

SURVEY ON PERIPHYTIC FRESHWATER CYANOBACTERIA AND ALGAE IN THE SULTANATE OF OMAN

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Abstract

During the period of February 2004 to April 2005, 74 samples from various forms of algal vegetations were collected from different periphytic freshwater habitats in Sultanate of Oman. These habitats include water streams of Aflaj systems, springs, wadis and rocky mountain regions of El-Dakhilia, Al-Dhahirah, Al-Batinah, Al-Sharqayah, and Muscat. Thirty cyanobacterial taxa were identified based on their morphological characteristics. Distribution analysis of the cyanobacterial flora in correlation with the studied areas obviously emphasized that the locality of Al-Taeen was the richest site, while localities of Bahla, Al-Hamra, Wadi Al-Moudin, Wadi Tanouf in Nazwa were the poorest sites by the diversified cyanobacterial flora. The microscopic identification of the natural assemblages of the biotopes of the studied localities indicated the presence of seventeen taxa of chlorophytes. The autecology of green algae revealed that the appearance and existence of rhizobenthic *Chara canescens* and the unbranched filaments of *Rhizoclonium heiroglyphieum* strongly confirmed the hardness of water habitats of Jalan area in Al-Sharqayah. On the other hand, water habitats of Nazwa area were found to be the suitable environments favoring the growth and dominancy of freshwater periphytic chlorophytes. Fifteen diatom taxa were identified from the investigated localities. The autecology of the identified diatom taxa of oligohalobien type (indicators for freshwater habitats), except *Biddulphia laevis* and *Achnanthes brevipes* var. *intermedia* of mesohalobien type of salinity. This observation added strength conformity for the hardness of water of Jalan locality.

Introduction

Reports dealing with the occurrence of cyanobacteria and algae in arid environments have been known in different parts of the Middle East Area, in Egypt (Kobbia and El-Batanony 1975, El-Otify and Mahalel 2000 and Hamed 2003), in Saudi Arabia (Chantachat and Bold, 1962; Mohsen and Bokhary, 1969 a, b; Abu-Zinada and El-Huseiny, 1975; Abou El-kheir, 1976; Aleem *et al.*, 1982; Al-Homaidan and Arif, 1998) and in Sahara of North African countries Particularly Libya and Algeria (Compere, 1985).

Till now, no information is available about the periphytic freshwater cyanobacteria and algae in the Sultanate of Oman, even in the recent literature dealt with (the biology of the central desert of Oman, Ghazanfar, 2004).

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The purpose of this study is to publish the results of the preliminary survey on some of the localities of the unique desert environment of Oman.

Materials and Methods

Study area

The Sultanate of Oman is located at the southwest corner of the Arabian Peninsula and has an area of about 309500 sq.km. It is within the geographic block lying between latitudes 16° 40' N and 27° 20' N and Longitudes 51° E and 59°40' E. The climate of the country is hot and humid in summer (June 31-45°C) and moderate in winter (January 20-25°C). The country experiences an average rainfall of 100 mm over the entire area with extremes of 300 mm over northern mountain regions and 55 mm over the central part of Oman. About 82% of the country is mainly sand and gravel desert. The Sultanate of Oman has two main sources of water: traditional groundwater and non traditional water produced from high-tech desalination plants. The natural water sources of both surface and / or underground one are used for domestic and irrigation needs through system of aflaj (MWR 1993).

Localities of samples collection

During the period of February 2004 to April 2005, 74 samples from various forms of algal vegetations were collected from different habitats including water streams of Aflaj systems, springs, wadis and rocky mountain regions. The survey covered the main geographical regions of the Sultanate of Oman (Figure 1) as follows:

A- El-Dakhilia region (41 samples) which comprising the following localities:

1- Nazwa (Firj – Marfa Garden – Falj Dares – Al-Qarn Garden – Wadi Tanouf – Manh). 2- Bahla. 3-Al-Hamra. 4- Izki. 5- Smail. 6- Birkat Al-Mouz. 7- Al-Gabbal Al-Akhdar. 8- Wadi Al-Moudin.

B- Al-Dhahirah region (3 samples) which comprising the locality of Ibri.

C- Al-Batinah region (13 samples) which comprising:

1- Nakhl. 2- Ain Al-Thoara

D- Al-Sharqyah region (14 samples) which comprising the following localities:

1- Jalan (Bani Abu Ali). 2- Al-Taen. 3- Al-Mudhabi.

