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Study of Algal Diatoms in some water resources in Shaglawa District. Erbil, Kurdistan Region of Iraq

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ABSTRACT

The current study was conducted to identify and study the spatial and seasonal variations of diatoms in some sites in Shaqlawa district in Erbil province for the period from September 2021 to August 2022 and considered the first attempt to identify diatoms in these sites and also considered as an intensive study of the various species of the diatoms under different environmental conditions. Eighteen; sites were selected, of which twelve are in springs, and six of which are along the stream, as well as use indices to evaluate the water quality, such as Shannon Wiener indicators (H), and Jaccard similarity indices (SJ), 57 species of diatoms were identified at eighteen sites, where central diatoms were of two species while pennies diatoms reached fifty-five species. The highest; number of diatoms species was recorded in springs, including site three, and the lower number was identified at site ten. *Diatoma; hiemal, D. moniliformis, Fragilaria construes, F. crotonesis, Ulnaria ulna, Cocconeis pediculus, Navicula radiosa, Gyrosigma acuminatum, Nitzschia dubia, Cymbella excise, Gomphonema olivaceous, Surirella oval* is considered more dominant than others diatoms species. According to; to Shannon Wiener, indicators (H), a great diversity was obtained in sites 3 and 18.

In contrast, lower diversity was observed in sites 5, 10 and 17. According to; to seasons, the maximum diversity was recorded in October-2021, and the minimum variety was calculated in January-2022. The highest similarity rate between Sites 3 and 4 was 29.0%, while the lowest similarity rate between Sites 1 and 10 was 7.9%. Generally, the similarity rate between the sites is considered quiet.

Keywords: Algal, Diatoms, Diversity, Erbil, Shaqlawa.

1. Introduction

Aquatic organisms have been utilized as bioindicators of pollution, as well as biological monitors to understand the interaction between organism's responses to environmental changes and their legal impact, and many microorganisms can be utilized as indicators for the quality of water in addition to pollutants that may lead to sudden death, or indicate the presence of toxic compounds in the environment. This makes them high value as indicators of environmental health[1, 2]. Algae have many characteristics that make them considered biomarkers for identifying changes in the aquatic environment. Alterations can be used in biological assessment programs such as phytoplankton, including diatoms, which are important factors affecting water quality, as biomarkers and beginning to play a fundamental role in environmental reports because it is a primary indicator of the environment[3]. Using; biological water quality assessment methods help detect long-term environmental effects because this kind of assessment can last longer[4, 5]. Algae, including diatoms, are utilized to evaluate conditions in aquatic habitats in all world countries and have been used as bioindicators of organic pollution in marine ecosystems and have been utilized to determine environmental conditions, including algal blooms[6]. Diatoms have a good ability to assess the quality of water and assess pollution in the stream water[7]. It; can be used in evaluating public sites and evaluating water quality in many sites as poor, good or excellent[4]. Many; of these studies have been done to determine water quality depending on the evidence of phytoplankton, particularly diatoms[8, 9]. The; diatom index is increasingly being utilized to evaluate the river's condition[10]. For; this reason, it is often used as an indicator quality of water and environmental health[11]. Water pollution owns the potential to threaten and impacts primary producers like diatoms; thus, diatoms can be utilized as an indicator of pollution. Since; diatoms are found in most waters, rapid changes in environmental conditions can be measured through them. Diatoms; are the dominant phytoplankton in most aquatic ecosystems. These algae can resist changes in the environment, and these algae are sensitive to a low concentration of pollutants compared to other groups of algae[12, 13]. The; quality and quantity of diatoms depend

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on the nutritional status of the aquatic ecosystem. These algae are used as diagnostic tools in biological monitoring and as biomarkers[1]. Diatoms; are globally utilized as indicators of water quality, especially in removing water Europe, Asia, Australia and North America[11]. This work aims study the diatoms found in some water resources in the Shaqlawa district, and it represents the first study on this site, and applies some algal indices to assess their water quality.

2. Materials and methods

2.1 Study area and sampling

Phytoplankton samples were collected from eighteen sites from September 2021 till August 2022 from two villages (Aquban and Sarkand) within the Shaqlawa district, close 50 km from Erbil city. Twelve; sites were springs (1, 2, 3, 4, 5, 10, 12, 13, 15, 16, 17, and 18), with six water streams (6, 7, 8, 9, 11, and 14) as illustrated in (Fig.1 and Table 1). A phytoplankton net (20 µm mesh) was used for sample collection, then preserved by adding Formalin solution 4%, or Lugal's; solution. In; the laboratory, the samples were cleaned according to procedure (Add reference) by adding 5 mL of a strong acid mixture (HNO3 + H2SO4, 2:1) into beakers contained 2ml of plankton samples inside the hood cabinet and heated at 90 °C for 2-3 hours, depending on the amount of organic matter in pieces; When the oxidation is complete, the samples are allowed to cool, then the diatoms are washed with distilled water to remove the acids, and diatom slides are prepared and microscopically examined depending on the diatom species[14], was the identification of morphology using a microscope (Olympus Microscope) was of high resolution with the help of several keys he mentioned[15-17].

Table 1: Shows type and location of the studied area within Shaqlawa District.

