Wasit Journal for Pure Science

Journal Homepage: https://wjps.uowasit.edu.iq/index.php/wjps/index
e-ISSN: 2790-5241 p-ISSN: 2790-5233

Assessment of Water Quality and Its Impact on the Distribution of *Chara* sp. Algae in Central and Northern Iraq

Mayada R. ALazawy[1], Buthena A. Al-Magdamy[2]*

[1,2]Department of Biology- College of Education for Pure Science (Ibn Al-Haitham)- University of Baghdad, IRAQ

*Corresponding Author: Buthena A. Al-Magdamy

DOI: https://doi.org/10.31185/wjps.603
Received 25 November 2024; Accepted 29 December 2024; Available online 30 March 2025

ABSTRACT: The physical and chemical factors of river water influence the distribution, spread, behaviour and adaptation of aquatic organisms. Thus, the current study was conducted in a number of central and southern regions of Iraq for the purpose of determining the physical and chemical environmental variables in which algae *Chara* sp. can be present. Some physical and chemical characteristics of water quality of different sites in central and southern Iraq were studied from October 2023 to April 2024 for villages and rural areas in Salah Al-Deen, Babylon, Kut, Diyala, Anbar and Mosul governorates, in addition to the city of Baghdad within the Tigris River and some natural and artificial water bodies and from 16 sites to find the relationship between the studied factors of water temperature, pH, transparency, electrical conductivity, dissolved oxygen, nitrates, phosphates, calcium, magnesium, water depth and the presence of *Chara* algae.

The results of the current study showed that the algae was present in seven sites and that the water in which the algae was present was with temperature, pH, light transmission close and low depth, low electrical conductivity, low levels of nitrate, phosphate, calcium, magnesium and high dissolved oxygen, which indicates that the algae prefers to live in such conditions and has the ability to remove some elements from the water and the northern or near areas are a preferred place for the presence of these algae. *Chara* sp. algae prefer clean, low-nutrient, shallow waters with high light transmission, away from organic pollution and phosphates and nitrates, and shallow depths.

Keywords: Water quality, *Chara*, Algae, Environmental factors, Central and southern Iraq.

1. INTRODUCTION

Rivers play a crucial role in shaping civilizations and biodiversity, influencing the distribution and adaptation of aquatic organisms through their physical and chemical properties [1, 2] because rivers have a continuous movement that leads to the process of mixing water with its upper and lower layers, and this is helps to distribute nutrients and organic matter among them. The movement of water helps to expose the lower layers to good ventilation, and this is making the environment of rivers often of high biodiversity in terms of the abundance of phytoplankton of all species and varieties, so they are productive high [3].

Algae differ in terms of the environment of their existence, therefore some of them prefer to be in lotic water, while the other prefers to be in lentic water inside lakes, and some of them prefer salt water and the other is fresh. As well as some of them are considered a biological index to pollution, so the process of searching for specific algae requires knowledge of the environment preferred by each species by temperature, nature of water and other physicochemical factors [4].

Chara algae play a key role in maintaining the balance and functions of the ecosystems that colonize them. It controls the nutrient cycle and biogeochemistry of the water body directly and indirectly. Directly by absorption of nutrients in plant biomass and indirectly by co-precipitation of phosphorus and calcium carbonate [5].

Therefore, a better understanding of the ecological preferences of this at-risk algal population is important for habitat conservation and restoration [6]. [7] indicated that the Iraqi environment is spread by 8 species of the genus *Chara*, and environmental and taxonomic studies of this algae and the interaction of its appearance with environmental variables as in the studies [8], [9], [10], [11] or the use of this algae as an environmental indicator [12, 13]. Thus, the current study

*Corresponding author: buthena.a.h@ihcoedu.uobaghdad.edu.iq

was conducted in a number of central and southern regions of Iraq for the purpose of determining the physical and chemical environmental variables in which algae *Chara* sp. can be present.

2. MATERIALS AND METHODS

2.1 Description of the studied sites

Field visits were carried out starting from October 2023 until April 2024 to the villages and countryside of the governorates of Salah Al-Deen, Babylon, Kut, Diyala and Anbar, in addition to the city of Baghdad within the Tigris River and some natural and artificial water bodies, as shown in **Table (1)** and **Fig. (1).**

Table 1. Studied sites in different governorates with latitude and longitude with the geographical location system locator

Governorates	Studied sites	Device Reading					
		Longitude (east)			Latitude (north)		
		″	′	°	″	′	°
Baghdad	First site (Taji)	44.32	17	44	20.39	28	33
	Second site (Imams Bridge)	30.83	21	44	19.28	22	33
	Third site (Adhamiya corniche)	11.88	22	44	51.30	21	33
	Fourth site (Al Zorah)	37	22	44	53	18	33
	Fifth site (Medical City Bridge)	43.77	22	44	31.20	20	33
	Sixth site (Al-Jadriyah compound)	37.51	22	44	5.98	16	33
	Seventh site (Al-Mahmoudia)	22.80	24	44	49.72	3	33
Diyala	Eighth site (Al-Sador Area / Diyala)	3.38	36	44	55.41	40	33
	Ninth site (College of Agriculture / Diyala)	58.02	8	45	24.05	46	33
Kut	Tenth site (Al-Sssaouira Farms)	22.6	59	44	13.6	45	32
Babylon	Eleventh site (Hilla)	22.80	24	44	49.72	3	33
Salah-Al-Deen	Twelfth site (Sheikh Jameel / Tikrit)	42.16	37	44	16.36	80	33
	Thirteenth site (Al Nabai)	30.21	5	44	55.03	41	33
	The fourteenth site (gravel quarries / Samarra)	8.15	52	43	38.93	9	34
	Fifteenth site (Al-Dhuluiya)	26.55	15	44	14.38	4	34
Mosul	Sixteenth site (Mosul)	27.84	9	43	56.14	20	36

