http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet

Asian Network for Scientific Information

308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 11 (10): 1293-1302, 2008
ISSN 1028-8880

Aerophytic Cyanophyceae (Cyanobacteria) from Some Cairo Districts, Egypt

Ahmed D. El-Gamal
Department of Botany and Microbiology, Faculty of Science, Al-Azhar University,
Nasr City, P.O. Box 11884, Cairo, Egypt

Abstract: Twenty three aerophytic blue-green algal species were isolated and identified from 5 districts in Cairo, namely: Nasr City, Abassiya, Downtown, Maadi and Tebbin. Downtown contained the highest numbers of total algal species (13 species) during the study throughout the years 2004-2005 in comparison to other districts. The composition of aeroalgal taxa varied with seasonal changes. *Chroococcus limenticus*, *Lyngbya lagerheimii*, *Phormidium ambigum* and *Schizothrix purpurascens* have been isolated during the both years 2004-2005, while the rest of algal species (nineteen species) have been trapped either in 2004 or 2005. *Nostoc* spp. is the most common isolate of all algal isolates during the study. Analysis of air pollutants such as SO_2, NO_2, suspended particles less than 10 μ (PM_{10}), black smoke and lead are also recorded. Downtown showed the highest concentration of SO_2, NO_2 and PM_{10} level during the present study in comparison to other sites. The interaction between air pollutants and aerophytic Cyanophyceae species was concerned.

Key words: Aerophytic cyanophyceae, air pollutants, Cairo districts, seasonal changes

INTRODUCTION

Egyptian studies dealing algae, have given an extensive attention on their role in soil, fresh and marine water habitats (Osman *et al*., 2003; ElShoubaky, 2005; Salah El Din, 2005; Abdel-Hameed, 2006; Shanab, 2006; Fathy and Mohammady, 2007). Although, aerophytic algae have received some significant interest around the world, Egyptian aerophytic biotopes are completely unknown.

The atmosphere contains many minute particles of solid matter, a large proportion of which are of biological origin, some being viable. Most viable airborne particles are spores of fungi, bryophytes and pteridophytes, pollen grains, moss gemmae, propagules of lichens, cells of algae, vegetative cells and spores of bacteria, cysts of protozoa and virus particles (Hawker and Linton, 1971). All of them constitute the air spora.

The first investigation of airborne algae was of Salisbury (1869), From the USA who identified algae from air and classified them as disease producing algaloids. On the other hand, the study by Overeem (1936) was considered the first scientific and actual investigation of airborne algae from Netherlands. In fact, his study form the basis of subsequent research as outlined by Schlichting (1961, 1964, 1974, 1975) and Schlichting *et al.* (1971, 1973) have studied the relevance of airborne algae with micrometeorological, geographic and topographic parameters. Moreover, the recent studies on aerophytic algae have reflected the great economic role and health consequences that can be played by algae (Carson and Brown, 1975; Sharma *et al*., 2006; Anna *et al*., 2007; Poulíèková and Hašler, 2007).

From ecological point of view, airborne algae studies may play an important role in a better understanding the interrelationships between the aerial biota and other factors controlling our ecosystem. The role of aerophytic algae may be more easily ascertained using them as an indicator of air quality and hence may inform about the air status of great cities. Cairo is one of great cities which characterized by rapid rate of economic and technological development over the fast 30 years. The industrial development, combined with rapid population growth, has led to an increase in the pollutants released into Cairo's air, water and soil. The high pollution levels have raised major concerns for public health. Higher rates of air pollution are becoming strongly correlated with economic progress; therefore, the goal of the present study is concerned with the identification of some airborne Cyanophyceae from some Cairo areas in regarding to some air pollutants.

MATERIALS AND METHODS

Sampling site: Five sites were chosen throughout Cairo districts during the period of 2004-2005. The sampling sites were selected according to the following categories: residential; mixed (residential/industrial or residential/heavily trafficked/commercial). The sampling sites of greater Cairo area, namely: (1) Nasr City including Al-Azhar Univ. Zone, Yossef Abbas street, Cairo stadium complexes zone, Abbas El-Akkad street and its extension

Corresponding Author: Ahmed D. El-Gamal, Department of Biological Science, Teachers College, Umm AlQurra University, Makkah, P.O. Box 2064, Saudi Arabia

and El-Sekka El-Hadid sporting club zone, (2) Al-Abbasiya district including a part of Salah Salem street (Industrial zone) and Ain-Shams Univ. zone, (3) Downtown district including different sites: Al- Azhar mosque zone, 6th October bridge, El-Tahrir square, Cairo tower zone, (4) Maadi site and (5) Tebbin site. Figure 1 showed the geographical locations of the different sites. Also, the numbers assigned to the sites, the site type and the district in which each sample is collected, are shown in Table 1.

Air sampling: Air sampling was made twice per year in July and in December periodically during the study. Hand-held Petri dishes containing agarised Z-medium (Staub, 1961) or Allen's medium recommended by Hughes *et al.* (1958) and modified by Allen (1968) were exposed to the air (5-10 min) from a moving, while a driving with approximately speed of 80 km h^{-1}. The Petri dishes were kept in a tight sealed case to prevent contamination and were brought to the laboratory.

