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INVESTIGATION OF FUNGI SPORES CONCENTRATION IN NIGDE ATMOSPHERE (TURKEY)

Talip ÇETER[1*], Esin BAYAR[1], Nuri Mohamed Mohamed ELTAJOURI[1], Cemil İŞLEK[2]

[1] *Kastamonu University, Arts and Sciences Faculty, Department of Biology, Kastamonu, Turkey*
[2] *Niğde Ömer Halisdemir University, Arts and Sciences Faculty, Department of Biotechnology, Niğde, Turkey*

ABSTRACT. Atmospheric fungi spores investigated in Niğde province with the help of Burkard volumetric trap between January 2014 -December 2014. As total of 70 561 spores belonging to 39 Fungi taxa were counted. The taxa which were observed are the following *Cladosporium*, *Alternaria*, *Melanomma*, *Leptosphaeria*, *Ustilago*, *Pleospora*, *Exosporium*, *Penicillium/Aspergillus*, Elipsoidal basidyospores, *Epicoccum*, *Drechslera*, *Stemphylium*, Multi-septate ascospores, 1-septate ascospores, Myxomycetes, *Pithomyces*, *Torula*, *Didymella*, *Puccinia*, *Chaetomium*, *Curvularia*, Non-septate ascospores, *Oidium*, *Nigrospora*, *Periconia*, Diatrypaceae, *Venturia*, *Arthrinium*, *Xylaria*, *Agrocybe*, *Fusarium*, *Botrytis*, *Peronospora*, *Coprinus*, *Sporormiella*, *Tetracoccosporium*, *Exosporiella*, *Melanospora* and *Boletus*. The concentration of spores which was determined in the atmosphere was 69,46% *Cladosporium*, 7,21% *Alternaria*, 2,98% *Melanomma*, 2,69% *Leptosphaeria*, 2,28% *Ustilago*, 2,15% *Pleospora*, 1,98% *Exosporium*, and the remaining 11.09% belong to 32 taxa which named as an others.
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1. INTRODUCTION

Fungal spores constitute one of the most important groups of airborne allergens. Recently, allergic diseases have developed pandemic health problem. Fungi can grow in a wide temperature range from -5 to 50 C° and higher [1]. Allergic diseases are considered to be one of the most important public health problems affecting up to 15–35% of individuals worldwide. Determination of the airborne spore types and

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talipceter@gmail.com-Corresponding author; esinbayarr@gmail.com; nurieltajouri2@gmail.com; cemilislek@gmail.com
0000-0003-3626-1758; 0000-0002-4045-4635; 0000-0002-0305-6187; 0000-0002-6690-2846

their concentration in highly populated cities are important in terms of helping patients suffering from diseases such as allergies. For this reason; the studies about the airborne fungal spore of different areas have been carried out by many researchers [2-13]. In our country, it has been reported that 25-30% of the population is affected by one or more allergic diseases [14]. Determination of fungal spore concentration in the atmosphere is important in terms of planning the treatment of sensitive individuals. About 100 fungal spores can cause an immunological response in susceptible people when inhaled with air. *Alternaria* and *Cladosporium* are recognized as the most important fungal species responsible for respiratory diseases such as asthma, eczema, rhinitis and chronic sinusitis. Besides these most popular types of fungi, limited studies can be found on *Didymella* and *Ganoderma*, although their allergenic properties have been clinically proven. Therefore, it is very important to monitor the concentration of allergenic fungal spores in the air, especially in densely populated areas. The spores produced by *Alternaria* and *Cladosporium* are considered the most important and together they can make up 93% of the total fungal spores found in the air. *Alternaria* alternative spores are one of the most frequently identified allergic fungal spores in atmosphere *A. alternata* has been studied most extensively of all *Alternaria* species and it has been found that Alt a 1 was defined to be the most important isolated major allergen. *Alternaria* spores can cause respiratory diseases such as asthma or chronic sinusitis [15-20].

