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Full Length Research Paper

A study on the fungi isolated from the carpeting, walls and Holy Qurans from the Blue Mosque and Little Hagia Sophia Mosque situated in the province of Istanbul

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In this study the sampling of microfungus content from the carpeting, walls and Holy Qurans of two different mosques in the province of Istanbul was undertaken and in order to determine quantities. Samples were taken in 2015 during the months of January, April, July and October. The samples were taken with non-agar based sterile swabs and were then taken to the laboratory. Throughout the duration of the study, 17 species belonging to 9 genera were isolated and a total of 193 colonies were examined. Throughout the study the most commonly isolated microfungus genus was *Aspergillus* at 52.9%. This genus was followed by *Penicillium* at 26.5%, *Cladosporium* at 7.8%, *Alternaria* at 4.7%, *Chaetomium* at 2.6%, *Trichoderma* at 3.2%, *Mucor* at 1.1% and *Eurotium* and *Rhizopus* 0.6%. Throughout the duration of the study the most isolated species of microfungus was *Aspergillus fumigatus* at 25.9%. This species was followed by *Aspergillus flavus* at 9.8%, *Penicillium palitans* at 9.3%, *Aspergillus niger* at 8.3%, *Penicillium citreonigrum* at 7.8%, *Penicillium solitum* at 6.3%, *Aspergillus sydowii* at 5.2%, *Alternaria alternata* and *Cladosporium sphaerospermum* at 4.7%, *Aspergillus parasiticus* at 3.7%, *Trichoderma longibrachiatum* at 3.2%, *Penicillium citrinum* and *Cladosporium cladosporioides* at 3.1%, *Chaetomium globosum* at 2.6%, *Mucor* sp. at 1.1%, and finally *Eurotium herbariorum* and *Rhizopus stolonifer* at 0.6%.

Key words: *Aspergillus*, *Penicillium*, fungus, carpet, mosque, Istanbul.

INTRODUCTION

The close relationship between fungi and mankind has existed from the beginning of time. Due to the fact that fungi can spread and disperse in all segments of nature such as soil, air and water and use all manner of resource to find nourishment, ensures that, with such characteristics, they find themselves a place in all geographies and climatic zones (Singh, 2005; Mallo et al., 2011; Yassin and Almouqatea, 2010). The following factors ensure that fungi is determined as being important globally: The dissolving of organic matter, the fact that they are both pathogen and allergen for humans and plants, the fact they are antibiotic forming and can cause

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foodstuffs to rot (Sarica et al., 2002; Çeter and Pınar, 2009).

Through spores which are the reproductive form of fungi, fungi can easily disperse in the air and because of this possess the characteristic of diffusing widely. They can be found in great quantities both indoors and outdoors (Asan et al., 2004; Ilhan and Asan, 2001). The determination and identification of the poor quality of inhaled air arising from indoor work and living quarters on humans is not only very difficult but can lead to complicated diseases. As a result of this, one or a chain of symptoms give rise to the syndrome or syndromes known as “Sick Building Syndrome (SBS)” (Keskin et al., 2005a). Symptoms that can arise in relation to the building include eye corner irritation, influenza type symptoms, various allergic reactions, skin and throat dryness, lethargy, headaches and sometimes asthma (Çobanoğlu et al., 2005; Keskin et al., 2005b).

A number of negative effects can be seen in those who have a fungal sensitivity (Özyaral, 2003). Patients who suffer from fungi sensitivity and can therefore considered to be allergy patients can complain of the following symptoms: 71% of patients complain of muscle pain, 70% complain of lethargy and extreme tiredness, 67% complain of cognitive disorders**,** 65% complain of sinusitis, 65% of headaches, 58% of digestive disorders, 54% complain of shortness of breath, 54% of depression, 46% of memory loss and other neuropsychiatric problems, 42% of problems with sight, 42% of chest pains and a feeling of congestion, 40% of sleeplessness, 40% of respiratory problems, 38% of drowsiness, 35% of apathy, 35% of laryngitis, 33% of sickness, 29% of fibromyalgia, 27% of skin irritation, 25% of shivering, 25% of colon disorders and 21% of heart palpitations (Stark et al., 2004).

The fungus species that cause allergies in humans are generally of airborne origin. The species that is primarily responsible for the mould that cause allergies in humans are species that are related to the genera of *Cladosporium*, *Alternaria*, *Penicillium*, *Aspergillus* and *Fusarium.* These species are commonly found throughout the world (Kalyoncu, 2010; Gelişken, 2008; Suerdem and Yildirim, 2009).

The allergens that are produced by moulds can cause Ige dependant responses such as allergic rhinitis immunologically and allergic asthma. Less commonly they can give rise to immune dependant disorders such as allergic bronchopulmonary aspergillosis (ABPA), allergic fungal sinusitis and hypersensitivity pneumonitis. Non-immune effects are those as infection, inhalation temperature, mucous membrane irritation and effects linked to mycotoxins (Mazur and Kim, 2006).

