# Study algae and fungi interaction in some artificial open sand mine ponds in Kalak sub district- Duhok, Iraq.

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## Abstract

Phycology, mycology and physicochemical parameters of some artificial open sand mine ponds in Kalak sub district-Duhok- Iraq were investigated, for a period of six months from July to December-2015. Water samples were collected monthly basis and analyzed for measuring of water temperature, turbidity, pH, electrical conductivity, nitrate, nitrite, ammonium, orthophosphate, dissolved oxygen and biochemical oxygen demand. Concerning algal communities, the results showed that the sixty taxa were identified in samples collected during the study period. They belong to classes Cyanophyceae (18 taxa) with percentage composition of 30%, Chlorophyceae (20 taxa) with percentage composition of 33.3%, Euglenophyceae (2 taxa) with percentage composition of 3.4%and Bacillariophyceae (20 taxa) with percentage composition of 33.3%.According to Shannon-Weiner index, species diversity varied from (2.053to 3.895bits/ind), in pond 3 and in July had the highest diversity were recorded. Concerning to Jaccard similarity index, the highest percentage of similarity to algal community observed between site2 and site 4 reached to 32%. The diatoms were the most noticeable algae in all ponds which represented by ***Cyclotella***, ***Navicula, Syndra*** and ***Cymbella*** with respect to the frequency of occurrence and number of individuals in all ponds. The diatoms showed their best growths through this study. The dominant of Chlorophyta and Cyanophyta followed by diatoms. The dominate species among non-diatoms were, ***Oscillatoria***, ***Pedistrum***, ***Oedogonium***, ***Cladophora***and ***Cosmarium***. Out of 23 fungal species belongs to 17 fungal genera were isolated. ***Trichoderma*** sp. was most frequent species, ***Aspergillus*** **spp.** followed by ***Penicillium*** **spp**. and ***Eurotium*** **spp.**

**Keywords:** Phycology, Mycology, sand mine pond, Kalak sub district.

# دراسة تداخل الطحالب والفطريات في البرك الناتجة من مقالع الرمل والحصو في ناحية الكلك- دهوك، العراق

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## الخلاصة

أجريت الدراسة الحالية للتحرى عن الفطريات و الطحالب في البرك الاصطناعية المفتوحة المستعملة لانتاج الرمال في ناحية كلك ، مدينة دهوك، العراق. بالاضافه لدراسة الخصائص الفيزياوية و الكيمياوية للمياه وذلك لغرض لقياس درجة حرارة الماء، العكورة، الاس الهيدروجيني، التوصيل الكهربائية ،النترات ،النتريت، الأمونيا، الفوسفات، الأوكسجين المذاب والاحتياج البايوكيمياوي للاوكسجين لمدة ستة أشهر من يوليو إلى ديسمبر عام 2015، جمعت عينات من المياه شهريا. وأظهرت النتائج أن ستين نوع تم تحديدها في العينات التي تم جمعها خلال فترة الدراسة وهم ينتمون إلى الطحالب الخضر المزرقة (18 نوع) 30 % ، الطحالب الخضر (20 نوع ) وبنسبة تكرار 33.3 %، الطحالب اليوغلينية (نوعان) وبنسبة تكرار 3.4% ، والديتومات (20 نوع) وبنسبة تكرار 33.3% من محتوى الكلي للطحالب. ووفقا لقانون شانون-وينر المعني بالتنوع الحيوي حيث تباينت النسب بين مايلي(2.053- 3.895 بيت/اند)، حيث أكبر تنوع حيوي سجل في البركة الثالثة وشهر تموز.وبالنسبة لدليل جاكرد للتشابه بين الانواع، أعلى نسبة تشابه بين مجتمعات الطحالب لوحظ بين بين البركة الثانية والرابعة حيث وصل الى 32% .الدايتومات أكثر المجموعات التي تم ملاحظتها بالنسبة للطحالب في كل البرك التي تم دراستها ، حيث تمثلت بالانواع التالية *Cyclotella, Navicula, Syndra* and *Cymbella* ، والتي هي الاكثر تكرارا وتواجدا بالنسبة لبقية الطحالب. أظهرت الدياتومات أفضل معدلات النمو من خلال هذه الدراسة. بالنسبة لسيادة الطحالب الخضر والخضر المزرقة تاتي بعد الديتومات.أن الانواع السائدة لغير الدايتومات تمثلت بالانواع الاتية *Oscillatoria, Pedistrum,*

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*Oedogonium*, *Cladophora*and *Cosmarium*. من أصل 23 نوع من الفطريات تم عزل 17 جنسا . *Trichoderma*
sp. هو من أكثر الأنواع الأكثر شيوعا ثم *Aspergillus* spp. تليها *Penicillium* spp. وأخيرا *Eurotium* spp.
**كلمات مفتاحية**: الفطريات، الطحالب، البرك الاصطناعية المفتوحة، ناحية كلك.

