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A Study of the Analysis of Chlorophyll-a Phytoplankton in the Tigris Rivers for Some Regions of Iraq by Using GIS Techniques

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Abstract: In this study, the distribution of chlorophyll-a for phytoplankton was monitored using Geographic Information System (GIS) techniques in selected regions of Iraq represented by the three governorates namely: *Salah al-Din* (Samarra (1), *Baghdad* (Al-Muthanna Bridge (2), Al-Utaifi (3), Al-Jadiriya(4), *Kut* (Al-Aziziyah (5), Al-Zubaydah (6), Al-Numaniyah (7), and Al-Muftah (8)) as human agricultural, and industrial activity rose in these locations. These stations, which are located along the Tigris River, were used as sites for collecting samples. The selection procedure was conducted on a monthly basis between February 2022 and January 2023. Chlorophyll-a measurements for phytoplankton throughout the sampling period varied from 3.7 to 2.59 g/L at stations. The two stations (Al-Utaifi and Al-Zubaydah) had similar values for both seasons, and the five stations in the dry season had values of less than 0.23 g/L. While phytoplankton numbers varied from 40.32 10^4 to 21.16 10^4cell/L for stations 3 and 5, respectively, they varied from 72.39 10^4 to 37.7 10^4cell/L for stations 6 and 8, respectively, throughout the wet season. In all of the stations and classes of phytoplankton, the amount of chlorophyll dye was approximately equal to the overall density of phytoplankton. The area under study's predictive maps of chlorophyll-a analysis also revealed changes in the concentration of dye in all stations.

Keywords: Chlorophyll-a, GIS, phytoplankton, some regions,Tigris River.

Introduction

Rivers are among the most significant freshwater sources and are very essential to the environment because they serve as pathways for the movement of nutrients and living organisms. This water system, which is characterised by the continuous circulation of water in one direction, displays large fluctuations in the water level as well as in the physical, chemical, and biological components along the river (Al-Ansari, 2019). An aquatic habitat needs certain physical, chemical, and biological characteristics in order to be healthy (Abed et al., 2021; Rasheed and Al-Ramahi, 2021). All types of life are dependent on water because water covers 71% of the surface of the Earth (Bhat, 2014). Phytoplankton are important contributors to the synthesis of organic matter in aquatic ecosystems, and their rate of energy storage has an impact on the ecosystem's overall primary productivity. In the phytoplankton community, all creatures at the higher trophic level have a need for energy, and they all have 23 vital tasks (James and Adejare, 2010). The topography, local climate and nutrients like nitrates, phosphates silicates etc., that are present in the water body, all have an impact on phytoplankton development. The breakdown of dead organisms, water mixing, and runoff from nearby areas

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are the main sources of these nutrients (Schaum et al., 2017). Phytoplankton are suitable pollution indicators because they are simple to employ, capable of detecting changes in water quality, relevant over wide geographic areas, and more tolerable than many other creatures found in the examined ecosystem (Nwankwo, 1992). The primary pigment utilised by phytoplankton to absorb light energy and transform it into biomass is called chlorophyll- a (Chl- a) (Lee, 2018). This is a useful biomass proxy for phytoplankton due to its specialisation in plants and simplicity in quantification, there are many studies concerning the properties of chlorophyll, the researchers (Al-Amiedyand Al-Azawi, 2022) conducted a study on the effect of al-Tharthar channel on the nutrient and chlorophyll values of River's water, the study concluded that the properties of chlorophyll in the Tigris River are affected by the al-Tharthar channel regarding river values within the study area. In Obaid (2021), researcher performed a study to measure the concentration of chlorophyll-a of diatoms attached to the reed plant, its values ranged between 1.3 and 8.3 µg / cm^2, the highest in the dry season and the lowest in the wet season. The study attributed this to changes in environmental conditions.

Geographic Information Systems (GIS) has recently made substantial advancements in the visualisation and analysis of water-related phenomena, in developing nations and those with economic growth, it is widely utilised for wastewater monitoring and management (Chang, 2006). In support of facility management, demand management mapping modeling, and short-term planning hydrological, GIS models for surface runoff, flood water flow and water quality have been developed (Al-Hassany et al., 2021; Al-Ramahi and Al Bahadly, 2022; Khadim and Oleiwi, 2021). GIS is sometimes used in public utilities like computerised maintenance, task orders, and commercial asset management (Al Ramahi and Al–Bahadl, 2020). This study aims to develop several maps that depict the spatial distribution of chl-a by analysing of chlorophyll-a extracted from phytoplankton for the Tigris River in some regions of Iraq, there are GIS studies on the Tigris River in different locations or stations in Iraq, but to evaluate water quality and study vegetation cover... studying environmental factors (Obiad, 2021).