It is known that carpets harbour a higher proportion of dust compared to wooden or nylon lined flooring. Studies have shown that some carpets harbour great quantities of allergens and in comparison to flat surfaces and air and it is observed cause a higher rate of fungus to be reproduced (Beguin and Nolard, 1999).

Mosques are open day and night, all year around, at all hours and are open to the young and old, men and women, the educated and uneducated and are educational institutions which are of the upmost spiritual significance. Due to the common aim mosques are utilised for, they are platforms that are subject to a heavy flow of traffic in the form of users

Mosques are subject to hundreds of visitors daily and even though they are aired, the opportunity to clean them in the same way that a small area would be cleaned does not arise. Because of this, microorganisms are harboured internally and this gives rise to huge problems and respiratory tract diseases such as sinusitis and allergic disorders, amongst others, are caused by mould (Çolakoğlu, 1996; Ponikau et al., 1999).

The aim of the research carried out was to isolate and subsequently identify the microfungi found on the carpets, walls and Holy Qurans of the Blue Mosque and Little Hagia Sophia Mosque situated in the province of Istanbul. Mosques are extremely important from a spiritual and cultural perspective and the micoflora found in the two mosques will be exploited to ascertain the species of fungus dominant. This study, which focuses on mosques which are communally used spaces, is significant in that it highlights the risks fungi present in causing infections.

MATERIALS AND METHODS

In the year of 2015 and in the months of January, April, July and October, samples were taken twice a month from the carpeting, walls and Holy Qurans of the Blue Mosque and Little Hagia Sophia Mosque in the province of Istanbul.

The samples were taken with non-agar based sterile swabs from the chosen stations. Sterile gloves were used during the sample taking procedure. The samples were taken at times to coincide when the mosques were full of visitors. Mosques in Istanbul used for sampling includes: (1) Blue Mosque, and (2) Little Hagia Sophia Mosque.

Isolation

The samples taken were brought to the laboratory and were cultivated in Peptone-Dextrose Agar. 30 mg/ml of Rose-Bengal an antimicrobic agent was added to the prepared culture in order to hinder the size of the colonies and sterilised for 15 min at a temperature of 120°C and after cooling from 45 to 50°C, 30 mg/ml of Streptomycin was added prior to pouring into Petri dishes in order to hinder the reproduction of bacteria (Menzies, 1965). The isolated fungi were spot cultivated in Malt Extract Agar (MEA) medium and the Petri dishes were left to incubate at room temperature (22-26°C) and after 7 to 14 days, pure colonies were detected (Çolakoğlu, 1983).

Macroscopic characteristics include:

1. Colony diameter
2. Colony texture
3. Colony shape
4. Colony colour from above and underneath
5. Sporulation

6. Zonation
7. Exudation
8. Pigmentation
9. Existence of various macroscopic reproductive structures

Microscopic characteristics include:

1. Colony texture with stereo microscope
2. Shape of conidia upon budding
3. Measurement of various sections with light microscope
4. Perimeter characteristics
5. Perimeter colours

The above listed characteristics were used in the identification process (Tikveşli, 2013).

In order for the microscopic structures of the microfungi to be examined under a microscope, lactophenol solution dyed in picric acid was used (Bilgehan, 2002). For examination purposes, lamellae mounted slides were prepared. A few drops of lactophenol solution were added to the slide followed by the microfungi using a sterile pipette and finally sealed by lamella. After a while, the lamellae corners were sealed with the aid of a clear nail polish.

The slides obtained from the pure fungi cultures were examined using a microscope. An Olympus Cx22 make microscope was used in the study. In order to obtain readings, the ocular micrometre was placed in the ocular of the microscope. The microfungi were captured using a digital camera and subsequently the identification of these fungi was based on both national and international literature (Çolakoğlu, 1983).

For the identification of general species, “Fungi and Indoor Fungi, “Identification of common *Aspergillus* Species” and the publications of CBS-KNAW were utilised” (Samson et al., 2010). In addition to the above, “The Genus *Aspergillus*” was used for the identification of *Aspergillus* species (Raper and Fennell, 1965), whereas ‘‘Dematiaceous Hyphomycetes’’ was utilised for the identification of the *Alternaria* and *Cladosporium* species (Ellis, 1971) and ‘‘A Manual of the *Penicillia*’’ was used for the identification of *Penicillium* species (Raper et al., 1949).

RESULTS

As a result of samples being taken and isolated from the carpets, wall and Holy Qurans of two different mosques in the province of Istanbul, 193 colonies detected from 9 genera and 17 different species were examined (Table 1).

