RESEARCH PAPER

Algae as indicator to assess trophic status in Dokan Lake, Kurdistan region of Iraq.

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ABSTRACT:

This survey was related to study the algal status of Dokan Lake to evaluate the trophic status of lake productivity. Data for application of phytoplankton compound quotient (PCQ) equations and dominant genus scores were collected from previous studies for Dokan lake periods during 1980, 2000 and 2016. A total of 101, 61 and 135 respectively algal taxa which has into 6 taxonomic groups were determined. From phytoplankton content in this survey, it seems that among diatom species Cyclotella ocellata, Stephanodiscus astreata, Nitzschia spp and Navicula spp were the most common taxa in this survey. On the other side, non-diatom species in this search were to be dominated by Pyrophyta in especially in warm months such as Ceratium hirundinella and Peridium cinctum. Ecological status of the Dokan Lake was mesotrophic in 1980 and 2000 while in 2016 was hypertrophic according to phytoplankton compound quotient (PCQ=4.5, 2.8 and 8.0) respectively. As a result of dominant genus scores (3.8, 4.2 and 6.5), the lake has a mesotrophic character according to trophic level in 1980 and 2000, and was meso-eutrophic in 2016. In addition, the water quality of Dokan Lake was moderate in 1980 and 2000 and moderate polluted in 2016.

KEYWORDS: Algae, Trophic, Status, Dokan, Lake.
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INTRODUCTION:

Algae play an important role for assess quality of water system. Algae are significant indicators of water environment since they response to both qualitative and quantitative composition of species in a wide range of water situations due to change in chemistry of water such as increases contamination depend on different wastes and affect the content of genus that are able to tolerate these condition (Bergström, 2010).

Algal abundance in a water system reflects the main ecological condition and, then, it may be used as an indicator of quality of water system (Saha et al. 2000). Pressure of population, urbanization, industrialization and increased activity of agriculture have importantly contribution to the contamination of aquatic systems. Continuous monitoring of the quality of aquatic ecosystems is one of the best protect method, using organisms for monitoring of water environmental is the most popular topic for the scientific community (Tokatli, 2013).

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The trophic status means to the value of productivity in a Lakes as calculated by phosphorus, algal composition, and the distance light penetration in depth of lakes. Trophic status in clean standing water depend on amount of biological productivity happing in the water (Chandrashekar et al., 2014). Increase primary productivity is not necessary means of poor condition as it is natural for Lakes to change from low to high trophic states but this is a slow process (Sullivan and Reynolds, 2004). Early recognition of various in the quantity and quality of phytoplankton in lakes play role to determine the origin of the trophic status of lake classification. The trophic system has continued to evolve and at the same time, there have been developments in the recognition of plankton types. These have been mainly concerned with the phytoplankton and include the use of a different of indices and quotients. This field has been developed mainly by European workers with, as yet, little application to the waters of North America (Chandrashekar et al., 2014). The objectives of this investigation were to determine the trophic status of Dokan Lake at different period and to determine the productivity of lakes by comparing the results of PCQ and dominant genus.

2. MATERIALS AND METHODS

2.1 Data collection
Application algae for phytoplankton compound quotient (PCQ) equations and dominant genus scores were collected from previous published studies for Dokan Lake (Shaban, 1980; Toma, 2000 and Farkha & Fatah, 2016).

2.2 Study area
The Dokan Dam constructed in Dokan district in the Lesser Zab River for concrete arch dam in Sulaymaniyah Governorate, Iraq (latitude: 35° 57' 15" N; longitude: 44° 57' 10" E). The dam was built from 1954 to 1959 as a multi-purpose dam for storage of water, irrigation and electricity production. It is 116.5m height and can withhold 6,970,000,000 m³ of water. The catchment area is 11,690 km² and surface area is about 270 km² (Goran, 2014) (Figure 1). This survey explains the content of phytoplankton as well as determining the environmental status of the lake. Ecological status of the lake depending to the phytoplankton compound quotient (PCQ) was calculated in the manner as proposed by (Nygaard G.1949) and (Ott and Laugaste, 1996) and arranged by Nygaard. PCQ gives quite good determination to lake trophic state, although algal groups in formula may contain species with various preferences to trophic conditions. Moreover, (Ott and Laugaste, 1996), added to the original formula 2 extra division: Cryptophyta to numerator and Chrysophyceae to denominator.

\[ \text{PCQ} = \text{Cyanophyta}^* + \text{Chlorophyceae}^* + \text{Centrales}^* + \text{Euglenophyceae}^* + \text{Cryptophyta}^* + 1/\text{Desmidiales}^* + \text{Chrysophyceae}^* + 1 \]

Where * is the number of different species.

