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Limnological study in Dokan Lake, Kurdistan region of Iraq

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Abstract

Samples from two sites of the surface of Dokan Lake were collected monthly over period of 8 months for physico-chemical analysis of water and investigated algal compositions. In this context, several limnological parameters were evaluated during the period from September 2008 to April 2009. The included physical and chemical parameters were: Air and water temperature, electrical conductivity, total dissolved solids, pH, alkalinity, total hardness, dissolved oxygen, Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, SO_4^{-}, Cl^{-} , and the concentrations of nitrite and phosphate. The study revealed that the air and water temperature ranged from 10 to 33 °C and 9 to 30 °C, respectively. Conductivity was in the range of 240-430 µS/cm, TDS was 161 to 280 mg/L, pH range was 7.3 to 8.0. Dissolved oxygen ranged between 5.5 to 9.2 mg/L. Calcium and magnesium concentrations varied from 30 to 52mg/L and 14 to 24 mg/L, respectively. Potassium and sodium ranged between 3.8-6.0 mg/L and 1.1-2.2 mg/L, respectively. Sulfate value varied from 130-224 mg/L and ranged between 18-25 mg/L for chloride. High value of nitrate was recorded. A total of 30 species of algae were recorded of which 14 species belong to Bacillariophyceae, 8 species belong to Chlorophyceae, 5 species to Cyanophyceae, 2 species to Pyrophyta, and one species to Euglenophyceae.

Key words: Limnological study, Dokan, Lake, Algae

Introduction:

People living on Earth and their aspirations are nowadays the main drive for exploitation of most of the living ecosystems. Huge economic progress means not only improved life quality but also higher human pressure on the environment and its global degradation. According to (Meybeck, 2003). Less than 17% of the present-day continental surface can be considered without direct human footprint. (Hobbs *et al.*, 2006). Claim that human activity is much greater than that of the nature.

Water is an extraordinary substance, which exist in the three states of matter (gaseous, liquid and solid states). It is often the most complex of all the familiar substances that are single chemical compounds. It is a very simple chemical compound composed of two atoms of hydrogen and one atom of oxygen, which bond covalently to form one molecule.

In its pure state, water is colorless, odorless, and insipid, freezes at O °C, and has boiling point of 100 °C at a pressure of 760 mmHg, with a maximum density of 1gcmG3 at 4°C. Chemically, it is a highly realistic substance, which is thermally stable at temperatures as high as 2,700 °C (Wilson, 1990). It is neutral to litmus, with a pH of 7 and undergoes a very slight but important reversible self-ionization.

The physical and chemical characteristics of water are important parameters as they may directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Moses, 1983). Water is known to contain a large number of chemical elements (Hutchinson, 1957). Physical parameters such as temperature, turbidity and current are also known to operate in Lake ecosystem (Schowoerbel, 1972).

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The interaction of both the physical and chemical properties of water plays a significant role in the composition, distribution and abundance of aquatic ecosystem. Apart form this, it also gives an insight into the relationships between the organism and their environment and can be used in determining water quality, and productivity of the lake. The physico-chemical study could also help in understanding of the structure and function of a particular water body in relation its habitants.

The proper balance of physical, chemical and biological properties of water in lake is an essential ingredient for successful production of aquatic resources.

The presence or absence of chemical elements in a water body might be a limiting factor in the productivity of such water body. Also the abundance of a particular element might suggest the types of organism that may be found as well as indication of ecologically unstable or unfavorable ecosystem which can have negative or positive impact on the population. Studies have shown that water rich in silica will contain a high population of diatoms (Pasche, 1980). Also high concentration of nitrogen and phosphate is indicative of eutrophication that may lead to algal bloom (Williams, 1970).

The physical and chemical limnology of a lake is characterized by hydrologic impact, autogenic nutrient dynamic and biological aspects. These factors were used to determine the water quality and consequently community of the lake (Mustapha and Osmotrosho, 2005; Sidnei *et al.*, 1992).

The physico-chemical characteristics of a lake can be significantly altered by human activities such as various agricultural practices and irrigation as well as natural dynamics which consequently affect the water quality and quantity, species distribution and diversity.