Growth conditions: Petri dishes were incubated at 30°C under standard condition of illumination of cool-white fluorescent tubes (approx.2500lux) on a 16:8 light: dark cycle. After 3 weeks, the colonies were isolated.

Algal identification: Identification of algal taxa was made using the following keys (Geitler, 1932; Desikachary, 1959; Starmach, 1966; Prescott, 1970). All obtained algal taxa were listed in alphabetic order without consideration to their arrangements which made by the previous literatures.

Air pollutant measurements: Measurements of SO_2, NO_2, suspended particles less than 10 μ (PM_{10}), black smoke and lead (μg m^{-3}) were performed during the period of study and provided kindly from the National Network for Monitoring Air Pollutants (NNMAP). NNMAP has 20 stations covering greater Cairo. The measurements of previous parameters were carried according to Japanese Industrial Standard (1995).

Table 1: The number assigned to each site, the site location and site type in which each sample is collected

Site No.	Site location	Site type
1	Nasr City	Residential zone
2	Abbasiya	Industrial/Residential zone (mixed)
3	Downtown	Residential/Commercial/heavily trafficked zone (Mixed)
4	Maadi	Residential
5	Tebbin	Industrial/Residential zone (mixed)

Fig. 1: The location of sampling sites in Cairo

RESULTS

The composition of airborne algal taxa: Table 2 shows that the isolated algal taxa throughout the years 2004 and 2005. Illustrations of twenty three algal species are given in Fig. 2-6. Distribution of airborne algae according to each site during the study period indicates that site 3 contains the highest number of total algal species. Thirteen species of algae are isolated from site 3, which represents 56.5% of the total algal isolates, while followed by site 4 and site 1 comprise 34.8 and 30, 4% of the total algal isolates, respectively. The lowest number of total algal species are isolated from site 2, representing 8.7% of total isolated algae.

Distribution of airborne algae according to seasonal variation: The data in Table 2 indicate that the composition of aeroalgal taxa varied with seasonal changes. With respect to the different species of algae, the number of airborne algal species was maximal in most cases during July throughout the years 2004-2005, except for site 4, where the number of isolated algae was maximal in December 2005.

Distribution of airborne algae according to annual rotation: The taxa *Chroococcus limenticus*, *Lyngbya lagerheimii*, *Phormidium ambigum* and *Schizothrix purpurascens* (Table 2) have been found during the both years 2004 and 2005, while the rest of algal species has been trapped either in 2004 or 2005. Of all genera, *Nostoc* spp. are the most common isolate (21.7%) of all algal isolates, followed by *Phormidium* spp. (17.4%). Fifteen species of algae are found specifically in one particular locality, while eight species are recorded in more than one locality. The index species represent 65.2% of all algal isolates.

Analysis of air pollutants: Table 3 shows the average concentration (μg m^{-3}) of SO_2, NO_2, PM_{10}, black smoke and lead concentration during the period of 2004 and 2005. Data show the highest concentration of SO_2, NO_2 and PM_{10} level at downtown (site 3), representing 49, 65, 163 μg m^{-3} for the year 2004 and 90, 69, 138 μg m^{-3} for the year 2005. Available data concerning black smoke and lead concentration indicate that Tebbin site records the highest concentration for both parameters, representing 58 and 1.3 μg m^{-3} for the year 2004 and 51 and 1.2 μg m^{-3} for the year 2005, respectively. While, the lowest value is recorded in Nasr city for black smoke (43 and 42 μg m^{-3}) for both years, respectively. With regarding the lowest value of lead, results show that downtown and Maddi are minimal records (1.1 μg m^{-3}) for 2004 and 0.8 μg m^{-3} for 2005, respectively.

Table 2: Distribution of airborne blue-green algae taxa at sampling sites during years 2004 and 2005

	Sample sites																				
	1				2				3				4				5				Algal frequency per all site
	2004		2005		2004		2005		2004		2005		2004		2005		2004		2005		
Algal taxa	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	Jul.	Dec.	
Calothrix marchica							√														1
Chroococcus limenticus									√	√	√	√	√	√	√	√					2
Gloeocapsa crepidinum									√												1
Hydrocoleum hetrotrichhum									√												1
Lyngbya lagerheimii	√	√	√	√																	1
Microcoleus chthonoplastes									√	√											1
Myxosascina sp.			√								√				√						3
Nodularia harvenyana																√					1
Nostoc linckia									√												1
N. muscorum																			√		1
N. paludosum									√	√											1
N. punctiform							√														1
N. sphaericum																			√	√	1
Phormidium ambigum														√		√					1
Ph. dictyothallum									√												1
Ph. tenue									√	√											1
Ph. uncinatum									√				√								2
Plectonema radiosum			√	√											√	√					2
Pseudoanabaena papillaterminta			√																		1
Schizothris purpurasceus	√		√						√	√	√	√	√								3
Sch. rivularis									√	√							√	√			2
Trichodesmum hildebrantii			√																√		2
Xenococcus sp.			√	√							√	√			√	√					3
Total No. of species/season	2	1	7	3	-	-	2	-	11	6	4	3	3	2	4	5	1	1	3	1	
Total No. of species/year	2		7		-		2		11		4		4		6		1		3		
Total No. of species/site	7				2				13				8				4				