Materials and Methods

The study was conducted from February 2022 to January 2023. Three governorates along the Tigris River including Salah al-Din (Samarra), Baghdad (Al-Muthanna Bridge, Al-Utaifi, Al-Jadiriya), and Kut (Al-Aziziyah, Al-Zubaydah, Al-Numaniyah, Al-Muftah) from which eight stations were selected as the study region, as shown in Figure 1 and Table 1. According to the information provided by the Iraqi General Authority for Meteorology and Seismic Monitoring 2022, samples were taken at these sites on a monthly basis, and the results were then converted to a seasonal scale.

These sites are impacted by human activities like farming and industry, which release heavy wastewater into the Tigris River without biological treatment, endangering the water to the possibility of pollution, especially plankton blooms (Al-Ansari, 2019; James and Adejare, 2010). Using GIS version 10.4, Phytoplankton samples were collected for the qualitative study using a phytoplankton net with a diameter of 20 µm. Nets are used in collecting samples from the sites. The procedure of collecting samples includes the following steps:

The net was placed upstream of the water and moved around in the boat for 10-15 minutes. Then the net was withdrawn, the contents of the net were collected in clean containers of polyethylene, and a solution was added (Lugol's solution is prepared by dissolving 10 grams of pure iodine in distilled water, then adding 20 grams of potassium iodide to it and completing the volume to 200 cm^3 of distilled water, then adding 20 cm^3 of glacial acetic acid) to it until laboratory examination. After shaking the well, one liter of sample per station was added to Lugol's solution (1:100). The numbers of phytoplankton individuals (diatom) were calculated based on the following equation (Hadi, 1981; Furet and Benson-Evans, 1982; Prescott, 1964).

Number Diatomaceous cells in 1 ml of concentrated form = The number of cells counted in one cross-section × Conversion factor.

While the numbers of phytoplankton individuals (non-diatom) were calculated based on the following equation:

The number of cells counted in 1 ml = The number of cells counted in one cross-section of the conversion factor of the concentrated sample

Following this, according to (Vollenweider, 1969), permanent slides were made to examine the plankton algae. Measurement of the concentration of chlorophyll a was used to filter one litre of the sample using 0.45 µm filter paper size type GF/F. Before ending the filtration procedure, 2 ml of magnesium carbonate was added to prevent dye decomposition, then it was moved to a crushing bowl and melted by using 203 ml of acetone with a concentration of 90%. The crushing bowl and the glass rod were cleaned with the acetone and the volume