The present investigation aims to study the changes in the physico-chemical properties and algal composition of Dokan Lake.

Description of the area:-

Dokan Lake (Figure 1) boundaries extended from (latitude 34º 25′- 36º 33′ N and longitudinal 43º 17′- 46º 24′ E) (Shaban, 1980), was constructed in (1954-1959) by the construction of Damez-Bullot Dam (a French company) on the lesser zab river near Dokan gorge for preventation flooding, irrigation, electric generation, fishery and recreation. The lake lies in the northwestern part of Sulaimamiyah about 76km from the city center. The lake has a full-pool operating altitude of 511m and unregulated spillway at 515m above sea level (Toma, 2000). The major inlets are lesser zab river with its major tributaries (Karfin and Shahrawan) and other waters in addition to rainfall and snow fall / snow melts and the outlet is Qashqooly main canal (Shaban, 1980). Volume of lake is 6.8 milliar cubic meters with surface area of about 270 km^2 at high level period and 48 km^2, a maximum depth reach to 100m near the dam (Toma, 2000). Geology of the area consist of marl, calcareous and limestone (Guest, 1966 and Rzoska, 1980). The collection decision of (Al-Shalash, 1966). and (Guest, 1966) regarding the climate of the studied area is a dry-summer approaches Irano-Turanian type characterized by the occurrences of three seasons: a cold winter, mild growing period of spring and hot-dry summer.

So, to meet the requirements of the study, selected physical, chemical and biological measurements were made a regular schedule at 2 sampling sites in Dokan lake .One which selected in the mid lake, while the second sites were selected down stream of the lake outlet (Figure 1).

Material and methods:

Surface water samples were analyzed at two sites (One which selected in the mid lake, while the second sites were selected down stream of the lake outlet) for chemical, physical and biological purposes, each site was visited on eight occasions during (September 2008 to April 2009). Water samples were collected from each well for physical and chemical analysis using pre-washed clean polyethylene buckets. Air and water temperature were measured in the field by using a clean mercury thermometer (0-60 $^{\circ}C$).