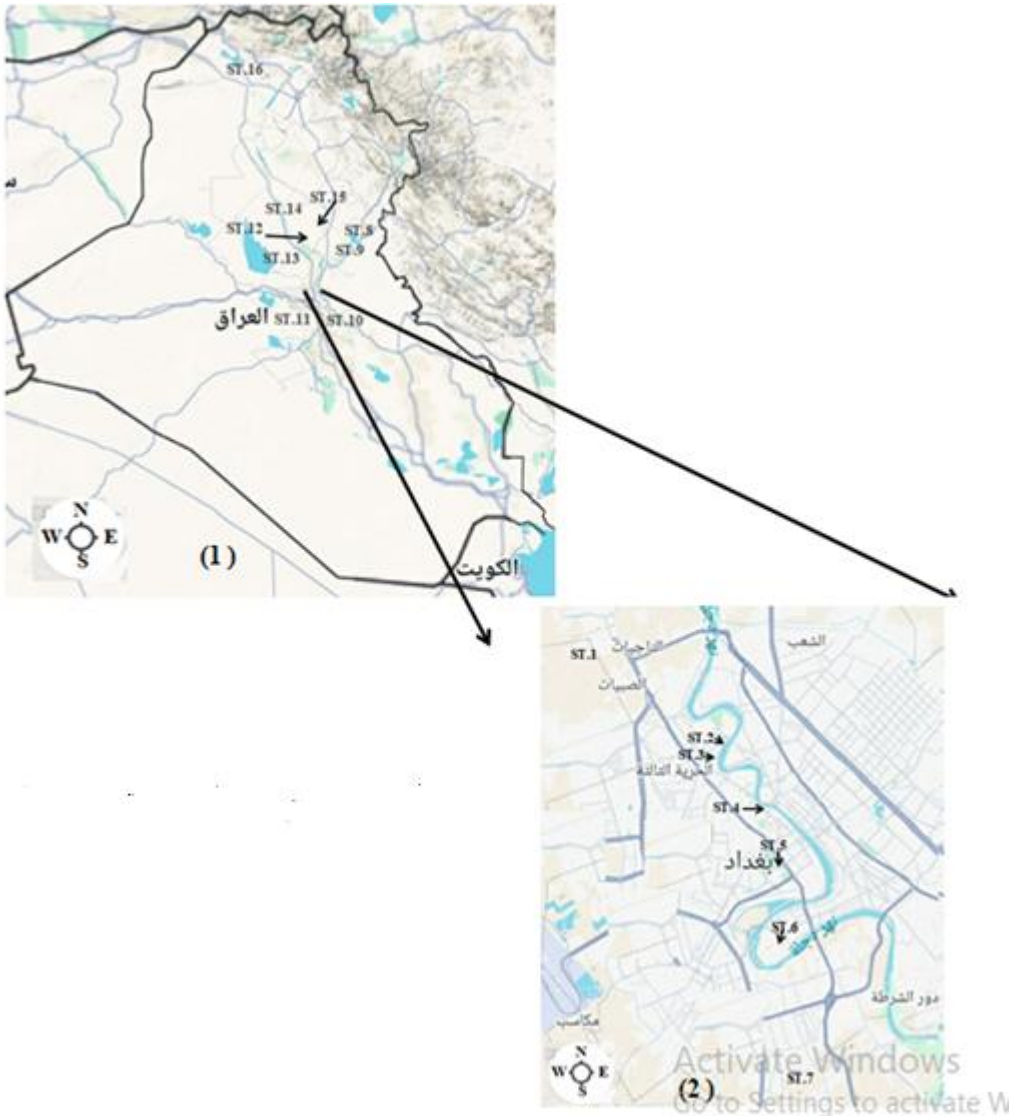

FIGURE 1. - Distribution of study sample collection sites within some Iraqi governorates (1) and within Baghdad city (2).

2.1 Materials and methods of work

The algae was collected manually and moved under water to remove the bulk of the suspended materials and mud and then placed in sterile plastic bottles and a little river water was added to it if it is in the site, and water samples were collected to measure some physicochemical variables as water samples were collected in polyethylene bottles (2) liters and kept refrigerated until reaching the laboratory and the water temperature was measured in the field using the mercury thermometer graduated from (0-100) º C and expressed the results in degrees Celsius (º C). A Secchi disk was used to measure light transmission and expressed the output in cm. The pH was measured in the field using the pH 7110 device from the English company Inullab. The electrical conductivity of water was measured in the field using the Conductivity Meter type 7110 from the English company Inolab and was estimated in µS/cm.

While the samples for measuring dissolved oxygen were collected in transparent Winkler bottles with a volume of 250 ml and according to the method described by [14] and oxygen was fixed in the field by adding 2 ml of manganese sulfate solution and Alkaline iodide-azide solution and the bottles were shaken several times and left to settle until a precipitate is formed up to a third of the vial approximately, then add 2 ml of concentrated sulfuric acid and shake the bottles several times until the precipitate is completely dissolved according to [15] and expressed the results mg/L. Nitrates were also measured according to the method described in [15] and the optical density of all samples and standard solutions at wavelengths of 220 and 275 nm was measured using a spectrophotometer and the results were expressed in mg/L.

The active phosphorus was estimated using the ascorbic acid method described by [16] and the absorbance was measured at wavelength 880 nm and the results were expressed in mg of phosphorus atom/L. The chloride ion was measured according to the method of perfusion against the standard silver nitrate solution 0.0141 N shown in [14] and expressed in mg/L.

The amount of calcium and magnesium was also measured by adding a solution of sodium hydroxide and an addition of a Meroxide reagent, and the model is powdered with an EDTA solution until the color changes according to the method of [17]. The depth of water at all sites was also measured and estimated in meters.

2.2. Statistical Analyses

The data was tabulated in a datasheet of IBM SPSS version 25.0, which was utilized to do the statistical analysis. The mean and standard errors of continuous variables were reported, and significant differences were tested using the analysis of variance (ANOVA) test, followed by the least significant difference (LSD) test. The Pearson's correlation coefficient was utilized to determine the correlation between different parameters under study. Statistical significance was defined as a probability value ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

Fig. (2) shows that the temperatures were variable according to the sites, and that the ninth site recorded the highest temperature of 23.67ºC, while the lowest temperature was the sixteenth site, where it recorded 18.32ºC in the city of Mosul, where *Chara* algae was found.

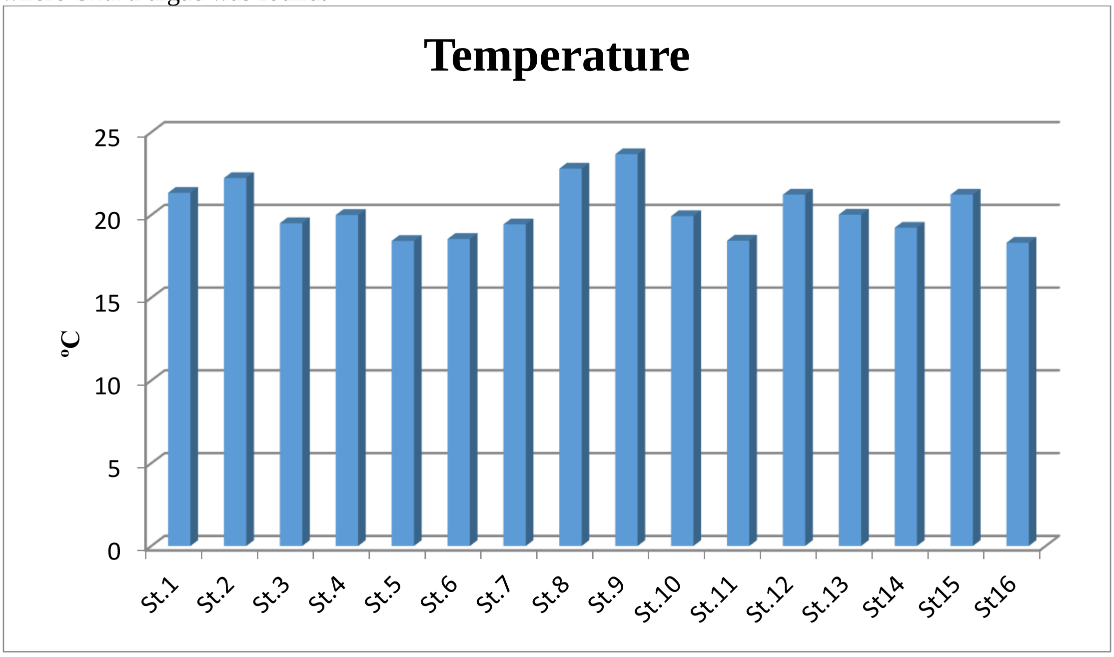

FIGURE 2. - Temperature in the studied sites.

Fig. (3) shows the light transmission of the sixteen studied site, the highest of which was 2.9 cm at the fifteenth site, while the lowest value was at the ninth site and amounted to 0.78 cm.

