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Phytoplankton Species Composition and Seasonal Variation at Wadi Al-Arab Dam Lake, Jordan

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Abstract: The composition of phytoplankton species thriving in Wadi Al-Arab Dam Reservoir, Jordan and their seasonal variation in relation to water ecology were studied between February 2001 and February 2002. A total of 75 species of phytoplankton were identified: *Bacillariophyceae* (diatoms) contributed with the highest number of taxa (39) followed by *Chlorophyceae* (23), *Cyanophyceae* (9), and *Dinophyceae* (4). Diatoms constituted 52% of the total phytoplankton flora of the reservoir and the most common species were *Synedra ulna, Cymbella affinis*, and *Cyclotella meneghiniana* with pennate and centric diatoms being the dominant species in May and October-November, respectively. Although Chlorophytes occurred most of the year, they contributed with less species to the total flora. During the summer, their occurrence was considerably reduced with dominant species of *Pediastrum, Scenedesmus*, and *Cosmarium*. *Cyanophyceae* dominated the phytoplankton population in summer and maintained high biomass. *Dinophyceae* was by far the most important group with *Peridinium* sp. as the most significant species thriving in the reservoir. *Peridinium* sp., *Peridinium cinctum*, with *Ceratium hirundinella*, and *Gymnodinium* sp. appeared occasionally in low numbers.

Key Words: Wadi Al-Arab Dam Lake, phytoplankton, seasonal variation

Ürdün'deki Wadi Al-Arab Barajındaki Fitoplankton Türleri Kompozisyonu ve Mevsimsel Değişiklikler

Özet: Ürdün'deki Wadi Al-Arap barajında yetişen fitoplankton türleri ve su ekolojisi ile ilişkisi Şubat 2001-2002 zamanları arasında çalışılmıştır. 75 farklı fitoplankton türü tanımlanmıştır: En fazla taksa ya sahip *Bacillariophyceae* (39) (diatome) grubunu *Chlorophyceae* (23), *Cyanophyceae* (9), ve *Dinophyceae* (4) takip etmiştir. Diatomeler barajdaki fitoplankton florasının % 52.0'sini oluşturur ve en yaygın türler *Synedra ulna, Cymbella affinis*, ve *Cyclotella meneghiniana*. Pinnat ve sentrik diatomeler Mayıs ve Ekim-Kasım`da dominant tür olmuştur. Her ne kadar Klorophytler yılın her zamanı olsalar da toplam floraya katkıları azdır. Fakat, klorofitler toplam fitoplankton biokütlesine ya da verimliliğe ve özellikle Mart ve Mayıs aylarında *Chlorella, Chlamydomonas*, ve *Staurastrum gracile* yaygın bulunduğu zamanlarda klorofil a konsantrasyonuna katkıda bulunurlar. Yazın bulunma sıklıkları baskın olan *Pediastrum, Scendesmus* ve *Cosmarium. Cyanophyceae* varlığı ile azalır ve yüksek biokütle oluşur. *Peridinuim* sp. ile barajdaki en önemli gruptur. *Peridinium* sp., *Peridinium cinctum*, ile *Ceratium hirundinella* ve *Gymnodinium* sp. nadir olarak çok az sayıda gözlenir. Barajdaki türlerdeki değişimler ve hücre sayısı bunların besinlerden ziyade diğer faktörlerden etkilendiğini göstermektedir. Çünkü bunlar bütün yıl boyunca yüksek konsantrasyonlarda bulunmaktadır.

Anahtar Sözcükler: Wadi Al-Arab baraj gölü, Fitoplankton, Mevsimsel değişi

Introduction

In the study of reservoir water quality, phytoplankton ecology, productivity, and species composition are of special importance as they play a prime role in the biological and chemical characteristics of natural water (1-3). Reservoir water quality and productivity are controlled to a large extent by the quantity and quality of external nutrient loading (4, 5). Algae are the dominant component of the primary producers in many water bodies, particularly in lakes. Therefore, species composition and community biomass are affected by the growth and loss rates of individual species that are determined by the availability of nutrients (6, 7).