√: Present, -: Not present

Table 3: The annual average concentration of Sulphur dioxide (SO_2), Nitrogen dioxide (NO_2), suspended particles less than 10 micron (PM_{10}), Black smoke and lead in 2004 and 2005

	Pollutant type ($\mu g\ m^{-3}$)									
	SO_2		NO_2		(PM_{10})		Black smoke		Lead	
Site location	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Nasr City	9	12	55	62	-	-	43	42	-	-
Abasseya	28	36	-	-	95	105	-	-		-
Downtown	49	90	65	69	163	138	-	-	1.1	0.8
Maadi	46	27	64	42	-	-	-	-	1.1	1
Tebbin	19	19	29	31	107	82	58	51	1.3	1.2

-: Data are not available

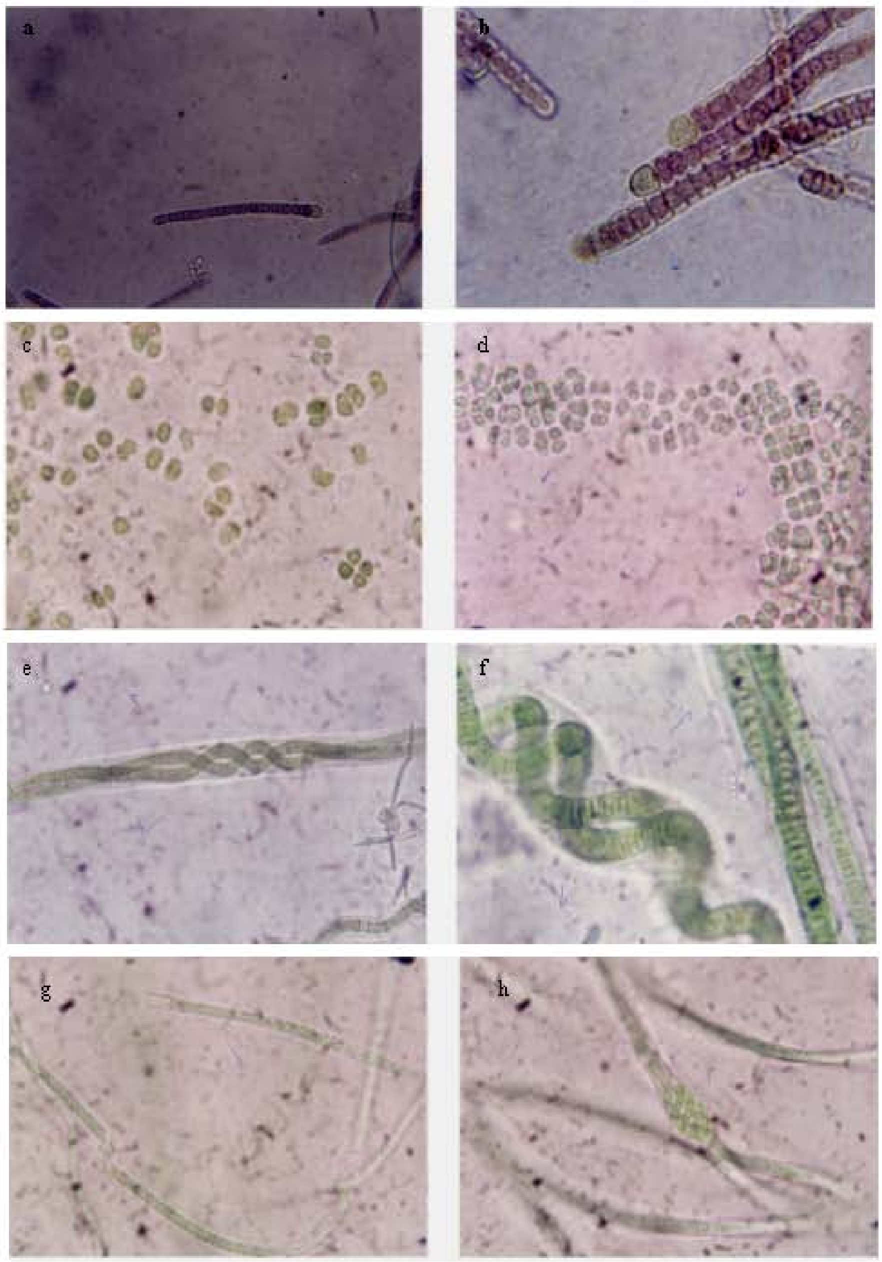

Fig. 2: (a, b) *Calothrix marchica*: (a), X 240; (b), X 600. (c) *Chroococcus limenticus*, X 1000. (d) *Gloeocapsa crepidinum*, X 1000. (e, f) *Hydrocoleum heterotrichum*: (e), X400; (f), X1000. (g, h) *Lyngbya lagerherheimii*, X1000