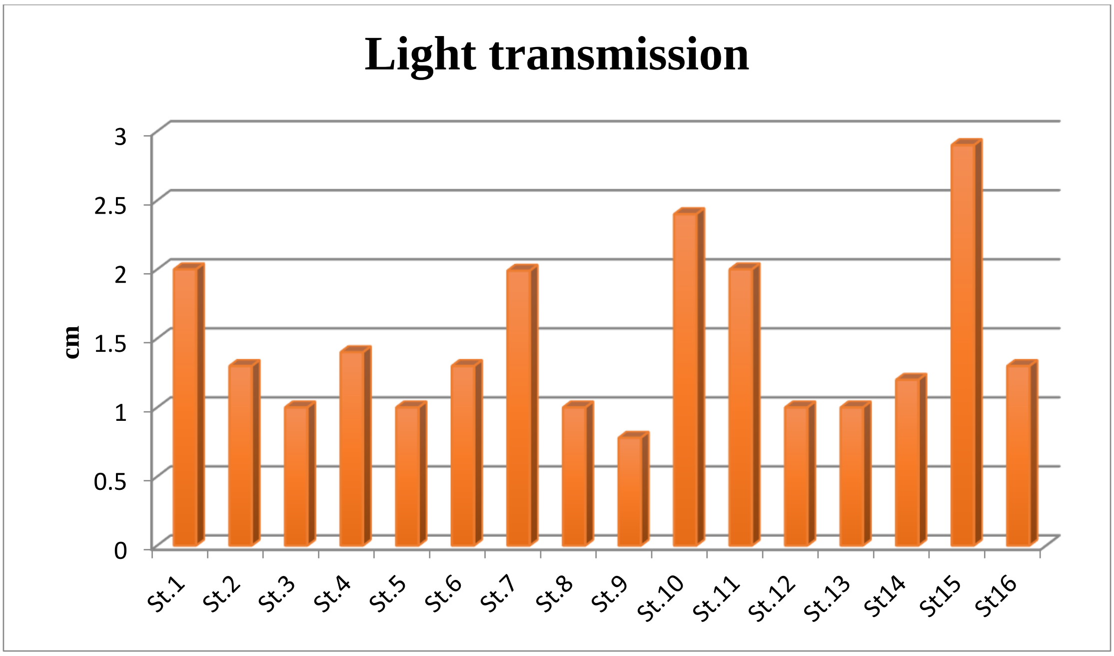

FIGURE 3. - Light transmission in the studied sites.

The results of the electrical conductivity showed clear differences in the studied sites, with the highest rate at the twelfth site reaching 3611 µS / cm and the lowest value was at the second and thirteenth sites and amounted to 211 µm/ cm (**Fig. 4**).

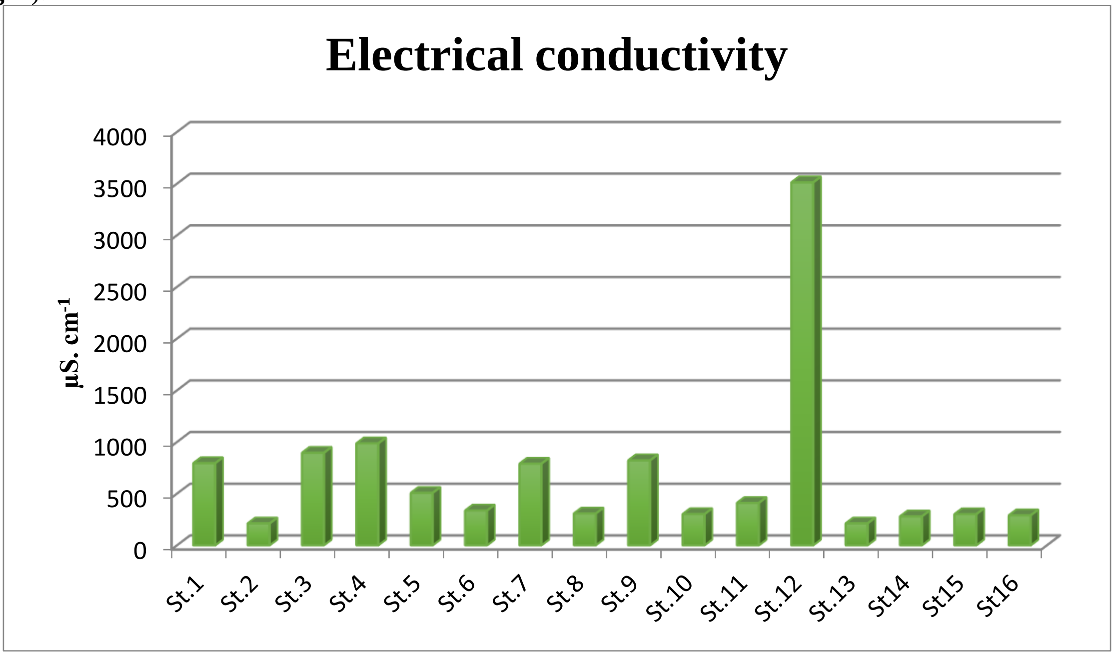

FIGURE 4. - Electrical conductivity in the studied sites.

The highest pH was recorded at the eleventh site and was 8.9 and the lowest rate was at the fifth site was 7.55 as shown in **Fig. 5**.

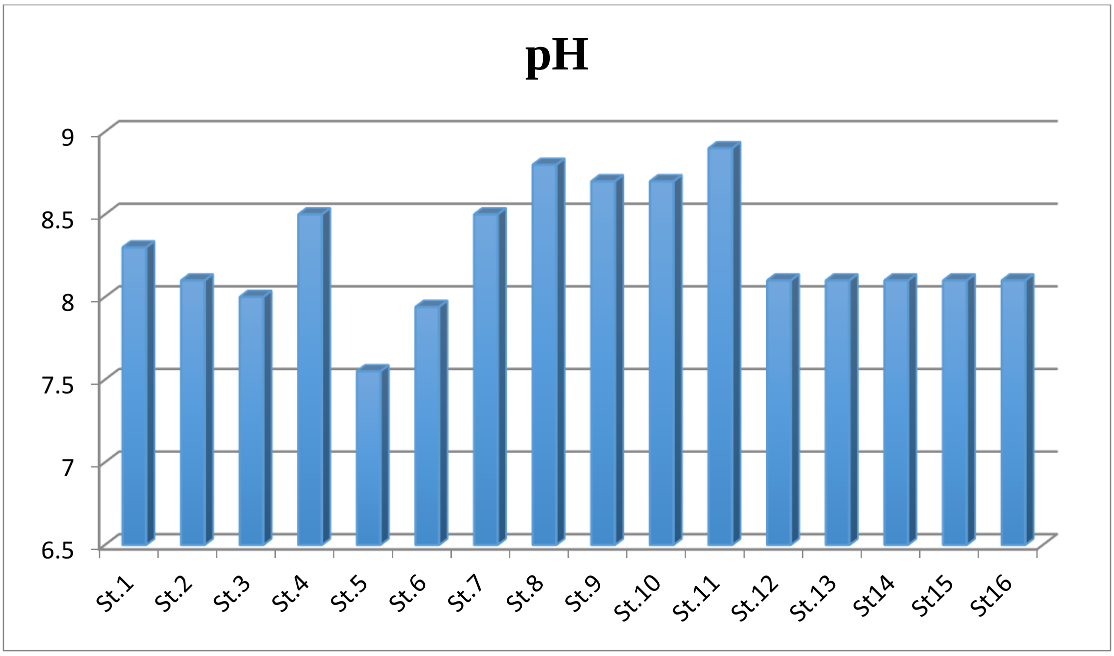

FIGURE 5. - pH in the studied sites

The value of magnesium was recorded at the sixth site with a value of 78 mg/L and the lowest value for this element was at the twelfth site with a value of 9.7 mg/L (**Fig. 6**).