Ecological status of the Dokan Lake estimated depending on planktonic algae content and the phytoplankton compound quotient (PCQ). PCQ was used to determine the ecological status of the lake (Table 1). Many researchers suggested the idea that the proportion of number of species of the groups existing in the phytoplankton with one another (Nygaard, 1949; Thunmark, 1945 and Hutchinson, 1967) indicates the efficiency of the lake. Among those proportions the coefficient proposed by (Nygaard, 1949) was applied more frequently. This index is one that is best useful for explaining the trophic degree of a lake. Nygaard’s compound index was modified by (Ott and Laugaste, 1996). The trophic status and PCQ values of the lakes have been indicated in Table 1.

| Lake status               | PCQ | Lake status   | PCQ |
|--------------------------|-----|---------------|-----|
| Oligotrophic             | < 2 | Eutrophic     | 5-7 |
| Mesotrophic              | 2-5 | Hypertrophic  | > 7 |

Species composition of the phytoplankton community is a good bioindicators for water quality (Peerapornpisal et al, 2007). In this study, the diversion of phytoplankton was studied and the water quality was determined based on the physical and chemical properties.
In Table (2), list of dominant genus and in Table (3) the ranges in determining the trophic structure of the lake and water quality according to dominant genus have been given. In determining the trophic status, several criteria are used in terms of nutrient concentration, species combination of phytoplankton, fauna and flora quantity and quality. And the differences that may arise in determining the trophy levels of the lakes among them are analyzed looking through several parameters. Trophic status brings a new approach to trophic restriction of lakes. PCQ (Ott and Laugaste, 1996) and dominant genus (Peerapornpisal et al, 2007) were used in order to determine trophy.

### Table 2. List of dominant genus scores of Dokan Lake according to (Peerapornpisal et al, 2007)

| Genus          | Score | Genus          | Score |
|----------------|-------|----------------|-------|
| Actinastrum    | 5     | Gymnodinium    | 6     |
| Acanthoceras   | 5     | Gyrosigma      | 7     |
| Amphora        | 6     | Isthmochloron  | 5     |
| Anabaena       | 8     | Kirchneriella  | 5     |
| Ankistrodesmus | 7     | Melosiera      | 5     |
| Aphanocapsa    | 5     | Merismopedia   | 9     |
| Aphanothece    | 5     | Micractinium   | 7     |
| Aulacoseira    | 6     | Micrasterias   | 2     |
| Bacillaria     | 7     | Microcystis    | 8     |
| Botryococcus   | 4     | Monoraphidium  | 7     |
| Centritractus  | 4     | Navicula       | 5     |
| Ceratium       | 4     | Nephrocytium   | 5     |
| Chlamydomonas  | 6     | Nitzschia      | 9     |
| Chlorella      | 6     | Oocystis       | 6     |
| Chroococcus    | 6     | Oscillatoria   | 9     |
| Closterium     | 6     | Pandorina      | 6     |
| Cocconeis      | 6     | Pediastrum     | 7     |
| Coelastrum     | 7     | Peridiniopsis  | 6     |
| Cosmarium      | 2     | Peridinium     | 6     |
| Crucigenia     | 7     | Phacus         | 8     |
| Crucigeniella  | 7     | Phormidium     | 9     |
| Cryptomonas    | 8     | Pinnularia     | 5     |
| Cyclotella     | 2     | Planktolyngbya | 7     |
| Cylindrospermopsis | 7 | Pseudanabaena | 7 |
| Cymbella       | 5     | Rhizosolenia   | 6     |
| Dictyosphaerium| 7     | Rhodomonas     | 8     |
| Dimorphococcus | 7     | Rhopalodia     | 5     |
| Dinobryon      | 1     | Scenedesmus    | 8     |
| Encyonema      | 6     | Staurostrum    | 3     |
| Epithemia      | 6     | Staurodesmus   | 3     |
| Euatrum        | 3     | Staunoeis      | 5     |
| Eudorina       | 6     | Strombomonas   | 8     |
| Euglena        | 10    | Surirella      | 6     |
| Eunotia        | 2     | Synedra        | 6     |
| Fragilaria     | 5     | Tetraedron     | 6     |
| Golenkinia     | 5     | Trachelomonas  | 8     |
| Gomphonema     | 6     | Volvox         | 6     |

