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Indoor aeromycobiota of monumental sites in Minia Governorate

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Abstract. The indoor aeromycobiota contaminating 45 monumental places in Minia Governorate were surveyed during the period from July 2008 to August 2009.The sedimentation plate method along with potato dextrose agar (PDA) medium containing 65 ppm rose bengal were used. A total of 56 fungal species related to 28 genera were obtained from all sampling sites which were chosen to cover four historic eras (16 Pharaonic, 9 Greek Roman, 8 Coptic and 12 Islamic). The major fungal components were *Aspergillus* (10 species), *Penicillium* (5 species), *Alternaria* (3 species), *Cladosporium* (2 species), *Mucor* (3 species), *Ulocladium* (3 species) and *Phoma* (1 species). These fungi are thought to be responsible for the biodeterioration of limestone and woody elements of these historic places.

Key words: Monumental places, aeromycobiota, Minia, Egypt.

Introduction

Studies on indoor aeromycobiota have attracted the attention of several aerobiologists (Arya *et al*. 2001, Gregory 1973, Sahab *et al*. 2003, Zielinska-Jankiewicz *et al*. 2008). The connection between molds and cultural heritage has a long history which includes some myths and mysteries. The so-called 'curse of the pharaoh' – the death of several archaeologists in the team of Howard Carter after discovery and opening of Tutankhamun's tomb – was later explained by the fact that spores of the pathogenic fungi *Aspergillus niger* and *Aspergillus flavus* were found on and in the sarcophagi and that a lung infection or other systemic mycosis – aspergillosis – was the possible reason for death. Molds always were and still are threatening historical and contemporary material of objects of art in libraries and in museums (Pangallo *et al*. 2009, Sterflinger 2010). Fungi are also found on mural paintings in churches, in caves and in catacombs and even as biodeteriogens of architectural surfaces and stone monuments (Ettenauer *et al*. 2010, Steiger *et al*. 2011). The oldest and most precious objects suffering from serious fungal invasions are rock art caves as for example Lascaux in France (Bastian and Alabouvette 2009). Fungi cause serious esthetical spoiling of paintings, sculptures, costumes, ceramics, mummies, books and manuscripts. Due to their ability to form hyphal networks they penetrate materials deeply, resulting in material loss due to acid corrosion, enzymatic degradation and mechanical attack. Fungi in libraries, museums and their storage rooms can seriously threaten the health of the restorers, of the museum personnel and of the visitors due to their allergic potential, the production of mycotoxins and their ability to cause systemic infections in humans (Crook and Burton 2010). Airborne fungal spores in storage rooms of museums can well reach levels of more than 8000 per m^3. According to Yang and Johanning (1997) and Urzi and Realini (1998), transport and ultimate settling on the surfaces is affected by: i) the physical properties of particles and/or of droplets (size, density and shape); ii) the environmental parameters (magnitude of air movement, relative humidity and temperature) and iii) the bioreceptivity of the surface itself and nutrient availability. In Egypt, El-Hissy *et al*. (1991) studied the mycobiota of water and mud samples from sacred lake and wells at Karnak Temple (Luxor), Dandara Temple (Qena) and Abidos Temple (Sohag)). The common fungi in these historic places were *Alternaria alternata, Aspergillus flavus, A. fumigatus , A. niger , A. terreus.* Other fungal species belonging to *Cladosporium, Fusarium, Mucor, Penicillium, Rhizopus, Ulocladium* were also recorded. However, no available records on the airborne mycobiota of monumental places in Egypt and their impact on monuments, rocks, wooden blocks, mummies, as well as on health status of workers and visitors. This study was undertaken to to isolate and identify the indoor airborne fungi in monumental sites related to four historic eras (Pharaonic, Greek Roman, Coptic and Islamic) distributed in Minia Governorate.