Airborne fungal spore concentrations change continuously according to the meteorological factors. Recently many studies focused on diurnal and seasonal distribution of fungi spores in the atmosphere of urban and rural area [21, 22]. Çeter and Pınar [6] determined fungi spores whole year in Ankara atmosphere, when highest concentration observed in July and the lowest concentration in January. They were observed strong positive correlation between spores concentration and monthly mean temperature, strong negative correlations between monthly mean relative humidity, precipitation spore concentrations, while wind speed has a slightly positive impact [6]. *Alternaria* and the *Cladosporium* are the primary fungal spores that trigger respiratory allergic reactions in Europe and the most abundant fungi in indoor and outdoor environments. The most common and abundant airborne fungal spores reported for Mexico City are *Cladosporium, Aspergillus, Alternaria, Ulocladium*, *Geotrichum, Penicillium* and *Physarum*. However, the different spore taxa that are present in the air, their concentrations, and their propagation directly depend on the geographic region, the meteorological parameters and climatic conditions, the land use and vegetation type of each locality, and the air pollution level [23].

The aim of this study is to determine the fungal spores found in the atmosphere of Niğde province on daily, weekly, monthly and yearly basis.

2. Materials and Methods

2.1 Study area

The altitude of the province of Niğde from sea level is 1,300 meters. Western parts have wavy flatness and other parts have a mountainous structure. It is neighbors with Aksaray in the northwest, Nevşehir in the north, Kayseri in the northeast, Konya in the west and southwest, İçel in the south, Adana in the southeast and east. It is located between the 37 ° 25 'north and 38 ° 58' north parallels, and the meridians 33 ° 10 'west and 35 ° 25' west in the west (Figure 1).

The continental climate is dominant in the province of Niğde, with hot and dry summers, cold and snowy winters. There is very little forest existence. It constitutes 1.7% of the provincial lands, and increases to 3 percent with the heathland. 50% of the provincial lands are cultivated-planted areas, from wheat fields, apple orchards and vineyards; 37% consists of meadows and pastures. The rest is made up of land that is not suitable for cultivation. Average annual rainfall is 349 mm with at least one of the wettest regions of Turkey. Most of this precipitation occurs during the winter months.

Figure 1. Location map of the studied area.

2.2. Aerobiological and meteorological data

Aerobiological data were collected during one year period (between January 2014 until December 2014) by placing the Burkard device at a height of about 12 meters from the ground on the entrance of the Niğde Ömer Halisdemir University Faculty of Arts and Sciences Building. Preparation and spores count procedures followed the

recommendations of the Spanish Aerobiological Network (REA: Red Española de Aerobiología)[24]. Four transverse traverses were counted on each slide, at a magnification of ×10 and x40. Counts were made daily bases and total daily counts were converted to number of spores per cubic meter of air [25-27]. The Spores were identified and counted at genus level. Meteorological data of Niğde province for the year of 2014, the monthly Average temperature, monthly total rainfall amount, monthly average relative humidity and monthly average wind speed were obtained from the General Directorate of Meteorology. The meteorological data obtained were presented in tables and graphs.

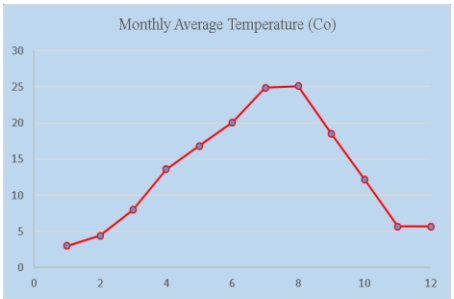
3. Results

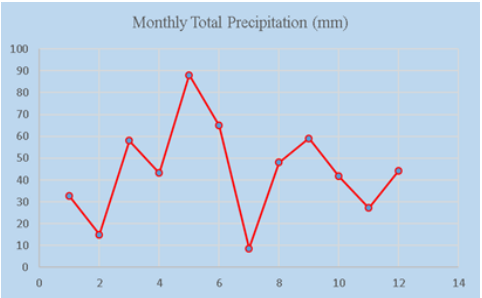
3.1 Meteorological data of Niğde province

Meteorological data (Table 1) and graphics of the meteorology station in Niğde are given below (Figure 2).