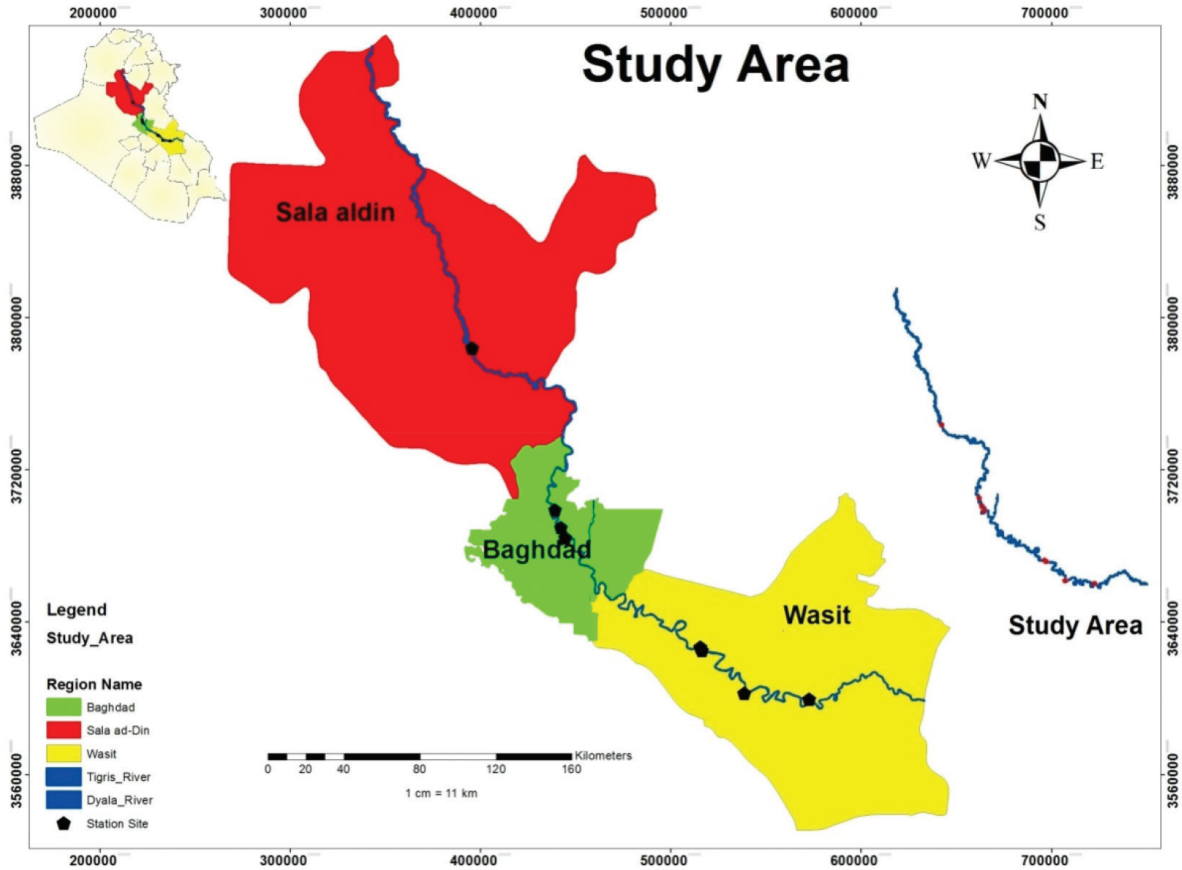

Figure 1: Study area map of Tigris river passing through three governorates in Iraq country.

Table 1: Distance between each site from the other and the length of the study area

Distance (km)	*Length (m)*	*City name*
782685	922812	Al-Kut to Omara boundary
782685	1660210	Samarra to Al-Muthanna Bridge
782685	2035370	Samarra to Karkuk boundary
782685	138869	Al-Muthanna Bridge to Al-Atifia
782685	937161.1	Al-Atifia to Al-Jadria
782685	1794340	Al-Jadria to Al-Azizia
782685	19695.3	Al-Azizia to Al-Zubadia
782685	523673	Al-Zubadia to Al-Numania
782685	638161	Al-Numania to Al- Kut

was completed to 10 ml. Afterward, they were left in the dark with a temperature of 4 ºC for two hours, then transferred to centrifuge with a velocity of 500 cycles per minute for 20 minutes. Absorbance was measured by the apparatus (665 and 750 nm), the results are given in g/L units. A Geographic Information System (GIS) was used to evaluate the data and determine all of the results (Hengl, 2009). The administrative borders of relevant regions and sample sites served as the foundation for the development of the GIS database. The spatial data used in this study was gathered from various sources and in diverse quantities. Furthermore, all information for a range of comparable sizes was standardised to a scale corresponding to the UTM coordinate system comparable sizes were standardised to a scale corresponding to the UTM coordinate system as demonstrated in Table 2. The Inverse Distance Weighted (IDW) is a technique for precise local deterministic interpolation (Panhalkar and Jarag, 2015). The unknown values at a particular location are estimated using the interpolation method, location is defined as the average distance between a place that is around an unknown point (Bouaziz et al., 2011; Madhloom and Alansari, 2018; Hassan et al., 2011). In IDW, points positioned closer to the forecast location will have a bigger impact on the predicted values than the ones farthest from them. The collected data was used as inputs to produce different predictive maps representing the spatial distribution of chl-a values.