## Introduction

During few decades, gravel- and sand-pit ponds have been created as a consequence of quarrying, especially in river flood plains (1). Most of these ponds are isolated water-bodies that receive mainly fed by groundwater and in wet months from rainfall (2). Due to their location in the riverine transitional zones they are often connected to rivers or channels, which greatly affected their hydrology and community structures (3). Algae represent the important nutritive base and have a significant effect on the biological productivity of a water body and on the properties of water quality such as color, smell, taste, dissolved oxygen, turbidity (4 and 5). Algae particularly diatoms are generally accepted as one of the most suitable bio-indicators of aquatic ecosystem for water quality monitoring and organic pollution (6). Specific algae grows in specific environments and therefore, their distribution pattern, periodicity and productivity are different vary from water to water body. Surveys of phytoplankton species composition in relation to habitat conditions are the baselines for the understanding of ecosystem functioning (7). Aquatic fungi play an important role in the cycling of carbon, nutrients and energy fluxes. The degradation of litter plant and animal residues is carried out by a number of poorly known groups within the phyla Chytridiomycota, yeasts, and hyphomycete lineages of Ascomycetes (8). Sediment aquatic fungi represent a significant component of the benthic microbial biomass in reservoirs, and these organisms are a vital biological force in regulating water quality through decomposition of organically bound C and N deposited on the bottom (9). Due to their valuable services in the ecosystem, changes in fungal assemblages could provide insight into the physicochemical assessment of river water quality and ecosystem health (10). The increased variations of the physical and chemical factors which in turn disturbs the biology of the water body and results in ecological imbalance and act directly on the growth of the algae and other microorganisms. Although, the composition of algal community has been changed little in the past 10 years especially, Cyanophyta because they are extremely very stress to environmental conditions (11). Local and seasonal variations of algae in different aquatic systems in northern part of Iraq are well studied by many researchers (12, 13, 14 and 15). In the Kurdistan region of Iraq, a many studies have been conducted on algae in a different freshwater ecosystem. The aim of this study was to investigate composition, abundance, distribution, similarity and diversity of algae (as producers) and fungi (as decomposer) in different gravel and sand mine ponds.

## Materials and Methods

### Description of the study area

Khabat sub district is far about 37 km from west of Erbil city located on the main road between Erbil and Mosul city. Khabat sub district located on the Great Zab River, the area is characterized by agricultural, tourism and production of raw construction material from many sand mine established along Greater Zab River banks. The study has been carried out in five neighboring ponds created as a result of sand mining with hydraulic dredging, approximately (150- 200 m apart) from the main course of the Greater Zab River near Gahatli village (Figure 1). The depth of these excavation open sand mine pits ranged between 5- 12 meters. All ponds have no inlet or outlet connections to the river, and are mainly fed by groundwater from the same source (from river and rainfall in wet months). The selected ponds were at the end of the excavation phase, when these artificial ponds become hydrologically mature, in order to known the colonization patterns during the excavation period.

**Sample collection**

Monthly surface water samples were taken from two selected station for the period of July to December 2015. Water temperature, EC and pH were measured in the field by using (pH-EC meter, HI 9812, Hanna instrument), while, turbidity, dissolved oxygen, biochemical oxygen demand, nitrate, ammonium and phosphate were estimated by standard procedures according to (16). Identification of algae was carried out using compound microscope model, Olympus in accordance to the available reference identification text books (17, 18, 19 and 20). The fungi were isolated from the pond water samples monthly during 6 months, by using dilution method, two types of culture media were used for isolation of fungi Potato dextrose agar (PDA) and Sabouraud's dextrose agar (SDA) supplemented with chloramphenicol (50 mg/l). While for the isolation of fungi from soil sediment made by dilution method, a dilution of $10^{-3}$ was chosen for the estimation of the fungal total count. After observing the growth under a stereoscopic binocular microscope it was cultured on SDA supplemented with chloramphenicol (50 mg/l) (21).


**Figure (1) Maps Shows A: Northern part of Iraq, B: Sampling artificial sand mine ponds on Greater Zab River bank (From Google earth).**

## Results and Discussion

**Physico- chemical properties:**

Water temperature values of the studied sites ranged from 19 ºC to 24ºC recorded in ponds 1 and 3 respectively (Table 1). This variation in temperature may be attributed to nature of the area and the time of samples collection, this result was similar to studies done by (14 and 15). In this survey, the turbidity value ranged from 1.0 to 36.0 NTU, this variation may be due to erosion, algal growth or other anthropogenic activities around ponds. (22) indicated that the effects is directly related to extraction and to changes in geomorphology include increased sedimentation, turbidity, and bank full widths. In general this result comes in accordance with (23). Generally, pH value of the most studied ponds is similar and it ranged from 7.2- 7.5, this return to the geology formation and the catchment area of the ponds which characterized by alkaline status (24). This found to be true for artificial open sand mine ponds in Kalak subdistrict in the present work. Similar observations observed by (13 and 25). Conductivity levels of the studied ponds water samples ranged from 347.8 to 592.4 µS.cm$^{-1}$. The variations in EC values of the water depend on pH, temperature, geological origin, and the content of the ionic salts such as calcium, magnesium, sulfur, and other ions (16).