Table 1. Meteorological data of Niğde province in 2014

YEAR / MONTH	1	2	3	4	5	6	7	8	9	10	11	12
Monthly Average Temperature (°C)	3	4.4	8	13.6	16.8	20.1	24.9	25.1	18.5	12.2	5.7	5.7
Monthly Total Precipitation (mm)	32.7	15	58	43.2	88	65	8.7	48.1	59.1	41.7	27.3	44.3
Monthly Average Relative Humidity (%)	66.5	53.6	54.3	42.3	45.6	42.8	33.5	37.2	53.7	63.2	65.1	71.9
Monthly Average Wind Speed (m / sec)	2.4	2.5	3	3	2.5	2.6	2.6	2.7	2.2	2.3	2.2	2.7





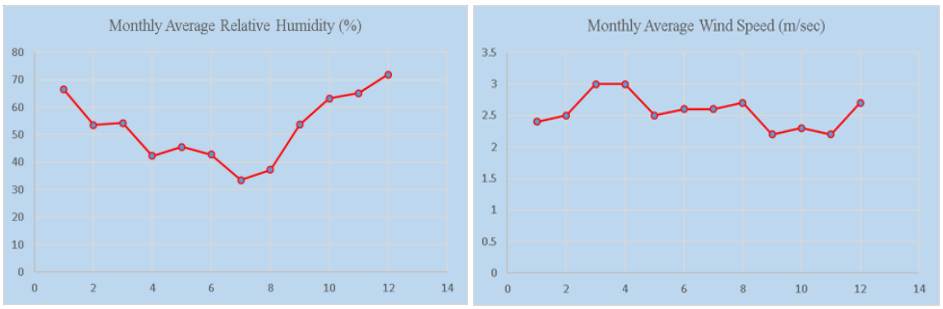


FIGURE 2. Monthly changes of meteorological parameters in Niğde province (2014)

3.2. Atmospheric fungal spore data

70561 spores belonging to 39 fungi taxa were counted in a one-year study between January 2014 and December 2014 with the Burkard volumetric trap in the atmosphere of Niğde. The determined taxa were *Cladosporium, Alternaria, Melanomma, Leptosphaeria, Ustilago, Pleospora*, *Exosporium*, *Penicillium/Aspergillus*, Ellipsoidal basidiospores, *Epicoccum*, *Drechslera, Stemphylium*, Multi-septal ascospores, 1-septal ascospores, Myxomycetes, *Pithomyces, Torula, Didymella, Puccinia, Chaetomium, Curvularia*, Non-septate ascospore, *Oidium, Nigrospora, Periconia, Diatrypaceae, Venturia, Arthrinium, Xylaria, Agrocybe, Fusarium, Botrytis, Peronospora, Coprinus, Sporormiella, Tetracoccosporium, Exosporiella, Melanospora*, and *Boletus*. There are 69.46% *Cladosporium*, 7.21% *Alternaria*, 2.98% *Melanoma*, 2.69% *Leptosphaeria*, 2.28% *Ustilago*, 2.15% *Pleospora*, 1.98% *Exosporium* and the rest of the total spore concentration detected in the atmosphere 32 taxa, 11,09% of which are expressed as other taxa. According these data, spore calendar of Niğde Province was prepared (Figure.3).