Studying the composition of plankton species is also important in lakes and reservoirs as some species have significant role in determining water quality (8). Such species might produce unpleasant taste and odor, or may be toxic and harmful. Specific differences in nutrient

requirements, rates of nutrient uptake, and growth temperature preferences result in seasonal succession of dominance of different phytoplankton groups (9-13).

No long term studies of phytoplankton productivity and distribution were conducted in most Jordanian freshwater bodies. Therefore the present study concentrates on the biological parameters prevailed in the Wadi Al-Arab Lake as they have a large potential effect on water quality. This includes the phytoplankton microflora, thus a floristic list of the phytoplankton species thriving in the dam water and their seasonal variation are introduced.

Study site

Wadi Al-Arab Dam (Reservoir) is located in the northern part of the Jordan Valley, on the east bank of the Jordan Rift Valley, about 10 km south of Lake Tiberias, and 25 km from Irbid City. The reservoir water comes partially from the King Abdallah Canal and from precipitation. The reservoir water is used to irrigate about 3125 ha from Al Shuna to Al Baqura. It also serves as a drinking water source during the periods of water shortage by draining to King Abdallah Canal (14).

The principal features of Wadi Al-Arab Dam Reservoir are summarized as follows: reservoir catchment area is 262 km^2 with gross, effective, and dead storage capacity of 20.0, 16.9, and 3.1 million cubic meters, respectively. The estimated precipitation per year is 7000 mm^3 and the annual total discharge is 33 million cubic meters (15).

Materials and Methods

One sampling station was selected for investigation. The station represents the open water area and was located in the middle of the reservoir. One sample per month was collected from February 2001 to February 2002. Samples were taken from a depth of 20-30 cm below water surface using a 20 µm standard phytoplankton net (Hydrobios, Japan). Samples were preserved with formalin until the time of examination.

Species identification of non-diatom flora was made from formalin-fixed samples, using a Nikon photomicroscope (Nikon, Japan) according to appropriate keys and monographs given by Presscot (16) and Kromakova and Cronberg (17). Diatoms were identified as described by Gerloff et al. (18) and Krammer and Bertalot (19). Diatoms were first cleaned by boiling with 30% hydrogen peroxide and mounted in Naphrax (Award's Biology, USA). Photos of algae were taken with a Konica camera (Konica, Japan). Samples were preserved with Lugol's iodine for long term use.

Results and Discussion

Phytoplankton periodicity still remains as one of the most discussed topics of freshwater research, mainly because of many unresolved issues on phytoplankton ecology (20, 21). In Wadi Al-Arab reservoir, different modes of periodicity was seen which is in line the abundance of certain species and their turnover.

Phytoplankton composition and species diversity

A total of 75 species of phytoplankton were identified during the study period. A list of all species recorded with their abundance and distribution is given in Table 1. The most common and dominant species are shown in Table 2. As seen in the tables, *Bacillariophyceae* contributed with the highest number of taxa (39) followed by *Chlorophyceae* (23), *Cyanophyceae* (9), and *Dinophyceae* (4). Photos of the most common phytoplankton taxa are given in plates 1-7.

Bacillariophyceae

Diatoms contributed considerably to the overall cell count as well as to species composition. They constituted 52% of the total phytoplankton flora of the lake and the most common species were *Synedra ulna, Cymbella affinis,* and *Cyclotella meneghiniana.* Considerable population of *Nitzschia* sp. (Plate 4_1) was also observed. Thirty- nine species of diatoms were identified with pennate and centric forms being the dominant species in May and October/November, respectively.

At a certain time of the year, they dominated the phytoplankton population in terms of occurrence and number of species identified. Their seasonality pattern was clear throughout the year. In May 2001, they dominated the population contributing almost 70% of the total count.