Materials and Methods

The airborne fungal spores were surveyed in 45 monumental places belonging to 4 historic eras distributed in Minia Governorate as follows

(16 Pharaonic, 9 Greek Roman, 8 Coptic and 12 Islamic eras) (Fig. 1, Table 1). The study was extended for 14 months from July 2008 to August 2009. The exposed plate method (Hoekstra *et al.* 2004) was employed to trap the fungal propagules contaminating the air inside these places. Three plates (9 cm diam.) containing sterile potato dextrose agar (PDA) with rose bengal (65 ppm) as a bacteriostatic agent were used. The sampling time was set for 30 minutes at an approximate height of 50 cm. from the floor. After trapping, cultures were incubated at 28°C for 7-10 days. The growing fungi were counted, isolated and identified. Non- sporulating and slow-growing fungi were transferred to other media such as Czapek's Dox agar, PDA and potato sucrose agar (PSA) without rose bengal to allow better growth and sporulation. The counts were expressed as colony-forming units (CFUs) / 3 plates in individual exposure.

Identification of the trapped fungi

Identification of fungal genera and species was done on the basis of morphological characteristics using taxonomic keys and descriptions given by Raper and Fennell (1965), Pitt (1979), Sivanesan (1987), Moubasher (1993, Leslie and Summerell (2006) and Domsch *et al.* (2007).

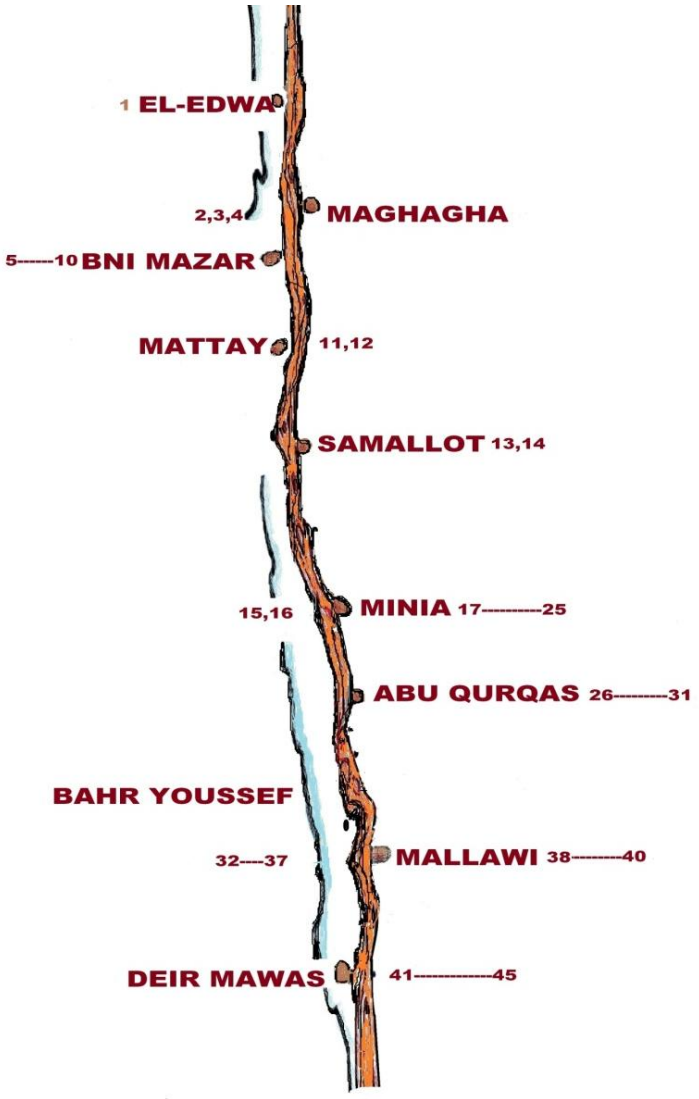

Fig.1: Map of monumental sites visited in Minia Governorate

Table 1: Sites from which airborne fungi were sampled.