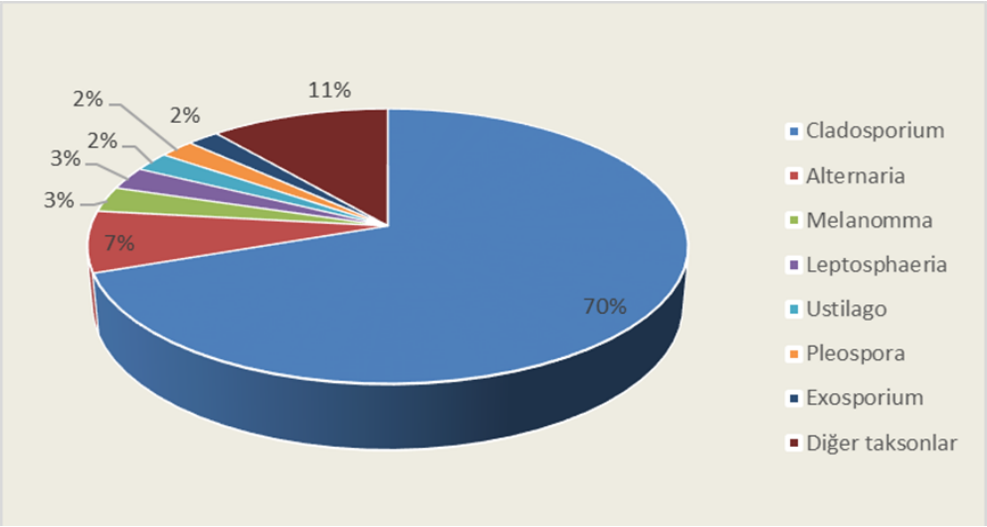


FIGURE 3. Percentage distribution graph of fungal spores detected in Niğde atmosphere.

In January, 647 spores belonging to 25 fungi taxa were counted in Niğde atmosphere. There are mostly *Cladosporium, Alternaria, Melanomma, Ustilago, Leptosphaeria*, Myxomycetes, and *Exosporium* spores were found in the atmosphere.

695 spores belonging to 24 fungi taxa were detected in the atmosphere of Niğde province in February. The spores which were detected were *Cladosporium, Ustilago, Melanomma, Leptosphaeria, Alternaria, Pleospora*, and *Exosporium* were most common.

In the atmosphere of Niğde, 3130 spores belonging to 28 fungi taxa were counted in March. In the analysis of air preparations. spores belonging to *Cladosporium, Leptosphaeria, Melanomma, Pleospora, Alternaria* and Multi-septal ascospores were mostly observed.

In April, 4280 spores belonging to 32 fungi taxa were detected in the atmosphere of Niğde province. *Cladosporium, Alternaria, Leptosphaeria, Pleospora, Exosporium, Melanomma*, Ellipsoidal basidyospore, Multi-septal ascospore, *Ustilago, Penicillium/Aspergillus* and Myxomycetes spores were most common.

7143 spores belonging to 35 fungi taxa were detected in the atmosphere of Niğde province in May. The spores of *Cladosporium, Alternaria, Ustilago, Leptosphaeria, Melanomma, Pleospora, Exosporium*, Ellipsoidal basidiospores, Multi-septal ascospore and *Pithomyces* are most common.

TABLE 2. The monthly spore concentrations for fungal taxa which are detected in Niğde atmosphere in 2014

