

Relationship between airborne fungal allergens and meteorological factors in Manisa City, Turkey

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Received: 8 September 2008 / Accepted: 18 April 2009
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Abstract In this study, the effect of relative humidity, temperature, and wind on airborne fungal allergens in the 11 different districts of Manisa City was investigated from January 2004 to December 2005. The aim of this study was to conduct a survey to get to know the relation between wind, temperature, and relative humidity and population of allergenic fungal spores in the atmosphere. A total of 792 samples were observed by using the Merck MAS100 air sampler and 12,988 fungal colonies were counted. Fourteen fungal genera could be determined; *Cladosporium* that was generally found as the predominant genus followed by *Penicillium*, *Aspergillus*, and *Alternaria*. During the entire study, seasonal variation was found to be related to atmospheric conditions especially. The optimal conditions of meteorological factors for the fungi growth resulted in the increased number of mycoflora, qualitatively and quantitatively.

Keywords Fungal allergy · Temperature · Humidity · Atmosphere · Manisa · Turkey

Introduction

Airborne fungal spores are among the most common organisms in nature. They were considered to be correlated with air pollution and were proposed as a cause of adverse health effects on humans, animals, and plants (Bush and Portnoy 2001; Shelton et al. 2002). Elevated levels of air pollution particles were associated with a decreased lung function, increased respiratory symptoms such as coughing, shortness of breath, wheezing, and asthma attacks, as well as chronic obstructive pulmonary disease, cardiovascular disease, lung cancer, and allergy (Hargreaves et al. 2003; Fang et al. 2005). Allergy is the consequence of exposure to an allergen, the name given to antigens (foreign bodies recognized by the immune system as “non-self”) or the low-molecular weight molecules that react with antibodies and are known as haptens. Some fungal spores or mycelial fragments are known to be allergens (Colakoglu 2004). More than 80 genera of fungi were reported to be associated with symptoms of respiratory tract allergies (Colakoglu 2004; Horner et al. 1995) and over 100 species of fungi were involved with serious human and animal infections, while many other species caused serious plant diseases (Cvetnic and Pepeljnjak 1997). *Alternaria*, *Cladosporium*, *Aspergillus*, *Penicillium*, and *Fusarium* were amongst the most common allergenic genera. For example, elevated

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concentrations of spores of *Cladosporium* were usually associated with respiratory symptoms (Su et al. 2002). Similarly, higher concentrations of spores of *Cladosporium* and *Penicillium* indoor could cause allergenic diseases (Gelincik et al. 2005).

The seasonal variation of the atmosphere also affects the population of fungi in the atmosphere. So this causes a direct relationship between the number of allergic incidences and population of fungi as well as the intensity of allergenicity (Afzal and Mehdi 2002). Common allergenic moulds have dry spores, so they release them to the atmosphere in dry and windy weather. But, some fungi need more humidity or rain to release their spores into the air (Ismail et al. 1999).

For their adverse effects on the human health, many studies were carried out about the fungal community both in outdoor and indoor environments. It was reported that the dominant fungi were *Penicillium*, *Aspergillus*, *Alternaria*, and *Cladosporium* in the atmosphere (Shelton et al. 2002; Hargreaves et al. 2003; Singh 2001; Huang et al. 2002; Adhikari et al. 2004; Asan et al. 2004) and their concentrations differed from place to place because of local environmental variables, fungal substrates, and human activities (Shelton et al. 2002).

The effects of atmospheric conditions on airborne fungal allergens of Manisa city have not been studied up to now. The aim of this study was to get to know the relation between temperature, wind, and relative humidity and population of allergenic fungi in the atmosphere. Because, the

incidences of allergic cases in the city hospitals are on increase day by day.

