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Effect of the Medical City Waste on the Non-Diatom Planktonic Algae in the Tigris River in Central Baghdad

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Abstract
We conducted a study on the quality of non-diatom planktonic algae in the Tigris River during the autumn 2022 and winter 2023 seasons. The study focused on the impact of the medical city waste discharge to the Tigris River at three sites: Al-Sarafiya Bridge in the north, Medical City, and the Bab Al-Mu'adam Bridge in the south of Khader Elias. The study also examined some physical and chemical variables of the river water. Findings showed that there are 74 species (38 genera) of non-diatom algae in four orders. The blue-green algae Cyanophyceae and Chlorophyceae had the most species, with 35 species belonging to 19 genera and 16 genera per division, or 47% of all algae. Euglenophyceae had 5%, with 3 species and 2 genera, and Chrysophyceae had only one species and a genus, making up 2% of all algae species. The study demonstrated that liquid waste had an impact on river water, leading to a rise in nutrient concentration, the emergence of new pollution-tolerant planktonic algae species, and an increase in diversity within the Medical City site, with the effect extending beyond its boundaries.
Keywords: Non-diatom algae, Medical City, Khader Elias, Green algae.

1. Introduction

Water is the main source of life that cannot be replaced by others, and in recent years a major challenge has emerged related to the quantity and quality of water, which requires work to maintain water quality and protect it from all types of pollutants that lead to damage to agricultural activities as well as being a threat to human health and safety as it is unsafe for human consumption. (1). Water quality is defined as a metric that assesses its suitability for various purposes (2). The chemical and physical properties of water, as well as biological properties, are among the most important indicators that affect water quality (3). While many researchers have pointed out that water quality depends mainly on its chemical composition and the total concentration of dissolved salts. While. Flayyih (4) noticed that the refinery waste affected increasing nutrient concentrations such as nitrate, phosphate, and silicate. The quality of fresh water depends mainly on the purification processes and not on the amount of waste that enters the water, and despite the ability of organic waste to biodegrade, it is one of the most important water problems because of its direct impact on the amount of oxygen dissolved in water. The sources mentioned many definitions and classifications of sources of pollution in the aquatic environment have been divided (5). Into natural sources and human sources, medical waste resulting from hospital activities causes great danger to water, as chemical, radiological, and biological substances discharged contribute to water pollution and affect its quality (6). And this pollution can lead to changes in some parameters such as dissolved oxygen (DO), biological oxygen demand (BOD), pH, and chemical oxygen demand (COD), which negatively affect aquatic organisms, plants, and humans, as well as the risks of these effluents to the aquatic environment (7). . Algae are one of the first forms of life discovered on Earth, found around the world under various conditions (8; 9; 10). They are widely distributed in seas, lakes, ponds, and swamps, where they are found in running and stagnant water, whether salty, fresh, or brackish (11; 12). They vary in terms of shapes, sizes, colors, and internal structure of the body, including prokaryotic or eukaryotic, some of which are plankton or benthic on surfaces, and most of them are only seen with a microscope (13). Algae stabilize light energy and convert it into chemical energy for the purpose of constriction organic compounds through the synthesis of simple inorganic substances, and 90% of these algae, especially planktonic algae, are responsible for this process and equip their environment with oxygen and food (14). Algae, like all plant species, form the basis of food chains and nets in freshwater and saltwater aquatic media, and aquatic organisms depend on them directly or indirectly for survival (15). It also acts as an early warning when any changes occur in the aquatic systems. The growth, diversity, and density of algal communities are influenced by one or more of these factors, and the impact is either directly or indirectly on aquatic systems (16, 17), and can therefore be used as a bio-index for the detection of water quality in these systems. Its existence can be inferred using modern techniques, some of which depend on satellites and remote sensing systems (18, 19). Due to the waste excreted by the Medical City in central Baghdad directly to the Tigris River without treatment, the objective of the current research is to know the effect of these wastes on the physicochemical properties of the Tigris River water and the quality of the plankton algae within the water column before, after, and during the place of waste discharge.