An examination of the overall total reveals that the most isolated microfungus was the *Aspergillus* genus at 52.9%. The following genus followed the above genus in terms of being the most isolated genus of microfungus; *Penicillium* at 25.6%, *Cladosporium* at 7.8%, *Alternaria* at 4.7%, *Chaetomium* at 2.6%, *Trichoderma* at 3.2%, *Mucor* at 1.1% and *Eurotium* and *Rhizopus* at 0.6% respectively (Table 1). Throughout the duration of the study the most isolated species was *Aspergillus fumigatus* at 25.9% and this was followed by *Aspergillus flavus* at 9.8%, *Penicillium palitans* at 9.3%, *Aspergillus niger* at 8.3%, *Penicillium citreonigrum* at 7.8%, *Penicillium solitum* at 6.3%, *Aspergillus sydowii* at 5.2%, *Alternaria alternata* and *Cladosporium sphaerospermum* at 4.7%, *Aspergillus parasiticus* at 3.7%, *Trichoderma longibrachiatum* at 3.2%, *Penicillium citrinum* and *Cladosporium cladosporioides* at 3.1%, *Chaetomium globosum* at 2.6%, *Mucor* sp. At 1.1% and *Eurotium herbariorum* and *Rhizopus stolonifer* at 0.6% (Table 1) (Figure 1).

According to the results of the research conducted, carpets were the material that microfungus were most isolated from, at a value of 37.2%. This was followed by walls at 34.2% and Holy Qurans at 28.5% (Table 1). According to the results of the research, the mosque which had the highest level of microfungus isolation was the Little Hagia Sophia Mosque with a value of 57.1% (Table 2).

The material at the Little Hagia Sophia Mosque that had the highest level of microfungus isolation was the carpets with a value of 23.9%. This was followed by the walls at 18.1% and the Holy Qurans at 15.1% (Table 1).

The species most isolated from the carpets of the Little Hagia Sophia Mosque was *A. fumigatus* at *26.1%,* while the species most isolated from the walls was *A. niger* at 17.2% and finally, the species most isolated from the Holy Qurans was *A. fumigatus* at 34.5% (Table 3).

At the Little Hagia Sophia Mosque in January, the species most isolated from the carpets was *P. palitans* with 4 colonies, whilst the species most isolated from the walls with 3 colonies were *A. niger* and *C. cladosporioides*. Whereas the species most isolated from the Holy Qurans with 3 colonies were *A. niger* and *C. globosum*. In the month of April, the species most isolated species was *A. fumigatus* with 4 colonies from the carpets and 2 colonies from the Holy Qurans and walls respectively. Whereas in the month of July, whilst the species most isolated from the carpet were *C. globosum* and *C. sphaerospermum* with 2 colonies *A. niger* was most isolated from the walls with 2 colonies and finally, the species most isolated from the Holy Qurans was *A. fumigatus*. In the month of October, the species most isolated from the carpets with 6 colonies, the walls with 5 colonies and the Holy Qurans with 4 colonies, was *A. fumigatus* (Table 3).

The month that microfungi was most isolated from the carpets of the Little Hagia Sophia Mosque was January with a rate of 34.8%. Whereas this was 34.3% for the walls in the months of January and October and 34.5% in the month of January for the Holy Qurans (Table 3).

The rate of microfungus isolated from the Blue Mosque was 42.9%. Of the materials sampled inside the mosque, the walls witnessed the most microfungus isolation at 16.1%. This rate was followed by the carpets and Holy Qurans at 13.4% (Table 1).

The species most isolated from the Blue Mosque was *P. solitum* at 26.8% while *A. fumigatus* was the species most isolated from the walls with 25.9% and was also the species most isolated from the Holy Qurans at 26.8% (Table 2).

A. flavus was the species most isolated from the carpets at the Blue Mosque in the month of January with 4 colonies. Meanwhile, the species most isolated from the walls were *C. sphaerospermum* and *P. palitans* with 2

Table 1. The percentage distribution and occurrences of microfungi genera and species isolated from the carpets, walls and Holy Qurans of the Blue and Little Hagia Sophia Mosques.

Genera and species name	Blue Mosque			Little Hagia Sophia Mosque			Total colony quantity	Percentage
	C	W	Q	C	W	Q		
Alternaria	**-**	**3**	**-**	**4**	**2**	**1**	**9**	**4.7**
Alternaria alternata	-	3	-	4	2	1	9	4.7
Aspergillus	**12**	**15**	**16**	**25**	**18**	**16**	**102**	**52.9**
Aspergillus flavus	4	2	5	4	2	2	19	9.8
Aspergillus fumigatus	6	8	7	12	7	10	50	25.9
Aspergillus niger	1	-	1	5	6	3	16	8.3
Aspergillus parasiticus	-	1	1	2	2	1	7	3.7
Aspergillus sydowii	1	4	2	2	1	-	10	5.2
Chaetomium	-	**-**	**-**	**2**	**-**	**3**	**5**	**2.6**
Chaetomium globosum	-	-	-	2	-	3	5	2.6
Cladosporium	**3**	**4**	**1**	**3**	**3**	**1**	**15**	**7.8**
Cladosporium cladosporioides	-	1	1	-	3	1	6	3.1
Cladosporium sphaerospermum	3	3	-	3	-	-	9	4.7
Eurotium	-	-	**-**	**-**	**-**	**1**	**1**	**0.6**
Eurotium herbariorum	-	-	-	-	-	1	1	0.6
Mucor	**1**	**-**	**-**	**-**	**1**	**-**	**2**	**1,1**
Mucor sp.	1	-	-	-	1	-	2	1.1
Penicillium	**9**	**9**	**8**	**8**	**11**	**6**	**51**	**26.5**
Penicillium citreonigrum	-	2	2	4	3	4	15	7.8
Penicillium citrinum	-	2	2	-	1	1	6	3.1
Penicillium palitans	2	4	3	4	4	1	18	9.3
Penicillium solitum	7	1	1	-	3	-	12	6.3
Rhizopus	**-**	**-**	**-**	**-**	**-**	**1**	**1**	**0.6**
Rhizopus stolonifer	-	-	-	-	-	1	1	0.6
Trichoderma	**1**	**-**	**1**	**4**	**-**	**-**	**6**	**3.2**
Trichoderma longibrachiatum	1	**-**	1	4	-	-	6	3.2
Total	**26**	**31**	**26**	**46**	**35**	**29**	**193**	
%	**13.4**	**16.1**	**13.4**	**23.9**	**18.1**	**15.1**		**100**
General %		**42.9**			**57.1**			**100**