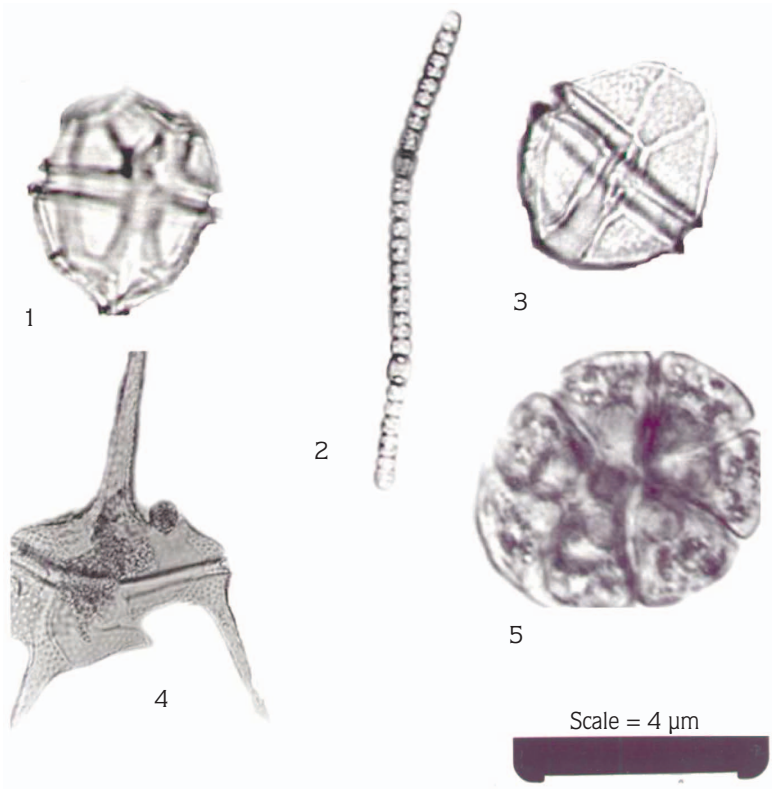
During summer, diatoms were recorded in moderate numbers, but another peak occurred in November 2001 when diatom population was dominated by the centric diatom *Cyclotella* sp., whereas the *Synedra ulna* and *Fragilaria* sp. were in considerably low numbers in the wet months.

Table 1. Phytoplankton species composition dominancy in the lake (Ab: Abundant, C : Common, F : Frequently, R : Rare, Vr : Very rare).