Sample N0.	Site and place	Era	District
1	El-Qayatty mosque	Islamic	El-Edwa
2	El-Shoulqamy mosque (Aba El-Waqf)	Islamic	Maghagha
3	Marry Gerges church (Ashnien)	Coptic	Maghagha
4	Deir El-Garnos church (Aye Esos)	Coptic	Maghagha
5	El-Hassan El-Saleh mosque (El-Bahnassa)	Islamic	Bani- Mazar
6	SedyAly El-Gamam area (El-Bahnassa)	Islamic	Bani- Mazar
7	Merry tree (old tree) (El-Bahnassa)	Islamic	Bani- Mazar
8	Abu- Samra mosque (El- Bahnassa)	Islamic	Bani- Mazar
9	Abu-Samraminarte (El-Bahnassa)	Islamic	Bani-Mazar
10	El-SabaaBannat region (El-Bahnassa)	Islamic	Bani-Mazar
11	Virgin Mary church (Bardanoha village)-Orthozex church	Coptic	Mattay
12	Ava Qastour church (Bardanoha village)-Orthozex church	Coptic	Mattay
13	Virgin Mary church (Gabal El-Teir)	Coptic	Samalott
14	The two monumental doors area –God Hathour closet- Merembtah area (El-Saryrya)	Pharaonic	Samalott
15	El-Lamatty mosque (Minia city)	Islamic	Minia
16	El-Amrawy mosque (Minia city)	Islamic	Minia
17	Nero Temple (Tehna El-Gabal)	Greek- Roman	Minia
18	Embalming area (Tehna El-Gabal)	Greek- Roman	Minia
19	The God Hathour room (Tehna El-Gabal)	Greek-Roman	Minia
20	Crocodile room (Tehna El-Gabal)	Greek-Roman	Minia
21	Anka-ankh tomb (Frezer tombs) (El-Hawarta village)	Pharaonic	Minia
22	Kahab tomb (Frezer tombs) (El-Hawarta village)	Pharaonic	Minia
23	Hnoka tomb (Frezer tombs) (El-Hawarta)	Pharaonic	Minia
24	Saint Abahour church (Sawada village)	Coptic	Minia
25	The Pyramide base (Zaweit Sultan village)	Pharaonic	Minia
26	KhenmHotop II tomb (Bani-Hassan El-Shorouq village)	Pharaonic	Abu-Qurqas
27	Khety tomb (No.17) (Bani-Hassan El-Shorouq village)	Pharaonic	Abu-Qurqas
28	Bakht tomb (Bani-Hassan El-Shorouq village)	Pharaonic	Abu-Qurqas
29	Amenemhattomb (No.2) (Bani-HassanEl-Shorouq village)	Pharaonic	Abu-Qurqas
30	Pakhttemple Queen Hatshepsut and Tuhtmos III temple (IstableAntar)	Pharaonic	Abu-Qurqas
31	Embalming room (IstableAnter)	Pharaonic	Abu Qurqas
32	El-Yousfy mosque (Mallawi city)	Islamic	Mallawi
33	El-Asqalany mosque (Mallawi city)	Islamic	Mallawi
34	Bazilica church (El-Ashmonein)	Greek-Roman	Mallawi
35	Petosiris tomb (Tuna El-Gabal)	Greek-Roman	Mallawi
36	Isadora tomb (Tuna El-Gabal)	Greek- Roman	Mallawi
37	Catacombs of Ibis and Baboons (Tuna El-Gabal)	Greek-Roman	Mallawi
38	Ramsis II Temple (El-Sheikh Ebada)	Greek-Roman	Mallawi
39	Anba Beshoy church (Deir El-Barsha)	Coptic	Mallawi
40	Abu-Hennis church (Deir Abu-Hennis)	Coptic	Mallawi
41	Pentu tomb (No.5) (Tell El-Amarna) (Ekhat-Aton)	Pharaonic	DierMawas
42	MerireI tomb (No.4) (Tell El-Amarna)	Pharaonic	DierMawas
43	Ahmos tomb (No.3) (Tell El-Amarna)	Pharaonic	DierMawas
44	Aye tomb (No.25) (El-Haj Qandel)	Pharaonic	DierMawas
45	Aye tomb (No.23)(El-Haj Qandel)	Pharaonic	DierMawas

Results and Discussion

Fifty- seven species belonging to twenty-eight genera were collected from the indoor air samples in all different places of the four historical places as shown in Table (2). *Aspergillus* was consistently the most frequent genus (100% of exposures) and contributed the broadest spectrum of species (10 species) of which *A. niger* and *A. flavus* were of high frequency (33 and 23 sites out of 45) contributing 38.42% and 8.61% of the total count respectively.