C, Carpet; W, Wall; Q, Holy Quran.

colonies respectively. Whereas the species most isolated from the Holy Qurans was *A. flavus* with 5 colonies. In the month of April, the species most isolated was *A. fumigatus* with 3 colonies from the carpets, 4 colonies from the walls and 3 colonies from the Holy Qurans. When the month of July is considered, *P. solitum* was the species most isolated from the carpets with 3 colonies, *A. niger* was most isolated from the walls with 2 colonies and with 3 colonies, *A. fumigatus* was the species most isolated from the Holy Qurans. In the month of October, the species most isolated from the carpets were *A. fumigatus* and *C. sphaerospermum* with 3 colonies. Whereas the species most isolated from the walls were *A. alternata* and *A. fumigatus* with 3 colonies. Finally, *A. fumigatus* was the species most isolated from the Holy Qurans with 3 colonies (Table 2).

January and October were the months that the most microfungi were isolated from the carpets of the Blue Mosque at a rate of 30.7%. Whereas October was the month that the most isolation was witnessed for the walls at 41.9%. However, it was in the month of January that the most isolation was witnessed for the Holy Qurans at a rate of 50% (Table 3).

As a result of the study carried out in the months of January, April, July and October of 2015, 65 colonies were detected during the month of January in the winter season. For the month of October which is in the autumn season, 64 colonies were detected. Whereas for the spring season in April, 36 colonies were detected and in the summer season in July, 28 colonies were detected (Table 4).

When the percentage distribution of microfungi achieved according to season throughout the study is considered, winter, with the month of January, comes in

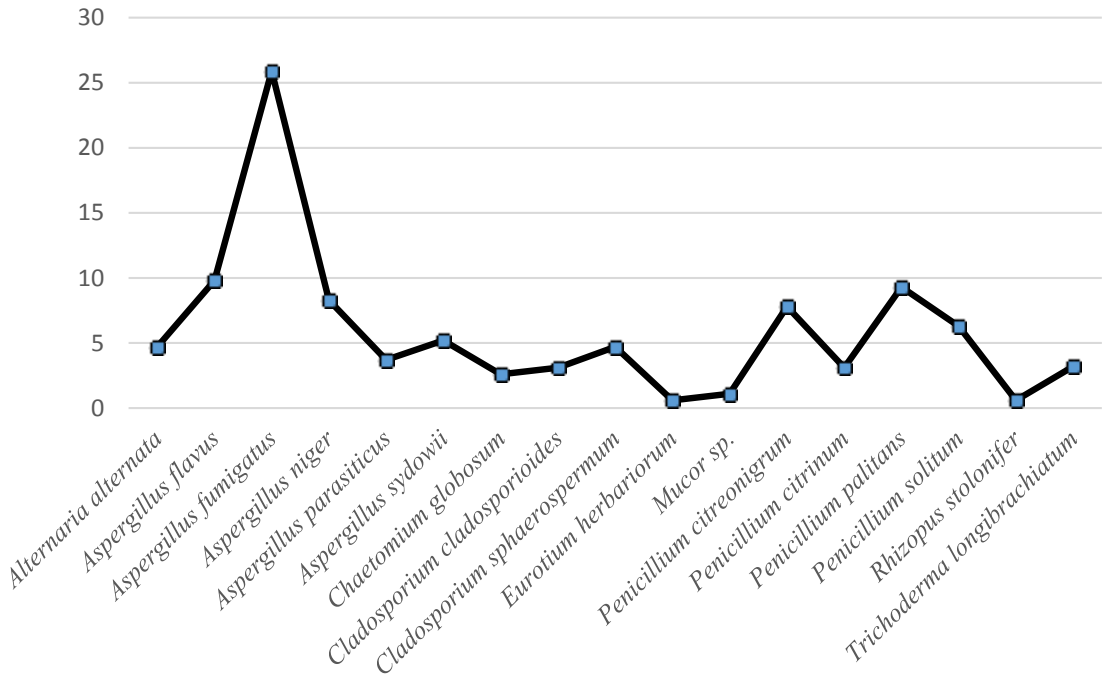

Figure 1. The percentage distribution and occurrences of microfungus species isolated from the Blue and Little Hagia Sophia Mosques throughout the study.

at first place with a percentage of 65%, autumn, with the month of October, achieves second place at 33.2% whereas spring, with April, achieves third place with a percentage of 36% and finally, summer, with the month of July, is in last place with 28% (Figure 2).