2. Materials and Methods

2.1. Study area

Baghdad city is located at a latitude of 33.34 and a longitude of 44.40 and above sea level with an estimated height of 41 meters and is divided by the Tigris River into Karkh and Rusafa. The medical city hospital is located to the left of the Tigris River next to Rusafa. Its impact is limited between the Al-Sarafiya Bridge in the north and the Bab Al-Mu'adam Bridge in the south (20). (**Figure 1**). The Medical City is one of the most famous health institutions in Baghdad and includes the largest hospitals in it, and these hospitals dispose of their waste from sewage directly to the Tigris River without treatment at a rate of three to four times a week and at a rate of three hours in the morning and another in the evening (21). These wastes affect the physicochemical properties of river water and change the quality of algae, so they need periodic checks of river water (22).

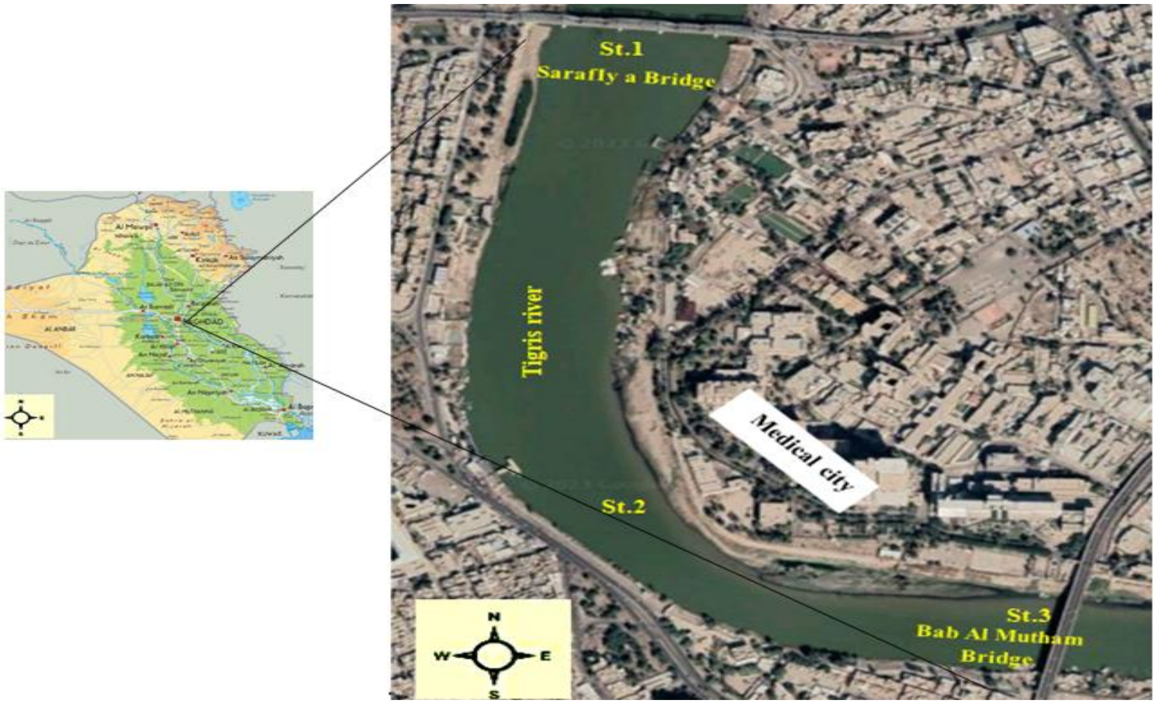

Figure 1. Map of the study area

2.2. Sample collection

Physicochemical analysis of the Tigris River: The samples were collected monthly from three sites chosen to collect samples: the first near Al-Sarafiya Bridge (KKhader Elias), south of the Medical City, and the second near the site of the release of Medical City waste water in the Tigris River. The third site was located north of the Medical City, in the Al-Shaljiyeh region, near the Bab Mu'adam Bridge (**Figure 1**). The samples were collected from October 2022 to February 2023 and represented as seasons. The field measurements of air and water temperature (C), electric conductivity (µS/cm), and pH were measured by the digital portable multimeter. The dissolved oxygen (mg/l), salinity (S‰), total dissolved solids (mg/l), total nitrogen (mg/l), and total phosphate (mg/l), estimated following the methodology of (23).

