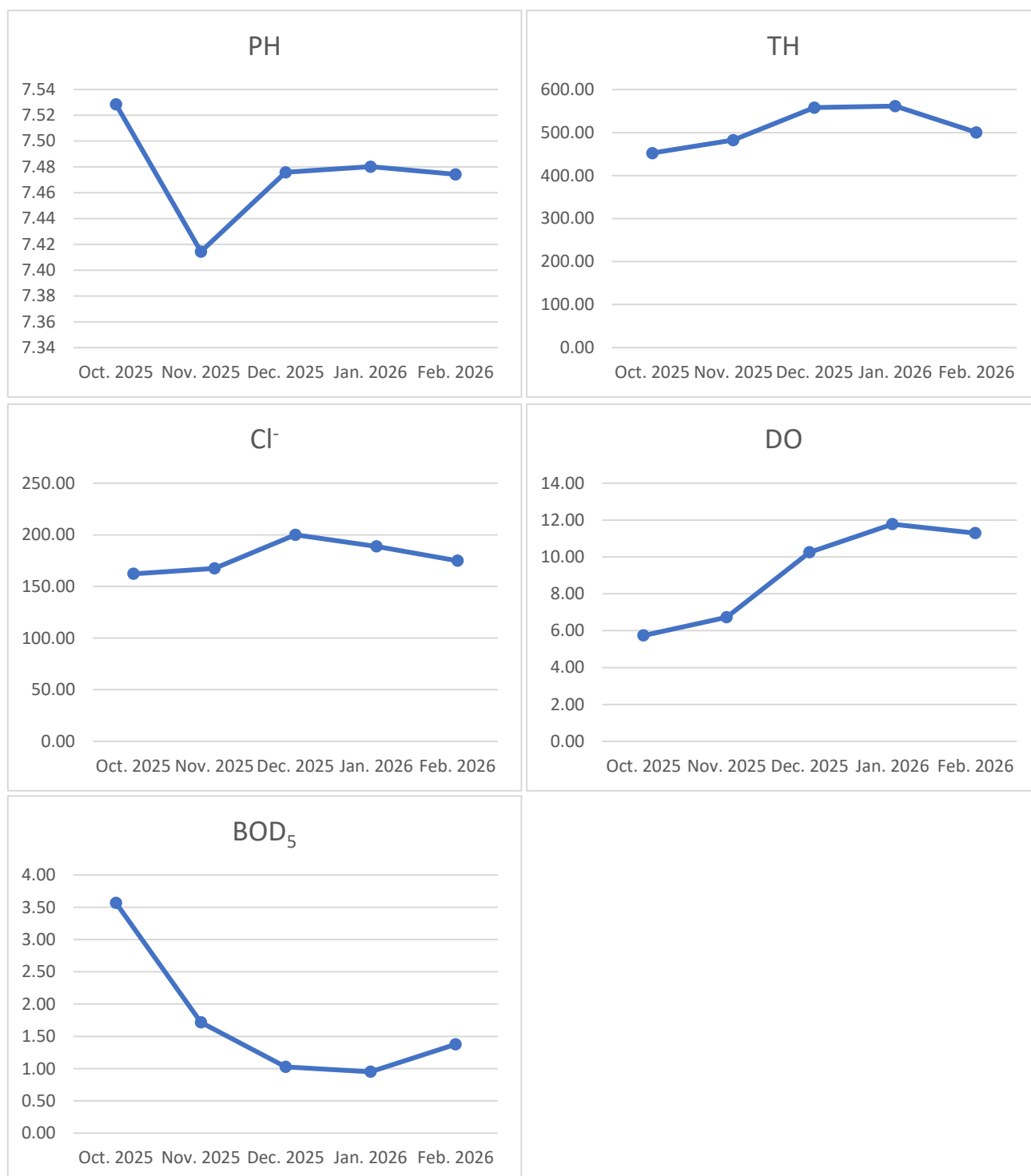


Figure 2. Monthly variations in the Chemical parameters of water samples at study sites.