Isolation of fungal species

A total of 18 fungal species were isolated namely (index fungorum):

Alternaria alternata (Fr.) Keissl. 1912
Aspergillus flavus Link 1809
Aspergillus fumigatus Fresen. 1863
Aspergillus niger Tiegh. 1867
Aspergillus parasiticus Speare 1912
Aspergillus sydowii (Bainier & Sartory) Thom & Church 1926
Chaetomium globosum Kunze 1817
Cladosporium cladosporioides (Fresen.) G.A. de Vries 1952
Cladosporium sphaerospermum Penz. 1882
Eurotium herbariorum (Weber ex F.H. Wigg.) Link ex Nees 1816
Mucor Fresen (1850)
Penicillium citreonigrum Dierckx 1901
Penicillium citrinum Thom 1910
Penicillium palitans Westling 1911
Penicillium solitum Westling 1911
Rhizopus stolonifer (Ehrenberg) Vuillemin) 1902
Trichoderma longibrachiatum Rifai 1969

DISCUSSION

An opportunity for microorganisms of a very varied and diverse nature to reproduce arises from time spent inside buildings, be it for living, working or purposes, for any given length of time (Ozyaral, 2004). Fungi lead the way in terms of microorganisms that reproduce and grow. Fungi possess the ability to exist abundantly in the environment. The probability of airborne saprophytic fungi causing invasive disease in individuals who otherwise have a healthy immune system is low. However, for those with pre-existing conditions, the potential for a disease to arise is quite high (Gürcan et al., 2006). Thus this is why it is imperative that the fungal concentration in such highly populated buildings such as hospitals (Sarica et al., 2002), schools (Hargreaves, 2003) and pre-school crèche facilities (Aydogdu and Asan, 2008) is researched. Mosques are one of the institutions that are subject to a very high flow of traffic as thousands of people visit them daily, for both worship and touristic purposes, and because of this it would be beneficial in terms of protecting the health of the public for mosques to be evaluated from the perspective of fungal concentration. Whilst many studies have been carried out on the above mentioned buildings such as hospitals, schools and crèches, only a very limited number of

Table 2. The percentage distribution and occurrences of microfungi genera and species isolated from the carpets, walls and Holy Qurans of the Blue Mosque according to month.

Genera and species name	Carpet						Wall						Holy Quran					
	Jan	Apr	Jul	Oct	Colony quantity	%	Jan	Apr	Jul	Oct	Colony quantity	%	Jan	Apr	Jul	Oct	Colony quantity	%
Alternaria	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**3**	**3**	**9.7**	**-**	**-**	**-**	**-**	**-**	**-**
A. alternata	-	-	-	-	-	-	-	-	-	3	3	9.7	-	-	-	-	-	-
Aspergillus	**5**	**3**	**-**	**4**	**12**	**46.3**	**2**	**5**	**2**	**6**	**15**	**48.5**	**9**	**3**	**1**	**3**	**16**	**61.5**
A. flavus	4	-	-	-	4	15.3	1	-	1	-	2	6.4	5	-	-	-	5	19.3
A. fumigatus	-	3	-	3	6	23.2	-	4	1	3	8	25.9	-	3	1	3	7	26.8
A. niger	-	-	-	1	1	3.9	-	-	-	-	-	-	1	-	-	-	1	3.9
A. parasiticus	-	-	-	-	-	-	-	-	-	1	1	3.2	1	-	-	-	1	3.9
A. sydowii	1	-	-	-	1	3.9	1	1	-	2	4	12.9	2	-	-	-	2	7.7
Cladosporium	**-**	**-**	**-**	**3**	**3**	**11.4**	**2**	**-**	**1**	**1**	**4**	**12.9**	**-**	**-**	**-**	**1**	**1**	**3.9**
C. cladosporioides	-	-	-	-	-	-	-	-	1	-	1	3.2	-	-	-	1	1	3.9
C. sphaerospermum	-	-	-	3	3	11.4	2	-	-	1	3	9.7	-	-	-	-	-	-
Mucor	**-**	**1**	**-**	**-**	**1**	**3.9**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-
Mucor sp.	-	1	-	-	1	3.9	-	-	-	-	-	-	-	-	-	-	-	-
Penicillium	**3**	**1**	**5**	**-**	**9**	**34.5**	**2**	**2**	**2**	**3**	**9**	**28.9**	**3**	**-**	**-**	**5**	**8**	**30.7**
P. citreonigrum	-	-	-	-	-	-	-	1	1	-	2	6.4	1	-	-	1	2	7.7
P. citrinum	-	-	-	-	-	-	-	-	-	2	2	6.4	1	-	-	1	2	7.7
P. palitans	-	-	2	-	2	7.7	2	1	-	1	4	12.9	1	-	-	2	3	11.4
P. solitum	3	1	3	-	7	26.8	-	-	1	-	1	3.2	-	-	-	1	1	3.9
Trichoderma	**-**	**-**	**-**	**1**	**1**	**3.9**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**1**	**3.9**
T. longibrachiatum	-	-	-	1	1	3.9	-	-	-	-	-	-	1	-	-	-	1	3.9
Total	**8**	**5**	**5**	**8**	**26**		**6**	**7**	**5**	**13**	**31**		**13**	**3**	**1**	**9**	**26**	
%	30.7	19.3	19.3	30.7			19.4	22.5	16.2	41.9		100	50	11.4	3.9	34.7		100