2.3. Plankton sample

The plankton algae were collected using a phytoplankton network with a mesh size of 20 µm, and the filter models were placed in polyethylene bottles and preserved by adding Lugel solution (24). Non-diatom algae were identified using a light compound microscope after preparing temporary glass slides for each site based on available reference keys (25, 26; 27; 28).

2.4. Statistical analysis

For statistical analyses (in SPSS 20), all variables were analyzed. T-tests estimated the differences in variables between different locations.

3. Results and Discussion

Aquatic systems are exposed to various environmental factors, whether geologically related to the nature of the water body or climatic changes and human activities, that change the different properties of water, and the pattern of distribution of algae is related to the chemical and physical properties of river water, meaning that these factors determine the stability of food chains in the aquatic environment (29). **Table 1** indicates the results of the factors studied.

Table 1. General averages, standard deviation and range for the characteristics studied by station.

Variables	Range: Minimum–Maximum Mean ± SD			LSD value
	S.1	S.2	S.3	
Air temperature °C	10.00-25.00 17.5±4.11	11.00-24.00 18.17±4.11	10.00-24.00 17.16±4.95	5.434 N.S
Water temperature °C	4.00-18.00 11.83±6.36	6.00 -14.00 10.67±5.24	4.00-14.00 9.17±5.77	7.154 N.S
pH	6.84-7.05 6.93±0.08	6.53-6.99 6.75 ±0.22	6.57-6.93 6.74±0.16	0.207 N.S
Electrical conductivity	388.50-480.21 434.49±49.99 b	649.85 -890.50 770.11±131.58 a	421.50-510.50 466.14±48.37 b	105.75 *
TDS	596.00-615.90 608.43±8.68 b	684.00-810.50 778.95±48.89 a	617.00-810.00 705.06±93.83 a	75.428 *
Turbidity	6.30-7.20 6.80±0.37 c	9.30-11.10 10.26±0.85 a	7.30-8.90 8.03±0.66 b	0.811 *
Total hardship	606.00-650.20 630.72±21.47 c	717.00-830.60 775.46±60.07 a	670.00-711.70 697.55±17.78 b	47.05 *
DO	4.51-4.90 4.67±0.14 b	4.51-4.90 4.67±0.14 b	5.40-5.99 5.69±027 a	0.247 *
BOD	2.97-3.30 3.10±0.15 c	4.40-5.30 4.87±0.37 a	3.20-3.90 3.54±0.32 b	0.368 *
PO_4	1.01-2.35 1.98±0.50 b	3.23-3.68 3.43±0.20 a	2.18-2.62 2.38±0.19 b	0.411 *
NO_3	8.00-10.12 9.06±1.05 b	13.50-18.90 16.11±2.66 a	10.12-12.80 10.98±1.03 b	2.165 *
SO_4	257.00-314.70 287.13±29.77 b	409.00-550.11 481.03±75.64 a	297.00-341.60 320.33±23.04 b	60.03 *

Averages with different letters within the same row differ significantly among themselves
*(P≤0.05), NS: Non-significant.