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	Total
Alternaria	38	18	94	314	340	1412	772	977	782	160	158	22	5087
Cladosporium	430	478	1947	2423	5073	8023	5591	8869	11835	2572	1365	406	49012
Botrytis						13	15	20	22	7	3		80
Pithomyces	9	12	43	36	50	54	19	45	24	14	14	10	330
Epicoccum	3	3	24	26	24	98	63	183	119	27	26	11	607
Periconia	8	4	5	21	19	30	19	20	14	7			147
Torula				23	20	60	46	28	115	11	15	12	330
Stemphylium	7	2	17	44	43	23	26	155	118	16	18	17	486
Drechslera		2	18	40	45	30	37	184	133	10	19	11	529
Exosporium	16	13	45	174	142	234	156	216	292	79	19	14	1400
Tetracoccosporium			7	11				7		6			31
Xylaria				9	13	29	13	15	7	20	12		118
Sporormiella		1	8	7	9	7	8	7	9	7	0		63
Leptosphaeria	21	22	206	234	250	430	165	238	215	56	32	28	1897
Curvularia	1	3	14	13	14	13	28	40	42	16	12	10	206
Nigrospora			15	13	14	10	18	44	18	9	9	9	159
Chaetomium	1	7	8	27	14	14	20	18	71	11	15	9	215
Fusarium	1		11		11	10	10	12	38	5			98
Melanomma	25	24	190	147	211	652	259	180	318	66	16	16	2104
Venturia	3	2	10		12	33	25	17	14	9		7	132
Melanospora	1	1			4								6
Didymella	7	17	42	25	21	21	11	16	99	8	10	10	287
Pleospora	15	19	182	220	193	126	239	50	416	33	14	14	1521
Oidium	9	9	21	22	8	8	18	9	56	8	12	7	187
1-septal ascospore	4	3	26	19	40	72	53	24	98	22	9	11	381
Coprinus	2		14	11	11				10	7	8	7	70
Agrocybe	1	3	7		22	26	16	8	9	10	1		103
Boletus											1	4	5
Puccinia				6	11	15	72	66	46	6	14	7	243
Ustilago	21	40	27	70	257	435	334	248	115	41	20		1608
Peronospora	1			10	10	14	7	15	8		1	6	72
Multi-septal ascospore	1	8	68	77	61	88	20	45	17	25		10	420
Elipsoidal basidyospore			45	88	86	182	46	35	86	41	44	16	669
Myxomycetes	18	3	27	61	14	127	27	39	36	16			368
Penicillium/Aspergillus				64	46	410	169	117	169	27			1002
Exosporiella						18			9				27
Diatrypaceae				18	9	14	33	9	30	14		10	137
Arthrinium	4	1	9	11	9	36	21	14	15	8			128
Non-septate ascospore				16	37	36	13	17	49	24			192
TOTAL	647	695	3130	4280	7143	12803	8369	11987	15454	3398	1950	705	70561

In June, 12803 spores which belonging to 35 fungi taxa were detected in the atmosphere of Niğde. They are *Cladosporium, Alternaria, Melanomma, Ustilago, Leptosphaeria*, *Penicillium/Aspergillus, Exosporium*, Ellipsoidal basidiospore, Myxomycetes, *Pleospora*, *Epicoccum*, Multi-septal ascospore, 1-septal ascospore, *Torula* and *Pithomyces* spores were most common.

8369 spores belonging to 34 fungi taxa were detected in the atmosphere of Niğde province in July. *Cladosporium, Alternaria, Ustilago, Melanomma, Pleospora,*

Penicillium/Aspergillus, *Leptosphaeria, Exosporium, Puccinia, Epicoccum* and 1-septal ascospores were the most common.

11987 spores belonging to 35 fungi taxa were detected in the atmosphere of Niğde province in August. The spores of *Cladosporium, Alternaria, Ustilago, Leptosphaeria, Exosporium*, *Drechslera, Epicoccum, Melanomma, Stemphylium, Penicillium/Aspergillus*, *Puccinia* and *Pleospora* were most common.

In September, 15454 spores belonging to 36 fungi taxa were detected in the atmosphere of Niğde province. *Cladosporium, Alternaria, Pleospora, Melanomma, Exosporium*, *Leptosphaeria, Penicillium/Aspergillus, Drechslera, Epicoccum, Stemphylium, Torula*, *Ustilago, Didymella*, 1-septal ascospore, Ellipsoidal basidyospore, *Chaetomium* and *Oidium* spores were found most frequently.

In October, 3398 spores which weree belonging to 35 fungi taxa were detected in the atmosphere of Niğde province. They are *Cladosporium, Alternaria, Exosporium, Melanomma*, *Leptosphaeria, Ustilago,* Ellipsoidal basidyospore, *Pleospora, Epicoccum*, *Penicillium/Aspergillus*, Multi-septal ascospore, Non-septal ascospore, 1-septal ascospore and *Xylaria* spores were most common.

