K.A.U.: Sci., vol. 1, pp. 15-22 (1409 A.H. / 1989 A.D.

Occurrence of Cyanobacteria and their Possible Toxicity

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ABSTRACT. A study has been made on the freshwater Cyanobacteria in Makkah province. For this purpose, four different locations were monitored, namely; Wadi-Fatimah, Khulays, Ash-Sharayi & Zaymah, and At-Taif & El-Hada.

It could be concluded that the number of algal taxas was obviously affected by the pH value and the level of salinity in the different locations under investigation. The maximum number of taxa was recorded in Wadi-Fatimah location (39) being with distinctly low salinity level and rather alkaline pH. Conversely, the least population (10 taxa) was determined in At-Taif & Al-Hada location with relatively high salinity and mild alkalinity.

Concerning the frequency of cyanobacterial taxa in each location, Wadi-Fatimah could be assumed as the sole location in which abundant and frequent populations were recorded, compared with other locations, where the taxa recorded showed rare occurrence. Also, preliminary toxicity tests, using different doses of algal extract, with either rabbits or germinating wheat grains indicated absence of toxic substances.

Introduction

In general, the algal flora of Saudi Arabia are relatively little known. Particularly, there is only fragmentary work on the freshwater algae. In this connection, Abdel Mohsen and Bokhary[1,2] studied the distribution and periodicity of freshwater algae as related to environment in Riyadh area and revealed some physiological aspects concerning four algae grown under controlled conditions.

A survey of the algal flora of different soil types in Riyadh was previously done[3].

Khoja *et al.*[4] studied the algal flora of Alkharj area (Riyadh region) and Al-Baha

area (Southern region) and discussed the taxonomy of the Cyanobacteria, Chlorophyta and Bacillariophyta collected from as wide a range of habitats as possible.

The intent of the present work is to provide a guide that may facilitate efforts to gain a general picture of Cyanobacteria (blue-green algae) (56 taxa) in different localities of Makkah province. Such information is no doubt of vital importance regarding the following points of view:

a) For economic and pollution research since some of freshwater Cyanobacteria have long been implicated in poisonings of water fowl, fish, plants and domestic animals[5,6] and

b) For academic knowledge and nature conservation.

Material and Methods

Algal material was collected from four different localities, in Makkah province, which were considered to be suitable for study throughout the period from 16.2.1984 to 26.5.1984. These localities were:

I. Wadi-Fatimah; about 30 km north Makkah (Makkah Al-Madinah road).
II. Khulays; about 90 km north Makkah (Makkah Al-Madinah road).
III. Ash-Sharayi and Zaymah; about 30 km south Makkah (As-Sayl road).
IV. At-Taif and El-Hada; about 80 km south Makkah.

The above mentioned four localities are indicated in Fig. 1.

The water source in the above mentioned localities (except At-Taif and El-Hada location) is from underground water, used in irrigation systems. This water is pumped from wells by electric pumps then stored temporarily in concrete reservoirs. Upon use, it is allowed to flow into one or more open ducts for irrigation. Water, in either reservoirs or ducts, is directly subjected to sunlight. The bottoms of these ducts vary from sandy clay to clay sandy. After irrigation is terminated, water vanishes from ducts but some is usually maintained within the reservoirs. Sampling was undertaken from such reservoirs and ducts.

A. Sampling and Preliminary Culturing

Algal material (56 taxa) was collected from different localities then examined alive then fixed with 4% formalin. Water samples from the same habitat were also obtained for feeding the preliminary culture and for detecting toxicity, if any. In each case, sampling was associated with measurement of pH, salinity and temperature. A portable Beckman pH-meter (model 72), and a mercury thermometer were used for the estimation of pH and temperature, respectively. Salinity was determined by using a conductivity meter (model EP) with reference to a standard curve using NaCl.