Changes in water temperature lead to changes in the physical and chemical properties of water, which affect the physiological adaptation of organisms within the environment [17][18]. This is because temperature has a direct effect on the normal behavioral functions of the aquatic ecosystem [19]. the amount of dissolved gases, such as oxygen, whose concentration can be either harmful or important for the migration, growth, and death of aquatic plants and animals [20]. Turbidity is another parameter in the analysis of drinking water, it is the cloudiness of water caused by a variety of particles and is also related to the content of pathogenic organisms in the water, which may come from surface runoff from the soil [21][22]. Electrical conductivity is a measure of the total ion content in water, where the presence of salts and pollutants in wastewater leads to an increase in water conductivity [23]. Higher levels may

indicate the presence of pollutants such as salts or heavy metals [24]. Total dissolved solids (TDS) usually refer to measuring the amount of all inorganic and organic components present in a liquid solution, usually water. It includes the total sum of ions, minerals, salts, metals, and other dissolved substances present in the water [25]. The results show that the total dissolved solids values are higher than the limits allowed by the World Health Organization, which are 1000, and that these values are higher during the rainy season, this is related to surface water and what it carries of inorganic materials and salts to river water, this is consistent with what was indicated that the results recorded higher values for total dissolved solids during rainy periods compared to dry periods [26]. Elevated total dissolved solids (TDS) values may not be separate from soil runoff contributions and increased river flow turbulence, which may have caused a re-increase of sedimentation [27][28]. the results of Total Suspended Solids fall within the fall within the permissible limits of the World Health Organization, the increase in suspended solids values during December is attributed to the increased erosion of soil and sediments into water sources with the start of the rainy season, in addition to the movement of sediments deposited at the bottom of tanks or transport networks as a result of changes in flow velocity.

Chemical parameters

Although there is no direct relationship between human health and water pH, it affects many other water quality parameters, so it should be considered a key factor in controlling the corrosion of water pipes in the water distribution network. pH also affects disinfection efficiency [29]. water hardness is not usually considered a risk to human health, it can affect the taste and quality of drinking water in general, because hard water may produce an unpleasant taste or smell, and it may cause mineral deposits to accumulate in water pipes, which may lead to problems with water flow and quality [24]. Natural sources, wastewater, industrial waste, deionized urban runoff, and brine intrusion are all sources of chlorides in drinking water [30]. Dissolved oxygen is important for all vital functions in the aquatic environment. It is needed for metabolic processes and aerobic respiration, the amount of dissolved oxygen in the water is a direct result of air diffusion and the photosynthetic activity of aquatic plants. Other factors that negatively affect the concentration of dissolved oxygen include the direct discharge of waste and dead organic matter, which consumes the available oxygen in the water when they decompose. [26]. exceeding standard limits. In this study the elevated dissolved oxygen levels during winter are attributed to lower temperatures and increased photosynthesis, consistent with the findings of [31]. the biological oxygen demand (BOD₅) measures the amount of oxygen consumed by organisms during the decomposition of organic matter under specific temperature and atmospheric pressure conditions over a defined period. This test is essential for assessing drinking water quality [32].

Conclusion

The results of the current study showed that most of the physical and chemical properties of the reservoir water were within the standards recommended by the World Health Organization. Temperature, turbidity, pH, and suspended solids all recorded values within acceptable limits, with some variation between the sampling locations and the months of the study. The results showed high electrical conductivity values at most study sites, indicating increased dissolved salt and ion content in the water. Some total dissolved solids and total hardness values exceeded standard limits. Dissolved oxygen levels were significantly elevated in some months of the study, particularly during the colder and rainier months, due to lower temperatures and increased water solubility. The study generally indicates that the water quality at the study sites is relatively acceptable, but the high level of some indicators requires the responsible authorities to intensify and continue periodic monitoring programs to maintain water quality and safety, especially for children, because they are vulnerable to various health problems if they are exposed to contaminated water.

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