**Table (1) Some water quality characteristics for sand mine ponds, data represented as minimum and maximum values.**

| Variables | Pond 1 | Pond 2 | Pond 3 | Pond 4 | Pond 5 |
|---|---|---|---|---|---|
| Water temperature (ºC) | 19- 20 | 21- 22 | 23- 24 | 22.5- 23.5 | 20- 21 |
| Turbidity (NTU) | 12- 27 | 22- 36 | 2.5- 10 | 1- 14 | 8- 22 |
| pH | 7.2- 7.3 | 7.3- 7.4 | 7.4- 7.5 | 7.4- 7.5 | 7.3- 7.4 |
| EC (µs.cm$^{-1}$) | 332- 349 | 453- 470 | 560- 557 | 406- 423 | 535- 552 |
| $NO_3$(mg.l$^{-1}$) | 1- 1.5 | 1.69- 1.85 | 2.29- 2.52 | 1.98- 2.14 | 3.16- 3.29 |
| $NH_4$(µg.l$^{-1}$) | 7- 7.7 | 9.1- 9.8 | 6.9- 7.7 | 5.6- 6.4 | 6.8- 7.5 |
| $PO_4$(µg.l$^{-1}$) | 5.1- 7 | 5.8- 7.2 | 3.4- 5.8 | 3-4.3 | 3.6-5 |
| DO(mg.l$^{-1}$) | 6.2- 6.6 | 4-4.2 | 5.4- 5.8 | 5.8- 6.1 | 5.1- 5.4 |
| $BOD_5$(mg.l$^{-1}$) | 5- 5.2 | 8.7- 8.9 | 3.8- 4.1 | 2.3- 3.6 | 4.1- 4.4 |

Surface water samples of studied area showed nitrate range between (1-3.29 mg.l$^{-1}$). This variation in nitrate levels depends on several factors such as the fertility of soil in the drainage basin, domestic sewage, mixing and rainfall (26). Concentration of ammonium in this survey varied from( 5.6-9.8 µg/L),this depending upon the quantity of oxygen, pH and water temperature or decomposition of organic matter and urea by microbial action in addition to other factors such as fertilizer and rainfall (27). The variation of phosphate concentration during this study may be connected to phytoplankton activities, and allochthonous inputs (27). Both nitrogen ($NO_3$ and $NH_4$) and phosphate content is very important for algal growth, the variation of these nutrients is coincided by algal fluctuation. Dissolved oxygen in surface pond samples was high during the entire sampling period in Kalak subdistrict was ranged from(4.0-6.6mg.l$^{-1}$), this fluctuation might be attributed to several reasons; the area of clear water exposed to the air, the circulation of water within system, and the amount of oxygen generated and used by the organism present (28). Generally, pond surface water was containing low organic matter which was shown from low values of $BOD_5$ 2.3-8.9 mg.l$^{-1}$ recorded during the studied period, this may due to nature and concentration of the organic substances in the water to be broken down, nature, number and adaptation of the microorganisms, the nature and quantity of nutrients for the microorganisms, temperature, and the effect of light (27), similar results by (13, 14 and 15) was mentioned.

**Phycological composition:**

The algae play an important role in aquatic ecosystems, as the primary producers, thus they are the first link in the food chain, and often cause nuisance condition (27). (28 and 29) stated that the algae are considered to be excellent indicators of water quality, and certain species are capable of indicating water conditions. During the present investigations, 60 species of algae were identified and classified into four following classes, of which 22 were Bacillariophyceae, 20 to Chlorophyceae, 20 belonging to Cyanophyceae and 2 to Euglenophyceae (Table 2). According to the present results, it seems that diatoms were more abundant than other groups. *Cyclotella*, *Fragilaria* and *Syndra* were more significant than other diatoms and algae since they were recorded in communities with larger populations (Table 3). These findings may indicate that, these diatoms have a larger ecological tolerance against the possible changes of conditions in the ponds across the year. The best growth period for diatoms in sand mine ponds was autumn months, while lower cell numbers was recorded during summer months (Table 4). Water temperature and light have been reported as the most effective factors on seasonal developments of algae; however, other factors also affected the number of algae (30). The role of zooplankton in shaping phytoplankton communities is well known, especially cladocerans (the active ingested filter feeder on phytoplankton and other microorganisms). The possibilities of filtering activity of herbivorous zooplankton had a major impact on phytoplankton community structure (31 and 32). Chlorophyta and Cyanophyta were other important algal groups in the ponds. Although green algae have been recorded in samples in all studied months, in which they were richer in species composition in summer months when diatoms were represented with less species. *Pedistrum* (3 taxa) and *Scenedesmus* (2 taxa) were the richest genera in terms of species number. Although *Closterium* and *Cosmarium* were represented with only one species, they were present in the ponds almost throughout the study period. *Cosmarium* appeared in the ponds only in summer months. Euglena has been the most important genus in Euglenophyta as being represented with 1 taxa. The appearance in very low number and in the sites during this survey indicate that the water is poorest with organic matter content (33). *Oscillatoria* was the richest blue-green algal genus in species composition. The occurrence of the blue-green algae, especially *Merismopedia*, in summer and autumn was noticeable, thus supporting the Round view's that the blue-green algae *Merismopedia, Anabaena, Lyngbya* and *Oscillatoria* grow better and are more common especially in summer months (34).

