Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Physical Properties of Darbandikhan Lake

Effects of Seasonal Changes on Water Quality in Darbandikhan Lake

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The current study aimed to investigate the physical properties of water in Darbandikhan Lake and the Sirwan River in Darbandikhan district, Sulaymaniyah province, at five locations: near Darbandikhan Dam, the middle of the lake, Banqween Island, Khwar Camp area, and Zala Naw resort. The study was conducted from September 2023 to February 2024.
The study measured several physical factors, including air and water temperature, turbidity, electrical conductivity, total dissolved solids, and suspended solids. The results showed that air temperatures ranged from 13.3°C to 36.4°C, influenced by the region's climatic conditions. Water temperatures ranged from 13.3°C to 29°C, reflecting the impact of air temperature. Turbidity values varied between 0.67 NTU and 5.45 NTU, and electrical conductivity values ranged from 300 to 469 µS/cm, within the permissible limit of 1000 µS/cm. Total dissolved solids (TDS) values ranged from 164 mg/L to 270 mg/L, indicating moderate levels within the acceptable range for Iraqi drinking water. Suspended solids values varied significantly between locations during the study period, ranging from 0.334 mg/L to 9.476 mg/L, with a notable increase in February due to rain and soil erosion mixing with the lake water.

Keywords: seasonal changes, water quality.

1. Introduction

Studying water resources and understanding their quality characteristics are crucial due to their direct connection to agricultural, industrial, residential, environmental, and even tourism activities. Water quality is influenced by surface water sources, groundwater movement, and the nature of the water-bearing rock layer, which are essential for determining water suitability for various uses (Ali and Mohammed, 2019).

The study of freshwater in Darbandikhan Lake is fundamental for environmental studies because water has highly sensitive properties that can change rapidly if exposed to external

pollutants. Recently, lake water quality in Iraq has been affected by climate change, global warming, and reduced river levels, in addition to the increasing demand for water to meet human needs amid population growth. The construction of dams on rivers in neighboring countries, such as on the Sirwan River in Iran and on the Tigris and Euphrates rivers in Turkey, has also impacted lakes, including Darbandikhan Lake in Sulaymaniyah (Al-Khatab, 2018).

2. Study Objectives

1. Identify the physical properties of water in Darbandikhan Lake within the study area and conduct a spatial and monthly comparison of the studied factors.

Importance of Water

Water resources are fundamental elements for environmental development, essential for life, and critical factors in agricultural production. They are also vital for industry, transportation, and electricity generation (Imran and Abdulrahman, 2018).

In Iraq, surface freshwater resources include perennial rivers and their tributaries, seasonal rivers, valleys, natural lakes, and water reservoirs upstream of dams. These sources form the backbone of Iraq's social, economic, and demographic life, with most of the population concentrated around these sources. Artificial lakes and reservoirs upstream of dams, filled by river runoff during flood seasons, serve as strategic reserves during droughts, especially with climate change and reduced rainfall, as well as the construction of dams on main tributaries in neighboring countries like Iran and Turkey (Ali et al., 2018).

Water Pollution

Pollution is defined as any negative change or impact on water quality, resulting in water becoming unsuitable for aquatic life such as fish and birds that rely on water for survival. Any alteration in water composition or state is considered pollution (Aqoun and Massous, 2021).

Physical pollution directly and indirectly affects water quality, negatively impacting uses such as irrigation, construction, and industry, and affecting individuals, families, and communities (Al-Jalali, 2017). Types of pollution include:

- Physical Pollution: Physical pollution causes changes in water standards, such as temperature or salinity increases due to river or lake water evaporation or reduced natural water sources, especially during droughts. Water temperature can increase due to the discharge of cooling water from factories into water bodies (Abdul Rahman, 2015). Turbidity and suspended solids, whether organic or inorganic, increase due to climatic factors like heat waves, cold spells, floods, and tropical cyclones, which directly affect rivers and lakes, such as Darbandikhan Lake, making these factors essential for aquatic ecosystem systems (Manek et al., 2017).