Table 2: Sample stations and their GPS values

Station no.	*Station name*	*Longitude (ϕ)*	*Latitude (λ)*	*X-Coordinate (UTM)*	*Y-Coordinate (UTM)*
1	Salah- Addin	3783877.163	395414.866	3783877.163	395414.866
2	Al-muthanna Bridge	44.343277	33.426066	3698715.025	438947.703
3	Al-Utifi	44.543277	33.326066	3690673.67	442219.4363
4	Al-Jadriya	44.401702	33.294768	3684125.385	444295.676
5	Al-Azizia	45.162487	32.778982	3626796.983	515216.599
6	Al-Zubaidi	45.173651	32.762858	3625011.197	516265.02
7	Al-Numani	45.409655	32.559483	3602526.899	538457.348
8	Al-Meftah	45.789193	32.545552	3599349.888	572649.1666

Results and Discussion

It makes sense that phytoplankton is a good indicator of pollution because it is simple to use, similarly, it has the capacity to measure changes in water quality, can be applied over a large geographic area, provides information on the environment and natural variability, and finally it is more tolerable than many other organisms used in ecosystem monitoring (Ismail, 1989; Yaqoob et al., 2023). In the dry and wet seasons, the quantity of phytoplankton algae increased from (21.16×10^4–40.32×10^4) to 37.7×10^4–72.39×10^4 Cell/L (Figure 2, Table 3), where red colour represents the

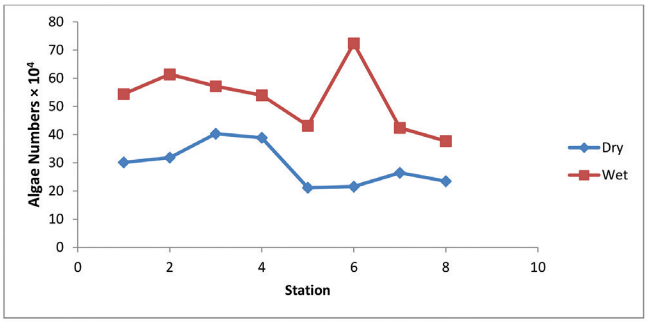

Figure 2: Seasonal variation in total numbers of phytoplankton in both seasons in all study area.

Table 3(A): Total numbers of phytoplankton species (Individuals × 10^4 cell /L) Tigris River during study in wet seasons

Class	*Sit.1*	*Sit.2*	*Sit.3*	*Sit.4*	*Sit.5*	*Sit.6*	*Sit.7*	*Sit.8*
Cyanophyceae	0	2.7	0.79	1.38	1.01	1.36	1.35	1.08
Chlorophyceae	5.79	5.58	3.38	2.33	3.32	6.6	3.74	9.54
Euglenophyceae	0	0	0	0	0	1.7	0	0.67
Mediophyceae	3.11	3.42	5.36	3.7	2.98	5.3	6.11	0
Bacillariophyceae	45.49	49.71	47.64	46.54	35.86	57.43	31.21	26.41
Total	54.39	61.41	57.17	53.95	43.17	72.39	42.41	37.7

Table 3(B): Total numbers of phytoplankton species (Individuals × 104 cell /L) Tigris River during study in dry seasons

Class	*Sit.1*	*Sit.2*	*Sit.3*	*Sit.4*	*Sit.5*	*Sit.6*	*Sit.7*	*Sit.8*
Cyanophyceae	2.86	2.45	2.06	2	0.9	1.98	1.9	2.01
Chlorophyceae	4.46	3	3.81	3.07	3.85	2.78	3.3	3.53
Euglenophyceae	0.31	0	0	0	0	0	0	0
Mediophyceae	0	0	0	7.1	0	0	0	0
Bacillariophyceae	22.52	26.38	34.45	26.7	16.41	16.8	21.26	17.92
Total	30.15	31.83	40.32	38.87	21.16	21.56	26.46	23.46

highest value and gray indicates the lowest value. As shown in Figure 3, phytoplankton populations were generally greater during the rainy season than they were during the dry season. These variances are a response to environmental factors such as fewer daylight hours, lower temperature measurements, and variations in stream velocity (Al-Thahaibawi et al., 2021).