**Table (2) List of algal species recorded during the studied period**

| | | | |
|---|---|---|---|
| **Division: Cyanophyta** | **Division: Chlorophyta** | **Family: Zygnemataceae** | **4- *N.acicularis Smith*** |
| **Class: Cyanophyceae** | **Class: Chlorophyceae** | ***Spirogyra* Link 1820** | **Order: Cymbellales** |
| **Order: Chroococcales** | ***Order:Volvocales*** | **15- *S. brunnea* Czurda** | **Family: Cymbellaceae** |

| | | | |
|---|---|---|---|
| **Family: Chroococcaceae** | **Family: Volvocaceae** | **16- *S. rivularis* Hass** | ***Amphora* Ehr 1840** |
| ***Chroococcus* Naegeli 1949** | **Eudorina Ehrenberg 1835** | **Order: Zygnematales** | **5- *A. ovalis* Kuetz** |
| **1- *C. minor* Ktz** | **1- *E. Elegans* Ehr** | **Family: Desmidiaceae** | ***Cymbella* Agardh 1830** |
| ***2- C. minutus* Ehr** | ***Gonium* Morum 1930** | ***Closterium* Ehr 1845** | **6- *C. affinis* Kuetz** |
| ***Merismopedia* Meyen 1889** | **2- *G. pectorale* Nael** | **17- *C. acerosum Schrank*** | **7- *C. tumida* Van** |
| **3- *M.convulata Heyen*** | ***Pandorina* Bory 1824** | ***Cosmarium* Lund 1890** | **8- *C. turgida* Kuetz** |
| **4- *M. elegans* A Brun** | **3- *P. morum* Bory** | **18- *C. laeva* Ktz** | **Order: Naviculales** |
| **5- *M. glauca* Ktz** | **Order: Chlorococcales** | ***Staurastrum* Ralfs 1848** | **Family: Naviculaceae** |
| **6- *M. minima* Heyen** | **Family: Hydrodictyaceae** | **19- *S. paradoxum* West** | ***Navicula* Bory 1824** |
| **7- *M. punctata Ehr*** | ***Pedistrum* Meyen 1829** | **20- *S. tetracerum* Nord** | **9- *N. bacillum* Ehr** |
| **Order: Oscillatoriales** | ***4- P. boryanum* Turp** | **Division: Euglenophyta** | **10- *N. cryptocephala* Kutz** |
| **Family: Oscilatoriaceaea** | **5- *P. duplex* Meyen** | **Class: Euglenophyceae** | **11- *N. cuspidata* Kuetz** |
| ***Lyngbya Agardh,* (1892)** | **6- *P. simplex* Lemm** | ***Order: Euglenales*** | **Family: Pleurosigmataceae** |
| **8- *L. limnetica Lemm*** | **Order: Sphaeropleales** | ***Family: Euglenacea*** | ***Grysosigma* Hass 1895** |
| ***Oscillatoria* Vaucher 1892** | **Family: Scendesmedaceae** | **Euglena Ehrenberg 1833** | **12- *G. acuminatum* Kutz** |
| **9- *O. anomala* Gomont** | ***Scenedemus* Kuetz 1890** | **1- *E. elastica* Pres** | **13- *G. Scalproides* Cleve** |
| **10- *O. angustissima*Ehr** | ***7- S. acuminatus Chodat*** | **2- *E.gracilis* Klebs** | **Order: Fragilariales** |
| **11- *O. lacustris*Ehr** | ***8- S. arcuatus Turp*** | **Division: Heterokontophyta** | **Family: Fragilariaceae** |
| **12- *O. limnetica* Roth** | ***9- S. bijuga Kich*** | **Class: Bacillariophyceae** | ***Fragilaria* Lyngb 1819** |
| **13- *O. tenuis*Agardh** | **10- *S. hystrix* Lagerhim** | **Order: Eupodiscales** | **14- *F. construens* Ehr** |
| **Family: Phormidiaceae** | **11- *S. quadricauda* Turp** | **Family: Cosinodiscaceae** | **15- *F. crotonensis* Ehr** |
| ***Spirulina* Tupin** | **Order: Cladophorales** | ***Cyclotella* Kuetz 1838** | ***Synedra* Ehr 1832** |
| **14- *S.laxissima* Ehr** | **Family: Cladophoraceae** | ***1- C. ocellata* Pant** | **16- *S. acus* Kuetz** |
| **15- *S.subsalsa* Gomont** | ***Cladophora* Ktz 1845** | **2- *C. meneghini* Ehr** | **17- *S. ulna* Ehr** |
| **Order: Nostocales** | ***12- C. glomerata* Ktz** | **Order: Achnanthales** | **Order: Surirellales** |

| | | | |
|---|---|---|---|
| **Family: Nostocaceae** | **13- *C. profunda* Ehr** | **Family: Achnanthaceae** | **Family: Surirellaceae** |
| ***Anabaena* Bory 1822** | **Order: Oedogoniales** | ***Cocconeis* Ehr1838** | ***Cymatopleura* Erh 1890** |
| **16- *A. affinis* Brun** | **Family: Oedogoniacaea** | **3- *C. plancentula* Ehr** | **18- *C. solea* Ehr** |
| ***17- A. anomala* Ehr** | ***Oedogonium* Link 1820** | **Order: Bacillariales** | ***Surirella* Turpin 1828** |
| ***Nostoc* Tupin 1890** | **14- *O. gracilius* Link** | **Family: Bacillariaceae** | **19- *S. angusta* Ktz** |
| **18- *N.muscorum* Brun** | **Order: Zygnematales** | ***Nitzschia* Hassal 1845** | **20- *S.ovata* Breb** |

Blue-green algae play an important role not only with their property of growing very fast but also with their effects on aquatic environment and on other organisms in ponds by give out various metabolic substances in water (15, 25 and 34).