E- Muscat region (3 samples) which comprising the locality of Al-Quriate.

Methods

The samples were removed from their habitats using a sharp blade shovel or easily removed by hand. Samples were tipped into small cleaned plastic bottles and preserved in 4 % formalin. Each sample was divided into two parts; one for preparing, identifying diatoms and the other for identifying the other cyanobacterial and algal species. The Jouse *et al.*, (1949) method was used for cleaning diatom frustules. Identification of diatom groups was carried out by

using Krammer and Lange-Bertalot (1986 and 1988) and Patrick and Reimer (1966 and 1975). Keys and literature used in the identification of cyanobacteria were Gollerbach *et al.*, (1953); Desikachary (1959); Anagnostidis and Komarek (1985 and 1988) and Komarek and Anagnostidis (1986). Green algae were identified by using the key of Prescott (1961). Photomicrographs were taken for the most cleared species and plated in plates I, II and III.



Figure (1): Localities of sample collection in the Sultanate of Oman

Results and Discussion

Throughout the period of investigation, various forms of algal vegetations were determined in different habitats including water streams of Aflaj systems, springs, wadis and rocky mountain regions in some localities of Oman.

Cyanobacteria

Natural water of Aflaj systems favoring the development of periphytic cyanobacteria. Thirty cyanobacterial taxa were identified based on their morphological characteristics. These were belonged to fourteen genera of three orders and five families (Table 1). In particular, twelve species of genus *Oscillatoria* were recorded from the total number. Regarding to the distribution of

the cyanobacterial taxa along the investigated localities, it was apparent that, *Gloeocapsa turgida* was the highly distributed taxon. Cyanoprocaryotes of *Gloeocapsa minor*, *Synechocystis aquatilis*, *Synechocystis pevalekii*, *Gomphosphaeria aponina*, *Oscillatoria geminate*, *Oscillatoria jasorvensis*, *Oscillatoria proboscidea*, *Oscillatoria subbrevis*, *Oscillatoria tenuis*, *Microcoleus chthonoplastes*, *Homoeothrix Juliana* and *Calothrix braunii*, each one was monospecific entity for certain geographical locality.

The habitat of Ain Al-Thoara spring was reflected the dominancy of some of chroococcean taxa (*Gloeocapsa turgida*, *Aphanothece nidulans*, *Merismopedia tenuissima*) and non-heterocystous filamentous forms of *Oscillatoria laete-virens*, *Oscillatoria obscura*, *Lynngbya martensiana* and *Stichosiphon sansibaricus*.

The topographical features (wadis, plains and mountains), their habitats are mainly of sand and gravel desert that receiving water of rainfall, making small water ditches and mountain streams. The cyanobacterial flora was composed of one chroococcean taxon of *Gloeocapsa decorticans*. One entophysalidacean form of *Chlorogloea microcystoides* and two species of oscillatorian, *Oscillatoria claricentrosa* and *Oscillatoria subbrevis*.

Distribution and frequency analysis of the cyanobacterial flora in correlation with the studied areas obviously emphasized that the locality of Al-Taeen was the richest site, while localities of Bahla, Al-Hamra, Wadi Al-Moudin, Wadi Tanouf were the poorest sites by the diversified cyanobacterial flora.

In general, cyanobacteria considered as one of the desert ecosystems (Bhatnagar and Bhatnagar, 2005), dominating in sandy-saline desert (Garcia-Pichel *et al.*, 2001), due to their forms are physiological resistance to desiccation, intense illumination and temperature extremes (Potts, 1994; Hawkes and Flechtner, 2002). All taxa are cosmopolitan; some of these taxa were previously recorded in the algal flora of Saudi Arabia (Abou El-Kheir *et al.*, 1976) and Egypt (El-Awamri *et al.*, 1996; Hamed, 2001 and 2003).