Site	X_Field	Y_Field	Elevation	Location	Name of Village
1	447065.42	4024114.692	905m	Sard Spring	Aquban
2	448620.345	4025272.842	902m	Piawan Spring	
3	449343.633	4023623.880	887m	Zhnan Spring	
4	450681.287	4022479.770	902m	Darmanawa Spring	
5	452251.64	4022654.189	912m	Mink Spring	
6	439655.001	4031776.001	736m	Stream1	Sarkand
7	437278.463	4033076.147	709m	Stream2	
8	435814.981	4034419.117	707m	Stream3	
9	434042.001	4035935.001	648m	Stream4	
10	434707.036	4037048.419	713m	Prenga Spring	
11	432436.724	4036853.074	669m	Stream5	
12	432416.266	4034657.028	712m	Nawkand Spring	
13	429994.136	4036337.350	651m	Chemma Spring	
14	430060.282	4038321.729	668m	Stream6	
15	431498.957	4038387.875	743m	Sarkand Spring	
16	432287.344	4039126.466	737m	Benwan Spring	
17	430142.964	4039528.893	707m	Azarian Spring	
18	428765.729	4039143.230	595m	Razga Spring	

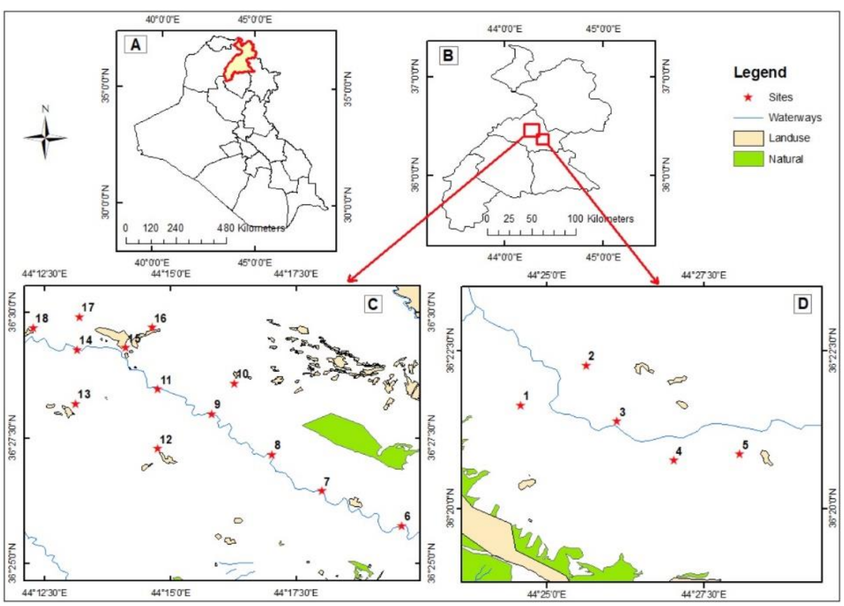

Figure 1: Illustrated A- Map of Iraq and Erbil Governorate shaded B- Map of Erbil C- Village of Sarkand D- Village of Aquban (illustrating the selected study sites).

2.2 Shannon Wiener Diversity Indicators (H)

Used by[18] Shannon-Wiener (H) indices are commonly used to determine biodiversity in the aquatic environment and are estimated by the equation(1)

$$H = \sum_{i=0}^{s} (Pi)\ln(pi) \quad \ldots\ldots 1$$

Where H = Shannon diversity indices

S = the number of species in the sample

Pi = the proportion of individuals belonging to species i

Several H values were evaluated from several resources, and it was suggested that between 1 and 3 indicated moderate pollution. Close to 4 were usually from uncontaminated streams, while values less than 1 showed the compact community affected by heavy organic pollution.

2.3 Jaccard Pointers of Similarity

The Jaccard similarity was used to compare sampling sites and to estimate those that were similar in taxa composition, as shown by[18] from formula (2)

$$SJ = C / (A + B + C) \times 100 \quad \ldots\ldots 2$$

Where

A = the number of species of the community a

B= number of community types b

C = the number of species in both communities

3. Results and discussions

In the current study, 57 species were identified in the Shaqlawa district in eighteen locations, 12 springs and six streams. The count of central diatoms reached two species, while the count of pennies diatoms arrived at 55. Whereas; the total number of identified diatoms in studied locations were (27, 25, 36, 23, 15, 9, 18, 22, 15, 16, 12, and 26 for springs and 29, 27, 24, 27, 22 and 16 for stream sites) species, while the highest number recorded in site three and lower number calculated in site 10 "Table;" 2, 3, 4, 5, 6 and 7. According to; to the months under this study, the maximum and minimum numbers were identified in October-2021 and February-2022, respectively Tables 8, 9 and 10. Several; researchers indicated the abundance of diatoms in Iraqi surface waters could change the conditions of their environment[19, 20], or may be due to their ability in changing environments coupled with their tough silica wall that enabled them to survive extreme conditions[21], like studying[22]. Some types of diatoms were dominant in terms of their number and presence in all sites *Diatoma hiemale, D. moniliformis, Fragilaria construnes, F. crotonesis, Ulnaria ulna, Cocconeis pediculus, Navicula radiosa, Gyrosigma acuminatum, Nitzschia dubia, Cymbella excisa, Gomphonema olivaceum, Surirella ovalis*, this dominance is a return to the broad tolerance of these species to different environmental variables like nutrient deficiency, temperature, dissolved oxygen availability, and the density of aquatic plants that supply appropriate conditions for algae[4, 23]. The current result is similar to that of[8] in the Tigris River. Two peaks of Diatoms were observed in the current study in October-2021 and June-2022, it may be due to the increase in nutrient concentrations in the autumn and spring seasons as they are exposed to additions from agricultural land and household waste from residential areas near water resources[24]. The decrease in the number recorded in the winter may and may be returned to decrease temperature and the lack of nutrient concentrations due to the low water level and the increase in the flow velocity in the river, which prevents the growth of phytoplankton, as it moves quickly to other areas that are not suitable for it. Its growth and reproduction, and this may be due to the lack of light transmittance as a result of the increase in turbidity from the flow velocity in the river, which works to move the lower sediments and return to the water column, which is what caused the occurrence of turbidity due to the lack of sufficient light access to the phytoplankton spread in the water column[24]. The increase and decrease in the number of diatoms can also be attributed to the disruption of water levels in the river[25]. The Shannon-Wiener Index is one of the most important indicators applied in algae studies and used to determine pollution. The results of this study showed that the Shannon index values were more than 1"Figures 2 and 3".