![Figure (1): A- Map of Northern Iraq show Dokan Lake. B- Map of Dokan Lake](image-url)
Table 3. Water quality scores followed trophic level and general water quality of Dokan Lake (Peerapornpisal et al., 2007)

| Score  | Water quality by trophic level | General water quality |
|--------|---------------------------------|-----------------------|
| 1.0 – 2.0 | Oligotrophic status         | Clean                 |
| 2.1 – 3.5 | Oligo-mesotrophic status | Clean-moderate         |
| 3.6 – 5.5 | Mesotrophic status           | Moderate               |
| 5.6 – 7.5 | Meso-eutrophic status       | Moderate-polluted      |
| 7.6 – 9.0 | Eutrophic status            | Polluted               |
| 9.1 – 10  | Hypereutrophic status       | Very polluted          |

3. RESULTS AND DISCUSSION

The phytoplankton composition of Dokan Lake in previous studies during 1980, 2000 and 2016. A total of 101, 61 and 135 algal taxa which have into 6 taxonomic groups were determined respectively. The range of taxonomic groups from the most rich in species to less species, were Bacillariophyta were dominant ranged from (55-68%), Chlorophyta varied by (14-23%), While Cyanophyta ranged between (8-14%) then, Chrysophyta and Pyrophyta changed from (1-5%), finally Euglenophyta fluctuated from (1 to 3%) respectively of Dokan Lake are given in figure 2, 3 and 4.

Table 4: Dominant genus recorded at different seasons in Dokan Lake (Shaban, 1980; Toma, 2000 and Farkha & Fatah, 2016)

| Dokan(1980) | Dokan(2000) | Dokan(2016) |
|-------------|-------------|-------------|
| Cyclotella  | Cyclotella  | Oscillatoria |
### Algal Dominants in Dokan Lake

| Species                                      | Identification  |
|----------------------------------------------|-----------------|
| Stephanodiscus                               | Navicula        |
| Synedra sp                                   | Nitzschia       |
| Ceratium sp                                  | Fragilaria      |
| Peridinium sp                                | Cymbella        |
| D. Hirundinella                             | Gomphonema      |

Algal species are good indicators of water quality and any changes in environment (Patrick, 1977 and Dixit et al, 1992). The content of phytoplankton is used to determine the trophic status, productivity rate, nutrient level, quality of water and rate of pollution in lakes (Reynolds, 1998). *Ceratium hirundinella*, *Dinobryon divergens*, *Cosmarium spp*, *Pediastrum spp*. examples of the algae are among the algal bio-indicators recorded in summer months observed in Dokan Lake from previous studies (Reynolds, 1990). *Ceratium hirundinella* and *Peridinium cinctum* among Pyrophyta are the algae dominant in hot season in Dokan Lake (Shaban, 1980 and Toma, 2000). *C. hirundinella* is the estimated of mesotrophic waters and they are usually common in the summer in oligotrophic and mesotrophic lakes (Eloranta, 1995 and Reynolds et al, 2002), the mass occurrence of this species has been noted in spring (Noges, 1998) and in summer in a mesotrophic lake (Huszar et al, 2003) and a shallow eutrophic lake (Gligora, et al, 2003). Another Pyrophyta, such as *Peridinium cinctum* has been recorded intensely in the hot months, also this species exists in mesotrophic lakes as well (Reynolds et al, 2002). Among Chrysophyta, *Dinobryon divergens* and *D. septolaria* are identified in Dokan Lake by (Shaban, 1980; Toma, 2000 and Farkha & Fatah, 2016). One or more than one studies in the same year by the same authors by (Kristiansen, 2005) had appeared that the presence of a few species such as *Dinobryon* may indicate oligotrophic, but high Chrysophyta species variance at lower overall biomass is more indicate of eutrophic conditions. The large biomass of *Dinobryon* was noted in spring in a mesotrophic lake (Laugaste et al, 1996) and in November in a Meso-eutrophic lake (Naselli-Flores and Barone, 2000). Among the Pyrophyta, *C. hirundinella* and golden-green algae *Dinobryon sp.* was recorded as dominant in Meso-eutrophic Lake Dokan in summer months (Zębek, 2009). Species of *Cyclotella ocellata* and *Stephanodiscus astrea* identified in Dokan lake and they are more dominant than species the others (Shaban, 1980; Toma, 2000 and Farkha & Fatah, 2016). (Reynolds, 1993) stated that some species were affected by ecological factors specially temperature, therefore species that come into prominence in winter and spring seasons was *Cyclotella* species. *Cyclotella* and *Stephanodiscus* species are recognized by many of the researchers as typical components of mesotrophic lakes (Trifonova, 1998 and Moss, 1998). According to (Round, 1956), *Cyclotella* and *Stephanodiscus* species are bio-monitor species in transition to eutrophic. (Reynolds (1990) stated that in midsummer *Cyclotella ocellata*, *Stephanodiscus astrea*, *Ceratium hirundinella*, *Dinobryon divergens* were mesotrophic species Cyanophyta, especially *Oscillatoria sp.* was found to be most frequent algae in many sites in Dokan lake by (Farkha & Fatah, 2016). (Fattah, 2010; Wu and Suen, 1985) concluded that *Oscillatoria sp.* was found in organic polluted water. Most of algal taxa disappear during rainy season may be due to high water turbidity and suspended solids (Fattah, 2010; Wu and Suen, 1985). Similar conclusion was made in Dokan Lake (Farkha & Fatah, 2016). A total of 92 diatoms were identified by (Farkha & Fatah, 2016) they belong to 24 genus in Dokan Lake; Pinnate diatoms make up almost all of the main bulk of Bacillariophyta. In most aquatic ecosystems bacillariophyceae species community, diatoms density, diversity and their association with environmental variables used as biological indicators for the assessment of water quality (Singh, et al, 2010). Many local and global survey concluded that lake phytoplankton were dominated by Bacillariophyta species (Soylu, and Gonulol, 2003; Al-Nakshabandi, 2002 and Fattah, 2010) this dominancy is related to that diatoms tolerate broad range of light, temperature and other ecological factors. The most common and diverse genera that identified by (Farkha & Fatah, 2016) in Dokan lake were *Nitzschia*, *Navicula*, *Peridinium*, *Stephanodiscus*, *Ceratium*, *Pediastrum*, *Nitzschia*, *Fragilaria*, *Cymbella*, and *Gomphonema*.  