1950 spores belonging to 26 fungi taxa were detected in the atmosphere of Niğde in November. The spores are spores of *Cladosporium, Alternaria,* Ellipsoidal basidyospore, *Leptosphaeria*, *Epicoccum, Ustilago, Drechslera, Exosporium, Stemphylium* and *Melanomma* were most common.

In December, 705 spores belonging to 25 fungi taxa were detected in the atmosphere of Niğde province. They are *Cladosporium, Leptosphaeria, Alternaria, Stemphylium, Melanomma*, Ellipsoidal basidyospore, *Exosporium, Pleospora, Torula, Epicoccum, Drechslera*, 1-septal asccospore, *Pithomyces, Curvularia, Didymella*, Multi-septal ascospores and *Diatrypaceae* spores were encountered (Table 2).

4. Discussion

Atmospheric fungal spores were investigated in the atmosphere of Niğde in a 12-month period between January 2014 and December 2014. Fungal spores were found during the working period in all months. That fungi taxa can tolerate wide living conditions, besides their ability to grow on a very wide substrate and habitat, their spores can be transported to long distances by wind can be listed among the main reasons for this result.

Additionally, in a significant part of the study high concentrations of fungal spores were found, the reason which plays an important role for this situation is that Fungi

species have large habitats and produce a large number of spores and release them to the atmosphere.

70561 spores belonging to 39 fungi taxa were detected in the analyzes performed over 12 months in the atmosphere of Niğde. Of these spores 69.46% *Cladosporium*, 7.21% *Alternaria*, 2.98% *Melanomma*, 2.69% *Leptosphaeria*, 2.28% *Ustilago*, 2.15% *Pleospora*, 1.98% *Exosporium* and the remaining 11.09 % belonging to 32 taxa, which are expressed as other taxa.

The taxa with spores detected in Niğde atmosphere are respectively *Cladosporium, Alternaria, Melanomma, Leptosphaeria*, *Ustilago, Pleospora, Exosporium, Penicillium/Aspergillus*, Elipsoidal basidyospor, *Epicoccum, Drechslera, Stemphylium*, Multiple septal ascospores, 1-septal ascospores, Myxomycetes, *Pithomyces, Torula*, *Didymella, Puccinia, Chaetomium, Curvularia*, Non-septal ascospore, *Oidium, Nigrospora, Periconia, Diatrypaceae, Venturia, Arthrinium, Xylaria, Agrocybe, Fusarium, Botrytis, Peronospora, Coprinus, Sporormiella, Tetracoccosporium, Exosporiella, Melanospora* and *Boletus*.

The concentrations of the taxa whose spores are found in the atmosphere are determined as daily, weekly, monthly and yearly and the obtained results are presented by tables and graphics.

Çeter [28] found 869 598 spores belonging to 35 taxa in his study conducted in the atmosphere of Kastamonu for 2 years between 2006-2007 and Çeter [29] determined 429264 spores belonging to 35 taxa in a study conducted in Ankara atmosphere for a period of 1 year [29]. In the study conducted in Adana atmosphere for 1-year, 197009 spores belonging to 34 taxa were detected [30], and 639282 spores belonging to 35 mushroom taxa were detected in 1-year period in Samsun atmosphere [31]. All study results show that spores of fungi are in high concentrations in the atmosphere. This situation arises as a result of the wide distribution of fungi and their release of high amounts of spores into the atmosphere. In our study, lower concentrations were found compared to the studies mentioned above. One of the reasons for this is thought to be due to the drier climatic conditions of the province of Niğde and the arid vegetation.

During the study, the lowest spore concentration was detected in December-February. The lowest spore concentration of the whole study period was seen in January 2014 with 647 spores. During this quarter *Cladosporium, Alternaria, Melanomma, Ustilago* and *Leptosphaeria* ascospores were found dominantly. Similarly, there are studies showing that low temperature and high relative humidity negatively affect spore concentration [29, 32, 33].

Kramer stated that fungal spores were low in the Kansas atmosphere, increased as of April, the highest spore concentrations were detected in June, July and August, and a decrease in spore concentration was observed as of September [34].

