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Diagnosis Some Non-diatoms Phytoplankton Algae near Three Pollution Sites Producing Dyes in Tigris River

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Abstract

The presence and distribution of phytoplankton algae, which are related to water properties, are affected by these factors. Non-diatomic algae samples were collected during the autumn season in 2024-2025 from three sites on the Tigris River, including the Samarra pharmaceutical industry, woolen spinning factory, and paper waste landfill, to identify algae resistant to dye pollution. The study found slight temperature variations in three sites, with the highest temperature in the first site being 23.62 ºC and the lowest in the second site being 20.67 ºC. The water was found to be alkaline, with slightly reduced pH values at the first site. The electrical conductivity (EC) values were high, with the highest rate in the first site at 956.33 µs/cm and the lowest at 537.67 µs/cm. The total dissolved solids in water varied significantly at the three sites. The study found a rise in sulfate concentration at the first site (318.00 mg/l), while the lowest was at the third site (184.00 mg/l). High nitrate and phosphate concentrations were found at the first site (30.30 and 7.06 mg), while the lowest were at the third site (2.10 mg). The study identified 24 genera of phytoplankton algae, with Chlorophyte having the largest number (15 genera and 32 species), followed by Cyanophytae (14 species due to 8 genera) and Euglenophytae (one genus and species). The study also found differences in planktonic algae species in different sites, with blue-green algae having the highest percentage in the second and third sites, making them a target for studying biological purification of dyes.

Keywords: Non-Ditomic algae, Industrial activity, water, Tigris

1. Introduction

The indiscriminate exploitation of water has become more pressing due to a number of circumstances, including rapid urbanization, industrialization, and technological advancement [1]. The presence and distribution of phytoplankton algae are linked to the chemical and physical characteristics of water and are impacted by climate change, which in turn affects the stability of the aquatic food web[2]. Other environmental factors that affect water systems include the morphology and geology of the water body, the presence of pollutants, and human activities[3, 4].
Water contamination is a global issue that has been made worse by rapid population increase and urbanization. The use of artificial dyes to color finished goods has increased in the industrial in response to the challenge posed by industrialization. Large amounts of these dyes are released into wastewater, and their presence in water reduces light transmission and photosynthesis, which has a significant impact on aquatic organisms. Paper, tanning, textiles, rubber, plastic, cosmetics, and coloring compounds are examples of materials that employ dye to provide color. The textile industry uses a lot of water and releases coloring compounds into the garbage, making it the most polluting of these industries[5].

Untreated sewage release poses a serious threat to both human health and the aquatic habitat. The textile industry is the largest user of water and dyes, which leads to serious water contamination. By decreasing the amount of light that reaches receiving water bodies, industrial dye-containing products have an impact on the development of bacteria and the photovoltaic activities of aquatic creatures. Additionally, by creating a thin layer on the receiving body of water's surface, vacuum dyes lower the amount of dissolved oxygen in the water[6]. Furthermore, the consumption of this kind of substance raises the chemical oxygen demand (COD), a measure of high-level pollution[7]. In addition, they cause severe harm to the liver, kidneys, reproductive system, brain, and central nervous system, as well as skin irritation, allergies, cancer, neurobehavioral problems, autoimmune illnesses, and other health conditions like nausea, vomiting, and paralysis [8-10].

Inks that contain a variety of chemical extracts and organic solvents, including di-isobutyl phthalate, ethanol, dimethyl sulfoxide DMSO, di-butyl phthalate, and propanol, are known as printing inks. Tiny but incredibly absorbent, ink dyes frequently include heavy metals, including cadmium, mercury, lead, and chromium, which can be harmful even if absorbed over an extended period of time. This newspaper can harm aquatic life and have an impact on humans through the food chain system when it is dumped into the water due to pollution or waste items [11-13]. Bacteria and microalgae have the capacity to decolorize wastewater by taking the place of the majority of other species [14, 15]. With the addition of nutrients, bioremediation technology uses biological agents (bacteria, algae, fungi, etc.) to promote the growth of its culture in a dye stress environment [16, 17]. Isolating and selecting the right microbes, then scaling up to enable textile waste treatment and decolorization, is another way to accelerate this process at the laboratory scale [18]. Numerous methods are employed by the microorganisms that carry out biodegradation, including biological absorption, bioaccumulation, dilution, elimination, and mineralization of hazardous wastewater molecules into innocuous or even advantageous compounds[19]. Using algae's capacity to remove or break down pollutants, algal remediation is a unique kind of bioremediation. Because of their unique metabolic properties, algae can remediate toxins in a variety of settings by using processes like bioabsortion, bioaccumulation, and breakdown [20, 21]. To identify the species, the study intends to ascertain the quality and quantity of the major algae found close to the locations where manufacturing waste rich in dyes is discharged from areas contaminated with dye waste.