For preliminary culturing, an aquarium was planted with such algae and established on a bench in the laboratory. One fluorescent lamp was used for illumination

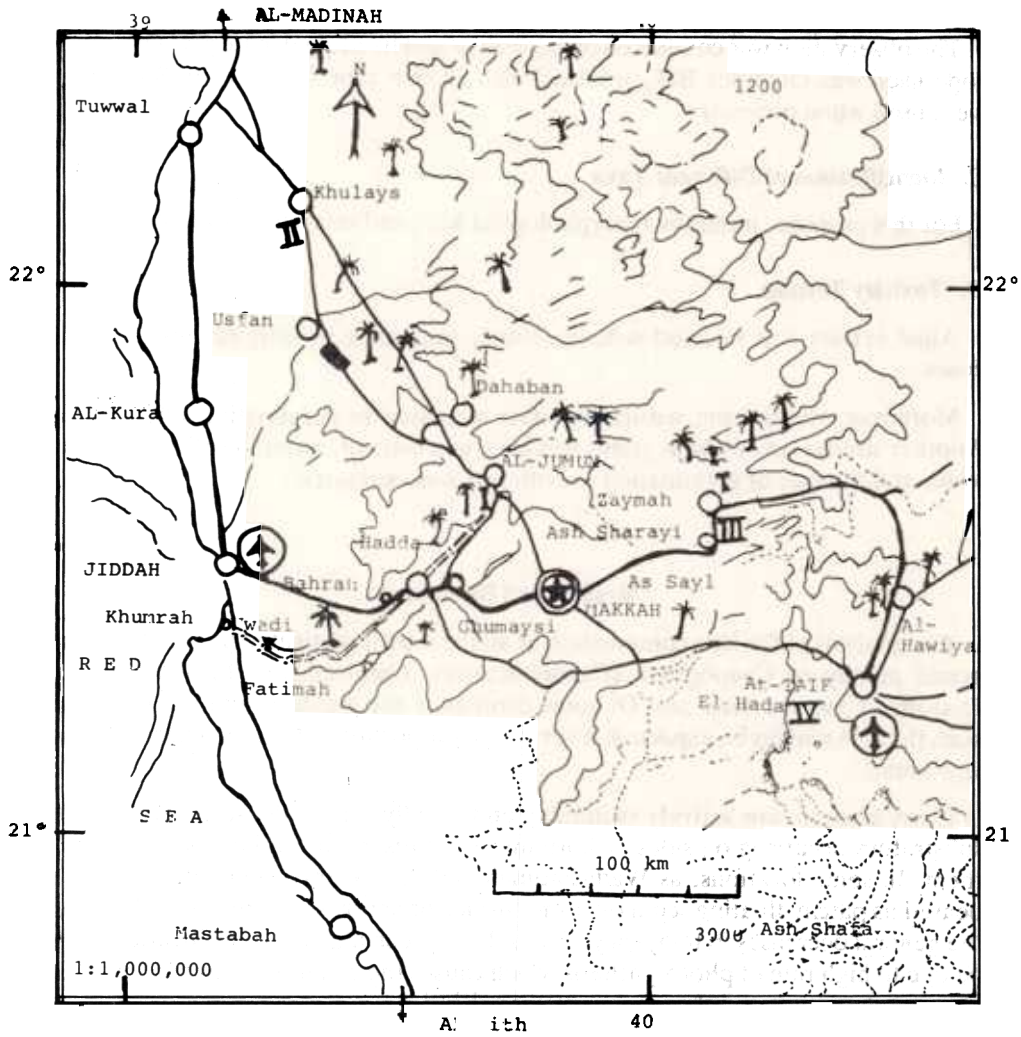

FIG. 1. The studied localities of Makkah Province

in addition to the indirect light reaching the laboratory *via* windows and door. The total light intensity was about 20W. Aeration was supplied by a small electric pump. The aquarium was nearly half-filled with tap water enriched from time to time with water sampled from natural locations, and few crystals of Na NO_3 (about 0.5 g) and KH_2PO_4 (about 0.1 g) were added to enrich the water of the aquarium and keep most of the algae vital. Loss of water due to evaporation was compensated by the addition of more or less equivalent amount of tap water.