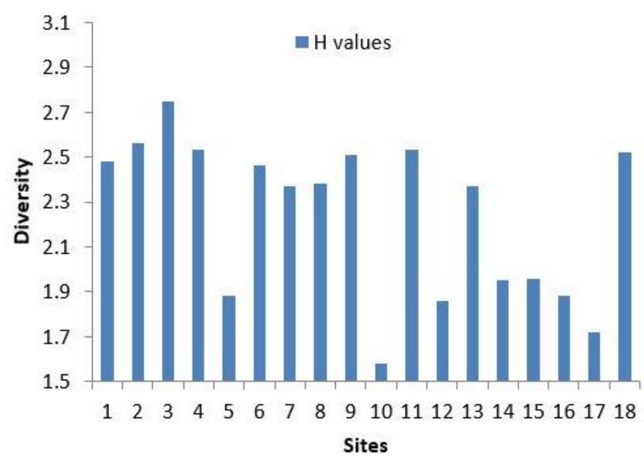

Figure 3: Diversity (H¯) recorded in studied sites in Shaqlawa district during the studied period.

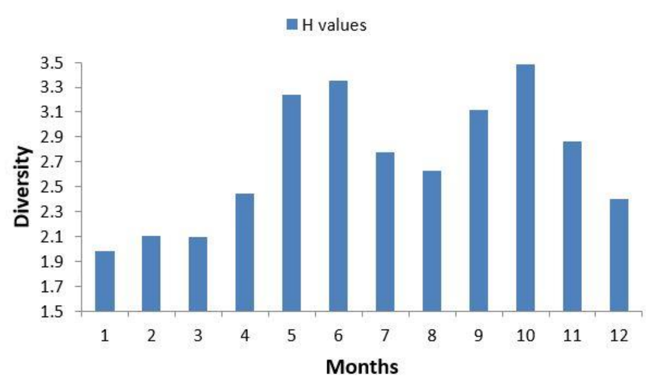

Figure 2: Diversity (H¯) recorded in months in Shaqlawa district during the studied period.

These results indicated a great diversity in the studied area and the lack of dominance of certain types of phytoplankton[24]. Both; high and low values were recorded in Autumn-October-2021 (for the high value) and Winter-January-2022 (for the low value). These; results confirmed that the water resources in the Shaqlawa region have high variance (diatoms) and also mean that there is no dominance of certain types of diatoms in the study area. Moreover, there was a similar species composition in all the studied locations with some variances related to the nature of each site and the kind of large cells in each studied location[26]. High values of H were recorded in the flowering period (spring and autumn). This finding is consistent with other studies on streams and springs. High H index values indicate good water quality of Shaqlawa water resources[27]. In general, the diversity of sites 3,9,11 and 18 was higher than other locations in this study. This may be returned to human activities that cause to increase in nutrients and elements that are used as food for algae[28, 29] concluded that many cases varied mildly to moderately in polluted sites higher than in clean water, and similar results were obtained in the current investigation[30]seems to confirm the present findings that the diversity increases in the hot months and becomes low in the cold months, which may be environmental conditions suitable for the growth and reproduction of algae in the summer months and vice versa in the winter months. Environmental variables are not suitable for its growth. The highest similarity rate observed between Sites 3 and 4 was 29.0%, while the lowest similarity rate observed between Sites 1 and 10 was 7.9% in the current studies, as shown in "Tables"11 and 12. The present results showed less similarity between algae species between sites. The reported variation of the species in the sites may be due to the nature of the studies sites, human activities, the geology of the different sites, the nature of the land in which the stream passes, the residential areas around the studies sites and the characteristics of the site[31]. Algal were used as good indicators for determining the quality of water and variation in the environment[32].

Table 2: *The distribution of diatom algal taxa among studied sites recorded in Shaqlawa district during the studied period.*

Taxa	**Springs Sites**											
	1	**2**	**3**	**4**	**5**	**10**	**12**	**13**	**15**	**16**	**17**	**18**
Class: Bacillariophyceae												
Order: Centrales												
Cyclotella (Kuetzing) de –Brebisson, 1838.												
C .meneghiniana Keutzing 1838		+						+				
C. ocellata Pant. 1844		+		+			+	+		+	+	+
Order: Pennales												
Diatoma Bory nom. Cons. Loureiro 1790												
D. anceps (Ehr) Kirchn var. *anceps* 1855												
D .hiemale (Roth) Heib var. *hiemale* 1863	+		+	+	+			+	+			+
D. moniliormis Kutzing var. *moniliformis* 1855	+	+	+	+	+	+		+				+
D. vulgare Bory var. *vulgaris* 1871		+						+	+			+
Meridion Ag 1824												
M. circulare (Grev) Ag var. *circulare* 1862	+											
Fragilaria Lyngbya, 1819.												
F. capucina Desm var. *capucina* 1825	+	+	+	+				+		+	+	
F. construnes Grunow var. *construnes* 1862	+	+	+	+	+			+		+		
F. crotonesis Kitton var. *crotonesis* 1885		+	+	+	+							
Ulnaria (Kuetz.) Compère 2001												
U. ulna (Kutzing) 2001	+	+	+	+	+	+	+	+		+	+	+
Tabellaria Ehr. 1840												
T. fenestrata Kutz var. *fenestrata* 1819	+		+	+				+				
Cocconeis Ehrenberg, 1835												
C. diminuta Ehr. var. *diminuta* 1863	+	+	+			+				+		
C. pediculus. Ehr var. *pediculus* 1863	+	+	+	+				+		+		+
C. placentula Ehr. var. *placentula* 1838	+	+	+				+				+	+
Caloneis Cleve, 1894.												
C. amphisbaena Bory var. *amphisbaena* 1894			+									
Navicula Bory, 1824.												
N. ambigua Kutz var. *ambigua* 1888												
N. antoni Kutz var. *antoni* 1838									+			
N. canalis Kutz var. *canalis* 1844	+	+	+	+	+							
N. peregrina (Ehr) Kutz var. *peregrina* 1844											+	
N. radiosa Kutz var.radiosa 1844	+	+	+	+	+		+	+			+	+
N.viridula (Kutz) Ehrenberg var. *viridula* 1838			+			+		+				