Materials and methods

Sampling sites

The city of Manisa (250,000 inhabitants) is located in the Ege Region of Turkey's west. The average altitude of city is 74 m. The climate is continental and annual mean temperature is 17.28°C and annual mean relative humidity is 67.63% and annual mean rainfall is 569.5 mm. The coldest month is January but the average temperature does not fall below 6.2°C. The hottest months are July and August when the average temperature is 28.3°C. The most precipitation takes place in the winter and the least in summer. The average number of the snowy days is less than 5 days in a year. The direction of the dominant wind is mostly S or SE. Climatic data was obtained from the Department of Meteorology, Manisa.

Eleven sites were selected for the study in Manisa. The salient features of the research stations and other relevant information are given in Table 1.

Sampling, isolation methods, and identification of fungi

Outdoor air samples were collected from the 11 research stations monthly between January 2004 and December 2005. Fungi were sampled

Table 1 Some features of the selected research stations

Number	Name	Locality coordinate	Altitude (m)
1	Spil Mountain	38°36'44.57" N/27°26'45.71" E	242
2	Governorship Square	38°36'52.03" N/27°26'3.39" E	82
3	Turgutlu Road	38°37'5.67" N/27°27'59.54" E	79
4	Akhisar Road	38°38'21.62" N/27°26'41.78" E	81
5	City Market	38°37'14.66" N/27°25'37.43" E	80
6	YSE Square	38°36'58.28" N/27°24'15.54" E	82
7	Laleli	38°37'12.55" N/27°23'10.14" E	89
8	Celal Bayar University, Campus of Medicine	38°36'30.52" N/27°22'31.22" E	80
9	Horozköy	38°38'0.78" N/27°23'52.15" E	75
10	Muradiye Square	38°39'14.46" N/27°21'13.18" E	85
11	Celal Bayar University, Muradiye Campus	38°40'35.28" N/27°18'42.42" E	92

by the using Merck MAS 100 air sampler and this sampler operated at 50 L air/min (Gelincik et al. 2005). The samples were taken in the morning (08.00–10.00) at 1.50 m above ground level when the weather was stable and dry (Gelincik et al. 2005; Asan et al. 2004). The sampling time was always the same during the day. Rosebengal Chloramphenicol Agar and Malt Extract Agar were used to collect fungal airborne propagules (Horner et al. 1995; Asan et al. 2004). The sampling period was 3 min with an airflow rate of 50 L/min and three Petri dishes were used at each station. In total, 792 samples were taken from the outdoor air during the research period. After exposure, the sampled agar plates were incubated at 27°C and examined after 7–10 days after which the resulting colonies were counted (Colakoglu 2004; Okten et al. 2005).

Each colony of fungi was inoculated onto Malt Ekstrakt agar (MEA), potato dextrose agar (PDA), Czapek Dox agar (CZ), Czapek yeast agar (CYA), and glycerol nitrate agar (G25N) media for identification and incubated at 27°C for a period of 7 days after which colony diameters were measured. Petri plates were first examined under the dissecting microscope (stereomicroscope) and then under a high resolution light microscope to determine the colonial features and the morphological structures of the fungi. The determination of the morphological structures was carried out on material mounted in lactophenol (Colakoglu 2004; Gelincik et al. 2005; Asan et al. 2004).

Many different culture media were used for the identification of species. Fungal species were identified on the basis of micro and macro morphology, reverse and surface coloration of colonies grown on CZ, MEA, PDA, CYA, G25N media. Fungi were identified to genus level using Barnett's work (1960). Cultures were identified to species level according to various mycological references (Domsch et al. 1980; Klich 2002; Pitt 1979, 2000; Samson and Pitt 2000; Samson et al. 2004).

Statistical analysis

All the experimental data were analyzed using SPSS Version 10.0 (SPSS, Standard Version).

Pearson Correlation analysis was performed to reveal the relationship between temperature, humidity, wind velocity, and fungal colony counts.

Results

For the purpose of study of relationship between temperature, relative humidity, wind, and occurrence of fungal allergens in the atmosphere of Manisa, results were clear to a great extent as according to 2 years (2004, 2005) data, listed in Table 2.