B. Microscopic Observations

The observation was conducted on both alive and fixed algal material. The microscope used was Olympus BH_2 provided with 35 mm camera and convenient filters were used when necessary.

C. Identification of Different Taxa

For this purpose, numerous morphological keys and references were used[7-11].

D. Toxicity Testing

Algal extract was injected subcutaneously into some healthy rabbits in varying doses.

Moreover, water from natural habitats was used in germinating wheat grains. Another similar set of wheat grains was used as a control, watered with ordinary tap water and the rate of germination in both sets was estimated.

Results and Discussion

The analysis of floristic composition of all the area investigated proved to be composed mainly of Cyanophyta (Cyanobacteria), Chlorophyta, Bacillariophyta or Diatoms. Cyanobacteria and Diatoms contribute the greatest numbers of algae to such flora. As might be expected, a very large proportion of Cyanobacteria (56 taxa) was found.

Cyanobacteria are actively swimming and usually form a dense covering on any substratum occurring on sides or bottoms of the reservoirs and ducts connected to them. In some locations, as Wadi-Fatimah and Ash Sharayi, in contrast, they appeared as patchy floating scum over the surface of nearly stagnant water. However, the general decreases in buoyancy of most blue-green algae in some locations might be due to high rate of photosynthesis which causes the collapse of gas vacuoles. This view agrees with those of some investigators[12-15].

Table 1 shows that the algal flora is rather rich in genera and species in Wadi-Fatimah location (39 taxa). Moreover, the frequency, of the recorded taxa is generally higher than the corresponding values in other locations. In this respect, it should be mentioned that *Gloetheca linearis, Oscillatoria princeps* and *Lyngbya aestuarii* were abundant; *Dermocarpa leibeiniae, D. hemisphaerica, Phormidium ambiguum, Ph. pristleyi, Spirulina major, Oscillatoria limosa* and *O. irrigua* more frequent (11 taxa) populations were only observed in Wadi-Fatimah location, whereas in other locations (II, III & IV) all the taxa recorded are of rare occurrence (Table 1). Conversely, the least population of Cyanobacteria was determined in At-Taif & Al-Hada location (10 taxa). On the other hand, the number of algal taxa showed intermediate values in Khulays and Ash-Sharayi & Zaymah locations (19 & 17 taxa, respectively).

TABLE 1. Occurrence and Frequency of Cyanobacterial Taxa in Different Localities of Makkah Province.