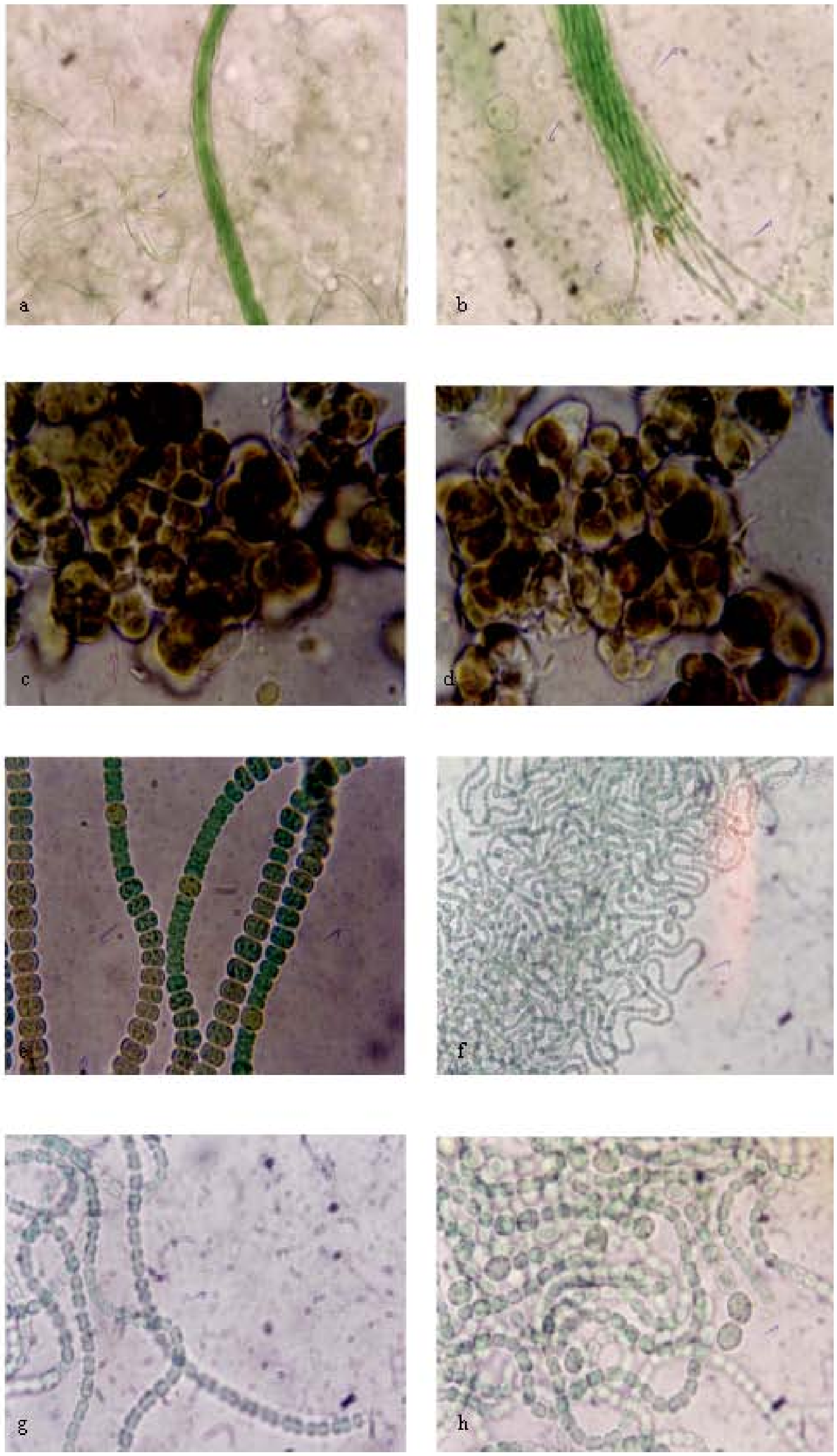

Fig. 3: (a, b) *Microcoleus chthonoplastes*: (a), X 400; (b), X 1000. (c, d) *Myxosarcina* sp., X650. (e) *Nodularia harvenyana*, X1250. (f-h) *Nostoc linkia*: (f), X400 (g) and (h), X1000