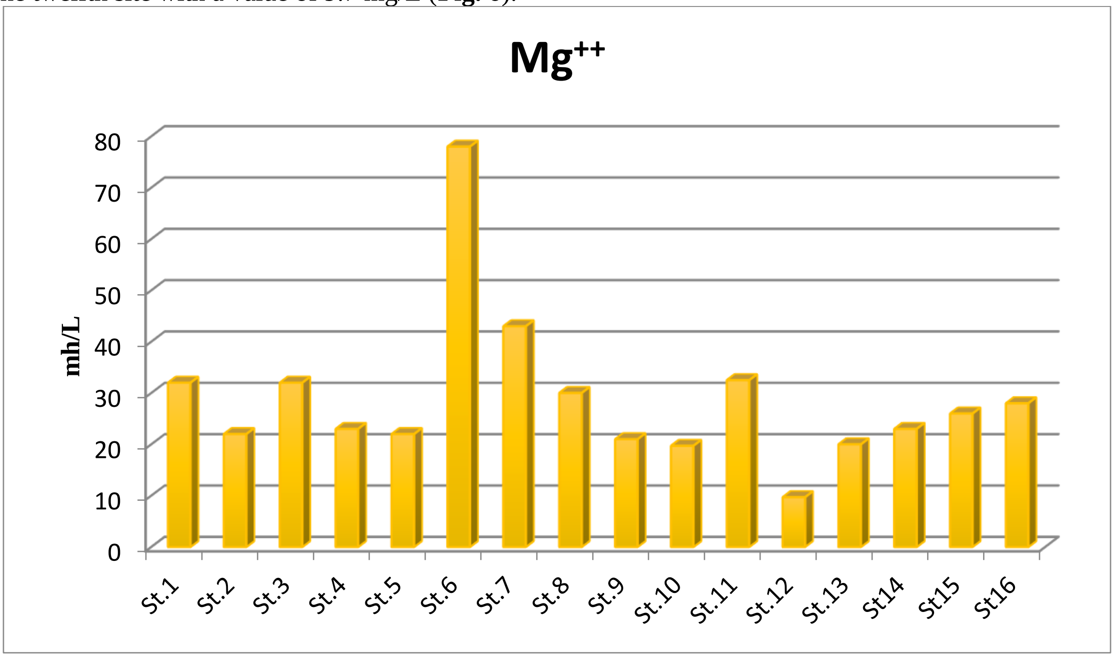

FIGURE 6. - Magnesium concentration at the studied sites.

The calcium concentration was highest at the eighth site (187.4 mg/L) and the lowest value was at the thirteenth site (39.2 mg/L) as shown in **Fig. 7**.

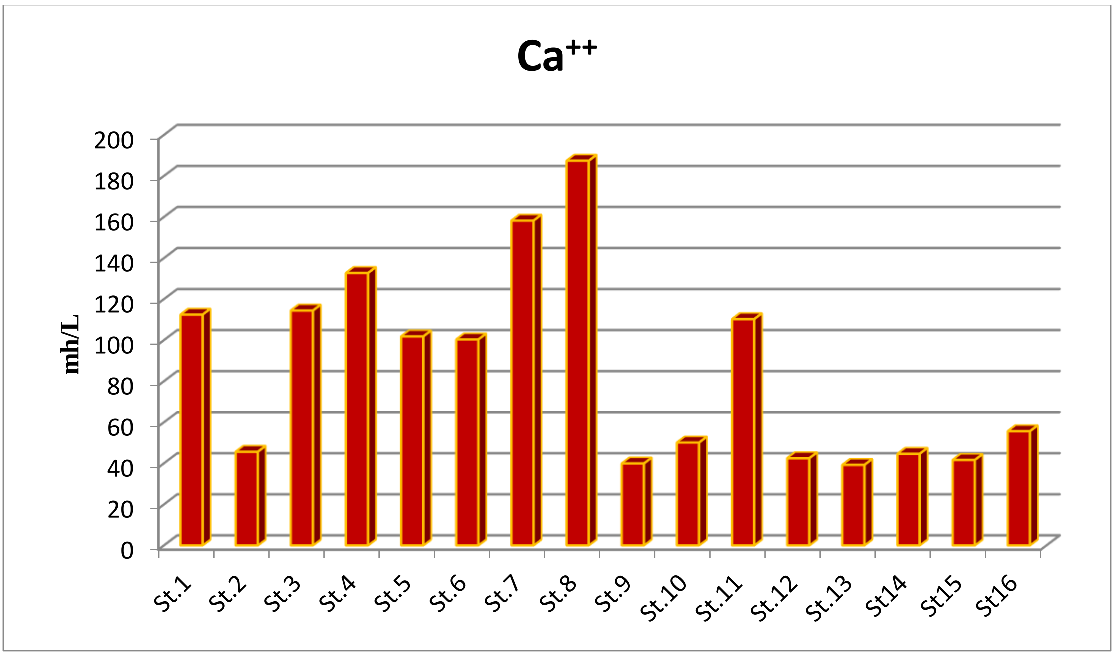

FIGURE 7. - Calcium concentration in the studied sites.

As for the available phosphate, the highest value was recorded at the eleventh site, which amounted to 0.87 mg/L, while the lowest value was in the second site, which amounted to 0.02 mg/L, as shown in **Fig. (8).**

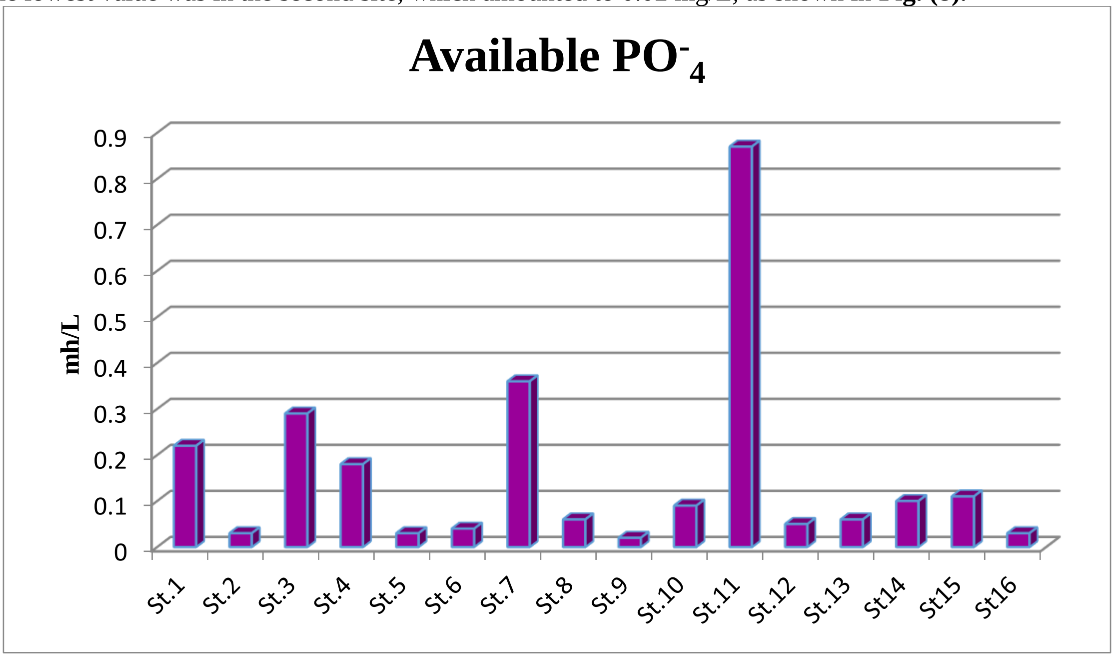

FIGURE 8. - Available phosphate concentration in the studied sites.