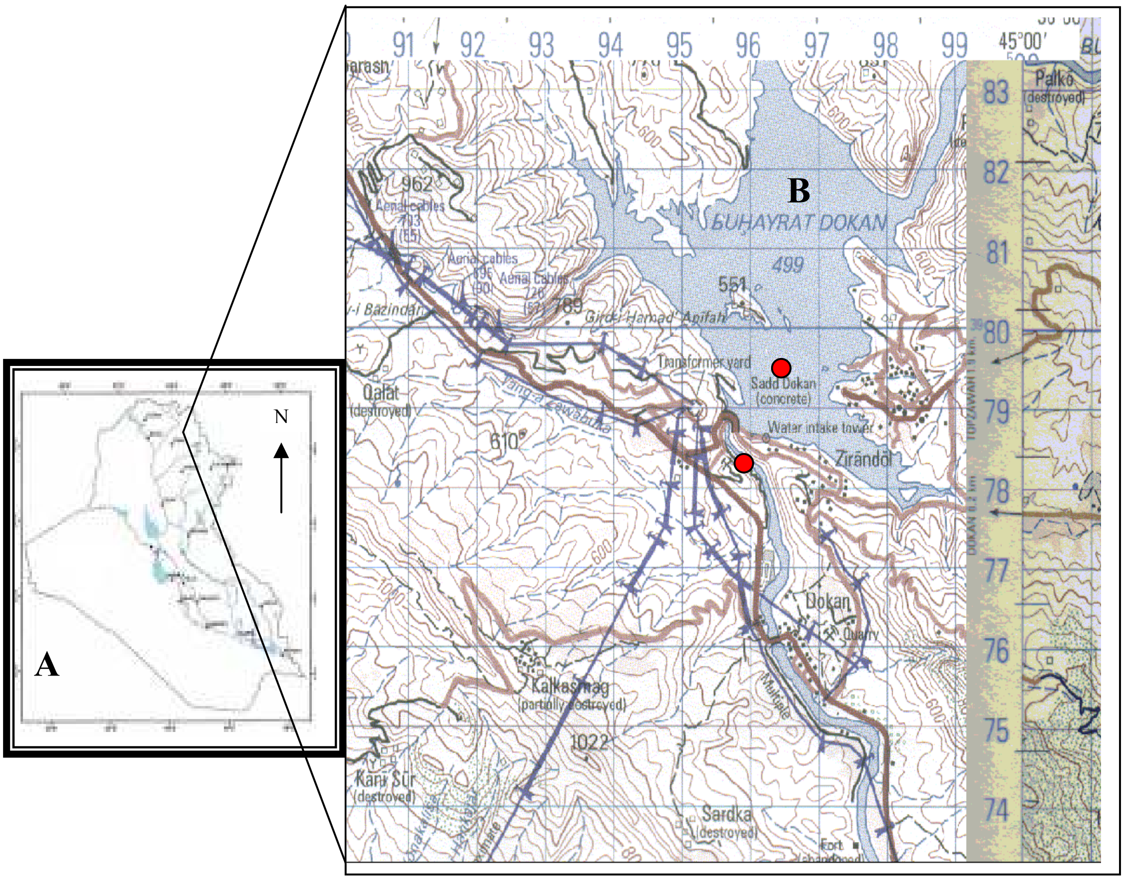

Figure (1): A. Shows map of Iraq Dokan Lake Shaded; B. Shows the studied area in Dokan Lake

EC, TDS and pH were measured immediately in the field by using (pH- EC- TDS meter, HI 9812, Hanna instrument). Total alkalinity, and total hardness, dissolved oxygen, calcium, magnesium and sodium, potassium and sulfate, chloride, nitrite and phosphate were estimated. The phytoplankton were collected by using phytoplankton net and identified to genus, and when possible to species using appropriate identification keys (Smith, 1950; Desikachary, 1959; Prescott, 1973; Patric and Reimer, 1966). The mean, standard error and less significant differences (LSD) values and t-test of each sites (physico-chemical variables) calculated at a probability of ($P < 0.05$) to find if found significant differences between two site fro each variables.

Results and discussions:

The physico-chemical parameters and algal composition are considered as the most important principles in the identification of the nature, quality and type of the water (fresh, brackish, saline) for any aquatic ecosystem (Toma, 2000).

Tables (1 and 2) show the monthly variation of physico-chemical characteristics in Dokan Lake and outlets during September-2008 to April-2009.

Table (3) shows the significant differences between the two sites for different physico-chemical characteristics that observe significant differences between the sites in some characteristics and not found in others characteristics.

Temperature is a factor of great important for aquatic ecosystem, as it affects the organisms, as well as the chemical and physical characteristics of water (Delince, 1992).

Related to air temperature recorded throughout during the study period, it seems that, the climate of Dokan Lake is mostly approaches to the Irano-Turanian type. However, the climate characterized by a semi arid type with a wide seasonal range between (10-33 °C) in air temperature. (Shaban, 1980). and (Al-Shalash, 1966). seem to confirm the present conclusion. Similar conclusions were made by many authors (Shaban, 1980 and Toma, 2000).

The recorded temperatures of air ranged from 9-30 °C in September-2008 and January-2009, respectively which affected mainly by the surrounded air temperature. Recorded water temperature showed a clear variation between months and sites. It is known that water temperature variation related to so many environmental factors such as current velocity, water depth, bottom materials, temperature of inlet waters and to exposure to direct sun light and degree of shading (Hutchinson, 1957; Bartram and Balance, 1996).

The high values of EC 430 µs/cm was recorded during hot seasons, while the lower values 240 µs/cm was recorded during cold seasons. The conductivity increased with the increase in total dissolved solids and water temperature (Entz, 1973). Results of the electrical conductivity throughout this survey come in accordance with the known conductivity values of Iraqi inland waters (Hutchinson, 1957; Bartram and Balance, 1996).The gradual reduction in conductivity with time may be due to the uptake of the ions by organisms for their metabolism. Similar observation has been reported by (Mustapha and Osmotrosho, 2005). The variation in electrical conductivity of the water depend on the climate, seasonal variation, soil source, geological origin the content of the ionic salts such as calcium, magnesium etc. (Wetzel, 1983).