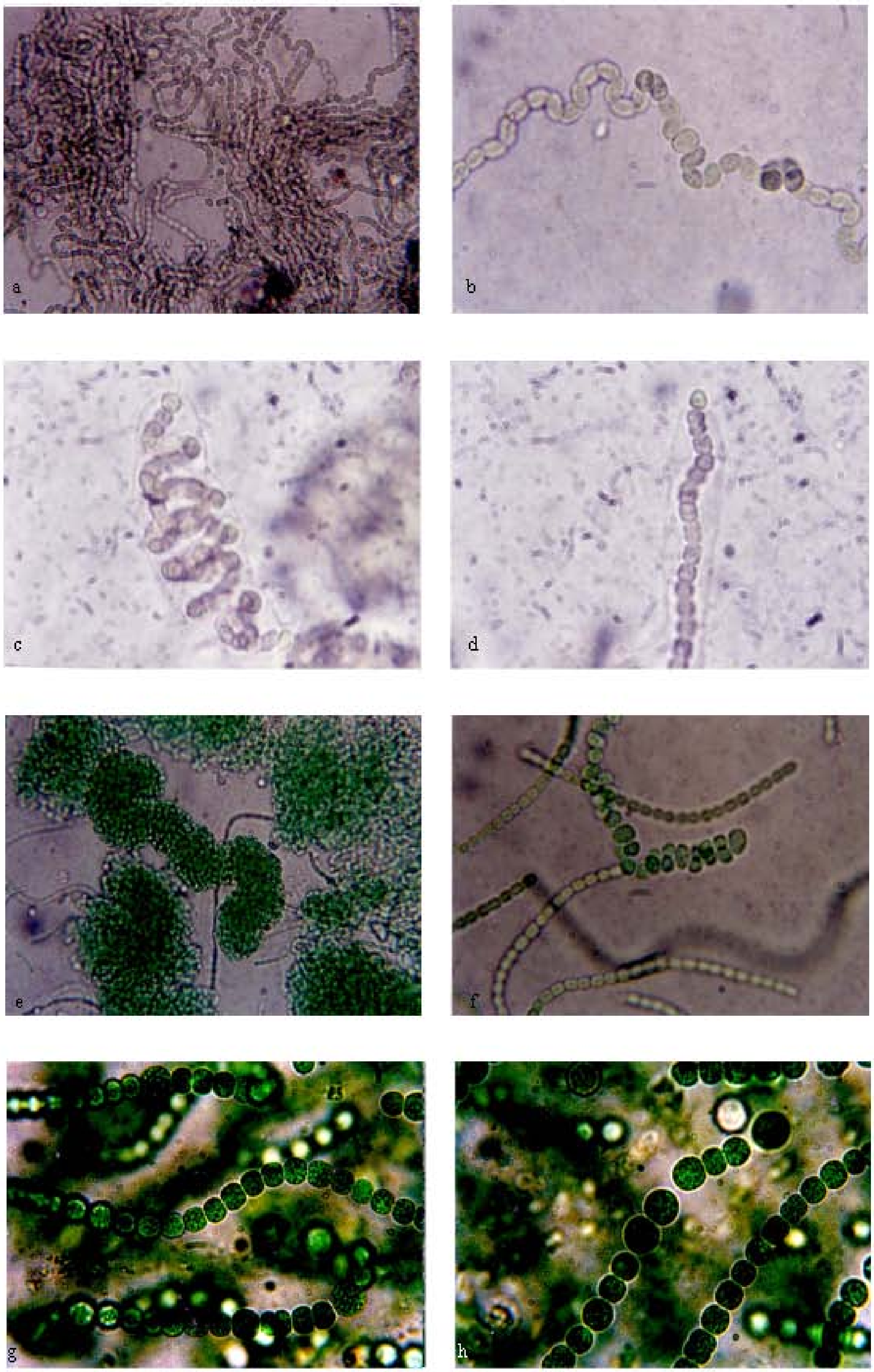

Fig. 4: (a, b) *Nostoc muscorum*: (a), X 500; (b), X 1250, (c, d) *Nostoc paludosum*, X 1000. (e, f) *Nostoc punctiforme*: (e), X 240; (f), X600. (g, h) *Nostoc sphaericum*, X625