+ (Presence)

Table 3: The distribution of diatom algal taxa in studied sites recorded in Shaqlawa during studied period.

Taxa	**Springs Sites**											
	1	**2**	**3**	**4**	**5**	**10**	**12**	**13**	**15**	**16**	**17**	**18**
N. viridulocalcis Lange-Bert **var. *viridulocalcis*** 2000	+						+			+		+
N. trivialis Lange-Bertalot **var.*trivialis*** 1980			+						+			
Pinnularia Ehrenberg, 1843.												
P. interrupta Ehrenberg, 1843												
Gyrosigma Hass., 1895.												
G. acuminatum (Kutz) var. acuminatum 1860			+			+	+	+	+		+	+
G. exile (Grun.) Reimer **var. *exile*** 1860												
G. scalproides (Roben.)1860 **var. *scalproides***			+			+			+			+
Rhopalodia O.Muller 1838												
Rh.gibba (Ehrenberg) Muller **var. *gibba*** 1838				+	+						+	
Nitzschia Hassal, 1845.												
N. angusta(Kutzing) **var**. ***angusta*** 1844												
N. dubia Kutz **var. *dubia*** 1844						+						+
N. hungarica Ktz **var. *hungarica*** 1845		+	+	+			+		+	+	+	+
N. levidensis Kutz **var. *levidensis*** 1845												
N. seriata Ehr **var. *seriata*** 1845			+									
N. sigmoidea W.Smith **var. *sigmoidea*** 1845		+	+			+	+		+	+		+
N. vermicularis Hantz **var *vermicularis*** 1840.			+				+		+	+		
Amphora Ehrenberg, 1844												
A. ovalis (Ktz.) Kutz **var. *ovalis*** 1832	+	+	+		+			+				+
A. veneta Kutz **var. *veneta*** 1844		+		+	+							+
Cymatopleura W.Smith, 1851.												
C. elliptica W.Smith **var. *elliptica*** 1851	+	+	+									+
C. solea (Brebisson) W.Smith **var. *solea*** 1851	+	+	+					+				+
Cymbella Kutzing 1890												
C. excisa Kutzing **var. *excisa*** 1894	+	+	+	+	+	+	+	+	+	+		+
C. neocistula Kirchner **var. *neocistula*** 1885	+			+				+	+			+
C. tumida (Breb ex.Kutz) V.H.**var**.***tumida***1849								+				+
C .cymbiformis Ag. **var. *cymbiformis*** 1830		+										+
Gomphonema Ehrenberg, 1831.												
G. accuminatum Ehr. **var**. ***acuminatum*** 1838	+											
G. capitatum Ehr.**var. *capitatum*** 1838	+		+		+							
G. coronatum Kutz **var. *coronatum*** 1844	+		+									
G. intricatum Kutz **var. *intricatum*** 1844	+		+	+			+	+				+

+ (Presence)

Table 4: The distribution of diatom algal taxa among studied sites recorded in Shaqlawa district during studied period.

Taxa	**Springs Sites**											
	1	**2**	**3**	**4**	**5**	**10**	**12**	**13**	**15**	**16**	**17**	**18**
G. manubrium Frick **var. *manubrium*** 1904			+				+					
G. micropus Kutzing **var. *micropus*** 1904	+		+	+	+		+	+				
G. olivaceum (Lyngb) Kutz **var. *olivaceum***	+	+	+	+	+			+	+	+		
G. parvulum (Ktz) Grun. **var. *parvulum***	+						+			+		
Rhoicosphenia Grunow, 1860												
Rh. abbreviatum (Ktz.)Grun **var. *abbreviatum*** 1860	+	+	+				+	+	+			+
Euonotia Ehrenberg, 1837.												
E. bilunaris Ehr **var. *bilunaris*** 1837												
Peronia Ross 1845												
P. fibula (Breb ex Kutz) Ross **var. *fibula*** 1845	+		+	+								
Epithemia Breb 1838												
E. sorex Kutz **var.*sorex*** 1891												
Surirella linearis W.Smith.**var**. ***linearis*** 1853		+	+	+	+		+		+	+	+	+
S. minuta Brebisson **var. *minuta*** 1849				+			+					
S. ovalis Brebisson **var.*ovalis*** 1856		+	+	+			+		+	+	+	+
S. tenera Gregory **var. *tenera*** 1856			+							+	+	+

+ (Presence)

Table 5: The distribution of diatom algal taxa in studied sites recorded in Shaqlawa district during studied Period.