Chlorophytes

The microscopic identification of the natural assemblages of the biotopes of the studied localities indicated the presence of seventeen taxa of chlorophytes (Table 1). The recorded green algae were belonged to six orders of Volvocales, Chlorococcales, Cladophorales, Oedogoniales, Conjugales and Charales. The main bulk of the productivity of chlorococcal type. The two filamentous forms of *Oedogonium* (*Oedogonium* sp₁ and *Oedogonium* sp₂) and the one species type of *Spirogyra* were identified to the level of genus because vegetative structures were not bearing the sexual stage (zygote formation), which is the main discriminating feature used in the identification to the level of species or variety. Richly branched filaments of *Cladophora glomerata* were highly distributed in the most of the

investigated localities together with the unbranched filaments of *Rhizoclonium implexum*. Cells of Cladophorales secrete mucilage and this is probably one of the main reasons why they are often loaded with epiphytes (Fritsch, 1935). Consequently, the above mentioned phenomenon interpreted the epiphytic colonization of *Cladophora* and *Rhizoclonium* filaments by the two cyanobacterial epiphytes of *Chroococcus cohaerens* and *Stichosiphon sansibaricus* respectively.

The appearance and existence of rhizobenthic *Chara canescens* and the unbranched filaments of *Rhizoclonium heiroglyphieum* strongly confirmed the hardness of water habitats of Jalan area. On the other hand, water habitats of Nazwa area were found to be the suitable environments favoring the growth and dominance of freshwater periphytic chlorophytes such as *Pandorina morum*, *Pediastrum duplex*, *Ankistrodesmus falcatus*, *Selenastrum* sp, *Franceia tuberculat*, *Senedesmus bijugatus* and *Mougeotia quadrangulata* (Lewis and Flechner, 2002).

Bacillariophytes

Fifteen diatom taxa were identified from the investigated localities. One taxon was belonging to Class Centrophyceae, while the rest were belonging to Class Pennatophyceae. The autecology of the identified diatom taxa of oligohalobien type (indicators for freshwater habitats), except *Biddulphia laevis* and *Achnanthes brevipes* var. *intermedia* of mesohalobien type of salinity (indicators for brackish water habitats) (Kolbe, 1932; Hustedt, 1959; Ehrlich, 1975). The previous observation added strength conformity for the hardness of water of Jalan locality that favoring the appearance of mesohalobien diatom taxa, together with the rhizobenthic charoid taxon *Chara canescens* and the unbranched green filaments of *Rhizoclonium heiroglyphieum*.

The quantitative analysis of diatom taxa along the the investigated sites, revealed that some localities having unique feature of dominance by certain diatom species as follows: 1- *Biddulphia laevis* and *Achnanthes brevipes* var. *intermedia* were the most dominating taxa of Jalan locality. 2- samples of the mountain streams of Al-Gabal Al-Akhdar obviously indicated the dominance by the freshwater entities of *Synedra ulna*, *Achnanthes minutissima*, *Cymbella ventricosa* and *Nitzschia filiformis*. 3- *Cocconeis placentula* was the most common diatom which attained its dominance as epiphytic on the filaments of *Cladophora glomerata* in Wadi Al-Moudin locality. 4- The site of Al-Quriate, revealed the dominance by *Gyrosigma acuminatum* and *Cymbella turgida*. 5- *Synedra rumpens* and *Nitzschia fonticola* were considered as monospecific diatom features for Manh and Ibrī localities respectively.

Pyrrophytes

One taxon of the cated dinoflagellate (*Peridinium* sp) was identified in the samples of Al-Quriate during March, 2005 as a dominant pyrophyte.

Table (1): Records of cyanobacteria and algae in some of the geographical localities in the Sultanate of Oman.[A- El-Dakhilia region: 1- Nazwa (Firq, Marfa Garden, Falj Dares, Al-Qarn Garden, Wadi Tanouf, Manh. 2- Bahla. 3-Al-Hamra. 4- Izki. 5- Smail. 6- Birkat Al-Mouz. 7- Al- Gabbal Al-Akhdar. 8- Wadi Al-Moudin . B- Al-Dhahirah region: 9-Ibri. C- Al-Batinah region: 10- Nakhl. 11- Ain Al-Thoara. D- Al-Sharqayah region: 12- Jalan (Bani Abu Ali). 13- Al-Taeen. 14- Al-Mudhabi. E- Muscat region 15- Al-Quriate]