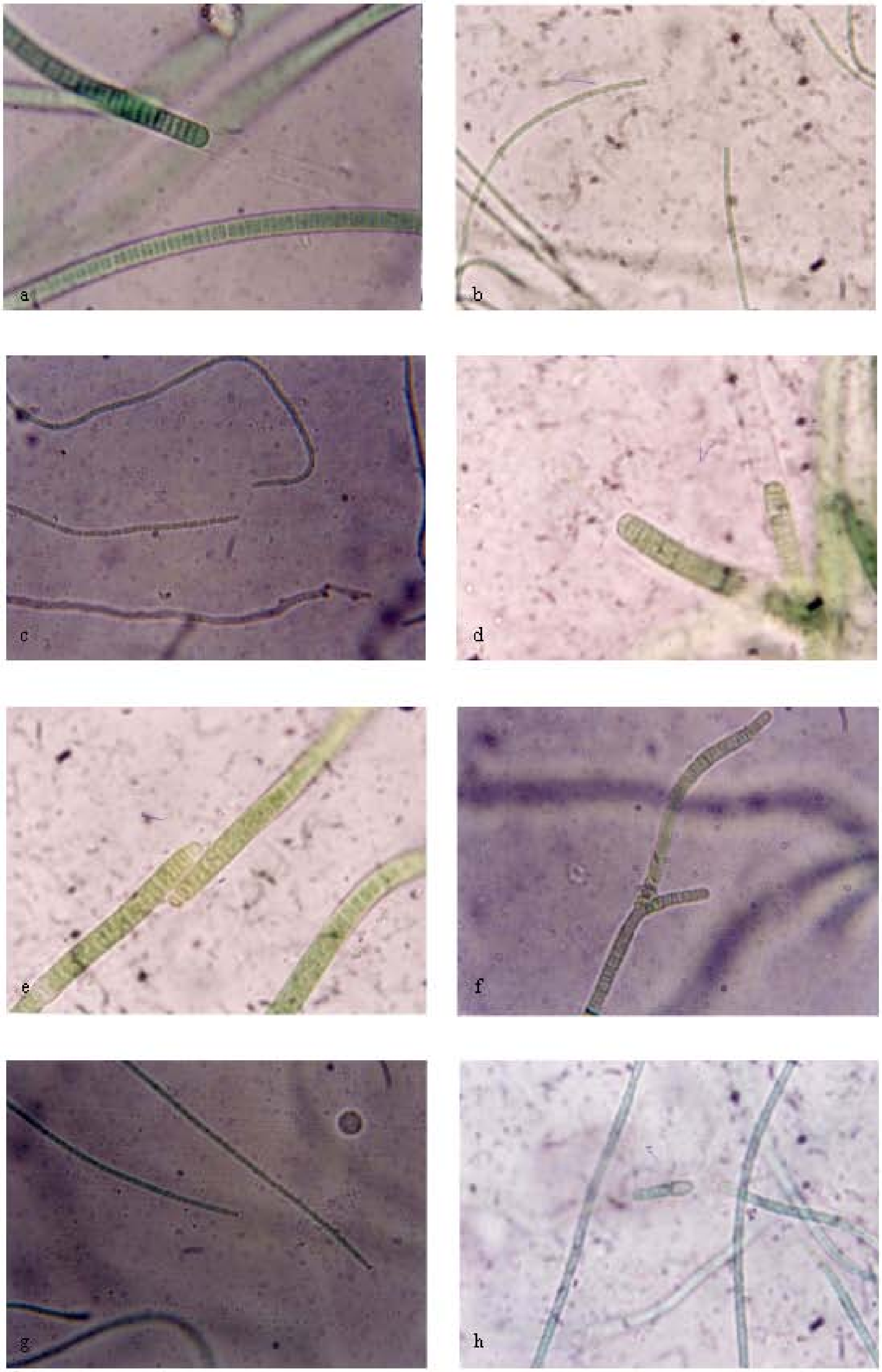

Fig. 5: (a) *Phormidium ambigum*, X 1250. (b) *Phormidium dictyothallum,* X 1000. (c) *Phormidium tenue*, X 500. (d, e) *Phormidium uncinatum*, X 1000. (f) *Plectonema radiosum*, X 1250. (g) *Pseudoanabaena papillaterminata*, X 600. (h) *Schizothrix purpurascens*, X 1000

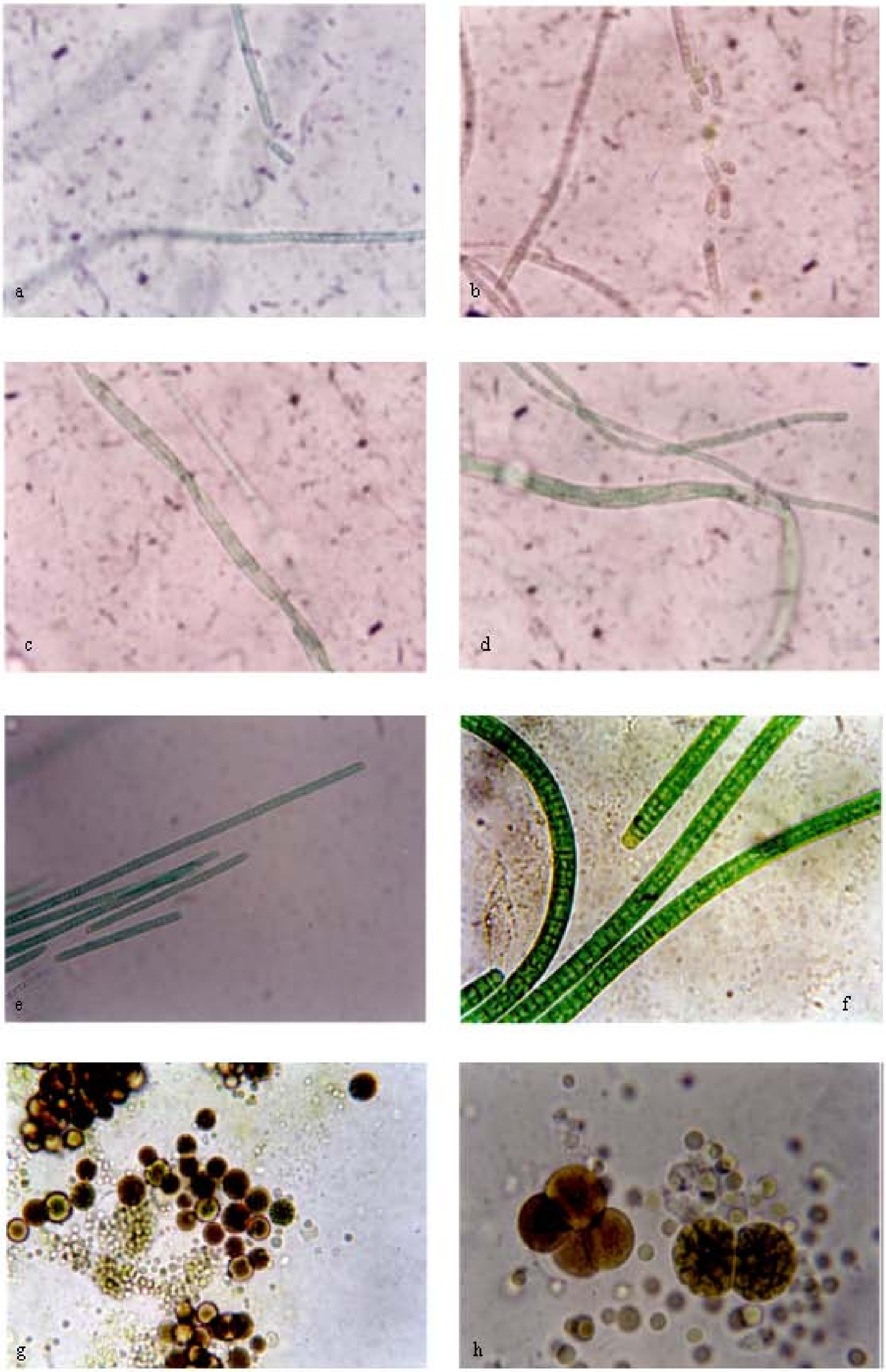

Fig. 6: (a, b) *Schizothrix purpurascens*, X 1000. (c, d) *Schizothrix rivularis*, X 1000. (e, f) *Trichodesmium hildebrantii*: (e), X240; (f), X600. (g, h) *Xenococcus* sp., X 250

DISCUSSION

Aerobiology is a rapidly developing branch of biology. One of the main fields of aerobiology has traditionally been to study biological particles, such algae and other microorganisms. Such branch also goes on periodicity, succession and quantities of airborne organisms.