	Location	Wadi Fatimah (I)	Khulays (II)	Ash-Sharayi & Zaymah (III)	At-Taif & (III) El-Hada
	pH-Value	8.5	6.6	5.9-6.2	7.1-8.1
	Salinity	0.175%	0.50%	0.20-0.50%	5.00%
	Taxa / Temperature	28°C	32°C	31-32°C	31°C
1	*Chroococcus cohaerens* (Breb.) Naeg.	–	+	+	–
2	*Ch. minutus* (Kütz.) Naeg.	++	+	–	–
3	*Ch.* sp. 1	–	–	+	+
4	*Ch.* sp. 2	–	–	+	–
5	*Ch. spelaeus* Erzegovic	++	+	–	–
6	*Ch. turgidus* (Kütz.) Naeg.	–	–	–	+
7	*Coelosphaerium dubium* Grunlow	+	–	+	–
8	*Eucapsis alpina* Clement et Shantz	+	–	–	–
9	*Gloeocapsa aeruginosa* Arch. Cooke	+	–	+	+
10	*G. alpina* (Naeg.) emend	+	+	–	+
11	*G. granosa* (Berk.) Kütz.	–	–	+	–
12	*G. polydermatica*	–	+	+	–
13	*Gloeotheca linearis* Naeg.	++++	–	–	–
14	*Merismopedia punctata* Meyen	++	+	–	–
15	*M.* sp.	–	+	–	–
16	*Synechococcus elongatus* Näg.	+	–	–	+
17	*Chamaesiphon incrustans* (Grunow.)	++	+	–	–
18	*Dermocarpa hemisphaerica* Lemin.	+++	+	–	–
19	*D. Leibeiniae* (Reinsch) Bornet et Thuret	+++	–	–	–
20	*D. Sphaerica* S. & G.	++	–	+	–
21	*Pleurocapsa haviatilis* Lagerh.	+	–	–	–
22	*Xenococcus gilkeyae* S. & G.	++	–	–	–
23	*Calothrix elenkinii* Kossinskaja	+	–	–	–
24	*Crinalium endophyticum* Crow.	+	+	–	–
25	*Lyngbya aestuarii* (Mert.) Liebm.	++++	–	–	–
26	*L. clarensis* W. West	+	–	–	–
27	*L. epiphytica* Hieron.	–	–	–	+
28	*L. erecta* Gardner	++	+	+	–
29	*L. hieronymusii* Lemm.	+	–	–	–
30	*L. Lachneri* Zimmer	+	–	–	–
31	*L. majuscula* Harvey	++	+	–	–
32	*L. shacklestoni* West, E. et G.S.	–	–	+	–
33	*L.* sp. 1	–	+	–	–
34	*L.* sp. 2	–	+	–	–
35	*L. spirulinoides* Gom.	–	–	–	+
36	*Oscillatoria coerulescens* Gieville	+	+	+	–
37	*O. irrigua* Kütz.	+++	–	–	+
38	*O. limosa* Ag.	+++	–	–	–
39	*O. nigro-viridis* Thwaites	–	–	+	–
40	*O. princeps* Vaucher	++++	–	–	+
41	*O. simplicissima* Gom.	++	+	+	–
42	*O. tortuosa* Gardner	–	–	+	–
43	*Phormidium ambiguum* Gom.	+++	–	+	–
44	*Ph. antarcticum* W. et G.S. West	+	–	–	–
45	*Ph. autumnale* (Ag.) Gom.	++	–	+	–
46	*Ph. calicola* Gardner	–	–	–	+
47	*Ph. lucidum* (Ag.) Kütz.	–	+	–	–
48	*Ph. mucosum* Gardner	+	+	–	–
49	*Ph. pendleyi* F.E. Fritsch	+++	+	–	–
50	*Ph.* sp.	–	–	+	–
51	*Porphyrosiphon fuscus* Gom.	+	–	–	–
52	*Prosterendothrix scolecioides* W. et G.S. West	+	–	–	–
53	*Spirulina breviarticulata* S. & G.	+	–	–	–
54	*Sp. major* Kütz.	+++	–	–	–
55	*Sp. platensis* (Nordst.) Geitl.	++	–	–	–
56	*Nostoc punctiforme* Kütz.	+	–	–	–

Absent ; (+) = Rare occurrence ; (++) = Frequent occurrence ; (+++) = More frequent occurrence ; and (++++) = Abundance of the Alga

Temperature variation among the 4 locations under study appeared likely to be insignificant (Table 1). Thus, the gradual decrease in the number of algal taxa from Wadi-Fatimah to Khulays and Ash Sharayi locations might be attributed to the mildy alkaline nature in Wadi-Fatimah (pH = 8.9) and the rather acidic nature in the latters (pH = 6.6 at Khulays and 5.9-6.2 at Ash-Sharayi). The markedly decreased number of Cyanobacterial taxa in At-Taif & El-Hada location (10 taxa) compared with that in Wadi-Fatimah (39 taxa) regardless that both locations are rather alkaline might be attributed to the substantially increased salinity in At-Taif & El-Hada (5.0%). Increased salinity in At-Taif & El-Hada location is assumed to be due to the fact that water (remaining from rainfall) is shallow, isolated, stagnant and exposed to direct sunlight. A reverse situation is expected to be responsible for the obviously decreased salinity in Wadi-Fatimah due to agricultural extension.