2. Materials and Methods

Three locations—two in the city of Baghdad and one in the province of Salah Al-Din—were used to Collection algal samples from the Tigris River. The locations were chosen based on the amount of waste present. In the Salah Al-Din Governorate, the samples were taken near the wastewater outlet of the woolen spinning and textile industry in the Al-Kadhimiya area and in the Al-Rashid area because of the landfills that contain waste from paper and printing presses **Figure 1**.

A GPS device was used to locate the sample collection locations on the map **Table 1**. Planktonic algae samples were collected using a network of plankton with a diameter of 20 µm, in accordance with the method adopted by Furet and Benson-Evans [22]. Water samples were collected at a depth of 30 cm from each site in sterile polyethylene containers with a capacity of 1 liter to determine some chemical variables upon return to the laboratory and some physical variables were measured directly during sample collection[23]. After making temporary glass slides for each place, the algae were examined using a light compound microscope. The diagnosis was made using a variety of available references[24-26].

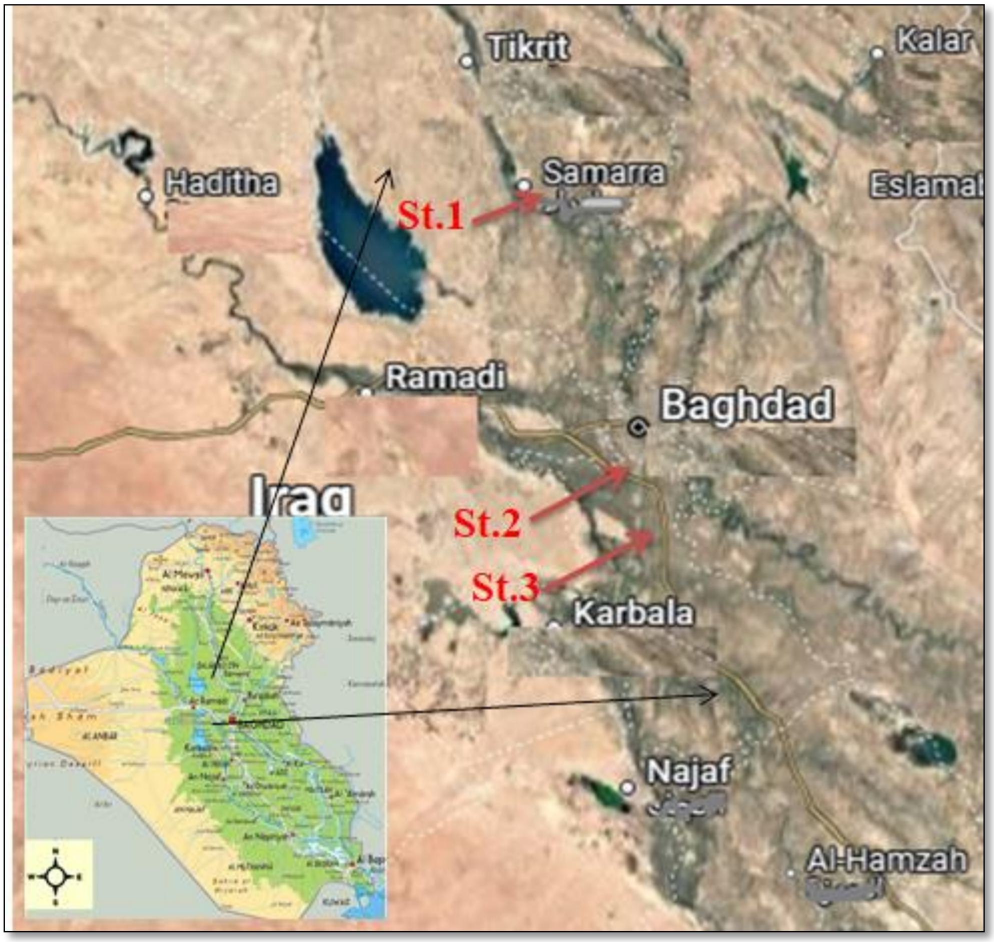

Figure 1. The study area at three sites from the Tigris River: two sites within Baghdad City and one site within the borders of Salah al-Din governorate with geolocation device[52].