Fig. (9) also shows the concentration of nitrate in the studied sites, and its highest value was in the first site, which amounted to 10.3 mg/L, and the lowest value was in the sixth site and the thirteenth site, which amounted to 0.11 mg/L.

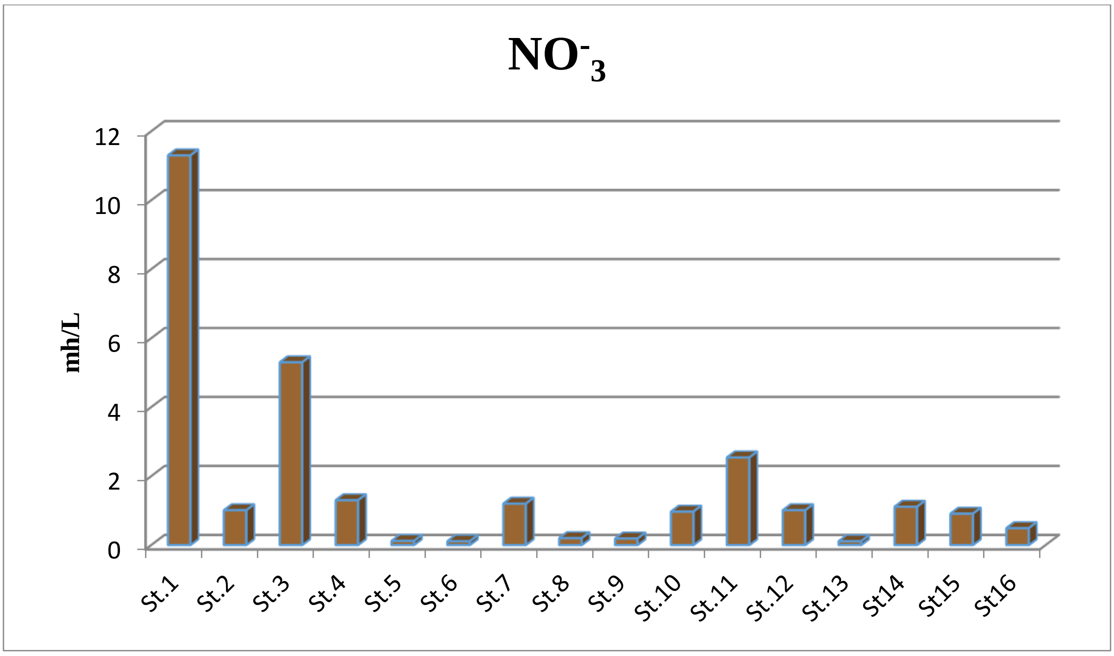

FIGURE 9. **- Nitrate concentration in the studied sites**.

As for the amount of dissolved oxygen in the studied sites, the third site recorded the highest percentage of 11.3 mg/L, while the ninth site recorded the lowest value of 7.4 mg/L, as shown in **Fig. (10).**

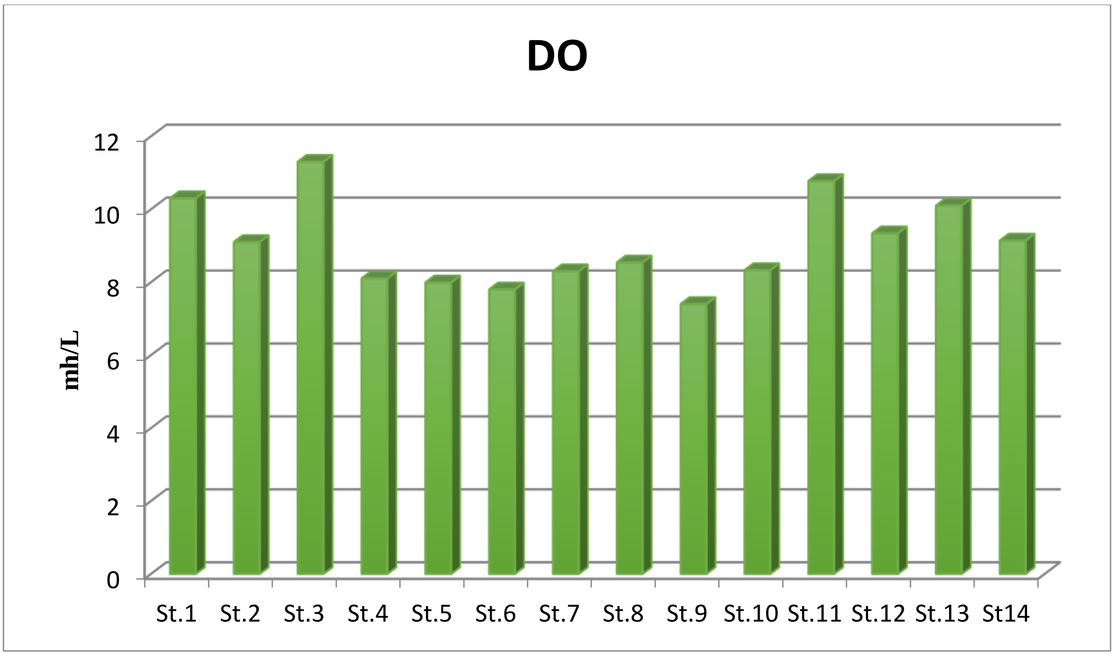

FIGURE 10. **- Dissolved oxygen in the studied sites**.

Fig. (11) shows the highest water depth was at the fourth site and reached 6.9 meters, while the lowest water depth was at the twelfth site, reaching only 1 meter.

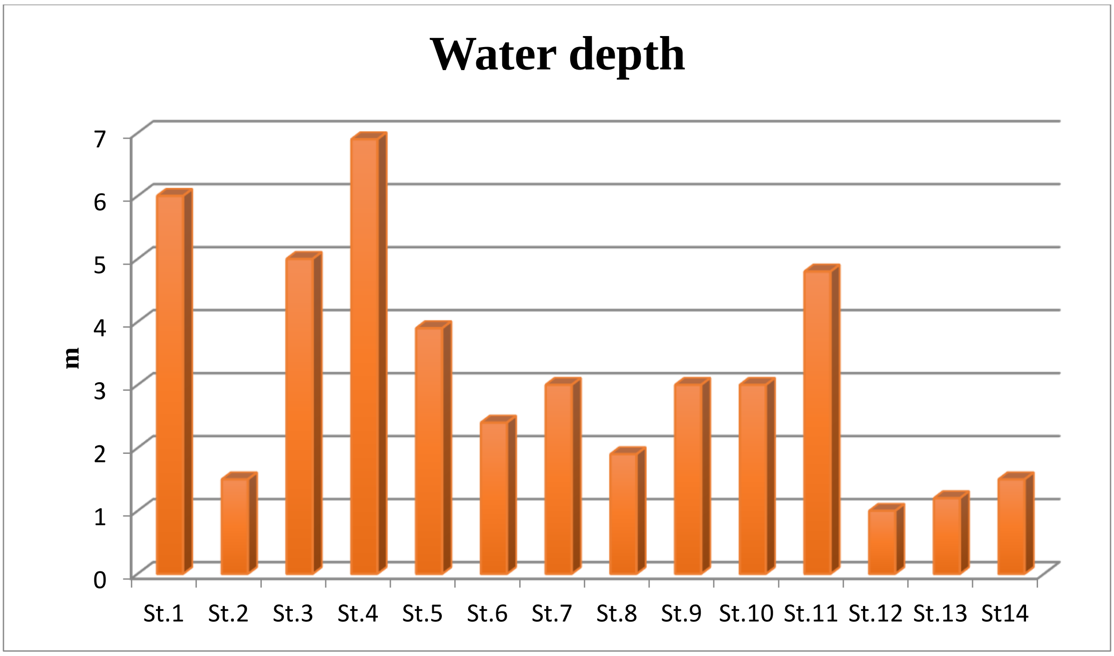

FIGURE 11. - Water depth in the studied sites.