**Table (3) Number of algal species recorded in different artificial ponds during the studied period.**

| Algal species | Sand mine ponds | | | | | Algal species | Sand mine ponds | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | | 1 | 2 | 3 | 4 | 5 |
| **1- *Chroococcus minor* Ktz** | | 3 | 1 | | | **31- *C. profunda* Ehr** | | 2 | 20 | | 2 |
| **2- *C. minutus* Ehr** | | 1 | | | 2 | **32- *Oedogonium gracilius* Link** | 1 | 31 | 1 | 32 | 6 |
| **3- *Merismopedia convulata* Heyen** | | 1 | | | | **33- *Spirogyra brunnea* Czurda** | 51 | | | 3 | |
| **4- *M. elegans* A Brun** | | | 3 | | | **34- *S. rivularis* Hass** | 5 | | | 2 | |
| **5- *M. glauca* Ktz** | | | 1 | | 2 | **35- *Closterium acerosum* Schrank** | | | 1 | 1 | |
| **6- *M. minima* Heyen** | 18 | 1 | | | 2 | **36- *Cosmarium laeva* Ktz** | 6 | 17 | 41 | 5 | 10 |
| **7- *M. punctata* Ehr** | | | | | 2 | **37- *Staurastrum paradoxum* West** | 8 | 3 | | | |
| **8- *Lyngbya limnetica* Lemm** | | | | 3 | | **38- *S. tetracerum* Nord** | 1 | 21 | | 2 | |
| **9- *Oscillatoria acutissima* Ehr** | | | 2 | | | **39- *E. elastica* Pres** | 2 | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10- *O. angustissima* Ehr | 43 | 1 | | | | 40- *E.gracilis* Klebs | 1 | 1 | | | |
| 11- *O. lacustris* Ehr | | | | 2 | | 41- *Cyclotella ocellata* Pant | 34 | 14 | 2 | 11 | |
| 12- *O. limnetica* Roth | 42 | 2 | 10 | 3 | 2 | 42- *C. meneghini* Ehr | 3 | 1 | 7 | | |
| 13- *O. tenuis* Agardh | 48 | 3 | 33 | 4 | 7 | 43- *Cocconeis plancentula* Ehr | | | 26 | | 3 |
| 14- *Spirulina laxissima* Ehr | 40 | | | 2 | | 44- *Nitzschia acicularis Smith* | 1 | | 3 | | 2 |
| 15- *S.subsalsa* Gomont | 30 | | | | | 45- *Amphora ovalis* Kuetz | | 1 | 2 | | 6 |
| 16- *Anabaena affinis* Brun | 16 | 2 | | | | 46- *Cymbella affinis* Kuetz | | | 28 | 1 | 6 |
| 17- *A. anomala* Ehr | 6 | 2 | | | | 47- *C. tumida* Van | | | 14 | | |
| 18- *Nostoc muscorum* Turp | 3 | 1 | | | | 48- *C. turgida* Kuetz | | | 3 | | |
| 19- *Eudorina Elegans* Ehr | | | | 2 | | 49- *Navicula bacillum* Ehr | | 1 | 2 | | 2 |
| 20- *Gonium pectorale* Nael | | | | 3 | | 50- *N. cryptocephala* Kutz | 51 | 11 | 23 | 4 | 10 |
| 21- *Pandorina morum* Bory | | | | 5 | | 51- *N. cuspidata* Kuetz | | 1 | 1 | | |
| 22- *Pedistrum boryanum* Turp | | | 2 | 3 | | 52- *Grysosigma acuminatum* Kutz | | 2 | 3 | 1 | |
| 23- *P. duplex* Meyen | | 3 | 2 | 2 | 1 | 53- *G. Scalproides* Cleve | | 1 | 1 | 1 | |
| 24- *P. simplex* Lemm | 5 | 4 | | 10 | 1 | 54- *Fragilaria construens* Ehr | 15 | | 5 | 10 | |
| 25- *Scenedemus acuminatus* Chodat | 1 | 3 | | | | 55- *F. crotonensis* Ehr | 50 | | 10 | | |
| 26- *S. arcuatus* Turp | 1 | | | | | 56- *Synedra acus* Kuetz | 41 | 1 | | | |
| 27- *S. bijuga* Kich | 30 | | 6 | | | 57- *S. ulna* Ehr | 43 | | 14 | 6 | 3 |
| 28- *S. hystrix* Lagerhim | | | 15 | | | 58- *Cymatopleura solea* Ehr | | | 1 | | 1 |
| 29- *S. quadricauda* Turp | | 1 | 1 | | | 59- *Surirella angusta* Ktz | | | | 1 | |
| 30- *Cladophora glomerata* Ktz | | 5 | 80 | 8 | 10 | 60- *S. ovata* Breb | | | | 1 | |

**Fungal composition:**

Table (5) show the identity and total CFU (Colony forming Unite) of fungi isolated monthly during studied period from sand mine ponds water, different fungal genera were isolated from ponds, the total of (68 CFU/ml of water), the highest rate of fungi was isolated from pond 3, followed by, pond 1, while the lowest rate of fungi was isolated from pond 4.