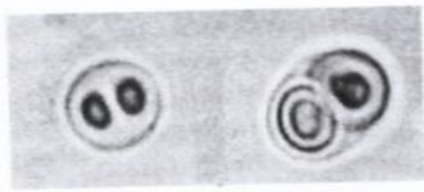
Localities taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Cyanobacteria															
Genus <i>Chroococcus</i> Nag.															
<i>C. cohaerens</i> (Breb.) Nag.	+							+						+	
Genus <i>Gloeocapsa</i> Kütz.															
<i>G. decorticans</i> Kütz.	+				+		+								
<i>G. gelatinosa</i> Kütz.													+	+	
<i>G. turgida</i> (Kütz.) Hollerb	+							+		+	+				+
<i>G. minor</i> (Kütz.) Hollerb	+	+													
Genus <i>Aphanothece</i> Nag.															
<i>A. nidulans</i> Richter, P.											+	+			
Genus <i>Synechocystis</i> Sauvageau															
<i>S. aquatilis</i> Sauv.														+	
<i>S. pevalekii</i> Erecgovic														+	
Genus <i>Merismopedia</i> Meyen															
<i>M. glauca</i> (Ehr.) Nag.	+			+										+	
<i>M. tenuissima</i> Lemm.	+														+
Genus <i>Gomphosphaeria</i> Kütz.															
<i>G. aponina</i> Kütz.										+					
Genus <i>Chlorogloea</i> Wille															
<i>C. microcystoides</i> Kütz.	+							+						+	
Genus <i>Stichosiphon</i> Geitler															
<i>S. sansibarius</i> (Hieron) Drout et Daily	+														
Genus <i>Oscillatoria</i> Vaucher															
<i>O. claricentrosa</i> Gardner	+							+							
<i>O. geminate</i> Menegh														+	
<i>O. jasarvensis</i> Vouk									+						
<i>O. laete-virens</i> (Crouan) Gomont	+														
<i>O. major</i> Vaucher	+									+					
<i>O. obscura</i> Bruhl et Biswas	+	+									+				
<i>O. proboscidea</i> Gomont															+
<i>O. sancta</i> (Kütz) Gomont	+													+	
<i>O. splendida</i> Grev. ex Gomont	+		+												+
<i>O. subbrevis</i> Schmidle	+							+							
<i>O. subtilissima</i> Kütz ex De Toni	+									+					
<i>O. tenuis</i> Agardh ex Gomont	+				+										
Genus <i>Lyngbya</i> Agardh															
<i>L. martensiana</i> Menegh. ex Gomont	+												+		
Genus <i>Microcoleus</i> Desm.															
<i>M. chthonoplastes</i> Thuret ex Gomont												+			
Genus <i>Nostoc</i> Vaucher															
<i>N. calcicola</i> Breb. ex Born. et Flah	+														
Genus <i>Homoeothrix</i> (Thuret) Kirchn.															
<i>H. Juliana</i> (Menegh.) kirchnev.	+														