A total of 12,988 fungal colonies were counted in 792 Petri dishes, quantified to determine the frequency of occurrence, and then identified. Some 14 fungal genera could be identified, among them the genus *Cladosporium* that was generally found as the predominant fungus followed by *Penicillium*, *Aspergillus*, and *Alternaria*.

The correlation analysis was performed between concentration of fungi and meteorological parameters such as temperature, wind velocity, and relative humidity. Correlation coefficients are given in Table 3. Fungal colony numbers correlated with above meteorological factors (Table 3).

During the present work, population of fungi were found to be closely related to fluctuation of temperature, marked increase or decrease in fungal population was noted. The lowest temperature was during January 2004 (−6.5°C) and February 2004 (−5.8°C), when the fungi colonies and genera decreased. Colonies of fungi were 441 and 480 and genera were four and five, respectively. The highest temperature was during August 2004 (40.4°C) and July 2004 (40.3°C), but the numbers of fungal colonies were recorded as low (436 and 468, respectively) because the fungi do not grow above 29°C easily (five). The colonies of fungi were recorded high in autumn because the air conditions were suitable for growing rapidly. The colony counts in October 2004 and 2005 were 780 and 725 and genera were 12 and 11, respectively. The optimum degree of temperature for fungi growth caused significant increase in colonies of fungi during the autumn season from September–November (Table 2).

As far as relative humidity is concerned, marked variations in quality and quantity of fungi

Table 2 Effect of temperature, relative humidity and wind on airborne fungal allergens recorded during 2004–2005

Months of the years	Min. temp. (°C)	Max. temp. (°C)	Mean temp. (°C)	Min. RH (%)	Max. RH (%)	Mean RH (%)	Wind direct/max. speed (m/s)	Total no colonies	Total. fungal genera
January									
2004	−6.5	18.4	6.2	45.0	96.0	66.6	S/23.2	441	4
2005	−4.2	20.3	7.1	43.4	95.1	65.4	S/20.7	473	6
February									
2004	−5.8	24.8	7.2	28.0	94.0	67.0	SSE/25.0	480	5
2005	−3.5	23.7	7.4	26.2	94.4	66.1	SE/22.4	495	7
March									
2004	−2.3	27.1	11.8	26.0	93.0	57.8	SE/20.7	502	7
2005	−1.9	29.1	12.4	28.1	93.6	58.9	NNW/15.4	510	8
April									
2004	1.6	30.0	15.6	25.0	92.0	58.2	WSW/15.7	516	9
2005	1.2	29.4	15.1	24.8	93.0	59.3	S/16.9	568	9
May									
2004	5.6	30.6	20.1	26.0	91.0	54.5	SE/20.9	490	10
2005	7.5	31.8	22.0	24.3	89.8	52.1	ENE/17.6	520	10
June									
2004	8.9	37.8	26.0	24.2	77.0	49.4	S/15.8	455	9
2005	8.1	36.9	27.2	25.0	79.1	46.9	NE/12.3	480	9
July									
2004	9.6	40.3	28.7	24.0	83.0	45.3	S/11.5	468	8
2005	9.4	39.2	27.6	25.2	79.0	43.7	NNW/10.8	476	7
August									
2004	16.9	40.4	27.8	23.0	77.0	49.9	NNE/11.8	436	7
2005	16.4	39.1	26.9	25.2	78.9	51.3	NNE/13.2	415	8
September									
2004	11.3	37.0	23.9	25.0	93.0	54.4	S/18.0	645	9
2005	12.1	37.0	24.8	24.5	90.0	52.4	NNW/15.3	612	10
October									
2004	9.5	32.4	20.0	25.0	98.0	70.8	N/19.6	780	12
2005	7.6	31.5	19.8	27.6	97.1	71.0	NW/18.1	725	11
November									
2004	−3.4	28.7	14.1	31.0	97.0	68.6	SSE/18.8	696	10
2005	−2.9	29.6	15.4	32.0	97.7	69.2	SE/19.3	680	12
December									
2004	−4.7	17.8	9.0	32.0	96.0	68.1	NNE/17.7	570	9
2005	−4.1	16.9	9.4	30.8	95.8	67.3	S/18.5	555	10

were observed due to fluctuation in relative humidity during the day. The months where relative humidity was high, higher number of species, and