The highest air temperature was 25.00 C at site three, but the lowest was 10 C at site three and site one. While the water temperature recorded its highest average in the first site (14) and the lowest average in the same site and the third site, and through the results, it is clear to what extent the water temperature is affected by air temperature and its variation, as the relationship between them is direct, and this is consistent with most studies in Iraqi internal waters. (21)
A convergence was observed in the pH values in the three sites during the months of the study, as they ranged between 7.05 and 6.53, with the highest value in the first site and the lowest value in the second site, and the results of the statistical analysis did not record significant differences between the sites. The nature of the water tended to be weakly acidic due to the low presence of aquatic plants, increased respiration rate, and high concentration of CO_2 in the water, which makes the medium acidic (30). There is a relationship between electrical conductivity and TDS. The conductivity expresses the ions contained in the water and increases with the increase of salts in the water and substances dissolved in water. (31,22) The electrical conductivity and TDS recorded high values in the second site throughout the study months, reaching 890.50 µS/cm and 810.50 mg/L, respectively, while the lowest average was 480.21 µS/cm. 615.90 mg/L at the first site of the conductivity and the third site of the total dissolved substances, respectively, and the results of the statistical analysis showed that there are significant differences in the values of conductivity and dissolved solids for the different study sites, and the increase in electrical

conductivity values in the second site of medical city may be due to the increase in waste discharged from this site to the Tigris River (32). Nutrients play a major determining role for the growth of many algae in the water column and include phosphorus and nitrogen (33). (34) Pointed out that the increase in nutrient concentration in water is significantly affected by higher temperatures due to increased organic degradation by increased bacterial activity. The highest average phosphate and nitrate, respectively (3.68) mg/L and 18.90 mg/L in the second site, and the lowest average (1.01 and 8.00) mg/L in the third site, the results showed an increase in nutrients in the winter months compared to the autumn months due to abundant amounts of rain during this season, which leads to high river levels and melting muddy sediments on the edges of the river, and this is consistent with the results of previous studies on the waters of the Tigris River (29, 30). The study identified 74 species (38 genera) of non-diatom algae belonging to four algae classes, in which the blue-green algae Cyanophyceae and Chlorophyceae dominated the same number of species. 35 species belong to (19, 16) genera for each phylum, respectively, and by 47% each of the total algae, while Euglenophyceae recorded 5% (3 species and 2 genera), and the lowest numbers belong to the class of algae Charysophyceae, one species and genus, and by 2% of the total number of diagnosed species (**Table 2, Figure 2**).

Table 2. Numbers of Sp. (G.) types diagnosed for all sites during the two season of the study.

Station / Division	S.1				S.2				S.3			
	Autumn 2022		Winter 2023		Autumn 2022		Winter 2023		Autumn 2022		Winter 2023	
	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.	G.	Sp.
Cyanophyceae	10	7	3	3	11	11	6	6	9	10	4	4
Chlorophyceae	6	8	1	1	8	11	6	9	6	12	6	10
Euglenophyceae	-	-	-	-	2	2	-	-	2	3	-	-
Charysophyceae	-	-	1	1	-	-	-	-	-	-	1	1
Total	16	15	5	5	21	24	12	15	17	25	11	15