The presence of *Chara* sp. algae has been determined at the third, tenth, twelfth, thirteenth, fourteenth, fifteenth and sixteenth sites (**Table 2**).

Most of the sample collection sites were characterized by organic pollution from sewage, agricultural and industrial water and household waste, and this affects the presence of Charophyta algae in general. **Table (2)** shows that most of the sites did not observe the presence of *Chara* algae.

Table 2. Presence of *Chara* sp. algae in the studied sites. + present of algae, - does not present.

Governorates	Studied sites	Algae present
Baghdad	First site	-
	Second site	-
	Third site	+
	Fourth site	-
	Fifth site	-
Diyala	Sixth site	-
	Seventh site	-
	Eighth site	-
	Ninth site	-
Kut	Tenth site	+
Babylon	Eleventh site	-
Salah-Al-Deen	Twelfth site	+
Mosul	Thirteenth site	+
	The fourteenth site	+
	Fifteenth site	+
	Sixteenth site	+

The presence of algae recorded a negative inverse correlation with the amount of calcium at the sites studied (**Table 3**).

Table 3. Pearson correlation coefficient among the features studied.

	Temperature	Light transmission	Electrical conductivity	pH	Mg	Ca	PO_4	NO_3	OD	Water depth	*Chara* present
Temperature	1.000										
Light transmission	-.183	1.000									
Electrical conductivity	.105	-.168	1.000								
pH	.360	.271	.115	1.000							
Mg	-.345	.331	.097	.020	1.000						
Ca	-.202	.184	.390	.234	.654**	1.000					
PO_4	-.151	.543*	.246	.323	.504*	.494	1.000				
NO_3	.005	.414	.402	.281	.308	.457	.750**	1.000			
OD	-.135	.070	-.093	.036	.147	.109	.437	.545*	1.000		
Water deth	-.114	.391	.516*	.181	.423	.548*	.529*	.496	-.052	1.000	
***Chara* present**	-.150	-.014	-.274	-.295	-.397	-.506*	.027	-.041	.396	-.384	1.000

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The physicochemical properties in the aquatic environment play an important role in the presence and activity of aquatic organisms, as they affect the vital activities of various aquatic organisms within the water column [18], and some of them are considered specific to the presence of certain types of organisms at the expense of other species [19]. For this reason, some physicochemical variables of sample collection sites were measured to know the nature of the environment in which *Chara* sp. algae is present.

Temperature is an important factor that affects water quality because it affects the physical, chemical and biological properties of the aquatic environment and thus affects the distribution of aquatic organisms, including algae [19, 20, 21]. The results showed a variation in the temperature of the studied sites depending on the geographical location of each site, the movement of air and clouds, and the intensity of solar radiation that affects water temperature [22].

The current study agreed with several local studies that recorded a variation in temperature between the central and northern regions of Iraq, which led to the growth of different algae species [23, 24, 25]. This was reflected in the presence of *Chara* sp. algae in the northern and nearby regions such as Mosul and Salah Al-Deen due to its suitability to the algae growth temperatures.

The current study showed a high pH for most sites and the reason may be attributed to the effect of biological factors that have a major role in controlling the pH value, such as some types of phytoplankton, plants and algae that increase the pH due to photosynthesis, which leads to the consumption of carbon dioxide gas and excretes oxygen [26].

pH is associated with an inverse relationship with carbon dioxide and a positive relationship with oxygen gas. The sites containing *Chara* sp. algae recorded approximately equal levels of pH value of 8.1, except for the tenth site (Kut) was slightly higher and this result is consistent with the study of [27] which indicates the growth of *Chara* sp. algae in an alkalinity environment.

Light transmission expresses the transparency of a body of water and is influenced by many factors such as current velocity, continuous water movement, weather condition and sample collection period [28]. Most of the sites where *Chara* sp. algae appeared had low light transmission due to increased plant death, wind movement, climate factors, dust storms and the pollutants and particulate matter they add to the water [29].

Dissolved oxygen is one of the most important indicators that determine the quality of water and the degree of pollution of the aquatic environment, as the lack of oxygen causes great damage to aquatic organisms and its lack indicates the presence of organic pollution [30]. Most of the sites where *Chara* sp. algae is present had a high level of dissolved oxygen, perhaps due to the fact that temperatures are lower than the rest of the sites and the low level of decomposition of organic matter [31]. In addition to the high-water levels, these sites recorded a greater depth than the rest of the studied sites, which led to mixing of oxygen in the water column, thus increasing the value of dissolved oxygen during low temperatures [32].

As for nitrates, which are one of the main nutrients in the aquatic environment, which the increasing their concentrations lead to the phenomenon of eutrophication, and the sites in which the *Chara* sp. algae was found recorded a decrease in the value of nitrates, perhaps due to high water levels or the consumption of nitrates by algae or some aquatic plants, and this is consistent with the study of [33]. The results of the study also showed that there is a decrease in the value of phosphate and this may be due to its consumption by aquatic plants that consume large amounts of phosphorus [34]. As well as the high-water levels during the study seasons, which may have caused the relaxation of nutrient concentrations, this study agreed with the study of [35].

The other studies have shown that Charophyta algae in general prefer clean water bodies far from organic pollution and the increase in nutrients from phosphates and nitrates, in addition to that they prefer to be found in water bodies with low nutrients, low depth and high light transmission [36], and this was found in the current study. The sample collection sites was16 in which *Chara* sp. algae was diagnosed only in seven sites (**Table 2**).

In general, magnesium ions ($Mg2^{+}$) are a key component of chlorophyll required as a growth factor for green algae and can be found in the ratio of equivalent elements to chlorophyll in photosynthetic tissues. Magnesium is the most important ingredient required for the proper growth of algae, and its efficiency can be increased by nitrates [37]. Magnesium is therefore essential for the growth and development of algae. It is of great importance in chlorophyll and affects the activity of photosynthetic enzymes [38]. However, magnesium, calcium and other alkaline earth minerals are responsible for water hardness. Water that contains large amounts of alkaline earth ions is called hard water, and water that contains small amounts of these ions is called soft water [39]. The calcification process in algae depends not only on photosynthesis activity, but also on inorganic carbon concentrations and magnesium/calcium ion ratios in water that algae obtain directly from water [40]. As well as nitrates lead to algae eutrophication within rivers [41]. These algae harm freshwater and seawater ecosystems, as they deplete oxygen during the night. Not only do these eutrophication algae significantly reduce oxygen concentration within these lakes and rivers, but they also release very harmful toxins that can kill many organisms in the aquatic environment [42].