Taxa	**Stream Sites**					
	6	**7**	**8**	**9**	**11**	**14**
Class: Bacillariophyceae						
Order: Centrales						
Cyclotella (Kuetzing) de –Brebisson, 1838.						
C .meneghiniana *Keutzing 1838*						
C. ocellata *Pant. 1844*	+				+	
Order: Pennales						
Diatoma Bory nom. Cons. Loureiro 1790						
D. anceps (Ehr) Kirchn **var. *anceps*** 1855	+	+				
D .hiemale (Roth) Heib **var**. ***hiemale*** 1863	+	+		+	+	+
D. moniliormis Kutzing **var. *moniliformis*** 1855	+	+	+	+	+	+
D. vulgare Bory **var. *vulgaris*** 1871	+	+	+	+	+	+
Meridion Ag 1824						
M. circulare (Grev) Ag **var. *circulare*** 1862						
Fragilaria Lyngbya, 1819.						
F. capucina Desm **var. *capucina*** 1825						+
F. construnes Grunow **var. *construnes*** 1862			+	+	+	+
F. crotonesis Kitton **var. *crotonesis*** 1885		+	+	+	+	
Ulnaria (Kuetz.) Compère 2001				+		
U. ulna (Kutzing) 2001	+		+		+	+
Tabellaria Ehr. 1840						
T. fenestrata Kutz **var. *fenestrata*** 1819	+	+		+		+
Cocconeis Ehrenberg, 1835						
C. diminuta Ehr. **var. *diminuta*** 1863						
C. pediculus. Ehr **var. *pediculus*** 1863	+	+	+	+	+	
C. placentula Ehr. **var. *placentula*** 1838	+	+	+	+	+	
Caloneis Cleve, 1894.						
C. amphisbaena Bory **var. *amphisbaena*** 1894	+	+				
Navicula Bory, 1824.						
N. ambigua Kutz **var. *ambigua*** 1888						
N. antoni Kutz **var. *antoni*** 1838						
N. canalis Kutz **var. *canalis*** 1844	+	+	+	+		
N. peregrina (Ehr) Kutz **var. *peregrina*** 1844	+		+	+		
N. radiosa Kutz var.radiosa 1844	+		+	+	+	+

+ (Presence)

Table 6: The distribution of diatom algal taxa among studied sites recorded in Shaqlawa district during the studied period.

Taxa	**Stream Sites**					
	6	**7**	**8**	**9**	**11**	**14**
N.viridula (Kutz) Ehrenberg **var. *viridula*** 1838						
N. viridulocalcis Lange-Bert **var. *viridulocalcis*** 2000		+				
N. trivialis Lange-Bertalot **var.*trivialis*** 1980			+			
Pinnularia Ehrenberg, 1843.						
P. interrupta Ehrenberg, 1843		+	+	+	+	
Gyrosigma Hass., 1895.						
G. acuminatum (Kutz) var. acuminatum 1860	+		+	+	+	+
G. exile (Grun.) Reimer **var. *exile*** 1860	+					
G. scalproides (Roben.)1860 **var. *scalproides***			+	+		
Rhopalodia O.Muller 1838						
Rh.gibba (Ehrenberg) Muller **var. *gibba*** 1838						
Nitzschia Hassal, 1845.						
N. angusta(Kutzing) **var**. ***angusta*** 1844	+					
N. dubia Kutz **var. *dubia*** 1844		+	+	+		+
N. hungarica Ktz **var. *hungarica*** 1845	+	+	+	+	+	+
N. levidensis Kutz **var. *levidensis*** 1845						
N. seriata Ehr **var. *seriata*** 1845						
N. sigmoidea W.Smith **var. *sigmoidea*** 1845	+			+		
N. vermicularis Hantz **var *vermicularis*** 1840.		+				
Amphora Ehrenberg, 1844						
A. ovalis (Ktz.) Kutz **var. *ovalis*** 1832	+	+		+	+	
A. veneta Kutz **var. *veneta*** 1844						
Cymatopleura W.Smith, 1851.						
C. elliptica W.Smith **var. *elliptica*** 1851						
C. solea (Brebisson) W.Smith **var. *solea*** 1851	+	+	+	+		
Cymbella Kutzing 1890						
C. excisa Kutzing **var. *excisa*** 1894	+	+	+	+	+	+
C. neocistula Kirchner **var. *neocistula*** 1885	+	+	+	+	+	
C. tumida (Breb ex.Kutz) V.H.**var**.***tumida***1849	+	+	+	+	+	
C .cymbiformis Ag. **var. *cymbiformis*** 1830				+		+
Gomphonema Ehrenberg, 1831.						
G. accuminatum Ehr. **var**. ***acuminatum*** 1838						
G. capitatum Ehr**.var. *capitatum*** 1838						
G. coronatum Kutz **var. *coronatum*** 1844						

+ (Presence)

Table 7: The distribution of diatom algal taxa among studied sites recorded in Shaqlawa in studied period.

Taxa	**Stream Sites**					
	6	**7**	**8**	**9**	**11**	**14**
G. intricatum Kutz **var. *intricatum*** 1844	+	+	+	+		+
G. manubrium Frick **var. *manubrium*** 1904	+	+				
G. micropus Kutzing **var. *micropus*** 1904	+	+	+		+	
G. olivaceum (Lyngb) Kutz **var. *olivaceum***	+	+	+	+	+	+
G. parvulum (Ktz) Grun. **var. *parvulum***	+	+				
Rhoicosphenia Grunow, 1860						
Rh. abbreviatum (Ktz.)Grun **var. *abbreviatum*** 1860	+	+		+	+	
Euonotia Ehrenberg, 1837.						
E. bilunaris Ehr **var. *bilunaris*** 1837						
Peronia Ross 1845						
P. fibula (Breb ex Kutz) Ross **var. *fibula*** 1845						
Epithemia Breb 1838						
E. sorex Kutz **var**.***sorex*** 1891						
Surirella linearis W.Smith.**var**. ***linearis*** 1853						
S. minuta Brebisson **var. *minuta*** 1849					+	
S. ovalis Brebisson **var**.***ovalis*** 1856		+	+		+	+
S. tenera Gregory **var. *tenera*** 1856						

+ (Presence)

Table 8: The distribution of diatoms taxa recorded in Shaqlawa district during the studied period.