An important medical application of aerobiology now is to study of the transmission of airborne diseases. Aerobiological studies conducted in different parts of the world have demonstrated the presence of different micro algal groups in the air (Carson and Brown, 1978). Cyanobacteria may become abundant in the air of tropic or subtropic zones with warm atmospheres (Schlichting, 1974).

In Egypt, survey on the incidence of aerophytic algae is completely unknown; therefore, the present study was designed to discover some aerophytic Cyanophyceae inhabiting Cairo's air in regarding to some air pollutants. The composition of airborne algal taxa of Cairo is characterized by isolation of 23 species of blue-green algae. Thirteen species are isolated from site 3 representing 56.5% of the total algal isolates, followed by site 4, which comprises 34.8%, then site 1 representing 30.4%. The highest numbers of algal species are isolated from downtown (site 3) which characterized as residential/heavily trafficked/commercial zone. High catches of algae in such site could be due to highest concentration of suspended particles recorded, as airborne algae which are readily carried away by wind. Another possible explanation might be due as adapted algal species to urban stresses are able to increase in number (McKinney, 2006). The lowest numbers of total algal species are isolated from site 2, then site 5, representing 8.7 and 17.4%, respectively of total isolated algae. Site 2 and site 5 are characterized as residential/industrial zones. It is assumed that industrial zones, especially in Abassiya and El-Tebbin generate a lot of pollutants and chemical compounds that diffused into the ambient air and adversely influencing all ecological system and in turns, decline the algal numbers in both areas.

The total numbers of present aeroalgal taxa varies with seasonal changes. In most cases, the number of airborne algal species was maximal in July throughout the years 2004-2005 while their number was minimal in December during the sampling years 2004-2005. Sharma *et al.* (2006) stated that different groups of algae respond differentially to the climatic conditions, resulting in periodicity and seasonal changes in the composition of algal community. Moreover, Kumar (1990) noticed that the higher incidence of algae in spring and summer and the lowest incidence in the rainy season (July-August) during a period of 20 years (1967-1968) from India. Another similar study by Sharma *et al.* (2006)showed that the most favored season for the appearance of cyanobacteria in the air was late summer to early rainy season (May and June), while they were the lowest during winter (January and February). Some of the airborne algal species exhibiting no effect of seasonal variation throughout the year, such as *Chroococcus limenticus*, *Lyngbya lagerheimii*, *Schizothrix purpurascens*, etc. The sampling year 2005 has registered a higher number of aeroalgal community than the sampling year 2004, this could be due to variation in climatic condition. Similar results were obtained by Schlichting (1964).

Distribution of airborne algae according to annual rotation indicates that *Chroococcus limenticus*, *Lyngbya lagerheimii*, *Schizothrix purpurascens* and *Phormidium ambigum* have been found during the both years 2004 and 2005, while other recorded algal species has been trapped either in 2004 or in 2005. This supports the idea that some species had no effect of annual rotation and others are showing effects towards annual rotation. *Nostoc* spp. is the most isolate of all algal genera (21.7%), followed by *Phormidium* spp. (17.4%). As well as, 15 species of cyanobacteria are found specifically in one particular locality, while 8 species are recorded in more than one locality. The index species represents 65.2% of all algal isolates.

The present results show that the predominance of some airborne algae in more than one place and this explaining how algal species can tolerate the hazards of long-distance transportation and hence, 34.8% of the present airborne algae are dispersed in more than one locality.

The Egyptian aerophytic algal studies will be hardly started and the present findings raising some objects of hope: the paper describes the first aerophytic cyanobacteria from some Cairo areas and this will soon permit for further studies. The differences in composition, periodicity and succession of algae indicate a huge potential of algal biodiversity in Egyptian aerophytic biotopes and hence, all these genera should be forced to monitor all kinds of air pollutions. More precise picture of pollutant impacts can be established by use algae as bioindicators. Aerophytic algae will be of great growing importance due to the increasing of air pollution.

REFERENCES

Abdel-Hameed, M.S., 2006. Survey of soil algal flora of some cultivated soils in Beni Suef, Egypt. Egypt. J. Phycol., 7 (1): 1-15.

Allen, M.M., 1968. Simple conditions for growth of unicellular blue-green algae on plates. J. Phycol., 4: 1-4.

Anna, C.L.S., M.T. de Paiva Azevedo, L.H.Z. Branco and J. Komárek, 2007. New aerophytic morphospecies of Nostoc (cyanobacteria) from Sao Paulo State, Brazil. Hoehnea, 34 (1): 95-101.