	Abundancy
Cyanophyceae	
Anabaena wisconsinese Presscot	C
Chroococcus turgidus (Kütz.) Naeg.	C
Chroococcus rufescens (Kütz.) Naeg.	F
Gomphosphaeria aponina Kütz.	F
Microcystis aeruginosa (Kütz.) Kütz	C
Oscillatoria aghardii Gomont.	F
Phormidium formosum (Bory) Anagnostids et Komárek	F
Oscillatoria tenuis C. Agardh.	Vr
Phormidium ambiguum Gomont.	Vr
Chlorophyceae	
Actinastrum hanszschii Lagerheim	Vr
Ankistrodesmus falcatus (Corda) Ralfs	F
Chlamydomonas sp.	C
Chlorella sp.	Ab
Chlorococcum sp.	C
Cladophora sp.	C
Closterium dianea Ehr. ex rals	Vr
Coelastrum sp.	F
Cosmarium sp.	Ab
Cosmarium subtumidum Nords.	C
Crucigenia sp.	F
Pandorina morum (O. Müeller.) Bory.	F
Pediastrum sp.	F
Pediastrum boryanum (Turp) Menegh.	F
Pediastrum duplex Meyen	Ab
Pediastrum obtusum Lucks	F
Pediastrum simplex Meyen	C
Scenedesmus dimorphus (Turp.) Kütz.	C
Scenedesmus lunetus (W. Smith) Chodat.	F
Scenedesmus obtusus Meyen.	F
Scenedesmus quadricauda (Turp.) Bréb.	C
Spirogyra subsalsa Kütz.	F
Staurastrum gracile Ralfs.	R
Baccillariophyceae	
Planothidium haukianum (Grun.) Round et Butiyarova	R
Amphora coffeaeformis (C. Agard). Kütz.	Vr
Amphora holastica. Hustedt.	R
Amphora montana Krasske.	R
Bacillaria paxillifer (Kütz.) Hendey	C
Caloneis silicula (Ehr.) Cleve.	Ab
Caloneis permagna. (J. W. Bailey.) Cleve.	F
Campylodiscus clypeus Ehr.	Vr
Cocconeis placentula var.euglypta. (Ehr.) Grun.	F
Cocconeis placentula var. lineata. (Ehr.) Cleve	F
Cocconeis scutellum Ehr	F
Cyclotella meneghiniana. Kütz.	F
Cyclotella striata. (Kütz.) Grun.	Ab
Cymatopleura solea. (Bréb.) W. Smith	F
Cymbella affinis Kütz.	F
Cymbella aspera (Ehr.) Cleve	F
Cymbella helvetica Kütz.	F
Cymbella kiamensis Meister	C
Cymbella minuta Hilse	C
Cymbella tumida (Bréb.) Van Heurck	C
Fragilaria construens (Ehr.) Grun.	C
Navicula sp.	C
Craticula cuspidata (Kütz) D.G.Mann	F
Navicula cryptocephala. Kütz.	C
Navicula radiosa Kütz.	C
Nitzschia sp.	C
Nitzschia amphibia Grun.	C
Nitzschia apiculata (Greg.) Grun.	C
Nitzschia circumstua (Bail.) Grun.	F
Trybionella hungarica (Grun.) D.G. Mann	F
Nitzschia obtusa. W. Smith	C
Nitzschia parvula W. Smith	C
Pinnularia sp.	R
Rhopalodia gibberula. (Ehr.) O. Müller	R
Stephanodiscus astraea (Kütz) Grun.	F
Surirella brebissoni Krammer & Lange-Bertalot	F
Surirella ovalis Bréb.	F
Synedra ulna (Nitz.) Her	Ab
Synedra fasciculata. (C. Agardh.) Kütz.	F
Dinophyceae	
Ceratium hirundinella (O. Müller) Dujardin	F
Gymnodinium sp.	F
Peridinium sp.	Ab
Peridinium cinctum (O. Müller) Ehr.	Ab

Table 2. Common and dominant species of Wadi Al-Arab Dam Lake

Species	Period of dominance
Peridinium sp.	Found all over the period of the study but maximized in March, April 2001 and February 2002
Microcystis aeruginosa	Appeared in February, dominate in early summer forming blooms then decline
Chlorococcum sp.	Found all the year, but maximized in summer months
Chlamydomonas sp.	Appeared in March, maximized in April 2001 and February 2002
Chlorella sp.	Found in all summer months, but dominate in April and February2002
Cosmarium sp.	Increased in March and April, found in summer, then increased in October
Scenedesmus sp.	Increased in March and April, decreased in summer, then increased in December
Pediastrum sp.	Maximized in April, found during summer, then increased in beginning of winter
Synedra ulna	Appear in April but dominate in May and June 2001
Cymbella aspera	Common in summer months while dominating in late October and November
Cyclotella meneghiniana	Appeared in summer, but dominate in November
Nitzschia sp.	Appeared in May, showed increase from July to October



Plates (1-7): All photos were taken under oil immersion (1000 ×)
Plate (1): 1. *Peridinium* sp., 2. *Anabaena wisconsinense* , 3. *Peridinium cinctum,* 4. *Ceratium hirundinella*, 5. *Chlorococcum* sp.