Table 1. Study sample collection sites according to latitude and longitude with geolocation device.

Study Sites	Device Reading					
	Longitude (East)			Latitude (North)		
	″	°	′	″	°	′
1st site	49.84	88	43	96.90	20	34
2nd site	80.83	32	44	45.54	38	33
3rd site	18.9	25	44	19.5	19	33

3. Results

Water temperatures varied somewhat between sites, with the first site recording the highest-level temperature at 23.62°C and the woolen spinning and textile industry in the Al-Kadhimiya area recording the lowest temperature at 20.67°C **Table 2**.

The findings of this investigation demonstrated that the water was alkaline in all three locations, with the woolen spinning and textile industry having the highest rate at 7.67 and the first site having the lowest rate at 7.60. The range of change was minimal **Table 2**.

The three sites' pH and temperature did not differ much, according to statistical analysis, and the outcomes were comparable. At the first site, the electrical conductivity (EC) values had the greatest rate, 956.33 µS/cm. The lowest rate in the second location was 537.67 µS/cm **Table 2**.

When electrical conductivity readings were compared to those from earlier investigations, they were found to be high. There was a discernible relationship between the electrical conductivity and total dissolved solids values; the first site had the greatest total dissolved solids rate, 676.33 mg/L, while the third site had the lowest rate, 396.33 mg/L **Table 2**. The first site had the highest percentage of sulfate at 318.00 mg/l, while the third site had the lowest percentage at 184.00

mg/l **Table 2**. The conductivity and TDS recorded high values compared to previous studies on the Tigris River at the same sites, as the high temperatures and increased evaporation rates help increase the concentration of salts and ions within the water column, but the high values of conductivity and TDS were not affected by the high temperatures. The highest rate recorded during spring is ascribed to the impact of the large amounts of ion-rich organic pollutants [45].
According to **Table 2**, the first site had the greatest nitrate and phosphate rates (30.30, 7.06 mg/l), the third site had the lowest nitrate rate (2.10 mg/l), and the second site had the lowest phosphate rate (3.22 mg/l). High nutrient concentration indicates a decrease in the number of planktonic algae because they are major nutrients and there is an inverse relationship between them. This is consistent with previous studies. [4,2]

Table 2. Physical and chemical parameters (average values) of water from different sites during the period studied.

Sites	Samarra Pharmaceutical 1st	The woolen spinning and textile factory / 2nd	Printing 3rd	P-value
Parameters	Mean±S.E			
Water temperature	23.62±0.88^a	20.67±1.00^b	22.17±0.17^b	0.05*
pH	7.60±0.06^a	7.67±0.91^b	7.65±0.03^a	0.01*
TDS(mg/l)	676.33±0.33^a	456.33±0.33^c	396.33±0.88^b	0.001**
Electrical conductivity (µs/cm)	956.33±0.33^a	537.67±0.33^c	542.00±0.00^b	0.001*
Sulfate (SO_4) mg/l	318.00±0.58^a	282.00±0.00^c	184.00±0.58^b	0.01**
Nitrates (NO_3) mg/l	30.30±0.05^a	3.30±0.00^a	2.10±0.00^b	0.05***
Phosphate (PO_4) mg/l	7.06±0.01^a	3.22±0.00^c	4.12±0.01^b	0.05**

The findings showed that the total number of planktonic algae species varied depending on the study sites **Table 3**. Specifically, 21 species were found in the second site, 20 species in the third site, and 16 species in the first site. Blue-green algae, on the other hand, had the most species in the second and third sites. While euglenoid algae recorded only one species across all sites, 10 species were recorded, with the initial site having the fewest number, just two **Figures 2** and **3**. Blue-green three-order characterized algae are displayed in **Table 4**. The order Chroocococales has the most species known to science. This order is distinguished by the fact that the majority of its members are either unicellular or aggregated in colonies, meaning that the majority of these species choose to live as plankton in the water column. Seven species were found belonging to the order Oscillatoriales, whereas the order Nostocales had the fewest species. While the order of Chlorococcales, dominated with 27 species, followed by Siphonocladales (Cladophorales) with three.

Table 3. The number of genera and species in the different study sites.