Months / Taxa	2021				2022							
	9	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Class: Bacillariophyceae												
Order: Centrales												
Cyclotella (Kuetzing) de –Brebisson, 1838.												
C .meneghiniana *Keutzing 1838*									+	+		
C. ocellata *Pant. 1844*	+	+	+	+				+	+	+		+
Order: Pennales												
Diatoma Bory nom. Cons. Loureiro 1790												
D. anceps (Ehr) Kirchn **var. *anceps*** 1855	+	+			+		+			+		
D .hiemale (Roth) Heib **var**. ***hiemale*** 1863	+	+	+	+	+			+	+	+	+	+
D. moniliormis Kutzing **var. *moniliformis*** 1855	+	+	+	+	+	+	+	+	+	+	+	
D. vulgare Bory **var. *vulgaris*** 1871	+	+	+	+	+	+		+	+		+	+
Meridion Ag 1824												
M. circulare (Grev) Ag **var. *circulare*** 1862	+	+	+		+	+	+	+	+	+		
Fragilaria Lyngbya, 1819.												
F. capucina Desm **var. *capucina*** 1825	+	+	+	+	+	+	+	+	+	+	+	+
F. construnes Grunow **var. *construnes*** 1862	+	+	+	+	+			+		+		+
F. crotonesis Kitton **var. *crotonesis*** 1885	+	+	+		+		+			+		
Ulnaria (Kuetz.) Compère 2001												
U. ulna (Kutzing) 2001	+	+	+	+	+	+	+	+	+	+	+	
Tabellaria Ehr. 1840												
T. fenestrata Kutz **var. *fenestrata*** 1819	+	+	+		+	+	+	+	+	+		
Cocconeis Ehrenberg, 1835												
C. diminuta Ehr. **var. *diminuta*** 1863	+	+	+						+	+	+	+
C. pediculus. Ehr **var. *pediculus*** 1863	+	+		+	+	+	+	+	+	+	+	+
C. placentula Ehr. **var. *placentula*** 1838	+	+	+	+	+	+	+	+	+	+	+	+
Caloneis Cleve, 1894.												
C. amphisbaena Bory **var. *amphisbaena*** 1894				+						+	+	+
Navicula Bory, 1824.												
N. ambigua Kutz **var. *ambigua*** 1888										+		
N. antoni Kutz **var. *antoni*** 1838										+		
N. canalis Kutz **var. *canalis*** 1844	+	+	+	+			+	+				
N. peregrina (Ehr) Kutz **var. *peregrina*** 1844							+		+	+		+
N. radiosa Kutz var.radiosa 1844	+	+	+	+	+	+	+	+	+	+	+	
N.viridula (Kutz) Ehrenberg **var. *viridula*** 1838		+			+	+		+	+			

+ (Presence)

Table 9: The distribution of diatoms taxa recorded in Shaqlawa district during the studied months.

Months / Taxa	2021				2022							
	9	**10**	**11**	**12**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
N. viridulocalcis Lange-Bert **var. *viridulocalcis*** 2000		+			+	+		+	+			
N. trivialis Lange-Bertalot **var.*trivialis*** 1980			+	+				+				
Pinnularia Ehrenberg, 1843.												
P. interrupta Ehrenberg, 1843	+	+	+	+	+	+			+	+	+	+
Gyrosigma Hass., 1895.												
G. acuminatum (Kutz) var. acuminatum 1860	+	+	+	+				+	+	+	+	+
G. exile (Grun.) Reimer **var. *exile*** 1860								+		+		
G. scalproides (Roben.)1860 **var. *scalproides***	+				+	+			+			
Rhopalodia O.Muller 1838												
Rh.gibba (Ehrenberg) Muller **var. *gibba*** 1838		+	+	+		+	+				+	+
Nitzschia Hassal, 1845.												
N. angusta(Kutzing) **var**. ***angusta*** 1844	+		+									
N. dubia Kutz **var. *dubia*** 1844	+	+	+	+	+	+					+	
N. hungarica Ktz **var. *hungarica*** 1845	+	+	+	+			+	+	+	+	+	+
N. levidensis Kutz **var. *levidensis*** 1845										+		
N. seriata Ehr **var. *seriata*** 1845		+	+							+	+	+
N. sigmoidea W.Smith **var. *sigmoidea*** 1845		+	+			+	+	+	+	+	+	+
N. vermicularis Hantz **var *vermicularis*** 1840.					+	+		+		+	+	+
Amphora Ehrenberg, 1844												
A. ovalis (Ktz.) Kutz **var. *ovalis*** 1832	+	+	+	+	+	+			+	+	+	+
A. veneta Kutz **var. *veneta*** 1844	+		+	+			+		+	+	+	
Cymatopleura W.Smith, 1851.												
C. elliptica W.Smith **var. *elliptica*** 1851	+	+	+	+	+		+		+			
C. solea (Brebisson) W.Smith **var. *solea*** 1851	+	+	+	+	+	+	+		+	+	+	+
Cymbella Kutzing 1890												
C. excisa Kutzing **var. *excisa*** 1894	+	+	+	+	+		+	+	+	+	+	+
C. neocistula Kirchner **var. *neocistula*** 1885		+	+	+			+	+	+	+	+	+
C. tumida (Breb ex.Kutz) V.H.**var**.***tumida***1849		+	+	+		+	+	+	+	+	+	+
C .cymbiformis Ag. **var. *cymbiformis*** 1830	+	+	+	+		+	+	+	+	+	+	+
Gomphonema Ehrenberg, 1831.												
G. accuminatum Ehr. **var**. ***acuminatum*** 1838	+	+	+		+	+						
G. capitatum Ehr.**var. *capitatum*** 1838	+	+	+		+	+						
G. coronatum Kutz **var. *coronatum*** 1844	+	+	+	+			+	+	+	+		+
G. intricatum Kutz **var. *intricatum*** 1844	+	+	+	+			+	+	+	+	+	+

+ (Presence)

Table 10: The distribution of diatoms taxa recorded in Shaqlawa district during the studied months.