Physical, Chemical, and Ionic Properties of Water

The physical and chemical properties of water are crucial for determining water quality and suitability, containing various organic and inorganic elements and compounds (Al-Douri, 2014). These properties play a fundamental role in the distribution and behavior of aquatic organisms, such as the growth and blooming of phytoplankton, influenced by temperature,

light, nutrients, salts, and dissolved oxygen, contributing to biodiversity in aquatic communities (Rutther, 2010). Lakes, being dynamic environments, affect and are affected by their surroundings, making the study of water properties essential for understanding water quality and its suitability for human use (Al-Munnami, 2002).

Physical Properties

Temperature: Temperature is a principal factor influencing the metabolic processes of living organisms, affecting the activity and distribution of aquatic life. It also plays a role in determining water's physical and chemical properties, influencing the solubility of oxygen and other gases, respiration, nutrient cycling, and phytoplankton (Hamed, 2021). Water temperature is directly affected by air temperature and is similar in surface waters (Baroud, 2010). Low water temperatures increase oxygen solubility, while high temperatures boost metabolic activities, leading to higher oxygen consumption, which can harm aquatic life (Al-Mughir, 2015).

Water quality differs between lakes and rivers, with thermal stratification occurring in lakes during summer, where surface water heats up while deeper layers remain cool, leading to a temperature gradient. This stratification diminishes in autumn, mixing the water layers and equalizing the temperature, which affects water quality (Al-Hamdani and Al-Khatab, 2004).

Electrical Conductivity (EC): Electrical conductivity measures the concentration of positive and negative ions in water, depending on the concentration of dissolved ionic substances and temperature, which affects ion movement. An increase in water temperature by one degree Celsius increases electrical conductivity by 2% (APHA, 2003). Thus, electrical conductivity is an indirect measure of dissolved salts in water, with a direct relationship to total dissolved solids (TDS) (Nezam and Mohammed, 2013). Water with high inorganic compounds has high conductivity, while water with non-degradable organic compounds has low conductivity (Al-Mujami, 2022). Conductivity is influenced by temperature, geochemical and hydrological factors, and evaporation, important in polluted water where organic decomposition affects conductivity (Al-Manawi, 2015). Conductivity increases as water levels drop in summer, concentrating dissolved salts and increasing conductivity and TDS values (Nezam and Mohammed, 2013).

Turbidity: Turbidity, a visual water characteristic, results from light scattering and absorption by suspended particles, affecting water clarity. It includes all non-dissolved materials that hinder light penetration, influenced by the concentration and size of suspended particles (Al-Saadi, 2005). Suspended materials can be organic (phytoplankton, zooplankton) or inorganic (clay, silt), causing water discoloration (Helfrich et al., 2005). Turbidity decreases in stagnant water (lakes, ponds) and increases in flowing water (rivers) due to sediment movement (Al-Saadi, 2005). High turbidity limits light penetration, affecting aquatic life such as bacteria, fungi, algae, and other impurities (Al-Dulaimi, 2018).

3. Materials and Methods

Description of Study Area: The research was conducted at the University of Tikrit, College of Education for Women, in the laboratories of the Department of Life Sciences, to study the physical, chemical, and biological properties of water in Darbandikhan Lake, Sulaymaniyah

province, from September 2023 to February 2024, with one sample collected monthly.

Sample Collection: Samples were collected from 8 am to 2 pm, from September 2023 to the end of February 2024. Bottles were rinsed with sample water several times before filling with minimal air space to preserve physical and chemical properties during transport. Polyethylene bottles (2.25 liters) were used for physical and chemical tests, rinsed three times with sample water before collection. Transparent and opaque Winkler bottles (250 ml) were used for biochemical oxygen demand measurement, and pre-sterilized glass bottles (200-250 ml) with tight caps were used for bacteriological tests, transported to the laboratory in an ice-filled plastic box to maintain sample properties until analysis. If not immediately analyzed, samples were stored at 4°C for up to 24 hours, avoiding light exposure (WHO, 1996; APHA, 1985). Laboratory equipment and glassware were washed thoroughly with distilled water and dried using an electric oven. Analyses were conducted in the laboratories of the College of Engineering, Chemical and Environmental Engineering Departments, University of Tikrit, and the Department of Water and Sewerage, Quality Control Section.