Taxa	St.1	St.2	St.3
Division: Cyanophyta Class: Cyanophyceae 1. Order: Chroocococales			
Chroococcus varius A. Braun.		+	
Gleocapsa aetuginousa (Gram) Keutzing		+	
Gleocapsa punctata. Naegeli.		+	+
Microcystis sp.		+	+
Merismobedia glauca (Ehrenb.) Naegeli.		+	+
Merismobedia punctata Meyen.		+	+
Merismobedia tenuissima Lenmmerwann.		+	
2. Order: Nostocales			
Anabaena wiscensinense Prescott.			+
Nodularia spumigena Mertens in Jurgens.			+
Nostoc linckia (Roth) Bornet.		+	
3. Order: Oscillatoriales			
Arthrospira platensis var. non Constricta (Banexjii).		+	+
Oscillatoria amphibia Agardh	+	+	+

Taxa	St.1	St.2	St.3
O. angustissima West and West	+		+
O. lacustris (Kleb.)Geitler.			+
Division: Chlorophyta Class: Chlorophyceae 1. Order: Chlorococcales			
Coelastrum cambricum Archer.	+		+
C. microsporum Maegeli in A.Braun		+	+
Pediastrium broyanum var. *undulatum* Wille.		+	+
P. duplex var. *cohaerens* Bohlin.			+
P. duplex var. *reticulatum lagerheion* Lagerheim.			+
P. simplex (Meyen)Lemmermann.			+
P. simplex var. *duodenarium* (Bailey)Rabenhorst .	+	+	+
P. tetras (Ehrenb.)Ralfs.	+	+	
Ankistrodesmus convolutus Corda.	+	+	+
Chlorella vulgaris	+	+	+
Kirchneriella contorta (Schmidle). Bohlim.			
Oocystis borgei Snow.	+	+	+
Tetraedron minimum.(A.Braun)Hansg.	+		
Westella botryoides.(W.West) De Wildemann.	+		+
Actionastrium gracillium G. M. Smith.		+	+
A. hantzschii var. *elongata*.G.M.Smith*			+
A. hantzschii Lagerheim.		+	
Crucigenia quadrata.	+	+	
Scenedesmus obliquus.	+	+	+
S. quadricauda.	+	+	
S. quadricauda var. *westii.*		+	
S. quadricauda var. *maximus.*			+
S. arcuatus var. *Platydiscus.* G. M. Smith.			+
S. bijuga (Trup.) Lagerheim.		+	+
S. bijuga var. *alternans* (Reinsch) Hans.		+	
S. quadricauda var. *longspina.*		+	
Tetrallantos lagerheimii Teiling	+	+	+
2. Order: Ulotichales			
Ulolhrix tenuissima Kuetzing.	+	+	
3. Order: Siphonocladales(Cladophorales)			
Cladophora glomerata (L.) KTZ.	+	+	
Cladophora insignis (Ag. C. A) Kg.	+	+	+
Cladophora oligoclona (L.) Hoe KTZ. (synt. *C. rivularis*).	+	+	
4. Order: Zygnematales			
Cosmarium meneghinii de Brebisson.			+
Division: Euglenophyta Class: Euglenophyceae Order: Euglenales			
Euglena gnacilles. Klebs.	+	+	+

Table 3. Number of genus and species pf algae diagnosed in study sites

Taxa / Site	Cyanophyta		Chlorophyta		Euglenophyta		Total	
	Genus	species	Genus	species	Genus	species	Genus	species
st.1	1	2	12	16	1	1	14	19
st.2	7	10	11	21	1	1	19	32
st.3	7	10	11	20	1	1	19	31
Total	8	14	15	32	1	1	24	47