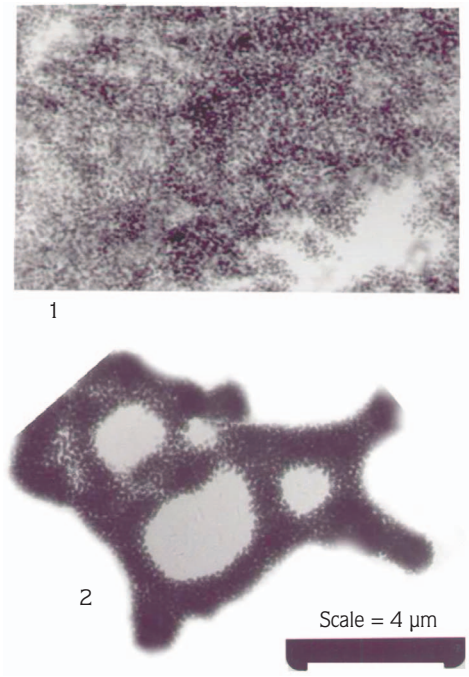


Plate (2): 1.and 2. *Microcystis aeruginosa*

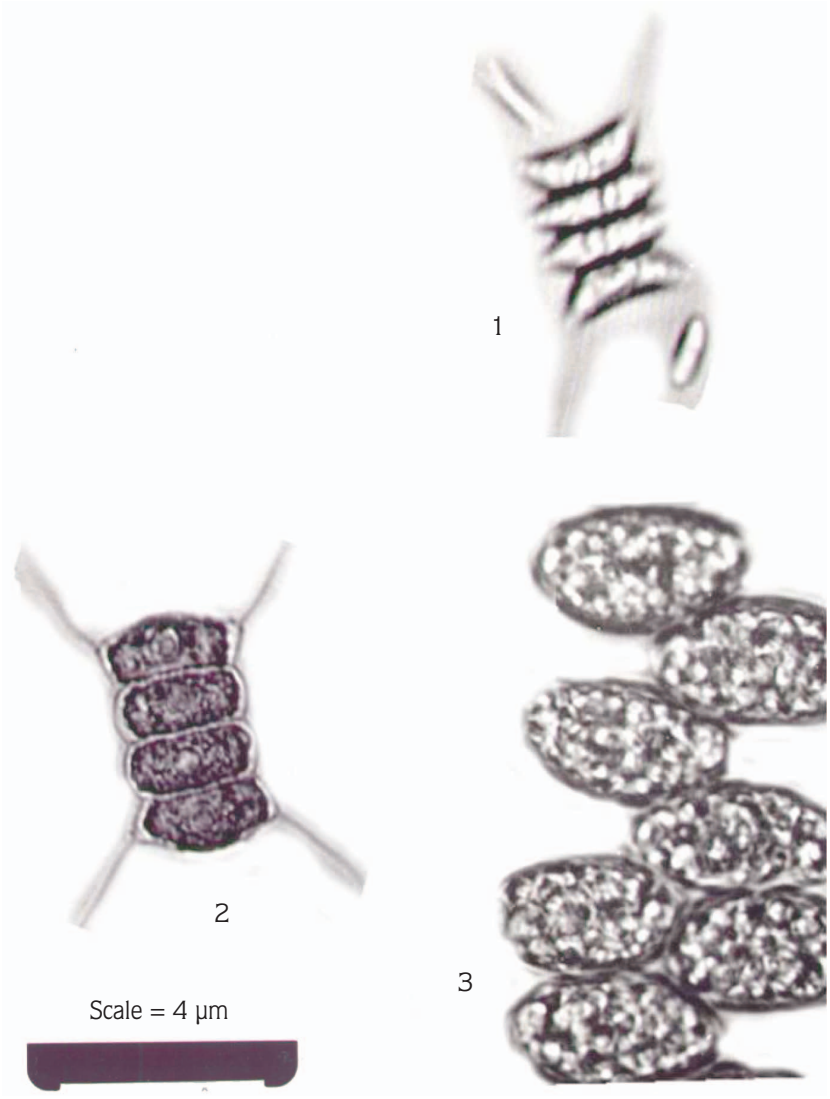


Plate (3): 1. *Scenedesmus dimorphus*
2. *Scenedesmus quadricauda*
3. *Scenedesmus obtusus*

Plate (4): 1. *Nitzschia* sp.