Carson, J.L. and R.M. Brown Jr., 1975. Quoted in Aerobiology, Ecological System Approach. Edmonds (Ed.) 1979. US/IBP Synthesis Series. Dowden Hutchinson and Ross, Pennsylvania.

Carson, J.L. and R.M. Brown, Jr. 1978. Studies of Hawaiian freshwater and soil algae III Algal colonization and succession on a dated volcanic substrate. J. Phycol., 14 (2): 171-178.

Desikachary, T.V., 1959. Cyanophyta. Indian Council of Agricultural Research, New Delhi.

ElShoubaky, G.A., 2005. Seasonal variations of seaweeds at ElArish coast of Mediterranean sea (Egypt). Egypt. J. Phycol., 6: 39-55.

Fathy, A.A. and N.G.E. Mohammady, 2007. Seasonal variation on biomass and agar quality extracted from the marine red algae *Pterocladia capillacea* and *Hypnea musciformis* growing along Mediterranean seashore of Alexandria, Egypt. Egypt. J. Phycol., 8: 29-38.

Geitler, L., 1932. Cyanophyceae. Akademische Verlagsgesellschaft m.b.h., Liepzig.

Hawker, L.E. and A.H. Linton, 1971. Micro-Organisms, Function, from and Environment. Edward Arnold (Publishers) LTD, Great Britain, pp: 529-537.

Hughes, E.O., P.R. Gorthan and A. Zehnder, 1958. Toxicity of unialgal cultures of *Microcystis aeruginosa*. Can. J. Microbiol., 4 (3): 225-236.

Japanese Industrial Standard, 1995. JIS Handbook Environmental Technology. Japanese Standard Association, Akasaka, Japan.

Kumar, S., 1990. Studies on incidence of algae in the air from India. Nova Hedwigia, 51 (1-2): 257-273.

McKinney, M.L., 2006. Urbanization as a major cause of biotic homogenization. Biol. Conserv., 127 (3): 247-260.

Osman, M.E.H., A. El-Naggar, H.H. Omar and G.H. Esmail, 2003. Distribution of different soil algal taxa in relation to physico-chemical characteristics of soil at Gharbia governorate. Egypt. J. Phycol., 4 (1): 37-54.

Overeem, M.A. van, 1936. A sampling apparatus for aeroplankton. Proc. Roy. Acad. Amst., 33: 981-990.

Poulíèková, A. and P. Hašler, 2007. Aerophytic diatoms from caves in central Moravia (Czech Republic). Preslia, 79 (2): 185-204.

Prescott, G.W., 1970. Algae of the Western Great Lakes Area. W.M.C. Brown Company Publishers, Dubuque, Iowa, USA.

Salah El Din, R.A., 2005. Changes in physico-chemical characters and its impact on phytoplankton structure of lake Manzala. Egypt. J. Phycol., 6: 111-126.

Salisbury, J.M., 1869. On the cause of intermittent and remittent fevers, with investigation which tends to prove that these affections are caused by certain species of Palmellae. Am. J. Med. Sci., 51 (11): 51-75.

Schlichting, H.E. Jr., 1961. Viable species of algae and protozoa in the atmosphere. Lloydia, 24: 81-88.

Schlichting, H.E. Jr., 1964. Meteorological Conditions Affecting the Dispersal of Air-Borne Algae and Protozoa. Lloydia, 27: 64-78.

Schlichting, H.E. Jr., G.S. Raynor and W.R. Solomen, 1971. Recommendations for Aerobiology Sampling in a Coherent Monitoring System: Algae and Protozoa in the Atmosphere. In: Aerobiology Objectives in the Atmosphere Monitoring US/IBP, Benninghoff, W.S. and R.L. Edmonds (Eds.). Aerobiology Programme Hand Book I, Univ. Michigan, Ann. Arbor., pp: 60-62.

Schlichting, H.E. Jr., R.M. Brown and P.E. smith, 1973. Airborne algae of Hawaii: A Model for Coordinated Aerobiological Research. Benninghoff, W.S. and R.L. Edmon (Eds.). Proceeding workshop/ Conference I. Ecological systems approach to aerobiology. II. Development, Demonstration and Evaluation of Models. US/IBP Handbook #3.Univ. Michigan, pp: 150-155.

Schlichting, H.E., Jr., 1974. Periodicity and Seasonality of Airborne Algae and Protozoa. In: Phenology and Seasonality Modeling. Springer-Verlag. Heidelberg, New York, pp: 620- 634.

Schlichting, H.E., Jr., 1975. Some subaerial algae from Ireland. Br. Phycol. J., 10: 110-115.

Shanab, S.M.M., 2006. Algal flora of Ain Helwan.I. Algae of warm spring. Egypt J. Phycol., 7 (2): 197-219.

Sharma, N.K., S. Singh and A.K. Rai, 2006. Diversity and seasonal variation of viable algal particles in the atmosphere of a subtropical city in India. Environ. Res., 102 (3): 252-259.

Starmach, K., 1966. Cynanophyta-Glaucophyta. Polska Akademia Nauk, Warszawa.

Staub, R., 1961. Ernaharungsphysiologisch autoakologische untersuchengen der planktischen blaualga *Oscillatoria rubescence*. D.C. Schweiz Z. Hydrol., 23: 82-198.