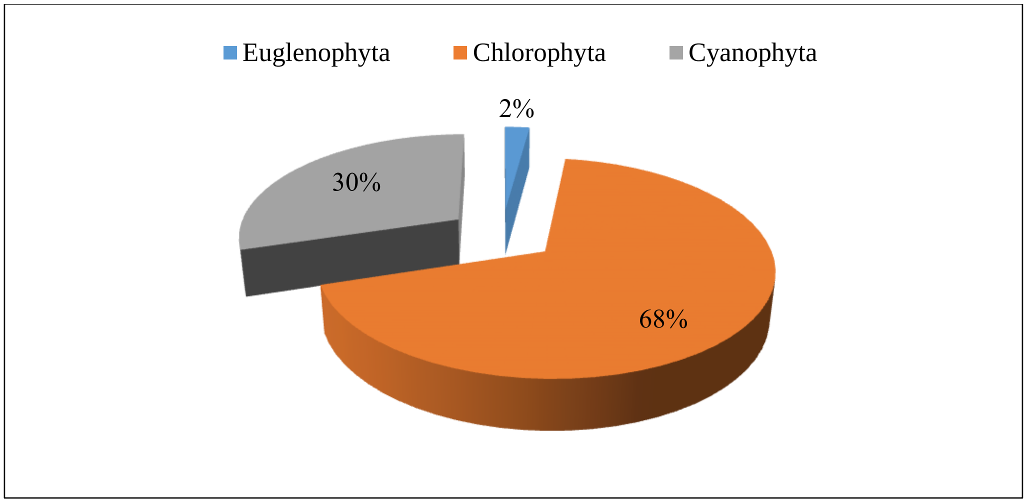

Figure 2. Percentages of algae species diagnosed at the three sites.

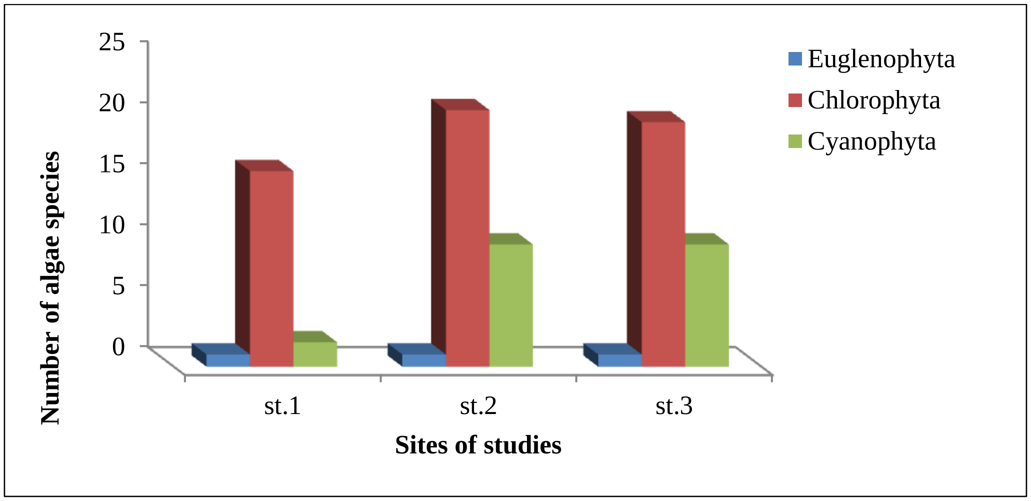

Figure 3. Numbers of species diagnosed for each algal divisions within the three sites.

4. Discussion

In the aquatic environment, temperature is the most significant environmental component. It impacts the characteristics of water and, consequently, the life forms that inhabit it. It is a crucial element that determines the distribution of living things on Earth and influences the physiological behavior of aquatic species [4, 27]. High or low temperatures have an impact on the pace of algal development because many algae need temperatures between 30 and 15°C for photosynthesis and cell division, whereas the ideal temperature range for growth is between 25 and 20°C. Additionally, high temperatures have an impact on protein synthesis [27].

The pH impacts on the chemical and physical characteristics of water and is linked to the presence of various biological forms. Since these characteristics are markers for evaluating water quality and are significantly impacted by climatic factors as well as the lingering effects of human activity, they play a significant role in the nature and behavior of a variety of aquatic species, including plant algae [28]. Alkaline water contains bicarbonate and carbonate ions and has an alkaline tendency; this could be the result of water hardness's regulating ability. This is in accordance with both past and present research on the Tigris [29, 30].

The growth of numerous species of algae in wastewater released from the first site straight into the river causes organic matter to rise and dissolved carbon dioxide gas to be produced, which is the cause of the minor drop in pH values at the first site [31]. Tons of sand sediment delivered by rivers and other salt-laden elements may be the cause of the rise in electrical conductivity, which is the supply of water to the electric current and is dependent on temperature, ion type, and concentrations [32].

The rise of electrical conductivity readings could be linked to an increase in the total dissolved solids in the water as a result of soil erosion in the river and rain[33]. Furthermore, the three locations differ from one another in a quite significant way. Due to the significant amounts of wastewater released from the first site, high conductivity levels were also noted at the third site during the research period [15]. Iraqi water is rich in sulfate ions, according to studies [34].