Pencillium was moderately recovered from the indoor air of 14 monumental places matching 8.8% of total fungal catch. It was represented by six species of which *P. chrysogenum* and *P. purpurogenum* were common sharing with 3.14% and 4.19% of the total count respectively.

Alternaria and *Cladosporium* appeared in moderate incidence in the air of monumental places (17 sampling sites for each) matching 4.6 % and 17.0% of total fungal catch. *Alternaria* was represented by species of which *A. alternata* was the basic constituent (14 sampling sites out of 45). *Cladosporium* was represented by two species, namely *C. herbarum* and *C. sphaerospermum* which appeared in 9 and 8 places contributing for 12.96% and 4.61% of total fungal catch respectively. The rest of genera and species were isolated in low frequency with counts ranging from 1.26% to 0.21% of the total count.

Comparing the indoor aeromycobiota of the individual historic eras, results in Table (3) revealed that the highest fungal counts (260 CFU) and the broadest spectra of fungal genera (21) and species (40) were obtained from the monumental sites belonging to the Pharaonic era. This might be due to the relatively greater number of sampling sites of that era (16 sites) compared to limited number of sites belonging to other historic eras. The richest places in aeromycobiota were the Pharaonic tombs Pentu (No. 41) and Khnem-Hotop-II (No.26) located respectively at Tell El-Amarna and Bani Hassan El-Shorouq villages (which yielded nine fungal species for each). The poorest place was the Pharaonic tomb of Bakhet (Abu-Qurqas from which *A. flavus* was the only isolated fungus). *Aspergillus* was the most dominant genus in the air of Pharaonic places. It was represented by eight species and contributed 67.3% of the total count. *A. niger* and *A. flavus* constituting 34.40% and 25.60% of the total count respectively. The other species were identified in low frequency. *Alternaria* occurred also in high incidence contaminating 50% of sampling sites accounting for 4.6% of total fungi. Among the three species of *Alternaria, A. alternata* was the major representative (50% of samples matching 4.6% of total fungi). *Penicillium*, *Cladosporium*, *Mucor* and *Ulocladium* occurred in moderate (25%-43.8% of samples contributing 2.0 %-8.8% of total fungal catch). *Penicillium* was represented by four species of which *P. chrysogenum* and *P. purpurogenum* were moderately encountered (25% of samples for each) matching 1.6% and 5.8% of total fungi respectively. The remaining genera and species were less frequently isolated from the indoor air of the monumental places belonging to the Pharaonic era.

Regarding the Greek Roman era, results in Table (3) indicated that the lowest fungal population (68 CFU) and the narrowest spectrum of fungal genera (7) and species (9) were isolated from the 9 monumental sites of this era. The richest sampling site was Isadora tomb which yielded 6 species whereas the poorest place was Catacombs which yielded only *Penicillium italicum.* The most common genus was *Aspergillus* which was recovered from all places contributing 73.5% of the total count. It was represented by *A. niger* and *A. flavus* which appeared in 4 and 5 sites out of 9 matching 16.7% and 47.6% of total fungal population respectively. Each of *Alternaria* and *Cladosporium* appeared in 33.3% of sampling sites accounting respectively for 13.2% and 8.8% of total fungal catch. *A. alternata* and *A. tenuissima* were only represented in 11.1% and 22.2% of air samples matching 4.2% and 9.0% of total fungi respectively. *C. herbarum* and *C. sphaeropermum* occurred in 33.3% and 11.1% of samples representing 5.1% and 2.6% of total fungi respectively.

From the monumental places of Coptic era, 83 fungal colonies were obtained and classified in 19 species belonging to 13 genera. *Aspergillus* was the most common genus (100% of samples) and was represented by four species comprising 32.5% of the total count. *A. flavus* was represented in 50% of air samples sharing in the total count with 7.2%. Each of *Cladosporium* and *Phoma* appeared in moderate incidence (37.5% of indoor air samples) matching respectively 37.5% and 3.5% of total fungal catch. *Penicillium*, *Alternaria* and *Mucor* occurred also in moderate incidence (25% of sampling sites for each) whereas the remaining genera and species were recovered in low frequency and in low counts. The highest number of fungal species was identified in Saint Abahour church (11 species) whereas the lowest number (one species) was isolated from Dier Abu Henes church which was identified as *A. niger*.