Chlorophyceae

Chlorophytes comprised 29.3% of the total numbers of species recorded. Although they occurred most of the year, they contributed with less species to the total flora. However, chlorophytes contributed well to the total phytoplankton biomass or productivity and chlrophyll *a* concentration (data not shown), particularly during the period between March and May when *Chlorella, Chlamydomonas,* and *Staurastrum gracile* (plate $5_{1, 2}$) were the most common chlorophytes. This increase was a result of a change in species composition from a mixture of species in March into a clear occurrence of chlorophytes *Chlamydomonas* sp. and *Chlorella* sp. that is known to have a high chlorophyll *a* content in comparison to other phytoplankton groups. During summer, their occurrence was considerably reduced with dominant species of *Pediastrum* (Plate 6 and 7) *Scenedesmus* (Plate $3_{1,2,3}$) and *Cosmarium* (Plate $5_{3, 4, 5}$). *Chlorococcum* sp. (Plate 1_5) also was present most of the year as it can tolerate lower temperatures, and dominated the chlorophycean population only in September-October period.

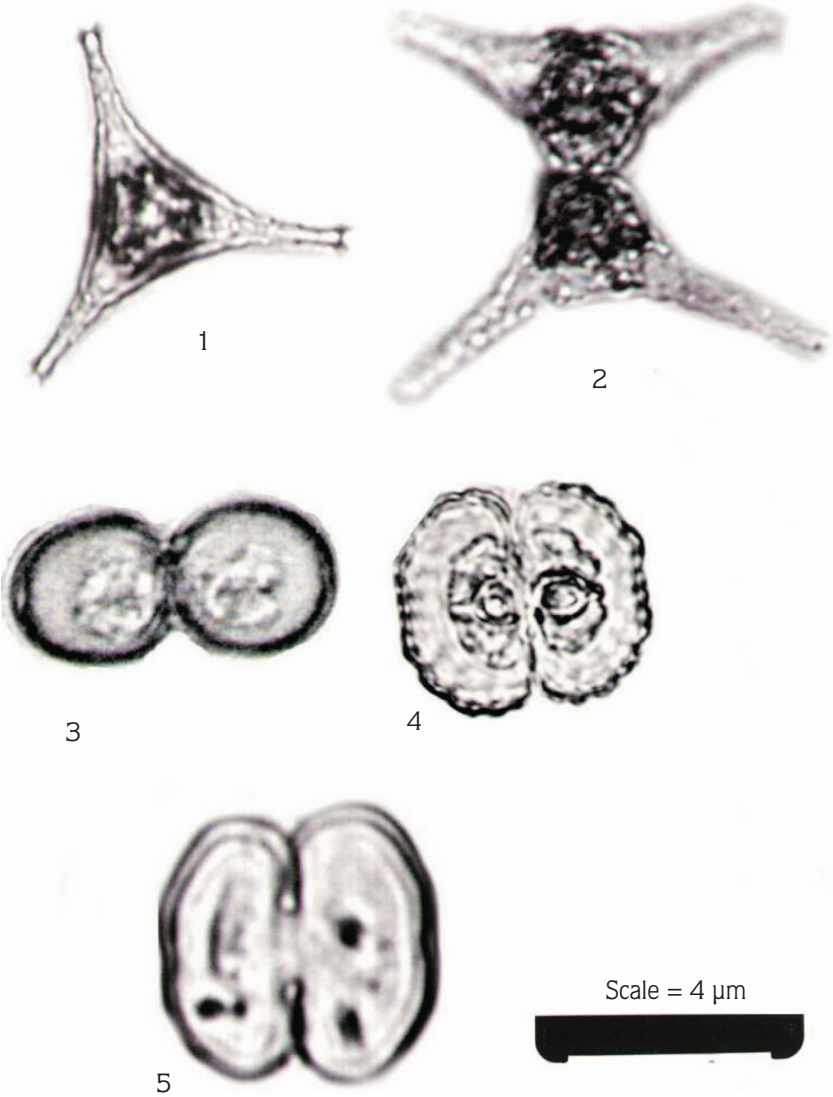


Plate (5): 1 & 2. *Staurastrum gracile*
3. *Cosmarium* sp.
4. *Cosmarium subcrenatum*
5. *Cosmarium subtumidum*

Cyanophyceae

Cyanophyceae were significant in the lake in terms of species density. They comprised 13.3% of the total number of the identified species. As temperature increased in summer (May-July), they dominated the phytoplankton population and maintained high biomass reaching the maximum in June and early July and then declined in August. *Microcystis aeroginosa* (Plate $2_{1,2}$) and *Anabaena wisconsinese* (Plate 1_2) developed a surface water bloom during May and June and then declined in July.