Çeter stated that the increase in temperature cause the increase on the fungal spore concentration. It has been stated that the average temperature and minimum temperature values exceeding 10-15 C° significantly increase the fungal spore concentration [28]. In our study, the average temperature being over 15 C° since April caused an increase in spore concentration.

Royes *et al*. [35] emphasized that temperature, amount of precipitation, relative humidity and Cooperman *et al*. [36] emphasized that the increase in temperature are important factors affecting the increase in spore concentration.

Studies have determined that the increase in temperature increases the spore concentration in the atmosphere, but when the temperature increases after a certain degree comes together with low rainfall and humidity, it has been found that the spore concentration is negatively affected [32, 37, 38, 39]. Although the temperature tolerances are different, many fungal spores show their best development in the range of 20-28 C°. When triggered by factors such as high temperature, low rainfall and low humidity, it has a negative effect on spore concentration.

The spore concentration has increased in the atmosphere of Niğde in May and June. In addition to the high average temperature values in July and August, the concentration of spore was found to be relatively low due to drought due to low rainfall. In September, due to the more favorable conditions, the highest spore concentration of the working period was determined. Çeter detected decreases of 25% and 50% in spore concentration in the months of July and August with the effect of heat and drought in the atmosphere of Kastamonu [28].

Çeter et al. [40] found 540908 spores belonging to 46 fungi taxa in a two-year period in their study in the atmosphere of Çankırı, 64% *Cladosporium*, 6% Ellipsoidal Basidyospores, 5% *Alternaria*, 5% *Leptosphaeria*, 4% *Pleospora* of these spores were determined as dominant taxa. The highest spore concentrations were detected in June-July. Similarly, the highest sports concentration was observed in the Gümüşhane atmosphere in June by Akdoğan et al [41] and determined the highest spore concentration in the Sinop atmosphere in July by Çeter et al. [42].

Li and Kendrick stated that rain, wind speed, humidity, temperature and vegetation are important factors affecting the concentration of spore in the air [37]. As emphasized in the studies conducted in the atmosphere of Ankara [29], Adana [30], Samsun [31], and Kastamonu [28], in this study it has been observed that, meteorological factors such as temperature, precipitation, relative humidity and wind speed are important. Low temperature and high relative humidity have been cited as

important factors reducing the concentration of fungal spores [32, 33]. The low number of fungal spores in the Niğde atmosphere in the December-February period is the result of this effect.

Like all living things, fungi thrive within certain temperature values. Studies have shown that some species of fungi are mesophilic and show optimal growth between 20-28 °C, some species are psychrotolerant and show optimal growth below 20 C° [43]. Many studies indicate that the fungal spore concentration increases with temperature [32, 37, 38, 39]. However, after a point, in temperature it has a negative effect on spore concentration. When triggered by low precipitation and low humidity values, it has a negative effect on fungal growth and atmospheric spore concentration decreases. As a result of a similar effect in July and August, the spore concentration was found to be low.

It is not sufficient to explain the fungal spore concentration only with general meteorological parameters. Since fungi are parasites, pathogens and saprophytes adaptable, many factors such as the presence and availability of the substrate where they develop, the vegetation period of the host on which they develop as a pathogen or parasite, the microclimate formed in the habitat affect the development and spore production capacity of fungi.

As a result of this study in which atmospheric fungal spores of Niğde city center were examined, the amount of spores identified in the atmosphere in a day was determined as m^3, and the data obtained by calculating weekly, monthly and annual amounts were presented in tables and graphs.

The variation of atmospheric spore concentration with meteorological factors has been studied and discussed.

It has been determined that the sensitivity to fungal spores varies geographically between 3 and 80% [44]. Determination of atmospheric spore concentration and preparation of the spore calendar will be a guide in the treatment of patients with fungal spore sensitivity, it will be possible to prevent labor loss and prevent unnecessary treatment expenses with more effective sensitization and treatment.

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