Bacillariophyceae, with 34.45×10^4–57.43×10^4 cell/L in both the wet and dry seasons at stations 3, 6, and 7, respectively, was the dominant group in both seasons. In contrast, the number of Mediophycae was (6.11×10^4–7.1×10^4) cell/L for the dry and wet seasons at station 7,4, as shown in Figure 4. Diatoms predominate Iraq's inland water habitats on a regular basis (Albueajee, 2020; Varoland Şen, 2018). Diatoms are able to do this because of their lifespan and resistance to a wide range of climatic conditions. Diatoms increase in Iraqi waters due to the high concentration of silica in the water, because the structures of diatoms are built from it (Jabbar and Al-Hassany, 2018). As a result, diatoms were widespread over the whole research period and accounted for the majority of the total quantity at all stations. Its exceptional capacity for growth and reproduction in the presence of a variety of environmental conditions, such as high temperatures, intense light, salinity, and plant nutrients, as well as its quick adaptation to changes in the physical, chemical, and biological elements of the aquatic ecosystem (Darweesh, 2017; Frankovich and Fourqurean, 1997; Leelahakriengkrai and Peerapornpisal, 2010; Mukai, 2006) which are just some of its many exceptional qualities. This study indicates that the center diatom (*Mediophyceae*) predominated over horned diatoms (*Bacillariophyceae*). These outcomes agree with those of earlier research (Darweesh, 2017; Mukai, 2006). When horned diatoms predominate in the center of the diatom community, the water becomes healthy, whereas prominent central diatoms indicate surface disturbances (Bakaeva and Al-Ghizzi, 2020; Suma and Rajeshwari, 2013). Chlorophyaceae recorded (4.46×10^4 -9.54×10^4) cell/L in the dry and wet seasons for stations 1 and 8, respectively. While the *Cyanophyceae* reached (2.86×10^4 - 2.7×10^4) cell/L in the dry and wet seasons for stations 1 and 2, respectively. *Chlorophyceae* was the dominant group after the *Bacillariophyceae* algae; it recorded (4.46×10^4 -9.54×10^4) cell/L, identical to the presence of *Chlorophyaceae*, as mentioned and noted (Al-Thahaibaw et al., 2021). In contrast, the Euglenophyceae was the lowest class in the current study, with (0.31×10^4 to 1.7×10^4) cell/L for the dry and wet seasons for 1,6 stations (Figure 4). The Tigris River was exposed to droughts and a change