Months / Taxa	2021				2022							
	9	10	11	12	1	2	3	4	5	6	7	8
G. manubrium Frick **var. *manubrium*** 1904	+		+	+	+	+					+	+
G. micropus Kutzing **var. *micropus*** 1904	+	+		+	+		+	+	+	+	+	
G. olivaceum (Lyngb) Kutz **var. *olivaceum***	+	+	+	+	+		+	+	+	+	+	+
G. parvulum (Ktz) Grun. **var. *parvulum***		+			+	+		+				
Rhoicosphenia Grunow, 1860												
Rh. abbreviatum (Ktz.) **var. *abbreviatum*** 1860	+	+	+		+	+	+		+	+	+	+
Euonotia Ehrenberg, 1837.												
E. bilunaris Ehr **var. *bilunaris*** 1837		+	+									
Peronia Ross 1845												
P. fibula (Breb ex Kutz) Ross **var. *fibula*** 1845	+	+		+	+	+		+	+	+		+
Epithemia Breb 1838												
E. sorex Kutz **var.*sorex*** 1891			+		+	+			+	+		
Surirella linearis W.Smith.**var**. ***linearis*** 1853				+					+	+		+
S. minuta Brebisson **var. *minuta*** 1849	+	+	+	+				+	+	+	+	+
S. ovalis Brebisson **var.*ovalis*** 1856	+	+	+	+				+	+	+	+	+
S. tenera Gregory **var. *tenera*** 1856	+	+	+	+			+	+	+	+	+	

+ (Presence)

Table 11: Jaccard resemblances (%) among studied spring sites.

1	1	2	3	4	5	10	12	13	15	16	17
2	21.2										
3	24.7	24.4									
4	23.0	23.8	29.0								
5	20.8	20.0	26.5	25.5							
10	7.9	12.2	19.4	8.8	11.5						
12	15.1	18.9	25.0	22.6	13.2	13.3					
13	25.0	24.6	21.8	11.8	25.0	12.1	16.3				
15	10.6	16.7	25.0	13.6	11.8	14.8	19.5	16.3			
16	17.3	22.7	26.0	17.0	13.8	14.3	22.7	15.9	18.4		
17	9.3	17.8	21.4	18.6	15.6	9.1	21.1	14.3	12.9	17.5	
18	20.3	22.1	22.2	19.0	19.5	16.3	14.8	24.6	20.4	15.4	18.4

Table 12: Jaccard resemblances (%) among studied stream sites.

6	6	7	8	9	11
7	27.3				
8	24.3	23.9			
9	25.3	26.0	27.1		
11	25.0	23.4	25.8	25.8	
14	19.6	18.9	23.0	24.6	22.4

Conclusion

Fifty-seven species of diatoms were identified in eighteen water resources within the district. Studied indices reflected the status of the water quality of some springs and stream sites within the area. A; Great diversity was observed in the studied area, and certain diatoms lacked dominance.

Conflict of interests

None

Author Contribution

Janan Jabbar Toma and Farhad Hasan participated in developing the idea of the search. The first author collected, cleaned and mounted and identified the diatoms under the supervision of the second author. Both authors participated in discussing the results to contribute to the final manuscript becoming in better form.

Authors declaration

-Conflict of interest: none.

-We now confirm that all figures and tables in the manuscript are our property. In addition, figures and images, which are not ours, have been granted permission for republication accompanying the manuscript.

-Ethical Clearance: The local ethical committee at Salahaddin University has approved the project.