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Genus <i>Calothrix</i> Agardh																			
<i>C. braunii</i> (A. Br.) Born et Flah	+					+													
Chlorophyta																			
Genus <i>Pandorina</i> Bory																			
<i>P. morum</i> (Muell.) Bory	+		+																
Genus <i>Pediastrum</i> Meyen																			
<i>P. duplex</i> Meyen	+																		
Genus <i>Ankistrodesmus</i> Corda																			
<i>A. falcatus</i> (Corda) Ralfs	+																		
Genus <i>Selenastrum</i> Reinsch																			
<i>S. sp</i>	+																		
Genus <i>Franceia</i> Lemm.																			
<i>F. tuberculata</i>	+																		
Genus <i>Scenedesmus</i> Meyen																			
<i>S. bijugatus</i> (Turpin) Kütz.	+		+																
<i>S. obliquus</i> Kütz.																			+
Genus <i>Rhizoclonium</i> Kütz.																			
<i>R. fontanum</i> Kütz.															+				
<i>R. heiroglyphicum</i> (C. a. Ag.) Kütz.															+				
<i>R. implexum</i> (Dillwyn) Kütz.	+	+			+	+	+	+											+
Genus <i>Cladophora</i> Kütz.																			
<i>C. glomerata</i> (L.) Kütz.	+		+	+				+	+	+	+								
Genus <i>Oedogonium</i> Link																			
<i>O. sp</i> ₁	+			+	+						+								+
<i>O. sp</i> ₂	+			+														+	+
Genus <i>Cosmarium</i> Corda																			
<i>C. granatum</i> Breb. ex Ralfs	+		+																
<i>C. subimpersulum</i> Borge	+							+											
Genus <i>Spirogyra</i> Link.																			
<i>S. sp</i>	+			+										+					
Genus <i>Chara</i> Linnaeus																			
<i>C. canescens</i> Loiseheur-Deslongchamps															+				
Bacillariophyta																			
Genus <i>Biddulphia</i> Gray																			
<i>B. laevis</i> (E.) Hust.															+				
Genus <i>Synedra</i> Ehr.																			
<i>S. rumpens</i> Kütz.	+																		
<i>S. ulna</i> (Nitzsch) Ehr.	+								+	+		+							+
Genus <i>Achnanthes</i> Bory																			
<i>A. affinis</i> Grun.												+			+				
<i>A. brevipes</i> var. <i>intermedia</i> Kütz.	+	+													+				
<i>A. minutissima</i> Kütz.	+	+							+										
Genus <i>Cocconeis</i> Ehr.																			
<i>C. placentula</i> Ehr.	+										+								
Genus <i>Amphora</i> Ehr.																			
<i>A. pediculus</i> Kütz.																+	+		
Genus <i>Gyrosigma</i> Hassall																			
<i>G. acuminatum</i> (Kütz.) Rabenh.																			+
Genus <i>Cymbella</i> Ag.																			
<i>C. affinis</i> Kütz.	+									+		+							
<i>C. turgida</i> (Greg.) Cl.																			+
<i>C. ventriccosa</i> Kütz.	+								+										
Genus <i>Gomphonema</i> Ag.																			

<i>G. parvulum</i> Kütz.	+			+			+			+				
Genus <i>Nitzschia</i> Hassall														
<i>N. filiformis</i> (W.sm.) Hust.	+						+							
<i>N. fonticola</i> Grun.									+					
Pyrrophyta														
Genus <i>Peridinium</i> Ehr.														
<i>Peridinium</i> sp	+													+