All seven sites share that they are of low depth, net, free or low pollution, and when searching for algae samples in agricultural areas, it was found that they prefer cement-lined waterways, perhaps because this water contains appropriate concentrations of calcium, which is necessary for the formation of calcareous structures on all parts of the algae [43].

This is consistent with the study of [44], where he indicated that the species of *Chara* algae can be deposited in the form of calcium carbonate on the outside of the algae, estimated at 589 g/m^2, as well as with the study of [45] which indicated the ability of *Chara* algae to remove magnesium and calcium from water. At this process is assisted by changes in the number of carbons and bicarbonates affected by the number of phytoplankton and aquatic plants and the consequent change in pH values, and this occurs in medium or low nutrition water with a slight rise in hardness, and this is consistent also with [46] and this is consistent with what was recorded in the seven sites where algae was found, which are distinguished by being lined with cement.

4. CONCLUSION

Chara sp. algae generally prefer clean waters away from organic pollution and the increase in nutrients from phosphates and nitrates, and they also favour waters with low nutrient content, shallow depths and high light transmission

REFERENCES

[1] B.A.H. Al-Magdamy, I.M.A. Al-Salman, "Variation of non-diatomic algae in a martyr monument lake under different climate factors," *IOP Conference Series: Earth and Environmental Science*, vol. 779, pp. 012084, 2021.

[2] L.N. Naka, F.P. Werneck, N. Rosser, M.W. Pil, J.P. Boubli "Editorial: The role of rivers in the origins, evolution, adaptation, and distribution of biodiversity" *Frontiers in Ecology and Evolution*. Vol. 10, pp. 1035859, 2022. doi: 10.3389/fevo.2022.1035859.

[3] T. Bere, J.G. Tundisi, "Effects of cadmium stress and sorption kinetics on tropical freshwater periphytic communities in indoor mesocosm experiments" *Science of the Total Environment*, vol. 432, pp. 103–112, 2012.

[4] Z.K. Abdulsahib, B.A.H. Al-Magdamy, "The effect of changing the culture medium on the growth curves of some Iraqi diatoms," *Biochemical and Cellular Archives*, vol. 22, no. 1, pp. 473, 2021.

[5] N.S. Yousef, R. Farouq, R. Hazzaa, "Adsorption kinetics and isotherms for the removal of nickel ions from aqueous solutions by an ion-exchange resin: application of two and three parameter isotherm models," *Desalination and Water Treatment*, vol. 57, no. 46, pp. 21925–21938, 2016. https://doi.org/10.1080/19443994.2015.1132474

[6] M. Mjelde, T. Swe, A. Langangen, A. Ballot, "A contribution to the knowledge of charophytes in Myanmar; morphological and genetic identification and ecology notes," *Botany Letters*, vol. 168, pp. 102–109, 2020.

[7] P.M. Maulood, S.A. Amin, X. Mustafa, Y.A. Shekha, "Allelopathic Influences of Lower Plants or Barley (*Hordeum vulgare* L.) Seed Germination and some Growth Characteristies," *Journal of Education and Science*, vol. 33, no. 2, pp. 72-80, 2024.

[8] J.S. Al-Hassany, H.E. AL Bayaty, "Screening of Epiphytic Algae on the Aquatic Plant *Phragmites australis* inhabiting Tigris River in Al Jadria Site, Baghdad, Iraq," *Bagdad Science Journal*, vol. 14, no. 1) pp.175, 2017.

[9] Z.Z. Aljanabi, F.M. Hassan, A.H.M.J. Al-Obaidy, "Heavy metals pollution profiles in Tigris River within Baghdad city," *IOP Conference Series: Earth and Environmental Science*, vol. 1088, pp. 012008, 2022.

[10] F.M. Hassan, M.M. El-Sheekh, T.A. Wahhab, "Environmental factors drive phytoplankton primary productivity in a shallow Lake," *Egyptian Journal of Aquatic Biology & Fisheries*, vol. 27, no. 2, pp. 1-12, 2023.

[11] T.A. Wahhab, F.M. Hassan, "Environmental parameters drive the phytoplankton community structure: a case study in Baghdad Tourist Island Lake, Iraq," *Ibn Al-Haitham Journal for Pure and Applied Sciences*, vol. 36, no. 1, 74-87, 2023.

[12] L.S. Abu_Hadal, J.S. AL-Hassany, "Using Diatom Indices to Evaluate Water quality In ABU -Zirig Marsh Thi-Qar Province /south Iraq," *Baghdad Science Journal*, vol. 17, no. 2 Special Issue, pp. 599-603, 2020.

[13] B. Kadhim, M. Hamdan, F.M. Hassan, M.M. El-Sheekh, "Carbon Sources and Riverine Algal Biomass: An Experimental Study" *Egyptian Journal of Aquatic Biology & Fisheries*. vol. 28, no. 2, pp. 39–50, 2024.

[14] C. Langdon, Determination of Dissolved Oxygen in Seawater By Winkler Titration using Amperometric Technique. In:" *The GO-SHIP Repeat Hydrography Manual: A Collection of Expert Reports and Guidelines*," Version 1, (eds E.M. Hood, C.L. Sabine, B.M. Sloyan). 18pp.. (IOCCP Report Number 14; ICPO Publication Series Number 134), 2010. DOI: https://doi.org/10.25607/OBP-1350.

[15] APHA (American Public Health Association) "Standard methods for the examination of water and wastewater ," 21st Edition. Washington, DC. USA, 2005.

[16] EPA (Environmental Protection Agency) "Method 3653: Phosphorus, All Forms (Colorimetric, Ascorbic Acid, Two Reagent)," US EPA. Washington, DC.USA, 1978.

[17] F.B. Salem, L.A. Abdulla, "Potentiometric Determination of Calcium and Magnesium in Water and Biological Fluid Using a Divalent Ion Electrode," *Reviews in Analytical Chemistry*, vol. 13, pp. 127–138, 1994.

[18] S.A. Shehata, S.A.Bader, "Water quality changes in Nile carrier, Egypt," *Journal of Applied Sciences Research*, vol. 6, no. 9, pp. 1457-1465, 2010.

[19] L.A. Al-Maliki, S.K. Al-Mamoori, N. Al-Ansari, K. El-Tawel, F. Comair, "Climate change impact on water resources of Iraq (a review of literature)," *IOP Conf. Series: Earth and Environmental Science*, vol. 1120, pp. 012025, 2022. doi:10.1088/1755-1315/1120/1/012025.

[20] L. Bonacina, F. Fasano, V. Mezzanotte, R. Fornaroli, "Effects of water temperature on freshwater macroinvertebrates: a systematic review," *Biological Reviews of the Cambridge Philosophical Society*, vol. 98, no. 1, pp. 191–221, 2023. https://doi.org/10.1111/brv.12903.

[21] T.A. Wahhab, F.M. Hassan, "Environmental parameters drive the phytoplankton community structure: a case study in Baghdad Tourist Island Lake, Iraq" *Ibn Al-Haitham Journal for Pure and Applied Sciences*, vol. 36, no. 1, pp. 74-87, 2023.

[22] M. Naserikia, M.A. Hart, N. Nazarian, B. Bechtel, M. Lipson, K.A. Nice, "Land surface and air temperature dynamics: The role of urban form and seasonality," *The Science of the Total Environment*, vol. 905, pp. 167306, 2023. https://doi.org/10.1016/j.scitotenv.2023.167306.