Table 2: Indoor aeromycobiota recovered from the 45 monumental places in Minia Governorate on PDA medium at 28°C.

Genera & species	Total count	Total count %	Frequency	O. R.
Aspergillus	252	52.83	45	H
A. candidus Link	2	0.41	2	L
A. clavatus Desmazieres	1	0.20	1	L
A. flavipes (Bain. & Sart.) Thom & Church	4	0.83	1	L
A. flavus Link	41	8.59	23	H
A. niger van Tieghem	182	38.15	33	H
A. fumigatus Fresenius	6	1.25	6	L
A. ochraceus Wilhelm	8	1.67	1	L
A. terreus Thom	4	0.83	4	L
A. ustus (Bain.) Thom & Church	4	0.83	2	L
Penicillium	42	8.80	14	M
P. chrysogenum Thom	15	3.14	5	L
P. funiculosum Thom	2	0.41	2	L
P. italicum Wehmer	5	1.04	6	L
P. purpurogenum Stoll	20	4.19	7	L
Alternaria	22	4.61	17	M
A. alternata (Fr.) keissler	19	3.98	14	M
A. chlamydospora Mouchacca	1	0.20	1	L
A. tenuissima (Kurze ex. Pers.)Wiltshire	2	0.41	2	L
Acremonium rutilum W.Gams	1	0.20	1	L
Botryodiplodia theobromae Patouillard	1	0.20	1	L
Cladosporium	81	17.00	17	M
C. herbarum (Pers.) Link: Fr .	59	12.36	9	L
C. sphaerospermum Penzig	22	4.61	8	L
Cochliobolus	5	1.03	6	L
C. bicolor Paul & Parbery	1	0.20	1	L
C. lunatus (Shear) Boedijn	4	0.83	5	L
Chaetomium	3	0.62	2	L
C. fimicola Cooke	2	0.41	1	L
C. indicum Corda	1	0.20	1	L
Drechslera erythrospila (Drechsler) Shoemaker	1	0.20	1	L
Doratomyces stemonitis (Persoon) Morton & Smith	1	0.20	1	L
Emericella nidulans var. *lata* (Eidam) Vuill.	1	0.20	1	L
Phoma epicoccina Punithalingam, Tulloch & Leach	9	1.88	7	L
Eurotium amstelodami Mangin	1	0.21	1	L
Fusarium	4	0.83	2	L
F. chlamydosporum Wollenw. & Reninking	2	0.41	1	L
F. semitectum Berk. & Rav.	2	0.41	1	L
Humicola grisea Traaen	1	0.20	1	L
Mucor	11	2.30	8	L
M. circinelloides van Tiegh.	2	0.41	1	L
M. fuscus Bainier	1	0.20	1	L
M. racemosus Fresenius	8	1.67	5	L
Malbranchea sulfurea (Miehe) Coony & Emerson	1	0.20	1	L
Nigrospora sphaerica (Sacc.) Mason	2	0.41	2	L
Oidiodendron chlamydosporum Robak	2	0.41	2	L
Papulaspora irregularis Hoston	1	0.20	1	L
Paecilomyees variotii Bainier	1	0.20	1	L
Rhizopus oryzae Went & Geerl.	3	0.63	2	L
Setosphaeria. rostrata (Drechsler) Subram. & Jain	3	0.63	3	L
Stachybotrys chartarum (Ehrenberg) Hughes	8	1.67	9	L