Jan, January; A, April; J, July; O, October; C, Carpet; W, Wall; Q, Holy Quran.

studies have been conducted on mosques.

This study examined the microfungi isolated from the carpets, walls and Holy Qurans from the Little Hagia Sophia and Blue Mosques respectively in 2015 during the months of January, April, July and October.

Overall, the concentration of microfungus at the Blue Mosque was 42.9%, whilst this was determined to be 57.1% for the Little Hagia Sophia Mosque (Table 1).

The microfungus varieties isolated throughout the study in order were as follows; *Aspergillus*, *Penicillium*, *Cladosporium*, *Alternaria*, *Trichoderma*, *Chaetomium*, *Mucor*, *Eurotium* and *Rhizopus* (Table 1). Similarly, to the current study, a study carried out in Brazil (2004) also identified the dominant genera isolated to be *Aspergillus*, *Penicillium*, *Cladosporium*, *Rhizopus* and *Alternaria* (Menezes et al., 2004). In another study carried out in Pennsylvania (2004), the isolation of the following genera was reported at high levels; *Aspergillus*, *Penicillium*, *Cladosporium*, and *Alternaria* (Horner et al., 2004). Likewise, a study carried out in Edirne (2005) determined that *Penicillium*, *Cladosporium* and *Alternaria* were the most isolated genera (Aydogdu et al., 2005). Research carried out in South Taiwan (2001) in

Table 3. The percentage distribution and occurrences of microfungi genera and species isolated from the carpets, walls and Holy Qurans of the Little Hagia Sophia Mosque according to month.

Genera and species name	Carpet						Wall						Holy Quran					
	Jan	Apr	Jul	Oct	Colony quantity	%	Jan	Apr	Jul	Oct	Colony quantity	%	Jan	Apr	Jul	Oct	Colony quantity	%
Alternaria	3	-	-	1	4	8.7	1	-	-	1	2	5.7	-	-	-	1	1	3.4
A. alternata	3	-	-	1	4	8.7	1	-	-	1	2	5.7	-	-	-	1	1	3.4
Aspergillus	6	9	3	7	25	54.3	4	4	3	7	18	51.5	5	3	3	5	16	55.2
A. flavus	1	1	1	1	4	8.7	-	-	1	1	2	5.7	2	-	-	-	2	6.8
A. fumigatus	1	4	1	6	12	26.1	-	2	-	5	7	20	-	3	3	4	10	34.5
A. niger	1	3	1	-	5	10.7	3	1	2	-	6	17.2	3	-	-	-	3	10.5
A. parasiticus	1	1	-	-	2	4.4	-	1	-	1	2	5.7	-	-	-	1	1	3.4
A. sydowii	2	-	-	-	2	4.4	1	-	-	-	1	2.9	-	-	-	-	-	-
Chaetomium	-	-	2	-	2	4.4	-	-	-	-	-	-	3	-	-	-	3	10.5
C. globosum	-	-	2	-	2	4.4	-	-	-	-	-	-	3	-	-	-	3	10.5
Cladosporium	1	-	2	-	3	6.5	3	-	-	-	3	8.6	-	-	-	1	1	3.4
C. cladosporioides	-	-	-	-	-	-	3	-	-	-	3	8.6	-	-	-	1	1	3.4
C. sphaerospermum	1	-	2	-	3	6.5	-	-	-	-	-	-	-	-	-	-	-	-
Eurotium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	3.4
Eurotium sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	3.4
Mucor	-	-	-	-	-	-	-	-	1	-	1	2.8	-	-	-	-	-	-
Mucor sp.	-	-	-	-	-	-	-	-	1	-	1	2.8	-	-	-	-	-	-
Penicillium	5	-	-	3	8	17.4	4	3	-	4	11	31.4	2	2	2	-	6	20.7
P. citreonigrum	1	-	-	3	4	8.7	1	1	-	1	3	8.6	-	2	2	-	4	13.9
P. citrinum	-	-	-	-	-	-	-	1	-	-	1	2.8	1	-	-	-	1	3.4
P. palitans	4	-	-	-	4	8.7	1	1	-	2	4	11.4	1	-	-	-	1	3.4
P. solitum	-	-	-	-	-	-	2	-	-	1	3	8.6	-	-	-	-	-	-
Rhizopus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	3.4
R. stolonifer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	3.4
Trichoderma	1	-	-	3	4	8.7	-	-	-	-	-	-	-	-	-	-	-	-
T. longibrachiatum	1	-	-	3	4	8.7	-	-	-	-	-	-	-	-	-	-	-	-
Total	16	9	7	14	46		12	7	4	12	35		10	5	6	8	29	
%	34.8	19.6	15.2	30.4		100	34.3	20	11.4	34.3		100	34.5	17.2	20.7	27.6		100