The first site had more sewage waste entering the river because of the sulfate ion richness of the sewage waste [35].

According to numerous studies, the abundance of organic materials released from the first site and detergent residues is the source of the increase in nutrients, which in turn leads to a rise in nitrates and phosphates [36].

Numerous studies indicate that the increase in nutrients, which in turn causes an increase in nitrates and phosphates, is caused by the amount of organic materials released from the initial site and detergent residues [37].

The high biodiversity of the study locations was facilitated by the availability of nutrients like nitrogen and phosphate as well as algae growth-promoting auxiliary factors like dissolved oxygen. When there are more species than genera of algae identified in any given ecosystem, it appears that there is high biodiversity because there are more growth-promoting elements available, such as dissolved oxygen and nutrients like nitrogen and phosphate [33].

The orders Ulotichales and Zygnematales each recorded one species, while euglenoid algae recorded the fewest species due to their preference for Euglenophyta prefer shallow, low-flowing sites rich in organic pollutants such as food debris, so few species were identified in the study[38].

The high number of species in the second and third sites was noted because the study sites were characterized by the presence of various pollutants, which made the water rich in phytonutrients represented by nitrates and phosphates[39]. The Tigris River in the second site is described as an open running area and is the most polluted with organic matters; in addition to the industry expository, many households dumped household waste into the river by houses near the river, and in addition to the movement of some organic pollutants represented by food residues, food utensils, and plastic bottles that drifted with the stream of water and accumulated near the sample collection site [40]. The increase in organic pollutants in river water causes a high diversity of planktonic algae, which provides many important nutrients for the growth and diversity of algae[33].

The presence of antibiotic residues and industrial trash is the cause of the first site's low diversity of planktonic algae[41]. showed that while the presence of antibiotics and industrial residues disrupts the growth of some algae species at the expense of other species, the waste discharged to the riverbed from the remnants of industry increases the nutrients that promote the growth of phytoplankton. Some species of Cyanophyta are resistant to high antibiotic concentrations; however, most other species are susceptible to antibiotics due to their prokaryotic nature and are more affected than green algae. As a result, the number of Chlorophyta species rises at the expense of Cyanophyta [42].

High concentrations of organic dyes found in grain dye are also suggested to be among the industrial residues; this is supported by a study [43], which found that azo dye accounts for 70% of all dyes used globally and makes up the majority of artificial dyes. Textile, paper, food, tanning, pharmaceutical, and cosmetic factories all use it. Concentrations of these dyes are present in purification tank water, and studies on the effectiveness of green algae in degrading industrial dyes have shown that these algae, particularly *Chlorella pyrenoidosa* and *Chlorella vulgaris*, have a higher capacity to break down azo dyes and transform them into amino compounds that are easier to absorb and decompose in the environment than blue-green algae, which have a lower surface area capacity than single-celled green algae [44].

Because it serves as a final dump for papers and printing ink remnants, as well as a location to dispose of the trash from the spinning and textile plant, this explanation is applicable to the second and third research sites. The most efficient way for algae to break down azo dyes into their simpler components was in these locations. *Chlorella vulgaris* was identified in every site, demonstrating their capacity to degrade industrial colors and their resilience to ink contamination. This is in line with research showing that numerous algae species, including *Chlorella* sp. and *Oscillatoria spis*, can break down azo dyes into their aromatic amines and convert those amines into carbon dioxide or simpler organic molecules [25, 26].

The fact that samples are being collected in special tanks for the collection of liquids released from the first site, which means that the area is smaller than that of the river and has low pollution from organic matters, is another factor contributing to the decline in species at the first site [34].

5. Conclusion

The study found slight temperature variations in three sites. The water was alkaline, with slightly reduced pH values. The electrical conductivity was high, and total dissolved solids varied significantly. The study identified 24 phytoplankton algae genera, with Chlorophyta having the highest percentage in the study sites, making them a target for studying biological purification of dyes. Especially the single-celled or colonial-like ones, as these species have a high ability to deal with various pollutants and are considered among the species resistant to pollution by various compounds. Compared to the filamentous species, which were identified in smaller numbers, whether they were Chlorophyta or Cyanophyta.

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Conflict of Interest

The two authors designed the study; Siham Mohaisen Jiheel carried out the field and laboratory work. The data were analyzed statistically by Buthaina Al-Magdamy. The first draft of the manuscript was written by Siham Mohaisen Jiheel. The final version of the manuscript was revised by Buthaina Al-Magdamy.

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