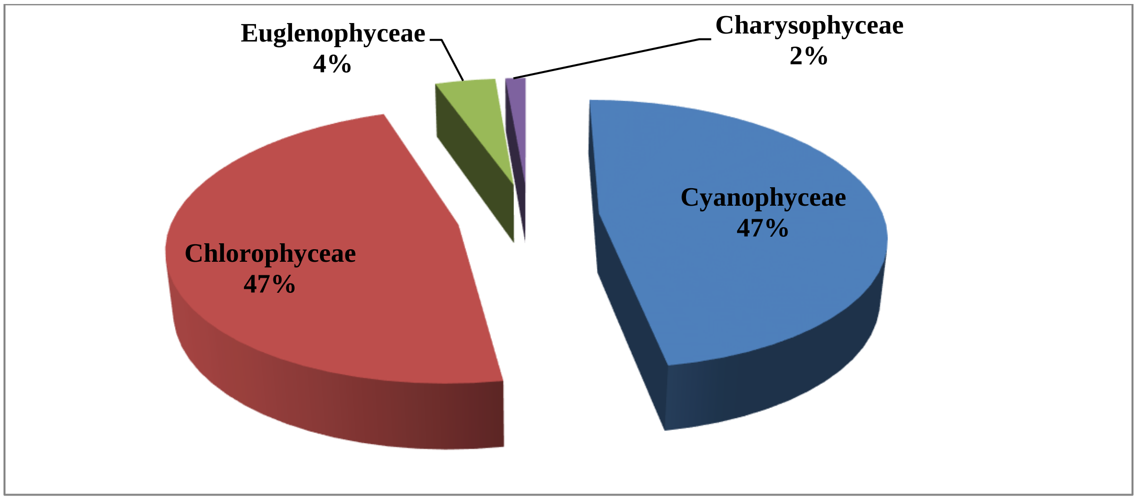

Figure 2. Percentages of plankton algae classes at the three study sites during the autumn and winter seasons.

The results showed an increase in the number of species over the number of genera, which is evidence of high biodiversity (**Table 2**); this is consistent with Prescott (26), who pointed out that aquatic bodies characterized by high biodiversity indicate the availability of catalysts for their growth such as dissolved oxygen and nutrients such as nitrogen and phosphates (6, 35).

During the two seasons of the study, the third site recorded the highest number of species, which amounted to 41 species, followed by the second site with 35 species, while the first site had the least species, 26 (**Table 2**). When observing the **Figures (3, 4)**, it was found that the green algae and blue-green algae are close in the number of species for all sites, and the difference in the number of genera and the number of blue-green algae genera increased from green algae by 19, 16 per class, respectively. This may be due to the fact that the identified species are highly tolerant to extreme environmental conditions of increased pollutants and nutrient diversity, including *Oscillatoria* and *Aphanothece* from blue-green algae (36). *Pediastrum* and *Scenedesmus* species prefer to be found in highly nutrient lotic waters (29), which have a predominance in the number of species, and this depends on the ability of most algae to live, grow, and reproduce in a wide range of environmental variables and different pollution sites (37). (4) found that the west water pollutants caused a decrease in the algal diversity. The results showed that the highest species were recorded in the third site near the Bab Al-Mu'adam bridge after the site of the medical city waste; this site was characterized by high organic pollution, followed by the number of species. The second site is close to the place of release of liquid waste to the medical city compound, and the site is characterized by the presence of unpleasant odors and slow river flow. Species of blue-green algae flourish, and this waste could lead to the emergence of new species for the Iraqi environment (38). The study recorded differences in the number of plankton algae species according to the two seasons of the study in all sites (**Table 2**). Autumn recorded the highest total number of species in all sites, while the study recorded the lowest number of species in winter for all sites (**Table 2**).

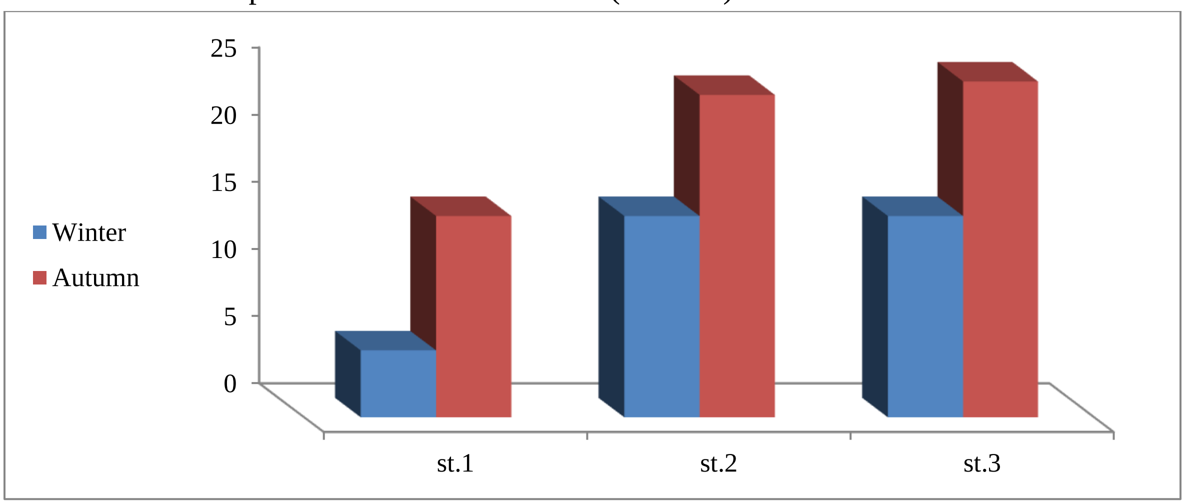

Figure 3. Numbers of algae species diagnosed in the two seasons of the study within the sites of the Tigris River.