Genera & species	Total count	Total count %	Frequency	O. R.
Stemphylium	2	0.41	2	L
S. botryosum Wallroth	1	0.20	1	L
S. vesicarium (Wallroth) E. G. Simmons	1	0.20	1	L
Syncephalastrum racemosum Cohn ex Schröter	1	0.20	1	L
Trichoderma harzianum Rifai	9	1.89	4	L
Tritirachium oryzae (Vincens) de Hoog	1	0.20	1	L
Ulocladium	7	1.46	5	L
U. botrytis Preuss	3	0.62	3	L
U. chlamydosporum Mouchacca	3	0.62	3	L
U. chartarum (Preuss) E. G. Simmons	1	0.20	1	L
Gross total count (CFU)	477			
Total No. of genera	28			
Total No. of species	52			

Occurrence remarks: High (H) = 23 – 45 sites, Moderate (M) = 11 – 22 sites and Low (L) = Less than 11 sites**.**

When the aeromycobiota of the 12 monumental places of Islamic era were surveyed it was observed that these sites were contaminated with twenty-seven species belonging to sixteen genera with a total fungal catch of 136 CFU. *Aspergillus* was also the most common genus contaminating the air of all sites. It was represented by six species contributing 63.0% of the total count. *A. niger* and *A. flavus* were also the most prevalent species being recovered from 100% and 50% of sites comprising 42.22% and 16.3% of the total fungal count respectively. *Penicillium, Alternaria, Cladosporium* and *Stachybotrys* occurred in moderate incidence (25%-41.7% of samples accounting for 3.7%-10.4% of total fungal population). The richest sample was recorded in El-Qayatty mosque which contained eight species. Two places were considered to be the poorest which were El-Yousfey mosque (Mallawi City) and El-Seidah Rouqaya area (Bani Mazar City) from which *Trichoderma harzianum* and *A. niger* were respectively isolated.

Results of the present investigation showed great similarity with those obtained from different monumental sites around the world. In Italy, Urzi *et al*. (2001) studied the air borne fungi of Messina museum and found that *Aspergillus, Penicillium, Fusarium, Alternaria, Cladosporium, Ulocladium, Aureobasidium* and *Phoma* were the most common. The authors mentioned that once fungi settle on and colonize stone surfaces they contribute to a great variety of alterations like black patinas, inter-granular growth, marble sugaring, biopitting, etc. In Roman catacombs, Saareia *et al*. (2004) isolated fungi from both air and biofilm samples namely *Lecanicillium psalliotae, L. aranearum, Torrubiella* spp. and *Beauveria alba* and less frequent fungi include *Alternaria* spp., *Cladosporium* spp. and *Curvularia* spp. In China, Wanfu (2010) studied fungal spores in open and closed caves from September 2008 to August 2009, the most prevalent species were related to *Cladosporium, Penicillium, Alternaria* and *Aspergillus.* In Turkey, Nuhoglu (2006) studied the accelerating effects of microorganisms on the biodeterioration of stone on monuments under air pollution aged from 441 to 823 years old. The results showed that the microorganisms could develop during the winter months when the night time average temperature was even -25°C.

In non-historic places the indoor mycobiota showed also high similarity with those identified in the present investigation. In Madrid (Spain), Silvia *et al.* (2007) made an aero mycological sampling during 2003 and 2004 in atmosphere of the University Campus. They were able to identify 70 fungal species in 2003 and 83 species in 2004, the most abundant were *C. cladosporioides, C. herbarum*, and unknown species of *Aspergillus, Pleospora* and *Bovista*. In Romania, Nicoleta and Dorina (2009) recorded the most prevalent fungal spores in the air were species of *Cladosporium, Setosphaeria, Alternaria* and *Epicoccum*. In Italy, Anna and Marinella (2000) surveyed the air spora of two Milan underground stations and found that *Cladosporium, Penicillium, Epicoccum* and *Alternaria* were the common genera.