Total dissolved solids refer to dissolved matter in water. They are very useful parameters describing the chemical constituents of the water and can be considered as a general of edaphic relations that contribute to productivity within the water body (Goher, 2002).

TDS was found in the same trend of the EC and salinity. However the higher value of TDS 280 mg/L was recorded during hot period. The lower value 161 mg/L was recorded during cold period. The obvious decrease in the TDS during cold period is mainly due to the decrease in temperature that consequently reduces the evaporation rate. Meanwhile, the higher values recorded during hot period, may be due to the elevation of the water temperature which leads to the increase in the evaporation rates and the accumulation of the dissolved salts in water. These results are coincident with that reported by (Abdel-Al-Star, 2005).

Hydrogen ion concentration plays an important role in the biological processes of almost all aquatic organisms (Welch, 1952). The pH value of the Dokan Lake was found in the alkaline side (pH > 7.0). The highest value of pH was recorded during hot period 8.0, while the lower value was found in the cold period 7.3. The decrease in pH values during cold period, especially in autumn, is mainly related to the high bicarbonate content, while the uptake of CO_2 by phytoplankton decreasing as a result of increasing in the concentration of HCO_3^- (Abdel- Satar, 2005).

(Ezz El-Din, 1990). Reported that the seasonal variation in pH was mainly affected by temperature, salinity, carbonate and bicarbonate system, rather than the photosynthetic activity of the primary producers.

The absolute values of total alkalinity fluctuated between 160 mg $CaCO_3$/l at site I in March and 240 mg $CaCO_3$/l at site II in September. The seasonal distribution of total alkalinity during the period of investigation showed a general decrease in Spring. On the other hand, a significant increase was recorded in summer season. The higher values of total alkalinity in Lake Dokan during summer may be attributed to the higher CO_2 content produced as a result of algal degeneration, as well as the important role of temperature in increasing photosynthetic activity (Abdull-Kassim, 1987). In contrast, the lower values of total alkalinity during spring may be due to the utilization of CO_2 during phytoplankton growth as well as the effect of drainage water discharged into the lake. In general the total alkalinity has increased during the last few years in this lake.

Total hardness content in Lake Dokan reached its minimum value (140mg $CaCO_3$/L) during February 2009 and its maximum (210 mg $CaCO_3$/L) in September-2008.The highest value probably related to evaporation which increase and concentrate the available cations, while the lower value may be related to the rainfall and dilution of cations content (Goldman and Horne, 1983).

Dissolved oxygen in Lake Dokan water fluctuated between a minimum of 5.5 mg/l in autumn and a maximum of 9.2 mg/l in winter. The lowest dissolved oxygen values were recorded in the central part of the lake. Dissolved oxygen showed lower values in autumn than the winter seasons, this may be due to several factors, the rise in temperature, increased biological activity, respiration of organisms and the increased rate of decomposition of organic matter.
Also, DO decreased when salinity increased, if other factors are kept constant (Ezz El-Din, 1990).

Generally, calcium and magnesium are the predominant cations in natural freshwater (Livingston, 1963). Calcium values (30-52 mg/L) were much higher than magnesium values (14-24 mg/L) at all studied sites and months, due to the calcareous nature of the sediment, as well as the reservoir under influence of regional soil and substrate characters.

The lower values of the calcium were recorded during spring and may be attributed to the uptake of the calcium by microorganisms (Bowling, 1975). However, the high calcium contents were recorded during summer and autumn may be related to the relative increase in the dissolved oxygen during these periods (Cole, 1979). Generally, calcium contents in the water is affected by the adsorption of calcium ion on the metallic oxides (Wilson, 1975). in addition, the effect of the microorganisms can play an important role in the calcium exchange between sediment and overlying water (Elewa, 1988). The present results show that magnesium concentrations in the water were lower than the calcium during the studied period. This may be attributed to, $MgCO_3$ is partially soluble during these seasons and the magnesium precipitated as Mg $(OH)_3$ (Goher, 2002). On the other hand, the slight variations in the distribution patterns of the magnesium during summer and autumn. This is mainly attributed to its minor biotic demand and high solubility characteristic of they salts that keeps a homogenous distribution and mass balance for magnesium contents during these seasons (Wetzel, 1983).