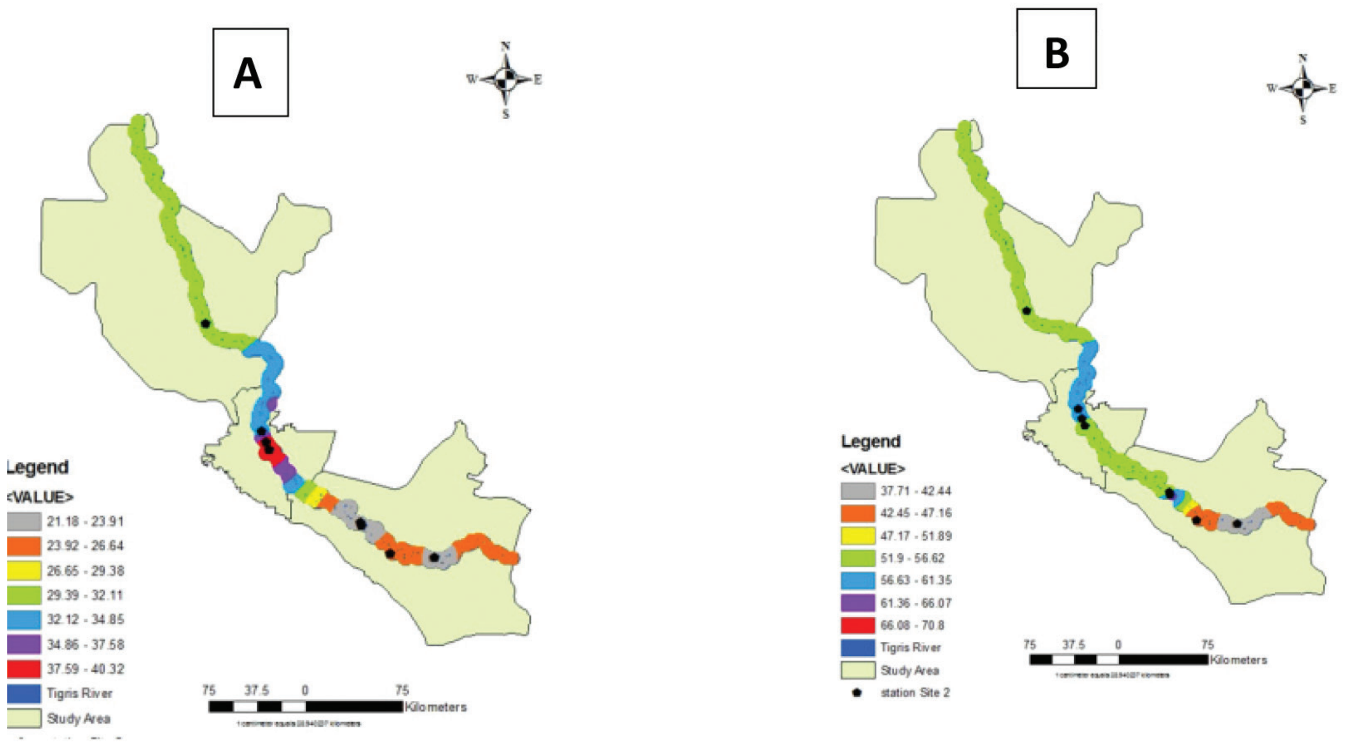

Figure 3: The interpolation maps of determining total number of species of phytoplankton during study period in both seasons (a) dry and (b) wet.