The expected source of indoor contamination by fungi is the movement of outdoor fungal propagules from open fields, vegetation, soil, deteriorating plants and others to thes monumental places. This expectation can be supported by the great similarity between these fungal species and those previously isolated by Mazen and Shaban (1983) from wheat fields in Minia Governorate. During that study *Aspergillus* spp. (*A. terreus, A. niger* and *A. flavus*), *Alternaria alternata, Cladosporium* spp. (*C. cladosporiodes* and *C. herbarum*) and

Table 3: Indoor aeromycobiota recovered on PDA at 28° C from the different monumental places

Eras	Pharaonic era (16 sites)					Greek Roman era (9 sites)					Coptic era (8 sites)					Islamic era (12 sites)				
Genera & species	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR
Aspergillus	175	67.3	16	100	H	50	73.5	9	100	H	27	32.5	8	100	H	85	63.0	12	100	H
A. candidus	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
A. clavatus	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	1.2	1	12.5	L	0	0.0	0	0.0	0
A. flavipes	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
A. flavus	64	25.6	9	56.3	M	13	16.7	4	44.4	M	6	7.2	4	50.0	M	22	16.3	6	50.0	H
A. fumigatus	4	1.6	3	18.8	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	2	1.5	2	16.7	L
A. niger	86	34.4	11	68.8	H	37	47.4	5	55.6	H	19	22.9	5	62.5	H	57	42.2	12	100	H
A. ochraceus	2	0.8	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
A. terreus	3	1.2	3	18.8	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	2	1.5	1	8.3	L
A. ustus	14	5.6	1	6.6	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Penicillium	23	8.8	7	43.8	M	10	14.7	1	11.1	L	8	9.6	2	25.0	M	14	10.4	4	33.3	M
P. chrysogenum	4	1.6	4	25.0	M	0	0.0	0	0.0	0	0	0.0	0	0.0	0	2	1.5	1	8.3	L
P. funiculosum	1	0.4	2	6.6	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
P. italicum	3	1.2	2	12.5	L	10	12.8	1	11.1	L	2	2.4	1	12.5	L	3	1.20	2	12.5	L
P. purpurogenum	15	68.	4	25.0	M	0	0.0	0	0.0	0	6	7.1	1	12.5	L	9	6.7	2	12.5	L
Alternaria	12	64.	8	50.0	H	9	13.2	3	33.3	M	4	4.8	2	25.0	M	5	3.7	4	33.3	M
A. alternata	10	4.0	8	50.0	H	2	4.2	1	11.1	L	4	4.7	2	25.0	M	5	3.7	4	33.3	M
A. tenuissima	1	0.4	1	6.3	L	7	9.0	2	22.2	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0
A. chlamydosporum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Acremonium rutilum	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	l
Botryodipolodia theobromae	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Chaetomium	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
C .indicum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
C. fimicola	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Cladosporium	16	6.2	5	31.3	M	6	8.8	3	33.3	M	31	37.3	3	37.5	M	12	8.9	5	41.7	M
C. herbarum	11	4.4	2	18.8	L	4	5.1	3	33.3	M	7	8.3	2	25.0	M	2	1.5	2	12.5	L
C. sphaerospermum	5	2.0	2	12.5	L	2	2.6	1	11.1	L	25	29.4	2	25.0	M	10	7.4	3	25.0	M
Cochliobolus	3	1.2	3	18.8	L	3	4.4	2	22.2	L	1	1.2	1	12.5	L	0	0.0	0	0.0	0
C. bicolor	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
C. lunatus	2	0.8	2	12.5	L	3	4.4	2	22.2	L	1	1.2	1	12.5	L	0	0.0	0	0.0	0