Surface water samples of Dokan lake and outlets showed sodium and potassium ranged from 3.8 to 6.0 mg/L and 1.1 to 2.2 mg/L respectively. Sodium concentration in natural water actually is more than potassium concentration (Reid, 1960). However potassium and sodium were relatively unaffectable by biological activities. Therefore the lower amounts in natural water are predictable (Owen *et al.,* 1972). The present results show a slight variation in the sodium distribution patterns during studied period. This is mainly attributed to the high solubility of these salts that keep a homogenous distribution and mass balance for sodium (Wetzel, 1983). The slight seasonal variations in the potassium of the ponds, indicate that the conservative nature of K (Wetzel, 1983).

The sulfate and chloride values were fluctuated in the ranges from 130-224 mg/L and 18-25 mg/L respectively during the studied period. The relative increase in the chloride and sulphate concentrations during hot period may be due to the increase in the air and water temperatures followed by the high evaporation rate (Mohammad, 2005). These results agree with that reported by (Abdel-Satar, 2005). On the other side, the high values in the sulphate and chloride concentrations unexpected during autumn. This is mainly attributed to the dissolution of some ions especially Cl^-, SO_4^{--} from the surrounding rocks and sediment which release into the water of the three ponds (Mohammad, 2005). Generally, the variation in sulfate and chloride in this survey may be related to rainfall, industrial, breakdown of sulphar-containing organic matter, agriculture, snow melts and sewage influents (Bartram and Balance, 1996).

The seasonal variations of nitrite showed there is a relative increase in the NO_2^- contents during winter and very high during autumn.

This is mainly attributed to the oxidation of existing ammonia, yielding nitrite as intermediate state especially in abundant oxygen during winter (Wetzel, 1983). This explanation is documented by the decrease in the ammonia concentrations during the same period. On the other side, there is a relative decrease in the nitrite contents during hot period. This is probably due to this reduction into ammonia. This is supported by the relative increase in the ammonia concentrations during this period, and uptake by the phytoplankton in the surface water.

The cycling of phosphorus within lakes and river is dynamic and complex, involving adsorption and precipitation reactions, interchange with sediments and uptake by aquatic biota (Broberg and Persson, 1988).

The monthly variations of $(PO_4)^{-3}$ concentrations were found to be from 2.9-6.0 µg/l during winter, spring, summer and autumn respectively. The decrease in the PO_4^{-3} values during summer season was probably due to the distinct drop in phytoplankton biomass, on which nutrient regeneration process depends. Also, the recycling processes of the nutrients depended on the nutritional status of algal cells (Lehman, 1980).

In addition, the weak mixing in the water and sedimentation of the phosphorus at high pH of the ponds (during summer) by combination with iron as ferric phosphate (Mesnage, 1995). On the other side, the relative increase in PO_4^{-3} during winter can be related to the complete mixing of the water column and more phosphorus release from the sediment, especially in presence of dissolved oxygen as reported by (Abdel-Satar, 2005).

The phytoplankton plays an important role in aquatic ecosystems, because, they are the primary producers. Thus they are the first link in the food chain and often cause nuisance condition (Hutchinson, 1967). Generally, large number phytoplankton in Dokan lake and its outlet during the studied period. This can be connected to the nature of the lake itself. However as stated by (Welch, 1952). and (Hutchinson, 1967). Dokan lake and its outlet main channel sites were showed a diverse genera and taxa (table 4). However 30 species were recorded. Fourteen species of the total belong to *Bacillariophyceae*, 8 species belong to *Chlorophyceae*, 5 species to *Cyanophyceae, 2* species to *Dinoflagellated,* and 1 species to *Euglenophyceae.*

Diatoms have been found to dominate the composition in the studied area. Similar conclusion made by (Shaban, 1980 and Toma, 2000).

As stated by (Welch, 1952 and Hutchinson, 1967). diatoms dominated numerically in the studied area. The dominancy of diatom species might be connected to their tolerance range to different environmental conditions as well as to availability of silica in lake (Bartram and Balance, 1996).