**Table (4) Number of algal species recorded in different months during the studied period.**

| Algal species | Months | | | | | | Algal species | Months | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J. | A. | S. | O. | N. | D. | | J. | A. | S. | O. | N. | D. |
| 1- *Chroococcus minor* Ktz | | | | 3 | 1 | | 31- *C. profunda* Ehr | | | | 16 | | 8 |
| 2- *C. minutus* Ehr | | 1 | 2 | | | | 32- *Oedogonium gracilius* Link | | 2 | 3 | | 5 | 61 |
| 3-*Merismopedia convulata* Heyen | | | 1 | | | | 33- *Spirogyra brunnea* Czurda | 53 | 1 | | | | |
| 4- *M. elegans* A Brun | | | | 1 | 2 | | 34- *S. rivularis* Hass | 6 | | 1 | | | |
| 5- *M. glauca* Ktz | 2 | | | 1 | | | 35- *Closterium acerosum* Schrank | 1 | | | | 1 | |
| 6- *M. minima* Heyen | 21 | | | | | | 36- *Cosmarium laeva* Ktz | 28 | 16 | 25 | 2 | 11 | 1 |
| 7- *M. punctata* Ehr | 2 | | | | | | 37- *Staurastrum paradoxum* West | | 2 | 9 | | | |
| 8- *Lyngbya limnetica* Lemm | 3 | | | | | | 38- *S. tetracerum* Nord | 20 | 4 | | | | 2 |
| 9- *Oscillatoria acutissima* Ehr | | | | | 2 | | 39- *E. elastica* Pres | | | | 2 | | |
| 10- *O. angustissima* Ehr | 44 | | | | | | 40- *E. gracilis* Klebs | 1 | | | 1 | | |
| 11- *O. lacustris* Ehr | 1 | | | | | | 41- *Cyclotella ocellatan*Pant | 3 | 17 | 17 | 3 | 16 | 1 |
| 12- *O. limnetica* Roth | 44 | 1 | | 1 | | | 42- *C. meneghini* Ehr | | 5 | 5 | 2 | 1 | |
| 13- *O. tenuis*Agardh | 53 | 6 | 2 | 4 | 10 | 21 | 43- *Cocconeis plancentula* Ehr | 3 | | 1 | 10 | 5 | 10 |
| 14- *Spirulina laxissima* Ehr | 42 | | 1 | | | | 44- *Nitzschia acicularis Smith* | 4 | | | 1 | 1 | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15- *S.subsalsa* Gomont | 30 | | | | | | 45- *Amphora ovalis* Kuetz | 7 | 1 | | | 1 | |
| 16- *Anabaena affinis* Brun | 16 | | | 2 | | | 46- *Cymbella affinis* Kuetz | 8 | 2 | | 10 | 5 | 10 |
| 17- *A. anomala* Ehr | 6 | | | 2 | | | 47- *C. tumida* Van | 1 | | | 5 | 3 | 5 |
| 18- *Nostoc muscorum* Turp | 3 | | | 1 | | | 48- *C. turgida* Kuetz | 3 | | | | | |
| 19- *Eudorina Elegans* Ehr | 1 | 1 | | | | | 49- *Navicula bacillum* Ehr | 4 | 1 | | | | |
| 20- *Gonium pectorale* Nael | 2 | 1 | | | | | 50- *N. cryptocephala* Kutz | 62 | | 1 | 13 | 6 | 18 |
| 21- *Pandorina morum* Bory | 4 | 1 | | | | | 51- *N. cuspidata* Kuetz | 2 | | | | | |
| 22- *Pedistrumboryanum* Turp | | 1 | 1 | 1 | 2 | | 52- *Grysosigma acuminatum* Kutz | 3 | | | | 2 | |
| 23- *P. duplex* Meyen | 1 | 1 | 4 | 1 | 1 | | 53- *G. Scalproides* Cleve | 1 | | | | | 1 |
| 24- *P. simplex* Lemm | 1 | 12 | 3 | 1 | 5 | | 54- *Fragilaria construens* Ehr | 15 | | | 15 | | |
| 25- *Scenedemus acuminatus* Chodat | | 1 | 3 | | | | 55- *F. crotonensis* Ehr | 50 | | | 10 | | |
| 26- *S. arcuatus* Turp | | | 1 | | | | 56- *Synedra acus* Kuetz | 42 | | | | | |
| 27- *S. bijuga* Kich | 30 | | | 1 | | 5 | 57- *S. ulna* Ehr | 47 | 4 | | 10 | 3 | 6 |
| 28- *S. hystrix* Lagerhim | 4 | | | 1 | 1 | 10 | 58- *Cymatopleura solea* Ehr | 1 | | | | | 1 |
| 29- *S. quadricauda* Turp | | | | | 1 | 1 | 59- *Surirella angusta* Ktz | 1 | | | | | |
| 30- *Cladophora glomerata* Ktz | | | | 48 | 20 | 40 | 60- *S. ovata* Breb | 1 | | | | | |