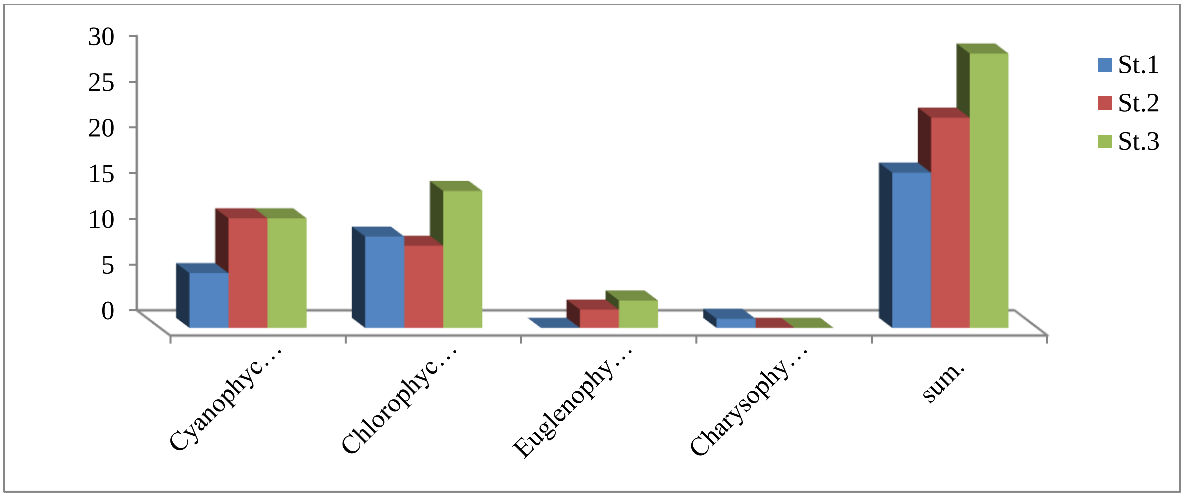

Figure 4. Number of algae species diagnosed per class at each study site within the Tigris River and total species at each site.

The third site recorded the highest number of species in the fall, which amounted to 25 species belonging to 17 genera, while the lowest species recorded in winter within the first site were 5 species belonging to 5 genera (**Figure 3**). The increase in algae species in the autumn is due to the increase in the concentration of nutrients from phosphates and nitrates of organic matter waste that reaches the river from the site of Khader Elias located directly under the Bab Al-Mu'adam Bridge and the continuous discharge of liquid medical city waste. The reason for the high population of phytoplankton species in autumn is due to the availability of suitable environmental conditions for their growth and reproduction of nutrients, appropriate lighting intensity, moderate temperatures (39), availability of dissolved oxygen, low flow speed, and low water levels (40). When observing **Figure (4)**, it is seen that there is a clear increase in the number of species and a convergence between the second and third sites as a result of their impact on the waste of the Medical City, which caused an increase in the nutrient ratios of nitrate and phosphate (**Table 1**), and this is consistent with what (21) indicated. The decrease in the number of species in winter may be due to the increase in river water levels as a result of the increase in the rate of rainfall before the date of collecting samples during the winter months, and this is consistent with some results of local studies (30).

4. Conclusion

The study demonstrated that liquid waste had an impact on river water, leading to a rise in nutrient concentration, the emergence of new pollution-tolerant planktonic algae species, and an increase in diversity within the Medical City site, with the effect extending beyond its boundaries.

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Conflict of Interest

The authors declare that they have no conflicts of interest.

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