From phytoplankton composition encountered in this work, it seems that among diatom species *Cyclotella ocellata* was the most common taxa in this survey. Similar conclusion made by (Shaban, 1980 and Toma, 2000).

On the other hand, nondiatom taxa in this study were seemed to be dominanated by *Chlorophyta* in particular in hot months such as *Pediastrum duplex* and *Pediastrum simplex*. Similar conclusion made by (Shaban, 1980 and Toma, 2000).

Cyanophyceae as stated by (Smith, 1950). usually occur in abundance only during the warm month's o the year, this was the situation in Dokan Lake. *Euglenophyceae* in this survey observed in autumn and spring, this can be connected to organic pollution (Hutchinson, 1967).

Dinoflagellated such as *Ceratium hirundinella* and *Peridinium cinctum* produced in the studied area with higher densities during hot months. (Hutchinson, 1967). indicated that the recorded above species are of warm water organism. (Reid, 1960). Stated that these organisms cause an odor, and this statement was seen to be true in the present study.

Conclusion:-

1. The climate of Dokan Lake does approaches to Irano-Turanian type;
2. With regard to nutrient enrichment status Dokan Lake can be Mesotrophic Lake.

Variable sample date	15-9-2008	15-10-2008	15-11-2008	15-12-2008	15-1-2009	15-2-2009	15-3-2009	15-4-2009
Air temp. °C	33	28	18	14	10	11	17	20
Water temp. °C	30	25	16	12	9	10	16	19
EC µs/cm	380	430	332	270	240	260	270	265
TDS mg/L	247	280	222	181	161	177	174	181
pH	8.0	7.8	7.8	7.5	7.3	7.4	7.7	7.5
Alkalinity mg $CaCO_3$/L	240	240	210	200	190	220	180	190
Hardness mg $CaCO_3$/L	180	190	180	180	164	140	160	160
Dissolved Oxygen mg/L	6.4	6.2	7.0	8.0	9.0	9.0	7.5	6.0
Ca^{+2} Mg/L	48	47	45	40	42	32	30	32
Mg^{+2} mg/L	19	18	19	16	17	15	14	15
Na^{+} mg/L	5.2	5.2	5.5	4.3	4.0	4.2	4.0	3.8
K^{+1} mg/L	1.8	2.0	2.0	1.8	1.2	1.1	1.3	1.2
$(SO_4)^{-2}$ mg/L	185	185	165	170	160	130	145	150
Chloride mg/L	24	22	22	22	20	18	18	20
µg N^-NO_2	0.7	0.65	0.5	0.5	0.4	0. 4	0.35	0.34
µg P^-PO_4	3.8	4.4	5.3	4.5	4.4	4.0	3.4	4.0

Table (1): Physico-chemical variables recorded in mid-Dokan Lake during the study period

Variable sample date	15-9-2008	15-10-2008	15-11-2008	15-12-2008	15-1-2009	15-2-2009	15-3-2009	15-4-2009
Air temp. °C	31	25	16	12	11	11	16	18
Water temp. °C	25	21	15	11	10	10	14	15
EC µs/cm	320	380	320	300	280	310	290	300
TDS mg/L	208	250	210	195	182	206	188	195
pH	7.8	7.6	7.6	7.6	7.4	7.6	7.6	7.6
Alkalinity mg $CaCO_3$/L	230	220	180	170	180	170	160	200
Hardness mg $CaCO_3$/L	210	200	190	200	190	160	180	170
Dissolved Oxygen mg/L	5.5	5.8	6.5	9.0	9.2	8.6	7.0	6.5
Ca^{+2} Mg/L	52	48	50	42	46	40	36	37
Mg^{+2} mg/L	24	24	16	18	17	18	14	15
Na^{+} mg/L	5.5	6.0	5.4	4.2	4.2	4.3	4.2	4.5
K^{+1} mg/L	2.0	2.0	2.2	2.0	1.4	1.5	1.2	1.3
$(SO_4)^{-2}$ mg/L	224	220	204	200	190	165	185	180
Chloride mg/L	25	24	23	20	22	18	20	18
µg N^-NO_2	0.84	0.50	0.60	0.56	0.60	0.44	0.50	0.44
µg P^-PO_4	4.8	6.5	4.6	5.6	5.0	2.9	4.0	0.44