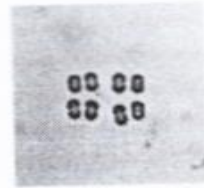
Plate I



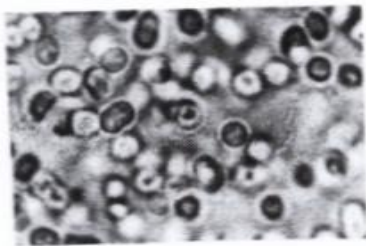
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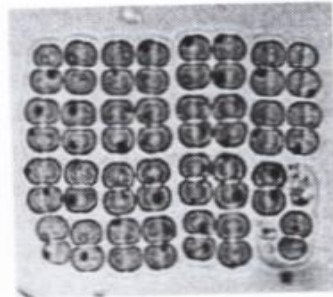
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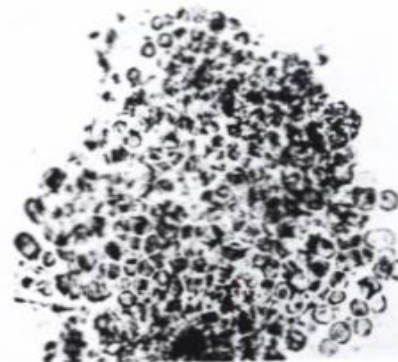
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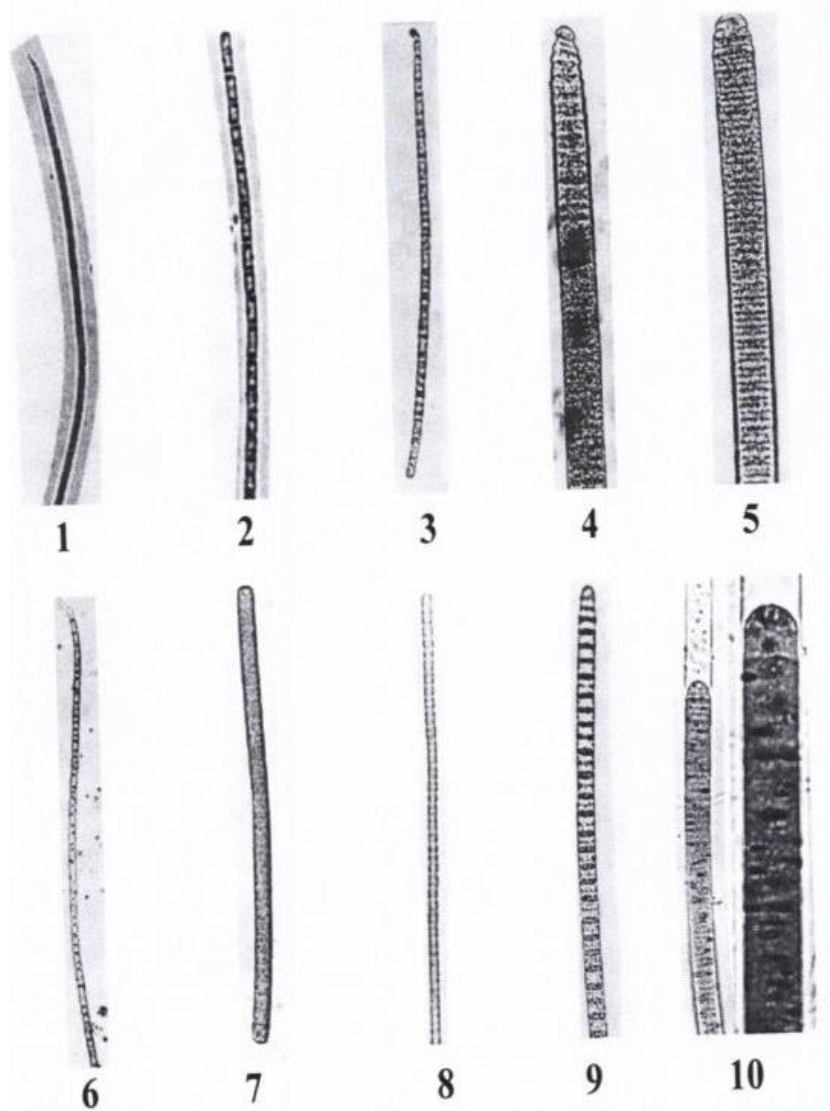
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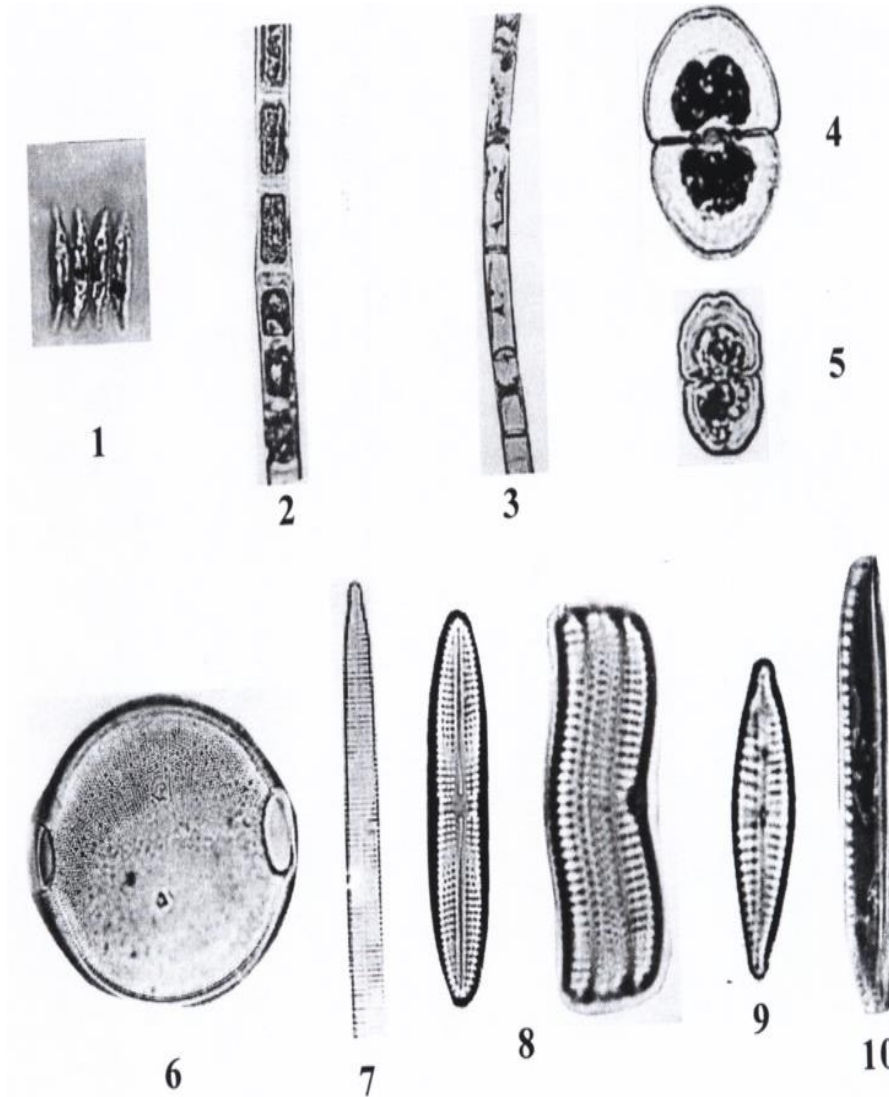
1- *Gloeocapsa gelatinosa* Kütz(600X);2- *Gloeocapsa turgida* (Kütz.) Hollerb (600X);
3-*Gloeocapsa minor* (Kütz.) Hollerb (600X); 4- *Synechocystis pevalekii* Erecgovic
(1500X); 5- *Merismopedia glauca* (Ehr.) Nag. (700X); 6- *Gomphosphaeria aponina*
Kütz. (450X);7- *Chlorogloea microcystoides* Kütz. (700X).