[23] J.J. Toma, F.H. Aziz, "Algal study in springs and streams from Shaqlawa district, Erbil Province, Iraq I-Euglenophyta," *Baghdad Science Journal*, vol. 19, no. 3, pp. 0483, 2022. https://bsj.uobaghdad.edu.iq/index.php/BSJ/article/view/6419.

[24] N.M. Al-Baghdadi, E.N. Sultan, A.A.M. Abdullah, "Effect of some environmental factors on the occurrence and distribution of Polychaeta *Namalycastis indica* (Southern, 1921) in the intertidal region of Shatt Al-Arab River Basrah Iraq," *Iraqi Journal of Aquaculture*, vol. 18, no. 2, pp.27–46, 2022. https://doi.org/10.58629/ijaq.v18i2.349.

[25] B.A.a.H. Al-Magdamy, A.M. Sultan, I.K. Abdulhassan, "Climate Changes and Their Impact on Phytoplankton and Physicochemical Properties of the Tigris River, Baghdad, Iraq," *Egyptian Journal of Aquatic Biology & Fisheries*, vol. 28, no. 4, pp. 1405–1416., 2024.

[26] L.A. Gaysina, "Influence of pH on the Morphology and Cell Volume of Microscopic Algae, Widely Distributed in Terrestrial Ecosystems," *Plants*, vol. 13, no. 3, pp. 357, 2024. https://doi.org/10.3390/plants13030357.

[27] A. Eremin, A.A. Bulychev, C. Kluge, J. Harbinson, I. Foissner, "pH-dependent cell–cell interactions in the green alga *Chara*," *Protoplasma*, vol. 256, pp. 1737–1751, 2019. https://doi.org/10.1007/s00709-019-01392-0.

[28] D.A.H. Al-Abbawy, "Assessment of trophic status for Shatt Al-Arab River using trophic state index (TSI)," *Journal of Basrah Research*, vol. 38, no. 3, pp. 36-44, 2012.

[29] S. Nurashov, G. Jumakhanova, S. Barinova, R. Romanov, E. Sametova, A. Jiyenbekov, S. Shalgimbayeva, T.E. Smith, "Charophytes (Charophyceae, Charales) of South Kazakhstan: Diversity, Distribution, and Tentative Red List," *Plants (Basel, Switzerland)*, vol. 12, no. 2, pp. 368, 2023. https://doi.org/10.3390/plants12020368.

[30] B. Ali, Anushka, A. Mishra, "Effects of dissolved oxygen concentration on freshwater fish: A review," *International Journal of Fisheries and Aquatic Studies* vol. 10, no. 4, pp. 113-127, 2022. DOI: https://doi.org/10.22271/fish.2022.v10.i4b.2693.

[31] D. Achá, S. Guédron, D. Amouroux, D. Point, X. Lazzaro, P.E. Fernandez, G. Sarret, "Algal Bloom Exacerbates Hydrogen Sulfide and Methylmercury Contamination in the Emblematic High-Altitude Lake Titicaca," *Geosciences*, vol. 8, no. 12, pp. 438, 2018. https://doi.org/10.3390/geosciences8120438.

[32] M.M. AI-Hejuje, "Application of water quality and pollution indices to evaluate the water and sediments status in middle part of Shatt AI-Arab River," Ph.D. Thesis, Coll. Sci., Univ. Basrah, pp. 240, 2014.

[33] N.A. Al-Naqeeb, J.S. Al Hassany, F.K. Mashi, "Assessment of the water quality of Um El-Naaj marshes by diatoms.," *Ecology Environment and Conservation*, vol. 26, no. 1, pp. 405 -410, 2020.

[34] S. Ansari, S.K.Singh, "Limnologicalstudies with reference to phytoplankton diversity in ponds of semi-arid zone of western Uttar Pradesh," *Biological Forum – An International Journal*, vol. 9, no. 2, pp.129-147, 2017.

[35] R.R. Al-Ani, A.M. Al-Obaidy, F.M. Hassan, "Multivariate analysis for evaluation the water quality of Tigris River within Baghdad City in Iraq" Iraqi Journal of Agriculture Science, vol. 50, no. 1, pp. 331-342, 2019.

[36] E. Pronin, M. Pełechaty, K. Apolinarska, A. Pukacz, "Oxygen stable isotope composition of carbonate encrusites of two modern, widely distributed, morphologically different charophyte species," *Hydrobiologia*, vol. 809, pp. 41-52, 2018.

[37] A.P. Carvalho, S.O. Silva, J.M. Baptista, F.X. Malcata, "Light requirements in microalgal photobioreactors: an overview of biophotonic aspects" *Applied Microbiology and Biotechnology*, vol. 89, no. 5, pp. 1275–1288, 2011.

[38] J.M. Salman, R.A. Grmasha, C. Stenger-Kovács, E. Lengyel, O.J. Al-Sareji, A.M.A.A. Al-Cheban, M. Meiczinger, "Influence of magnesium concentrations on the biomass and biochemical variations in the freshwater algae, Chlorellavulgaris" *Heliyon*. Vol. 9, no. 1, pp. e13072, 2023.

[39] W. Jahnen-Dechent, M. Ketteler, "Magnesium basics" *Clinical Kidney Journal*, vol. 5, no. (Suppl 1), pp. i3–i14, 2012.

[40] F.Ragazzola, R. Kolzenburg, J. Zekonyte, S. Teichert, C. Jiang, A. Žuljević, A. Caragnano, A. Falace, "Structural and Elemental Analysis of the Freshwater, Low-Mg Calcite Coralline Alga Pneophyllum cetinaensis" Plants, vol. 9, no. 9, pp.1089, 2020.

[41] E.I. Metcalf, G. Tchobanoglous, F.L. Burton, H.D. and Stensel, "Wastewater Engineering: Treatment and Reuse" 4th ed. New Delhi: Tata McGraw-Hill Limited, 2003.

[42] N. Tak, P. Wagh, S. Sandhu, A. Reddy, H. Wagh," A quantitative analysis on the effect of varying nitrate concentrations on pH levels on the growth of algae" *Applied Cell of Biol*ogy, vol. 9, pp. 24-8.

[43] K. Siong, T. Asaeda, "Calcite encrusite in macro-algae *Chara* and its implication to the formation of carbonate-bound cadmium," *Journal of Hazardous Materials*, vol. 167, no. 1-3, pp. 1237–1241, 2009. https://doi.org/10.1016/j.jhazmat.2009.01.068.

[44] M. Pełechaty, J. Ossowska, A. Pukacz, K. Apolinarska, M. Siepak, "Site-dependent species composition, structure and environmental conditions of *Chara* tomentosa L. Meadows, western Poland," *Aquatic Botany*, vol. 120, pp. 92-100, 2014. https://doi.org/10.1016/j.aquabot.2014.06.015.

[45] L.H.A. Al-Azawii, M.R. Nashaat, M.N. Al-Azzawi, "Determination of Polycyclic Aromatic Hydrocarbon (PAHs) in the Tigris River through Passing Baghdad Province" *Iraqi Journal of Science*, vol. 56, no. 2B, pp: 1372-1384, 2015.

[46] C. Poschenrieder, J.A. Fernández, L. Rubio, L. Pérez, J. Terés, J. Barceló, J. "Transport and Use of Bicarbonate in Plants: Current Knowledge and Challenges Ahead," *International Journal of Molecular Sciences*, vol. 19, no. 5, pp. 1352, 2018. https://doi.org/10.3390/ijms19051352.