The highest rate of fungi (mold) isolated from ponds water were: *Trichoderma* sp., followed by *Aspergillus* sp. which was 7 CFU/ml of water, the other isolated fungi were *Aspergillus niger, Penicillium* sp., *Emericella* sp., *Penicillium citrinum*, *Penicillium janthinellum*, *Aspergillus flavus* and *Alternaria* sp. were (5, 5, 4, 4, 4, 3 and 1 CFU/ml of water) respectively. While the isolated yeast from water samples during this study were *Rhodotorula glutinis* followed by *Cryptococcus albidus* which were 20 and 6 CFU/ml respectively. It may reveals the human activities (Tourist and waste disposal) as bacterial population was estimated in higher concentration from water samples collected from the bank of the ponds (35). Surface waters tend to contain larger amounts of organic matter, which both provide nutrients and a substrate for fungal growth. Differences in acidity and calcium content may also account for some of the variation (36). This result is agreement with that found by (37 and 38) who isolated numbers of yeasts and filamentous fungi in pond waters as *Aspergillus niger*, *Trichoderma* sp., *Acremonium* sp., *A. tamarii* and *Rhizpous* sp., except for November, when adverse conditions of undetermined nature reduced the fungal populations. (39) reported that the occurrence of *Mucor* sp. in earthen ponds could be attributed to the fact that the earthen ponds was a more conducive environment for their growth and proliferation due to the presence of soil and plants in the earthen ponds. The waters of streams, ponds, lakes, and estuaries always contain spores of many kinds of fungi. However, total fungal count was high during October while the lowest rate of isolated fungi was at July (7.6 $CFU.ml^{-1}$), this may be related to human activities and waste disposal around ponds bank.

**Table (5) Total fungi isolated from water of sand mine ponds during studied period**

| Fungi | Sand mine ponds | | | | | CFU/ml |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| ***Alternaria* sp.** | | | | | 1 | 1 |
| ***Aspergillus flavus*** | 1 | | 2 | | | 3 |
| ***Aspergillus niger*** | 1 | 1 | 2 | | 1 | 5 |
| ***Aspergillus* sp.** | 2 | | 3 | 1 | 1 | 7 |
| ***Emericella* sp.** | 1 | | 3 | | | 4 |
| ***Penicillium citrinum*** | 2 | | | 2 | | 4 |
| ***Penicillium*** | 1 | | 1 | | 2 | 4 |
| ***Penicillium* sp.** | | 2 | 2 | | 1 | 5 |
| ***Trichoderma* sp.** | 2 | 1 | 3 | 2 | 1 | 9 |
| ***Cryptococcus albidus*** | | | 5 | | 1 | 6 |
| ***Rhodotorula glutinis*** | 2 | 4 | 14 | | | 20 |
| **Total** | 12 | 8 | 35 | 5 | 8 | 68 |

**Table (6) Total fungi isolated from sediment of sand mine ponds during studied period**

| Fungi | Sand mine ponds | | | | | . |
|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | |
| ***Absidia*** **sp.** | | 1 | | 1 | | 2 |
| ***Alternaria*** **sp.** | 1 | | 1 | | 1 | 3 |
| ***Aspergillus flavus*** | 1 | 1 | 2 | 1 | | 5 |
| ***Aspergillus fumigatus*** | | | 1 | | | 1 |
| ***Aspergillus niger*** | 2 | 1 | 3 | 2 | | 8 |
| ***Aspergillus ochraceus*** | 1 | | | 1 | | 2 |
| ***Aspergillus*** **sp.** | 1 | | 3 | | 1 | 5 |
| ***Cladosporium*** **sp.** | 1 | 1 | | 1 | | 3 |
| ***Drechslera*** **sp.** | | 2 | | | 1 | 3 |
| ***Emericella*** **sp.** | 1 | | | | 3 | 4 |
| ***Eurotium*** **sp.** | 1 | | | | | 1 |
| ***Mucor sp.*** | 1 | | 2 | | 1 | 4 |
| **Mycelia sterilia** | | 1 | 3 | | 2 | 6 |
| ***Penicillium citrinum*** | 1 | | | 2 | | 3 |
| ***Penicillium janthinellum*** | | 2 | 2 | | 2 | 6 |
| ***Penicillium*** **sp.** | 1 | 1 | | 2 | | 4 |
| ***Rhizopus*** **sp.** | | 2 | 4 | 1 | 1 | 8 |
| ***Stachybotrys*** | 4 | 2 | | | 2 | 8 |
| ***Stemphylium*** **sp.** | | 1 | | 1 | | 2 |
| ***Trichoderma*** **sp.** | 5 | | 5 | 3 | 3 | 16 |
| ***Candida albicans*** | 1 | | 1 | | | 2 |
| ***Cryptococcus albidus*** | | | 3 | 1 | | 4 |
| ***Rhodotorula glutinis*** | 3 | 5 | 9 | | 6 | 23 |
| **Total** | 25 | 20 | 39 | 16 | 23 | 123 |