Plate II



1- *Oscillatoria claricentrosa* Gardner (600X); 2- *Oscillatoria geminate* Menegh (1000X); 3- *Oscillatoria jatorvensis* Vouk (700x); 4- *Oscillatoria proboscidea* Gomont (600X); 5- *Oscillatoria sancta* (Kütz) Gomont (600x); 6- *Oscillatoria splendida* Grev. ex Gomont (750X); 7- *Oscillatoria subbrevis* Schmidle (400X); 8- *Oscillatoria subtilissima* Kütz ex De Toni (700X); 9- *Oscillatoria tenuis* Agardh ex Gomont (700X); 10- *Lyngbya martensiana* Menegh. ex Gomont (600X-1500X).

Plate III



1- *Scenedesmus obliquus* Kütz. (400X); 2- *Rhizoclonium implexum* (Dillwyn) Kütz. (400X); 3- *Oedogonium* sp₁ (400X); 4- *Cosmarium granatum* Breb. ex Ralfs (800X); 5- *Cosmarium subimpressulum* Borge (700X); 6- *Biddulphia laevis* (E.) Hust. (1000X); 7- *Synedra ulna* (Nitzsch) Ehr. (1300X); 8- *Achnanthes brevipes* var. *intermedia* Kütz. (1500X); 9- *Gomphonema parvulum* Kütz. (1500X); 10- *Nitzschia filiformis* (W.sm.) Hust. (1700X).

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مسح لسيانوبكتيريا وطحالب المياه العذبة السطحية في سلطنة عمان

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خلال الفترة من فبراير 2004 حتى أبريل 2005 تمت دراسة فلورة السيانوبكتيريا و طحالب المياه العذبة السطحية في سلطنة عمان. و قد تم جمع 74 عينة من مختلف بيئات المياه العذبة مثل الأفلاج و الينابيع وأسطح الجبال في مناطق الداخلية و الظاهرة و الباطنة و الشرقية و مسقط. أسفرت الدراسة عن تسجيل 30 نوعا من السيانوبكتيريا و 17 نوعا من الطحالب الخضراء و 15 نوعا من الدياتومات إضافة إلى نوعا واحدا من الطحالب الدياتومية و كلها تسجل لأول مرة في سلطنة عمان. و كان موقع الطائين (المنطقة الشرقية) أكثر المواقع سيادة بالسيانوبكتيريا بينما كانت الطحالب الخضراء أكثر انتشارا في نزوى (المنطقة الداخلية). و تميزت المنطقة الشرقية أيضا بالأنواع التي تقضل الماء العسر مثل *Rhizoclonium heiroglyphieum* و *Chara canescens* (من الطحالب الخضراء).
Achnanthes brevipes var. intermedia و *Biddulphia laevis* (من الدياتومات).