References

1. Hassan FM, Shaawiat AO. Application of diatomic indices in lotic ecosystem, Iraq. Global J Appl Phycol. 2015;4(4):381-8.
2. Abdalhameed TA, Al-Hassany JS. The qualitative and quantitative composition of epiphytic algae on Ceratophyllum demersum L. in Tigris River within Wassit Province, Iraq. Baghdad Science Journal. 2019;16(1):1-9.
3. Shekha YA, Ali LA-Q, Toma JJ. Assessment of water quality and trophic status of Duhok Lake Dam. Baghdad Sci J. 2017;14(2):335-42.
4. Marhoon KA, Hussain EM, Abed SA, Ewaid SH, Salim MA, Al-Ansari N. Assessment of the trophic status at Al-Sabil River using the trophic indices in Al-Shinafiya district, Southern Iraq. EurAsian J Biosci. 2020;14(2):5661-7.
5. Toma JJ, Aziz FH. Antibacterial Activity of Three Algal Genera against some Pathogenic Bacteria. Baghdad Sci J. 2023;20(1):32-40.
6. Ali S, Hassan F, Abdul-Jabar R. Evaluation of water quality by trophic diatom index (TDI) in Tigris River within Wasit province. Indian J Ecol. 2017;44(4):711-6.
7. Darwesh DA, Shekha YA, Toma JJ. Aplication the DRIS Equation to assess the nutrient status of Dukan and Duhok lakes in Northern of Iraq. Diyala Agricultural Sciences Journal. 2017;9(special Issue):31-9.
8. Jabbar SH, Al-Hassany J. Use of indices of algae and water quality to assessment of Tigris river in AL-Gheraiat area in Baghdad city, Iraq. Mesop Environ J. 2018;4(3).
9. El-Serehy HA, Abdallah HS, Al-Misned FA, Al-Farraj SA, Al-Rasheid KA. Assessing water quality and classifying trophic status for scientifically based managing the water resources of the Lake Timsah, the lake with salinity stratification along the Suez Canal. Saudi J Biol Sci. 2018;25(7):1247-56.
10. AM A-TA-N, AS A-oN. Water Quality Assessment by Epiphytic Diatoms in Euphrates River between Haditha and Al-Baghdadi - Iraq. Annals of RSCB. 2021;25(3):2022 - 32.
11. Norian A, Amini F, Sakhaei N, Archangi B, Mokhtarpour A. Evaluation of biodiversity of phytoplankton and determination of biological health quality of Arvand River (south west of Iran) using Trophic Diatom Index (TDI). Iran J Fish Sci. 2022;21(4):1047-63.
12. Al-Shaheen MA. Diatoms in Khor Al-Zubair mudflats and Khor Abdullah lagoons, southern Iraq. Pollution Research. 2021;40(3):441-8.
13. Shekha YA, Toma JJ, Ismael HM. Study algae and fungi interaction in some artificial open sand mine ponds in Kalak sub district-Duhok, Iraq. Diyala Journal for Pure Science. 2017;13(2):109-31.
14. Taylor J, Harding W, Archibald C. A methods manual for the collection, preparation and analysis of diatom samples. Version 1 WRC Report TT 281/07, Water Research Commission, Pretoria, South Africa. 2007:60.
15. Patrick R. The diatoms of the United States (exclusive of Alaska and Hawaii). Monographs of the Academy of natural Sciences of Philadelphia. 1966;13:1-688.
16. Patrick R. The diatoms of the United States, exclusive of Alaska and Hawaii. Vol. 1. Fragilariaceae, Eunotiaceae, Achnanthaceae, Naviculaceae. Monographs of the Academy of Natural Sciences of Philadelphia. 1966;13:1-688.
17. Patrick R, Reimer CW. The diatoms of the United States, exclusive of Alaska and Hawaii: Entomoneidaceae, Cymbellaceae, Gomphonemaceae, Epithemiaceae, vol. 2. Academy of Natural Sciences of Philadelphia, Monographs 213p. 1975.
18. Hellawell J. Biological Surveillance of Rivers. Water Res. Centre,; 1978.
19. Ali S, Hassan F, Abdul-Jabar R. Ecological study of epiphytic diatoms on two submerged aquatic macrophytes in Tigris River, Iraq. The Iraqi Journal of Agricultural Science. 2019;50(3):1109-19.
20. Al-Barzingy YOM, Toma JJ, Shekha YA. Algal Survey in Wastewater Channel of Erbil City, Iraq. Diyala Journal for Pure Science. 2016;12(4):39-57.
21. Jawad HJ, ALrufaye ZTA, editors. Ecological study of diatoms community of Al Hussainya River in Kerbala City Iraq. AIP Conference Proceedings; 2020: AIP Publishing LLC.
22. Al-Hussieny AA. Algae of Iraq: Environment and Taxonomy. 1st Edition. Publications of dar culture – Ministry of Culture of Iraq Baghdad. 2018:440pp.
23. Hasan AF, Al-Mayaly IKA, Farhan TY. Planktonic Community Of Algae In Sawa Lake, Southern Iraq. Plant Arch. 2018;18(2):2213-23.
24. Ali SF, Abdul-Jabar RA, Hassan FM. Diversity measurement indices of diatom communities in the Tigris river within Wasit Province, Iraq. Baghdad Sci J. 2018;15(2):117-22.
25. Al-Meshhdany WY, Hassan FM. Five Diatom species identified by using potential application index generation and sequencing Bulletin of the Iraq Natural History Museum (P-ISSN: 1017-8678, E-ISSN: 2311-9799). 2020;16(1):39-61.
26. Meteeb NH, Al-Tamimi A-NAM, Al-Obaidy AHMJ. Epipelic Diatoms as Bioindicators to Assess the Water Quality Status of Baghdad Tourist Island Lake-Iraq. HIV Nursing. 2023;23(1):986-91.
27. Al-Thahaibawi BM, Al-Mayaly IK, Al-Hiyaly SA, editors. Phytoplankton community within Al-Auda marsh in maysan province southern Iraq. IOP Conference Series: Earth and Environmental Science; 2021: IOP Publishing.
28. Hana N. Using aquatic insects as bioindicators in water quality assessment of Bekhal (Maran), Zar Gali, and Khalan streams. MScThesis Univ of Salahaddin Erbil. 2015:141.
29. Mercado LM. A comparative analysis of the phytoplankton from six pampean lotic systems (Buenos Aires, Argentina). Hydrobiologia. 2003;495(1-3):103-17.
30. Toma JJ. Response of Algal Distribution to Environmental Condition of Shaqlawa District and their Antibiotic ActivitiesPH DThesis Univ of Salahaddin Erbil. 2022.
31. Toma JJ, Aziz FH. Algal study in springs and streams from Shaqlawa district, Erbil Province, Iraq I-Euglenophyta. Baghdad Sci J. 2023;20(1):32-40
32. Toma JJ. Algae as indicator to assess trophic status in Duhok Lake, Kurdistan region of Iraq. JUG. 2019;6(SCAPAS Conferance):90-8.