According to results presented in Table 1, the different taxa of Cyanobacteria could be roughly systematized into the following categories:

A. Acid-loving Taxa: *Chroococcus cohaerens, Ch.* sp. 2, *Gloeocapsa polydermatica, G. granosa, Phormidium lucidum, Ph.* sp., Oscillatoria nigro-virdis, O. tortuosa, Lyngbya shackletoni, L. sp. 1 and *L.* sp. 2.

B. Alkaline-loving Taxa: *Synechococcus elongatus, Gloetheca linearis, Eucapsis alpina, Dermocarpa. leibeiniae, Pleurocapsa haviatilis, Xenococcus gilkeyae, Phormidium antarcticum, Proterendothrix scolecoidea, Spirulina major, Sp. breviarticulata, Sp. plantensis, Porphyrosiphon fuscus, Oscillatoria princeps, O. limosa, O. irrigua, Lyngbya aestuarii, L. cliarensis, L. lachneri, L. hieronymusii, Nostoc punctiforme,* and *Calothrix elenkinii.*

C. Taxa of mild alkaline and highly saline habitat: *Chroococcus turgidus, Phormidium calicola, Lyngbya spirulinoides,* and *L. epiphytica.*

D. Taxa living under conditions of pH and salinity variations:

These taxa are presented in Table 1. They are those which have not been mentioned previously under A, B or C categories.

Another point of certain interest is the cyanobacterial poisoning hazard in freshwater; a subject which has been discussed by many authors[16-19,6].

In the present work subcutaneous injection of experimental animals (rabbits) with different doses of the algal extract preliminary indicated the absence of any toxic material. A similar conclusion had been also attained when a toxicity test was carried out using wheat grains as a test object. In this case, grains watered with water from natural habitat showed the same percentage and rate of germination as those watered with ordinary tap water. However, this point needs further work because cyanobacterial poisoning has been mentioned by many authors not to cause spontaneous death, in most cases, but to induce weakness or internal symptoms in the digestive tract, liver and photosensitivity in survivors[20].

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الطحـــالب الخـــضراء المـــزرقـــة ومـــدى سميتـــها

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أجرى هذا البحث لدراسة الطحالب الخضراء المزرقة التي تعيش في المياه العذبة بمنطقة مكة ، ولذا اختيرت أربعة مواقع للدراسة في وادي فاطمة ، خليص ، الشرائع والزيمة ، الطائف والهدا . وقد أمكن حصر (٥٦) وحدة تصنيفية طحلبية تتبع الطحالب الخضراء المزرقة ووجد أنها يتأثر وجودها وترددها بوضوح بقيمة الأس الهيدروجيني ومستوى الملوحة في المواقع المختلفة التي تمت دراستها .

ومن ثم فقد سُجِّل أكبر عدد من هذه الوحدات التصنيفية (٣٩) في موقع وادي فاطمة الـذي تميز بانخفاض نسبة الملوحة وبالأس الهيدروجيني الذي يميل إلى القلوية ، وعلى عكس ذلك قُدِّر أدنى تعداد لهذه الوحدات التصنيفية (١٠) في موقع الطائف والهدا حيث تميز الوسط بالملوحة العالية والقلوية المعتدلة .

وبالنسبة لتردد الوحدات التصنيفية للطحالب الخضراء المزرقة في المواقع المختلفة فقد أمكن اعتبار موقع وادي فاطمة هو الوحيد الذي يحظى بوفرة وشيوع أكبر عدد من هذه الـوحـدات وذلـك بمقـارنتـه بالمواقع الأخرى التي تمت دراستها حيث كان وجود غالبية الوحدات التصنيفية في صورة نادرة .

ومن جهة أخرى أجريت اختبارات مبدئية لتعيين مدى سمية هذه الطحالب ، وذلك بحقن الأرانب أو معاملة حبوب القمح المستنبتة بجرعات مختلفة من المستخلص الطحلبي وقد أوضحت نتائج هذه التجارب عدم وجود مواد سامة .