Jan, January; A, April; J, July; O, October; C, Carpet; W, Wall; Q, Holy Quran.

an indoor building environment by Su et al. (2001) aimed to determine the dominant levels of airborne fungi, endotoxins and allergens and concluded that they were the following genera; *Cladosporium*, *Aspergillus*, *Penicillium* and *Alternaria* (Su et al., 2001). Another similar study

Table 4. Distribution of isolated microfungi throughout the study from the Blue and Little Hagia Sophia Mosques according to season.

Season	Colony quantity
Winter	65
Autumn	64
Spring	36
Summer	28
Total	193

focused on the detection of fungi in the indoor spaces of residential areas of individuals who displayed allergic symptoms. Fungi was observed to be present on house dust, laundry and within building structures and the nature of fungi transmission and their role in causing illness was investigated. The fungus found to be most present in order are as follows; *Penicillium*, *Aspergillus*, *Cladosporium*, *Alternaria* and other genera of fungus. Particularly in relation to indoor areas, contamination by fungus can pose a serious threat to human health (Takatori, 2001). The results of a study carried out in Turkey concluded that the most detected fungus genera were, in order, as follows; *Cladosporium, Penicillium, Alternaria* and *Aspergillus* (Tikveşli, 2013). In another study carried out nationally, the following genera were the most detected in the air of indoor areas; *Alternaria, Cladosporium, Penicillium* and *Aspergillus* (Kızılyaprak et al., 2007).

Despite there being hundreds of *Aspergillus* genus, only a proportion of these can be said to be related to causing illness. *A. fumigatus, A. flavus* and *A. niger* constitute the species that are responsible for causing over 95% of infections (Kuştimur, 2002). In addition to causing allergic symptoms, *Aspergillus* genus can also cause ear infections (www.dehs.umn.edu). *A. fumigatus* is the species of fungus of the *Aspergillus* genus most isolated in human infections. *A. flavus* is the second most commonly isolated species (Valk et al., 2008). In the research carried out by Hedayati et al. (2010) on the concentration of *Aspergillus* fungi in the homes, internal and external environments of individuals with asthma, *A. flavus* and *A. fumigatus* were detected in both internal and external environments (Hedayati et al., 2010). Similarly, the current study concluded that the most isolated species was *A. fumigatus* at 25.9%, followed by *A. flavus* at 9.8% and *P. palitans* at 9.3% (Table 1), (Figure 1).

Some of the fungi isolated throughout this study such as *Alternaria*, *Aspergillus*, *Cladosporium* and *Penicillium*, can cause allergic symptoms, to differing degrees, in those individuals who are predisposed genetically (Celtik et al., 2011). In addition to this, *Alternaria*, *Aspergillus*, *Penicillium* and *Cladosporium* can give rise to respiratory illnesses from allergic rhinitis to asthma to varying (Oliveira et al., 2009; O'Gorman and Fuller, 2008).

The current study found the *Alternaria* genus to generate a positive result in terms of IgE dependency and is a commonly encountered allergen. It is most commonly found on carpets, textile products, the basements of buildings and on window frames. The spores of this fungus can be found in the mouth, nose and upper respiratory pathways. In chronic cases, pulmonary emphysema can develop and acute symptoms include oedema and bronchospasms. In contrast, it is known that the *Penicillium* genus is the most commonly encountered fungus in the human environment. It can be considered to be allergic because it causes hypersensitivity pneumonia and allergic alveolitis; whereas the *Cladosporium* genus was the type of spore most detected in the air. In contrast to outdoor environments, it is found less in indoor environments. It can cause mycosis, has more than 10 antigens and is the cause of extrinsic asthma. The *Mucor* genus which is part of the Zygomycetes branch is allergenic and can give rise to mucorosis in immune compromised individuals. Areas affected by infection include the lungs, nasal sinuses, brain, eyes and skin (www.dehs.umn.edu).

As it became apparent that the fungi and allergens found in house dust were a primary source of allergy, several studies globally have been carried out on their prevalence and typology and relationship to allergic complaints and diseases (Aycan, 2002).