Table (2): Physico-chemical variables recorded in outlet of Dokan Lake during the study period

Sample sites / Variables	Site 1	Site 2	Site 1 & site 2
Air temp. °C	18.87+2.84	17.5+2.52	T= 2.98 P= 0.02
Water temp. °C	17.12+2.59	15.12+1.90	T= 2.64 P= 0.03
EC µs/cm	305.87+24.00	312.50+10.18	T= 0.44 P= 0.67
TDS mg/L	202.87+14.92	204.25+7.40	T= - 0.15 P= 0.88
pH	7.62+0.08	7.60+0.03	T= 0.42 P= 0.68
Alkalinity mg CaCO3/L	208.75+8.11	188.75+8.95	T= 3.19 P= 0.015
Hardness mg CaCO3/L	169.57+5.71	187.5+5.90	T= 6.73 P= 0.001
Dissolved Oxygen mg/L	7.38+0.42	7.26+0.51	T= 0.55 P= 0.59
Ca^{+2} mg/L	39.5+2.56	43.87+2.12	T= 5.62 P= 0.0007
Mg^{+2} mg/L	16.62+0.67	18.25+1.34	T= 1.54 P= 0.16
Na^{+} mg/L	4.52+0.23	4.78+0.25	T= 2.22 P= 0.06
K^{+1} mg/L	1.55+0.13	1.70+0.13	T= 2.80 P= 0.02
$(SO_4)^{-2}$ mg/L	161.25+6.79	196+7.08	T= 22.67 P= 8.21
Chloride mg/L	20.75+0.75	21.25+0.94	T= 0.83 P= 0.43
µg N^{-} NO_2	0.48+0.047	0.56+0.045	T= 2.13 P= 0.07
µg $P^{-}PO_4$	4.22+0.20	4.71+0.37	T= 1.35 P= 0.21

Table (3): Mean and standard error recorded in mid and outlet Dokan Lake during the study period

When T= t-test P=P calculated value at level 0.05

Species	**Winter**	**Spring**	**Summer**	**Autumn**
Division : Cyanophyta				
Class: Cyanophyceae				
Order: Chroococales				
Family: Chroococaceae				
1. *Chroococcus dispersus* Keissl	-	-	+	+
2. *Gloeocapsa punctate* Naegeli	-	-	+	+
Order: Oscillatoriales				
Family: Oscillatoriaceaea				
1. *Oscillatoria acutissima* Kufferath	-	-	+	+
2. *O. articulata* Gardner	-	-	+	+
3. *O. tenuis* Agardh	-	-	+	+
Division: Chlorophyta				
Class: Chlorophyceae				
Order: Chlorococcales				
Family: Hydrodictyaceac				
1. *Pediastrum. boryanum* Turp.	+	+	+	+
2. *P. duplex* Meyen	+	-	+	+
3. *P. simplex* Meyen	+	-	+	+
Family: Oocystaceae				
1. *Chlorella vulgaris* Bejerinck	-	+		
Family: Oocystaceae				
1. *Scenedesmus bijuga* Turp.	-	+	+	+
Order: Siphonocladales				
Family: Cladophoraceae				
1. *Cladophora glomerata* (L.) Katz	-	+	+	+
Family: Desmdiaceae				
1. *Colsterium* sp	-	-	+	+
2. *Cosmarium* sp	-	-	+	+

Table (4):-The algal species recorded in mid and outlet of Dokan Lake during the studied period