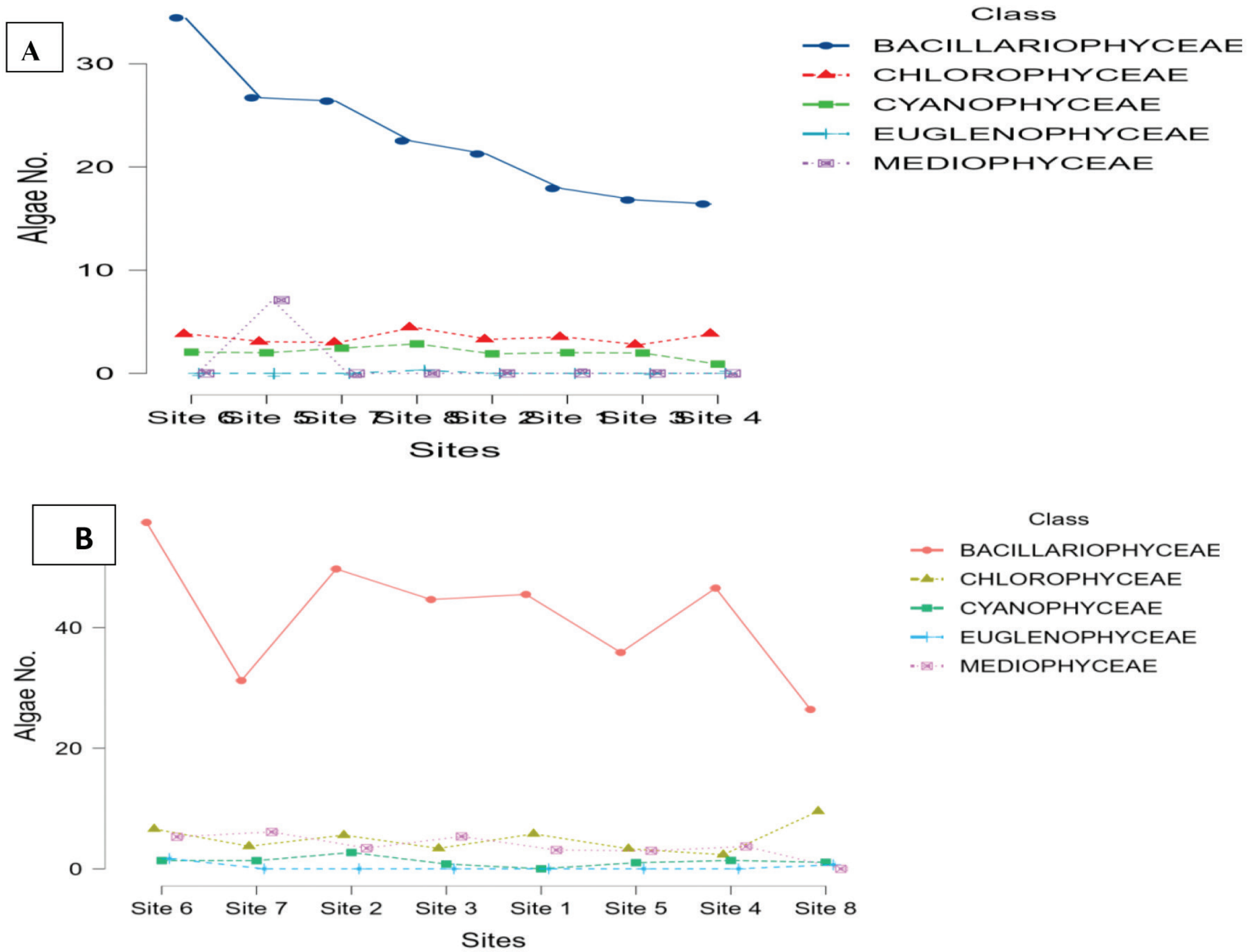

Figure 4: Flex plot explains seasonal variation in total numbers of phytoplankton in (A) Dry and (B) Wet seasons in all study area.

in the nutritional state throughout the current period, as evidenced by the decrease in the total quantity of *Chlorophyceae*, *Cyanophyceae*, and *Euglenophyceae* in the river. For all rows detected during the rainy season, the increase in drifting algae is typically caused by an increase in rainfall that removes organic matter from fertilisers containing phosphorus and nitrogen, which are essential nutrients for algae (IMF, 2012). This result is in line with (Abdul, 2010), or it could be caused by an increase in organic materials in the water column as low temperatures slow down their decomposition. The increase in silicate concentration during the wet season may also be a contributing factor to this increase (Sivri et al., 2012). Chlorophyll is present in every photosynthetic organism, including cyanobacteria, algae, and land plants, as it is the primary chemical involved in photosynthesis (Hurtado et al., 2020). Due to this reason, cyanobacteria are a significant indicator of a water body's primary productivity.

The concentration of chlorophyll-a for phytoplankton throughout the sampling period ranged between 3.7,3.59 and 0.23 g/L for stations 3, 6, and 5 during the dry and wet seasons (Figure 5)**,** red colour stands for the highest value and the gray color for the lowest value, as shown in Figure 6. Typically, variations in the number of phytoplankton algae classes come as a result of changes in environmental conditions that can be associated with seasonal variations in the quantity of chlorophyll-a. For example, nutritional availability, which influences pigment reduction in diatoms in addition to photosynthetic enzymes might be the reason behind these variances. The difference between the values for chlorophyll-a and the overall number of reported algal classes may be the result of

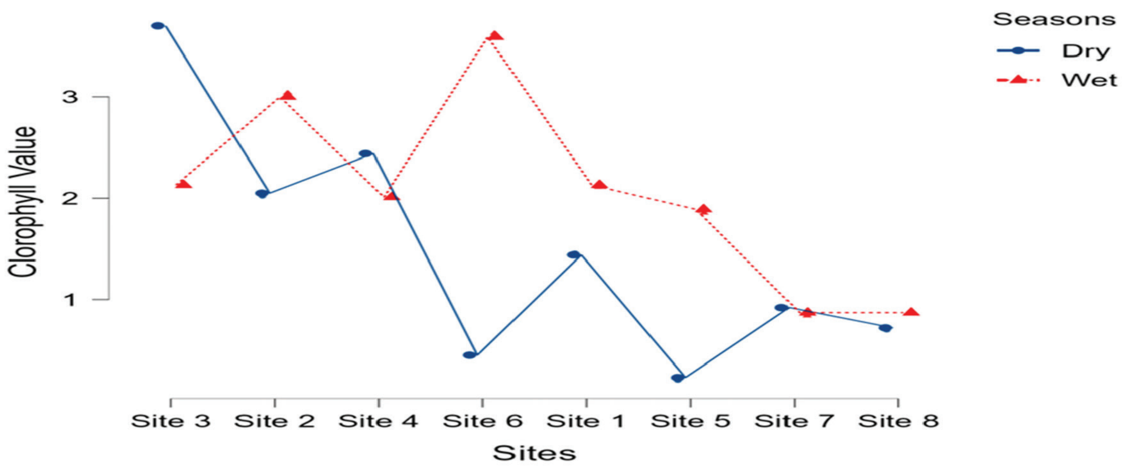

Figure 5: Flex plot explains seasonal variation in total numbers of chlorophyll-a of phytoplankton in (Dry and Wet) seasons in all study area.