Dinophyceae

Dinophyceae were by far the most important group with *Peridinium* sp. (Plate 1_1) as the most significant species thriving in the lake. *Dinophyceae* dominated almost exclusively by a single species, *Peridinium* sp., *Peridinium cinctum* (Plate 1_3) with *Ceratium hirundinella* (Plate 1_4) and *Gymnodinium* sp. appeared occasionally in very low numbers. *Peridinium* sp. was recorded in high numbers and showed a peak in March and April and constituted 54% and 75% of the total cell count, respectively. Such mode of seasonality of *Peridinium* sp.

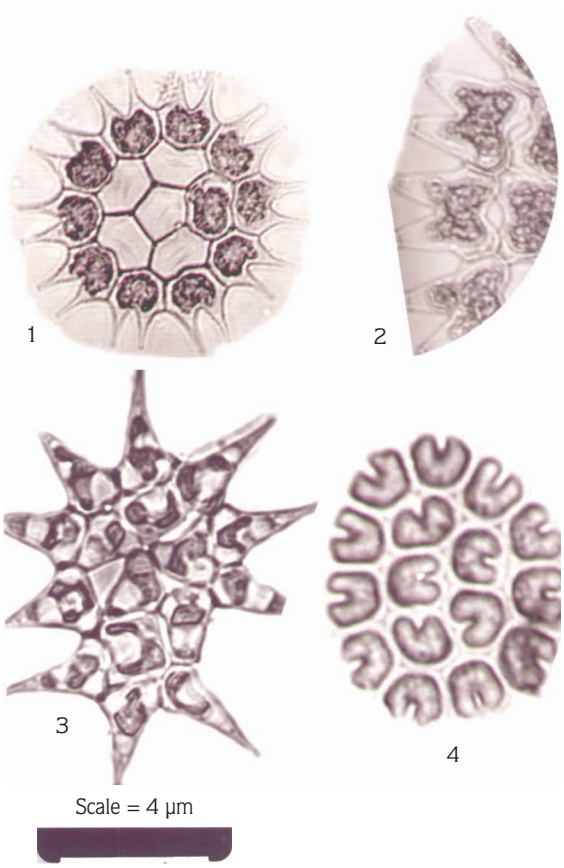


Plate (6): 1. *Pediastrum boryanum*, 2. *Pediastrum duplex*, 3. *Pediastrum* sp.1, 4. *Pediastrum* sp.2

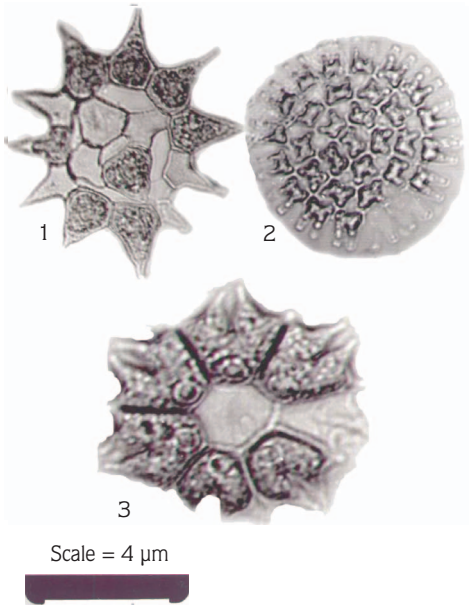


Plate (7): 1. *Pediastrum simplex*, 2. *Pediastrum duplex*, 3. *Pediastrum obtusum*

has also been observed in Turkwel Lake in Kenya (21). The Cucumber smell of *Peridinium* sp. was very clear in April along with a change in water color to brownish green.

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