(+) means present (-) means absent

Species	Winter	Spring	Summer	Autumn
Division: Euglenopyta				
Order: Euglenales				
Family: Euglenaceae				
1. *Euglena gracilis* Klebs	-	+	-	-
Division: Pyrophyta				
Class : Dinophyceae				
Order: Gonyaulacales				
Family: Ceratiaceae				
1. *Ceratium hirundinella* Muell.	-	+	+	+
Order: Peridiniales				
Family: Peridiniaceae				
1. *Peridinium cinctum* Muell.	-	+	+	+
Division Chysophyta				
Class: Bacillariophyceae				
Order: 1. Centrals				
1. *Cyclotella ocellata* Pantocsek	+	+	+	+
2. *Melosira granulata* (Ehr.) Ralfs	+	+	+	+
Order: 2. Pennales				
1. *Caloneis bacillum* (Grun.) Cleve	-	+	+	-
2. *Cocconeis. pediculus* Ehrenberg	-	+	-	+
3. *Cymbella affinis* (Kuezing)	+	+	+	-
4. *C. turgida* (Greg.) Cleve	+	+	-	+
5. *Diatoma vulgare* Bory	+	+	+	+
6. *Fragilaria capucina* Desmazieres	+	+	+	+
7. *F. construens* (Ehr.) Grunow	+	+	+	
8. *Gyrosigma scalproides* (Rabenhorst	-	+	-	+
9. *Navicula cuspidata* (Katz.) Kuetzing	+	+	+	+
10. *Nitzschia* sp	+	+	+	+
11. *Surirella angusta* Ktuezing	+	+	-	-
12. *Synedra ulna* (Nitzs.) Ehrenberg	+	+	-	-

Table (4):-The algal species recorded in mid and outlet of Dokan Lake during the studied period (Continued)

(+) means present (-) means absent

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الملخص العربى

دراسة لمنولوجية لبحيرة دوكان، اقليم كردستان العراق

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الملخص

تم أخذ عينات المياه السطحية لبحيرة دوكان لقياس العوامل الفيزيائية والكيميائية وكذلك فحص وتركيب الطحالب من موقعين شهريا وخلال ٨ أشهر. تم تقييم العوامل اللمنولوجية خلال الفترة من ١٥ تشرين الأول ٢٠١٠ الى ١٥ ابريل ٢٠١١. وشملت العوامل الفيزيائية : درجة حرارة الهواء والمياه ، والتوصيل الكهربائي والمواد الصلبة الذائبة. وشملت المعوامل الكيميائية : درجة الحموضة ، والقاعدية، العسرة الكلية ، الأوكسجين المذاب ، الكالسيوم ، المنغسيوم ، الصوديوم ، البوتاسيوم ، السلفات، الكلوريد ، وتركيز النتريت والفوسفات. وكشفت الدراسة أن درجة حرارة الهواء والماء تراوحت ١٠ الى ٣٣ درجة مئوية و ٩الى ٣٠ درجة مئوية على التوالي ؛ وأوضحت الدراسة ان التوصيل الكهربائي في حدود ٢٤٠ الى ٤٣٠ ميكرو سمنس / سم ، المواد الصلبة الذائبة : ١٦١ الى ٢٨٠ ملغم / لتر ، درجة الحموضة تتراوح بين ٧،٣ الى ٨،٠ . القاعدية: ١٦٠ الى ٢٤٠ ملغم كاربونات الكالسيوم / لتر، و العسرة: ١٤٠ الى ٢١٠ ملغم كاربونات الكالسيوم / لتر و الأوكسجين المذاب فى نطاق ٥,٥ الى ٩,٢ ملغم/ لتر؛ الكلسيوم و الماغنيسيوم تركيزات مختلفة من ٣٠ إلى ٥٢ و ١٤ إلى ٢٤ ملغم / لتر على التوالى. الصوديوم و البوتاسيوم تراوحت بين ٣,٨ - ٦,٠ ملغم / لتر و ١,١ - ٢,٢ ملغم / لتر على التوالي. قيم كبريتات تباينت بين ١٣٠ الى ٢٢٤ ملغم/ لتر والكلورايد تراوحت ما بين ١٨ – ٢٥ ملغم/لتر. القيمة العالية للنتريت وصلت الى ٠,٨٤ مايكروكرام / لتر وللفوسفات وصلت الى ٦,٥ مايكروكرام/ لتر على التوالي. تم تسجيل ٣٠ نوعا من الطحالب. ١٤ نوعا منها تنتمي إلى الدايتومات ، ٨ أنواع تنتمي إلى الطحالب الخضر ، 5 انواع تنتمي الى الطحالب الخضر المزرقة، ونوعان ينتموا الى الطحالب البنية. و نوع واحد الى الطحالب اليوغلينية .