Table 3 Correlation coefficients (r) between colony numbers and meteorological factors (January 2004–December 2005)

Type of correlation	With temperature (°C; r)	With relative humidity (%; r)	With wind velocity (m/sn; r)
Pearson	0.654 ^a	0.732 ^a	0.271 ^b

^aCorrelation is significant at the 0.05 level

^bCorrelation is not significant at the 0.05 level

colonies of fungi were found. The highest relative humidity was during 2004 in October (98%) and during 2005 in November (97.7%), respectively. In October, 780 colonies and in November, 680 colonies were recorded while the number of genera during both the years was 12. On the other hand, the lowest relative humidity was observed during August 2004 (23%) and July 2004 (24%), the qualitative and quantitative picture of fungi was also limited. During August 2004, only seven genera with 436 colonies were recorded. Similarly, during July 2004, eight genera with 468 colonies of fungi were isolated from the atmosphere.

During the study, wind direction and speed showed limited effect on the number of fungal colonies in the atmosphere. The highest speed of wind was recorded in February 2004 (25 m/s) and then the number of fungal colonies was 480. The lowest speed of wind was recorded in July 2005 (10.8 m/s) and number of fungal colonies was 476. This results show the effect of wind on colony number related to other atmospheric conditions such as temperature and humidity.

The air temperature and relative humidity in the city of Manisa are more favorable for fungi growth in autumn than in other seasons. Most fungi have an optimum temperature for development between 20 and 24°C and do not grow above 29°C easily. It has been determined that for fungi to grow, the minimum relative humidity in the air needs to be at least 50% but commonly >65% (five). In the present study, in October 2004, the maximum and minimum temperatures of air were 32.4°C and 9.5°C and the mean relative humidity 70.8% (Table 2). In this month greatest numbers of colonies were present in air.

Discussion

It is well known that microfungi can live under extreme conditions in almost all regions and all climates. They usually live in soil and can be dispersed into the atmosphere owing to various factors. In recent years, aerobiologists have shown a great interest in airborne fungi due to both their constant existence in the air and the increase of allergies caused by them. Monitoring of airborne fungi would provide valuable data to evaluate fungal spore counts. Everything may expose to molds, but fungal density in air and exposed time are very important for effect of molds (Okten et al. 2005).

Cladosporium was the most frequent and predominant genus detected in this study, followed by *Penicillium*, *Aspergillus*, and *Alternaria*. *Cladosporium* species are very common in air and found predominant in many studies (Hargreaves et al. 2003; Okten et al. 2005; Pepeljnjak and Segvic 2003). Also Sakiyan and Inceoglu (2003) found *Cladosporium* species to be predominant in air followed by *Alternaria* in Ankara (Turkey).

In some studies *Penicillium* was found predominant genera followed by *Cladosporium* and *Alternaria* (Colakoglu 2004; Adhikari et al. 2004; Asan et al. 2004). Okten et al. (2005) noted that *Cladosporium* and *Alternaria* is known to be allergic and common fungi worldwide and they suggested *Alternaria* allergens contribute to severe asthma. Myszkowska et al. (2002) noted that 4–7% of the European population show sensitivity to *Cladosporium* and *Alternaria* spores.

In conclusion, there seems to be a close relationship between the occurrence of fungal allergens and seasonal fluctuation of the meteorological factors. Hence, the patients of respiratory and skin allergy may be advised to avoid exposure to fungi and take necessary precautions in the months where fungal population is supposed to be more concentrated. So this study will be helpful to the people who are suffering from the problem of the allergy and immunodeficiency, especially in the city of Manisa.

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