It is known that carpets accrue more dust than wooden floors. Studies show that carpets contain more allergens and studies show that carpets contain more allergens (Beguin and Nolard, 1999). A carpet is an important allergen reservoir (Tranter et al., 2009). Old and worn-out carpets can be a breeding ground for fungi (Roberts et al., 1999). Studies have proven the strong link between dust and disorder symptoms (Niemeier et al., 2006).

The species most isolated from the Blue Mosque was *P. solitum* at 26.8% while *A. fumigatus* was the species most isolated from the walls with 25.9% and was also the species most isolated from the Holy Qurans at 26.8% (Table 2). The species most isolated from the carpets of the Little Hagia Sophia Mosque was *A. fumigatus* at 26.1%, while the species most isolated from the walls was *A. niger* at 17.2% and finally, the species most isolated from the Holy Qurans was *A. fumigatus* at 34.5% (Table 3). In a similar vein to the current study, a study by Hicks et al. (2005) determined that the genera *Aspergillus* and *Penicillium* were the most commonly found in carpet dust (Hicks et al., 2005).

Throughout the duration of the study, the season that witnessed the highest rate of reproduction was winter, followed by autumn, spring and summer (Figure 2).

The current study determined that *Alternaria* witnessed the highest level of isolation in the month of October. A study carried out in Edirne (2013), like the current study, concluded that overall the most microfungi was isolated both indoors and outdoors in the autumn season (Tikveşli, 2013). In the current study undertaken, the isolation of

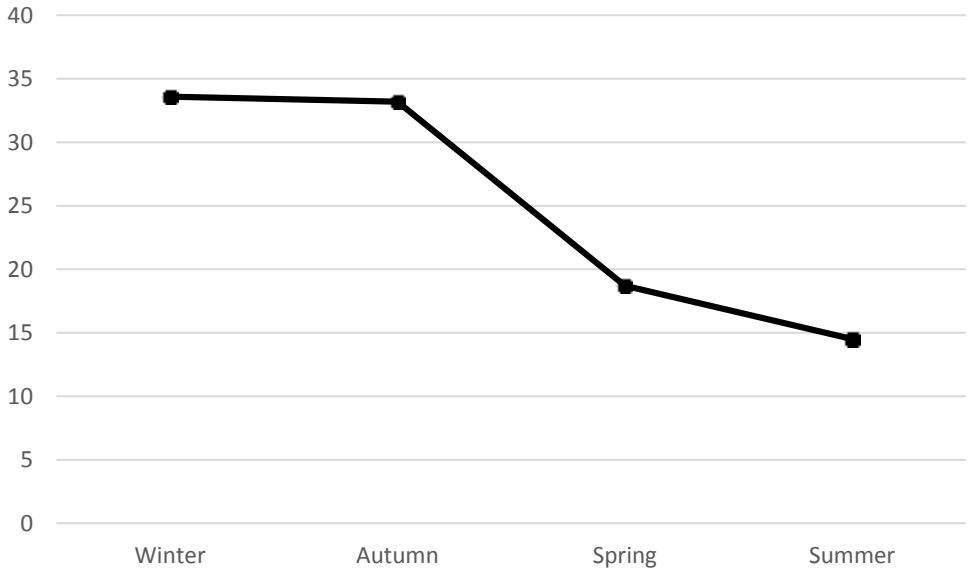

Figure 2. The percentage distribution of fungi species isolated from the Blue and Little Hagia Sophia Mosques throughout the study according to season.

was most isolated during the autumn season (Tikveşli, 2013). The *Penicillium* genus witnessed the most isolation in the month of January. Like the current study, a study carried out in Istanbul (2006) determined that the *Penicillium* genus was most isolated during the winter season (Karaltı and Çolakoğlu, 2012). In addition to this, the Edirne study (2005) also concluded that the concentration of *Penicillium* increased during the winter season (Tikveşli, 2013).

This study is one of a kind internationally. As far as is known, a study either nationally or internationally that has researched the carpets, walls and Holy Qurans in terms of fungus species and concentration of two different mosques has yet to be encountered. All of the above factors being part of this study ensure that it is one of a kind. Despite the fact that such studies are few and far between in Turkey, they have nonetheless gained momentum in terms of becoming more varied over the last few years. An increase in studies on this topic has ensured that public health is now more protected than before. The following steps can be taken in the name of protecting public health:

1. At specified intervals the cleaning of the mosque carpet may result in the reduction of fungus quantity.
2. The more frequent washing of ablution areas would also have the same effect of lowering fungus quantity.
3. It could be argued that the use of antifungal carpets by carpet manufacturers would have the effect of reducing fungus quantity.
4. The necessary environment for feet to dry completely following ablution should be created (Raboobee et al., 1998).
5. The Holy Qurans in mosques should be cleaned during appropriate methods at specified frequencies to act in the way of a precaution to help reduce fungus concentration.
6. The frequent wiping of the mosque walls and washing down with pressurised water would contribute to the reduction of fungus concentration.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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