4. Results and Discussion

4.1. Physical and Chemical Measurements

Temperature:

The study results showed spatial and temporal variations in air temperature across all study sites. Spatial differences were significant at the probability level of $P \leq 0.05$, while temporal differences were not significant during the study months, as shown in Table (1) - (4-1A). Air temperatures ranged from 13.3°C to 36.4°C, with the lowest air temperature recorded at 13.3°C in February 2024 at site St1, and the highest temperature recorded at site St4 in September 2023. The study area has a mountainous nature with a humid and semi-humid Mediterranean climate, with the rainy season starting in winter and lasting until the end of May. Monthly temperature variations are attributed to these climatic characteristics (Khattab, 2018).

Regarding water temperature during the study period, it ranged from 13.3°C to 29°C, with the highest recorded at site St3 in September 2023, and the lowest at site St3 in February 2024. Statistical analysis results indicated no significant temporal differences between study sites, while significant spatial differences were recorded at the significance level of $P \leq 0.05$.

Monthly water temperature changes are due to seasonal weather variations, where air temperature fluctuations directly affect the water. Additionally, the reduction in water levels due to evaporation and increased solar radiation on the lake contributes to temperature changes, as shown in Table (4-1B).

The lowest water temperature (13.3°C) at site St3 in February 2024 is due to the high lake level, abundant rainfall, low temperatures, and reduced solar radiation on the lake water (Patil et al., 2011).

These findings are comparable to the study by Ali (2023) on Darbandikhan Lake, where temperatures ranged from 13°C to 30°C. They are also similar to the study by Nizam and Mohammed (2013) on Lake Muzayrib in Syria, where temperatures ranged from 12.5°C to

28°C, and lower than the study by Al-Dulaimi (2018) on Tharthar Lake, where temperatures ranged from 20°C to 35°C. Additionally, they are higher than the study by Al-Hamdani and Khattab (2015) on Mosul Lake, where surface water temperatures ranged from 10°C to 25°C.

Temperature directly affects the biological processes of aquatic life. Lower temperatures during winter reduce the activity of microorganisms due to decreased metabolic processes (Weiner, 2000). Higher temperatures decrease dissolved oxygen due to increased microbial activity and oxygen consumption (Kulkarni et al., 2007).

Table 1: Monthly and Site Variations in Air Temperature (A1-4)

Months	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mean
St1	34	33.5	24	17.4	-	13.3	24.4 B
St2	32	30	22	17.8	-	14.3	23.2 B
St3	35	31.7	21	18.5	-	13.8	24.0 B
St4	36.4	31.8	24	19.7	-	17	25.8 AB
St5	36	32	27.8	22	-	19.2	27.4 A
Mean	34.7 A	31.8 b	23.8 c	19.1 d	-	15.5 E	

Table 2: Monthly and Site Variations in Water Temperature (B1-4)

Months	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mean
St1	28	25.5	23	19.1	-	13.4	21.8 A
St2	26	25	20	19.2	-	14.4	20.9 A
St3	29	25.7	20	19.4	-	13.3	21.5 A
St4	13.8	14.7	15.7	16	-	16.3	15.3 B
St5	16	15.9	18.4	16.1	-	16.4	16.6 B
Mean	22.6 A	21.4 a	19.4 b	18.0 b	-	14.8 C	

Electrical Conductivity (EC):

The EC values of water samples varied by location and season during the study months, as shown in Table (3). Spatial and temporal differences were significant at the probability level of $P \leq 0.05$, with values ranging from 399 to 469 µS/cm. The highest value of 469 µS/cm was recorded at site St4 in February 2024, and the lowest value of 300 µS/cm in October 2023. February values were higher due to increased dissolved salts and ions during the rainy season, influenced by runoff and soil erosion containing ionizable materials. Geology and agricultural activities also impact EC by contributing to higher conductivity due to fertilizer runoff (Barzanji et al., 2009). EC is directly proportional to salt concentration and is a measure of water quality and dissolved ions (Bhat et al., 2018).