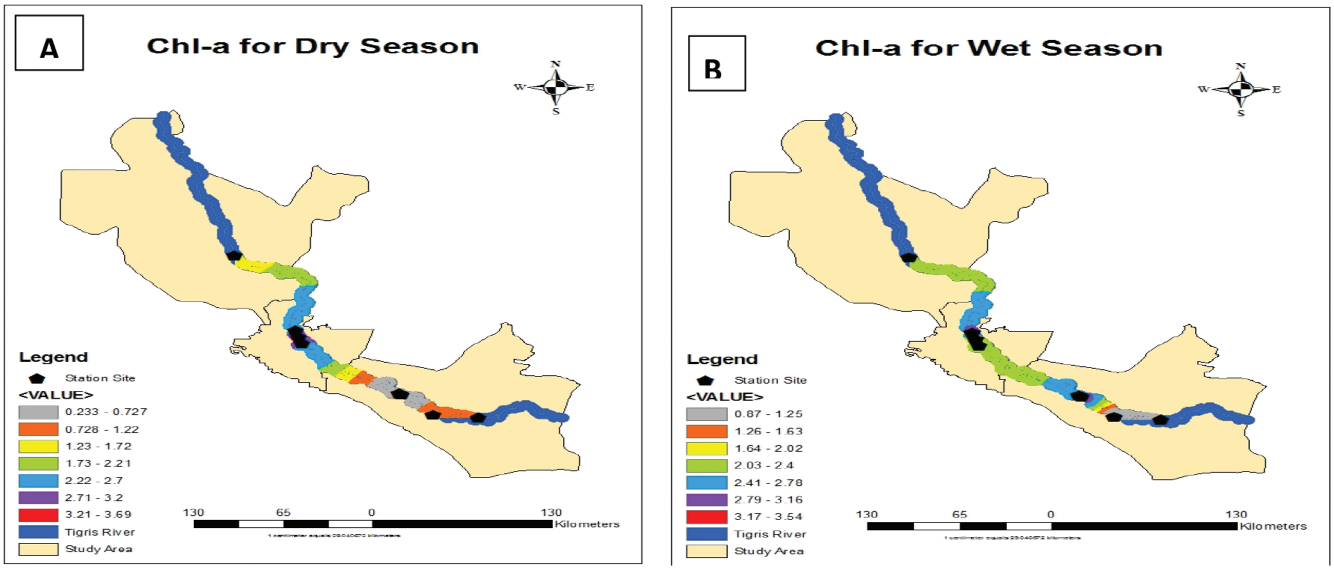

Figure 6: The interpolation map of determining chlorophyll-a concentration of Phytoplankton during study period in both seasons (A) dry and (B) wet.

the disappearance of the red region's high value on the map due to its small area on the map represented by stations 3 and 6 (Al-Amiedy and Al-Azawi, 2022; Albueajee, 2020; Basak et al., 2021; Hurtado et al., 2020). This is because the percentages of chlorophyll-a in an algal cell may fluctuate greatly. Numerous factors, including elevated nutrient levels, light availability, and water temperature, can positively influence phytoplankton biomass, which in fact can lead to a rise in Chl-a concentrations in freshwater systems (Paerl and Huisman, 2009; Schindler, 2006). Because of their capacity for predation, increased zooplankton grazing pressure can have a negative effect on phytoplankton biomass and concentration of Chl-a level (Sandu et al., 2003). Chlorophyll-a concentrations are influenced by river flow and water residence time; increased flow rates may dilute nutrient concentration and decrease phytoplankton biomass (Descy and Gosselain, 1994). Also, Chl-a fluctuations in aquatic systems due to high concentrations of pollutants like pesticides or heavy metals might inhibit phytoplankton growth, depending on the hazardous degree of pollution (Otsuka et al., 2018).

Due to an abundance of nutrients, the water environment in Iraq is typically favourable for the growth, presence, and diversity of phytoplankton.

However, recently, water environment has been threatened by drought and a lack of rain, which have a detrimental effect on aquatic organisms, including phytoplankton.

Conclusions

The study showed seasonal and temporal variation in total number of phytoplankton algae. Bacillariophyceae class was the most dominant class in terms of total cell number this was followed by Chlorophyceae then Cyanophyceaeclasses of algae. The wet seasons recorded the highest of the total number of phytoplankton. Seasonal changes had a greater impact on the total numbers of phytoplankton algae than were the study locations. The GIS application showed the distribution of chlorophyll –a concentrations that are high in the wet season and low in the dry season. The chlorophyll concentration values were almost identical for the seasonal and local phytoplankton numbers.

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