Table 3: Continued

Eras	Pharaonic era (16 sites)					Greek Roman era (9 sites)					Coptic era (8 sites)					Islamic era (12 sites)				
Genera & species	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR
Doratomyces stemonitis	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Drechslera.erythrospila	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Emericilla.nidulans var. *lata*	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Eurotium.amstelodami	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Fusarium	1	0.4	1	6.3	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	0	0.0	0	0.0	0
F. chlamydosporum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
F. semitectum	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	1.2	1	12.5	L	0	0.0	0	0.0	0
Humicola grisea	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Malbranchea sulfurea	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Mucor	5	2.0	4	25.0	L	0	0.0	0	0.0	0	2	2.4	2	25.0	L	2	1.5	2	12.5	L
M. circinelloides	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	12.5	L
M. fuscus	1	0.4	1	6.3	L	0	0.0	0	0.0	0	2	2.4	1	12.5	L	0	0.0	0	0.0	0
M. racemosus	4	1.6	3	18.8	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	1	0.7	1	8.3	L
Nigrospora sphaerica	2	0.8	2	12.5	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Oiodiodendron chlamydosporum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.7	1	8.3	L
Paecilomyces variotii	1	0.4	1	6.3	L	0	00.	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Phoma epicoccina	2	0.8	2	12.5	L	4	5.1	1	11.1	L	3	3.5	3	37.5	M	2	1.5	1	8.3	L
Rhizopus oryzae	1	0.4	1	6.3	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	0	0.0	0	0.0	0
Setosphaeria. rostrata	1	0.6	1	6.3	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	2	1.5	1	12.5	L
Stachybotrys chartarum	2	0.8	2	12.5	L	0	0.0	0	0.0	0	1	1.2	1	12.5	L	5	3.7	3	25.0	M
Stemphylium	2	0.8	2	12.5	L	0	0.0	0	0.0	0	0	0.0	1	0.0	0	0	0.0	0	0.0	0
S. botryosum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	0.40	1	6.3	L
S. vesicarium	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Syncephalastrum racemosum	1	0.4	1	6.3	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Trichoderma harzianum	2	0.8	2	12.5	L	6	8.8	1	11.1	L	0	0.0	0	0.0	0	1	0.7	1	8.3	L

Table 3: Continued:

Eras	Pharaonic era (16 sites)					Greek Roman era (9 sites)					Coptic era (8 sites)					Islamic era (12 sites)				
Genera & species	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR	TC	%TC	F	%F	OR
Tritirachium oryzae	0	0.0	0	0.0	0	0	0.0	0	0.0	0	1	1.2	1	12.5	L	0	0.0	0	0.0	0
Ulocladium	7	2.8	5	31.3	M	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
U. botrytis	2	0.8	3	12.5	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
U. chartarum	3	1.2	3	18.8	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
U. chlamydosporum	2	0.8	2	12.5	L	0	0.0	0	0.0	0	0	0.0	0	0.0	0	0	0.0	0	0.0	0
Total Count (CFUs)	260					68					83					136				
No. of genera No. of species	21 40					7 9					13 19					16 26				

% F= Percentage frequency (calculated per 16 places from Pharaonic era, 9 from Greek Roman era, 8 from Coptic era and 12 from Islamic era); OR= Occurrence remarks; H= 50.0% - 100%, M=25.0% - 49.0%, L= Less than 49.0% (Pharaonic), Counts are calculated as colony- forming units (CFU) / 3 plates and 30 min. exposure each.

Fusarium solani were isolated. In Assuit, Moubasher and Moustafa (1974) isolated *Cladosporium*, *Alternaria*, *Aspergillus* and *Penicillium* as common air borne fungi. Also Ismail *et al*. (2010) recorded *Alternaria*, *Aspergillus*, *Cladosporium*, *Eurotium*, *Penicillium* and *Rhizopus* from the indoor air of the external dermatology clinics of Assuit University Hospitals.

As mentioned by Helmi *et al*. (2011) biodeterioration of mural paintings by *A, niger* and *A. flavus* has been proved in different mural paintings in Egypt. These fungi were observed on mural paintings of Nfer Bau Ptah Tomb, Giza, Egypt. Successful cleaning of these paintings was done with the antibiotic "6-penthyl α-pyrone phenol" extacted from *Trichoderma* sp. followed by fumigation of the tomb by isopropy (alcohols to avoid any new contamination by fungal spores). During their mycological analysis of some Egyptian mummies, Elnagger *et al*. (2010) were able to isolate *Alternaria tenuis, Aspergillus niger, Chaetomium globosum* and *Penicillium corylophilum.* Lopez-Martinez *et al*. (2007) isolated 469 fungal colonies from 12 mummies deteriorated with fungi. Among the isolated fungi, *Penicillium, Cladosporium* and *Aspergillus* were identified. Abdulla *et al*. (2008) isolated some species of actinomycetes from decayed and sound stone taken from a tomb at Tell Basta, Zagazig City, Egypt.

In conclusion, The results of this study indicated that the air mycoflora of monumental places were almost similar to those obtained from other places. The role of these fungi on deterioration of monumental elements will be studied in the future.

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