Table (6) show the identity and total CFU (Colony forming Unite) of fungi isolated from pond sediment, the total of (123 x $10^3$ CFU/gm. of sediment) fungi was isolated, the fungi isolated from different sites as follows: (ponds: 3, 1, 5, 2 and 4) were (39, 25, 23, 20 and 16 CFU/gm. of sediment) respectively; the highest rate of fungi isolated from pond water were: *Trichoderma* sp. (16 x $10^3$ CFU/gm. of sediment), followed by *Aspergillus niger*, *Rhizopus* sp. and *Stemphylium* sp. each were (8 x $10^3$ CFU/gm. of sediment), the other most isolated fungi were *Pencillium janthinellum*, *Mycelia sterilia*, *Aspergilus flavus*, *Aspergillus* spp., were (6, 6, 5, and 5 x $10^3$ CFU/gm of sediment) respectively. (40) elucidate that Sediments serve as seedbank for resting spores of not only aquatic fungi but also of various terrestrial species. In the upper sediment layers, the response to antibiotic addition suggested a possible heterotrophic fungal activity in this habitat. While the isolated yeast from the present study were *Rhodotorula glutinis* followed by *Cryptococcus albidus* and *Candida albicans* which were 23, 4 and 2 x $10^3$ CFU/gm. of sediment respectively. These results comes with that found by (41, 42, 43 and 44) who reported that the dominant isolated filamentous fungi in raw water were *Aspergillus* spp., followed by *Penicillium* spp. and *Cladosporium* spp., yeasts were *Cryptococcus curvatus*, *Candida*, *Rhodotorula mucilaginosa* and *Sacccharomyces cerevisiae* relatively.

**Community structure and biodiversity:**

Our results show that while some species could tolerate and thrive at certain levels of some physicochemical parameters, others showed sensitivity to the same parameters at these levels. The environmental requirements of different species differ, hence defining how they respond to variations in these factors. Our study has shown that the occurrence and abundance of green algae species in these ponds are closely linked to their physicochemical characteristics. In addition, most parameters analyzed showed specific temporary and/or spatial variation. Monthly variations of phytoplankton showed the maximum density in summer months which indicates that the temperature of these months played an important role in increasing the population of phytoplankton. Similar observations were made by (45) and the dominance of various phytoplankton species was less in monsoon months. This may be due to dilution of water on account of rain as well as greater water movement and flooding due to heavy rain. Generally, Shannon's values were reached three or more during entire sampling period. This probably due to, that phytoplankton communities in sand mine ponds, which were consist of a diverse assemblages of species influenced by a wide range of environmental parameters, such as; temperature, light, and nutrients (46). As demonstrated by (47 and 48), predominance of one or two species results in low diversity, while high values occur when populations of several species each from moderate proportions of the total counts. The higher values in Shannon's index were recorded during July 2015, while the lower ones were calculated during September 2015 (Table 7). Statements that of (47) seem to confirm the present results, however, as stated by same authors, on a seasonal basis, particularly in temperate waters, diversity tends to increase in hot months and below in cold months. On the other hand as outlined by (48), in perturbed waters by man activities such as use of fertilizers, rapid change in species composition which in turn shifts diversity values would be expected. On the other hand, fungal diversity in sediment was higher than in water sample in all studied ponds. High species occurrence, isolation and diversity index (H`) and counting in sediments than in water, may be related to availability of organic detritus on sediments that supply a good sources of food and habitat for these decomposers (49). It seems quite clear that the availability of organic matter, pH and water temperature play important role in the existence and propagation of aquatic fungi in lakes (50). Same phenomenon was observed by (42) during their study on Duhok impoundment. Ponds 1 and 3 showed more species diversity compare to other ponds, this may return to nature of ponds and physico- chemical characteristics.

**Table (7) Shannon-Weiner diversity (H) recorded during the study period**

| Sites | Pond 1 | Pond 2 | Pond 3 | Pond 4 | Pond 5 | Average |
|---|---|---|---|---|---|---|
| Algae in water | 2.908 | 2.053 | 3.895 | 2.639 | 2.673 | |
| Fungi in water | 2.202 | 1.213 | 1.868 | 1.054 | 1.906 | |
| Fungi in sediment | 2.487 | 2.316 | 2.363 | 2.306 | 2.200 | |

The similarity index provides a quantitatively based measurement for comparing two populations. The Jaccard similarity index often used to measure the species-diversity for the optimum size for natural protection (51). There are only slight differences as concerning the floristic affinities among the communities of the ponds. The values of Jaccard similarity index exhibit low values and uniformity: the maximum 32% found between ponds 2 and 4, minimum 9% being the joining level of pond 1 to the main aggregate (Table 8). While, for fungal composition, maximum similarity 70% and 60% found between pond 3 and other ponds 1 and 5.

This pattern is due to the location in chain of the ponds, namely pond 2 and 4 are the nearest ones receiving first the river water, and pond 1 is the most remote one alimented with the water after it flows through all other ponds. In ponds 2 and 4 occur most of the rheophilic elements detected for this wetland, by the contrary pond I is characterized by the occurrence of numerous typically lentic species., this variation of similarity between sites may be related to the pH, temperature, nutrient and other factors like climate, soil of the studied area that play important role to increase and decrease the diversity of each site during this survey (48).

**Table (8) Jaccard similarity (%) between studied sites**

| Algae | | | | | | Fungi | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Sites | 1 | 2 | 3 | 4 | | Sites | 1 | 2 | 3 | 4 |
| 2 | 22 | - | - | - | | 2 | 33 | - | - | - |
| 3 | 17 | 18 | - | - | | 3 | 70 | 36 | - | - |
| 4 | 19 | 32 | 15 | - | | 4 | 38 | 17 | 20 | - |
| 5 | 9 | 17 | 20 | 18 | | 5 | 36 | 38 | 60 | 25 |

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