The study showed elevated values in winter due to soil erosion increasing dissolved salts (Thirumalini and Joseph, 2009). EC is positively correlated with TDS, indicating the type and nature of dissolved ions. Current EC values were within the permissible limit set by the World Health Organization, which is 500 µS/cm.

The current results align with Al-Hamdani and Khattab (2008), who found EC values between 315-450 µS/cm, and are similar to Hamada (2007) with values of 354-3302 µS/cm for Samarra Lake. They are higher than Mohammed (2010) who reported values of 0.22-343 µS/cm for Dukan Lake and lower than Al-Safawi et al. (2009) who found values of 844-2013 µS/cm.

Table 3: Monthly and Site Variations in Electrical Conductivity (2-4)

Months	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mean
St1	320	300	329	364	-	368	336 B
St2	351	320	335	368	-	371	349 B
St3	331	340	352	365	-	400	358 B
St4	430	418	406	397	-	469	424 A
St5	440	420	410	410	-	464	429 A
Mean	374 bc	360 C	366 c	381 b	-	414 A	

Turbidity:

Results in Table (4) showed significant spatial but not temporal differences in turbidity at the probability level of $P \leq 0.05$. Turbidity values ranged from 0.67 to 5.45 NTU, with the highest value recorded in December 2023 at site St4, and the lowest at site St4 in September 2023.

The high turbidity at site St4 is due to fast water currents, construction activities, and added rocks, which increased sediment and algae activity. Rainfall also contributed to increased turbidity due to soil erosion. Turbidity is a measure of water clarity (Water Watch, 1997).

Monthly variations in turbidity are influenced by factors such as rainfall, surface runoff, and water currents (Wolde et al., 2020). Fast water currents affect sedimentation and turbidity (Taun et al., 2016; Sultan, 2019).

The results are comparable to Toma (2000), who recorded 5.7 NTU for Dukan Lake, and similar to Al-Dulaimi (2018), who found values of 1.7-7 NTU. They are lower than Al-Dulaimi (2021), who reported 8-13 NTU for Lake Habbaniyah.

Table 4: Monthly and Site Variations in Turbidity (3-4)

Months	Sep 2023	Oct 2023	Nov 2023	Dec 2023	Jan 2024	Feb 2024	Mean
St1	1.55	1.24	2.68	3.03	-	3.81	2.46 A
St2	1.29	1.97	2.88	2.86	-	3.61	2.52 A
St3	2.13	3.24	2.41	4.13	-	2.01	2.78 A
St4	0.67	1.07	2.29	5.45	-	4.29	2.75 A
St5	1.22	1.28	3.41	5	-	4.44	2.56 A
Mean	1.37 C	1.76 C	2.73 b	4.09 a	-	3.63 a	

5. Conclusions:

1. All physical and chemical characteristics of the studied water samples were within the permissible limits of Iraqi standards, despite slight variations in some elements due to natural or human-induced changes.
2. Air temperature showed a wide range, with water temperature variations following air temperature changes.
3. Lake water in the study areas tended to be alkaline during the study months.

6. Recommendations:

1. Implement a periodic monitoring system to track pollution levels and contributing factors through continuous testing.
2. Identify pollution sources and work to prevent them from reaching the lake.
3. Encourage cooperation between environmental authorities and citizens, especially tourists, and enforce regulations to reduce pollution near the lake, particularly in resort and chalet areas close to the lake shore.

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