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Gomphonema, Fragilaria, Cymbella these genera considered calcareous and were rich in studied water bodies due to the geological nature of the studied area and high CaCO3 content, these results were in agreement with the result obtained by (Fattah, 2010; Celekli and Kulkoyluoglu, 2007). Nitzschia and Navicula were the most represented genera at all studied sites in Dokan lake because of their wide environmental condition tolerance range (Fattah, 2010).

Ecological status of the Dokan Lake during 1980, 2000 and 2016 according to the phytoplankton compound quotient (PCQ) (Ott and Laugaste 1996. PCQ value was calculated as 4.5, 2.8 and 8 respectively. According to this trophic status of Dokan Lake is mesotrophic 1980 and 2000, while was Hypereutrophic in 2016. Algal species are excellent indicators of water quality and environmental change (Patrick, 1948 and Dixit et al, 1992 ). Algae as indicators are used for assessment quality of water and trophic level of water. In this investigation, the important species among Dokan Lake planktonic algae which are recorded as dominant were given in (Table 5). The water quality and trophic level of Dokan Lake were determined depending to dominant genus scores (Peerapornpisal, et al, 2007) .

The dominant genus scores and phytoplankton compound quotient (PCQ) obtained was 3.8, 4.2 and 6.5 and 4.5, 2.8 and 8 in Dokan lake during years 1980, 2000 and 2016 respectively which exist widespread in mesotrophic lakes were the dominant taxon through this study. Ecological status of the Dokan Lake was Mesotrophic in years 1980 and 2000 while changed to Hypereutrophic according to the phytoplankton compound quotient and trophic (Table 6). Since this value is included in the range of 3.6–5.5, trophic level of Dokan Lake is “mesotrophic” and moderate water quality in 1980 and 2000 and Hypereutrophic and moderate polluted in 2016 depending on table (3).

| Table 5:- Dominant genera and scores in the Dokan Lake during 1980, 2000 and 2016 |
|---------------------------------|------|------|-----------------|
| Genus                          | Score| Genus | Score           |
| Cyclotella                     | 2    | Peridinium | 6               |
| Stephanodiscus                 | 1    | Oscillatoria | 9               |
| Synedra sp                     | 6    | Navicula    | 5               |
| Ceratium                       | 4    | Nitzschia   | 9               |
| Fragilaria                     | 5    | Cymbella    | 5               |
| Gomphonema                     | 6    |             |                 |

| Table 6:- phytoplankton compound quotient (PCQ) and dominant genus score in Dokan Lake during 1980, 2000 and 2016 |
|---------------------------------|------|-----------------|
| Dokan lake | PCQ | Dokan lake | dominant genus score |
| 1980        | 4.5 | 1980          | 3.8               |
| 2000        | 2.8 | 2000          | 4.2               |
| 2016        | 8   | 2016          | 6.5               |

4. CONCLUSIONS:

The trophic structure of Dokan Lake varied depending on the structure of phytoplankton community and species dominancy as well as others environmental factors. Ceratium hirundinella and Peridinium cinctum that belong to Pyrophyta, and Dinobryon divergens and D. sertularia that belong to Chrysophyceae level of Dokan Lake is “mesotrophic” and moderate water quality in 1980 and 2000, Hypereutrophic and moderate polluted in 2016 depending according to PCQ and dominant genus scores.

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