Avrupa Bilim ve Teknoloji Dergisi
Sayı 19, S. 334-343, Ağustos 2020

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
No. 19, pp. 334-343, August 2020

Research Article

İstanbul İli Avrupa Yakası Bazı Bölgelerinde Hava Kalitesinin Mikrobiyolojik Yoğunluk Açısından İncelenmesi

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(İlk Geliş Tarihi 10 Şubat 2020 ve Kabul Tarihi 23 Mayıs 2020)

(**DOI:** 10.31590/ejosat.701133)

ATIF/REFERENCE: Aydın. S, Bayhan, H. & Ergüven, G. Ö. (2020). İstanbul İli Avrupa Yakası Bazı Bölgelerinde Hava Kalitesinin Mikrobiyolojik Yoğunluk Açısından İncelenmesi. *Avrupa Bilim ve Teknoloji Dergisi*, (19), 334-343.

Öz

İstanbul'un dış havasının mikrobiyal faunası avrupa yakasına ait dört faklı bölgede (Bakırköy, Fatih, Başakşehir ve Esenler) aktif ve pasif sedimentasyon örnekleme metoduyla incelenmiştir. Meteorolojik faktörlere ilave olarak, kentleşme ve trafik yoğunluğu mikrobiyal yükleme için tespit edilmiştir. Dış hava örnekleme Nisan 2014-Kasım 2015 arasında yürütülmüştür. Sedimentasyon yöntemi standart plate count agar (PCA) kullanılarak hazırlanan petri kutularının kapakları açılarak yapılmıştır. PCA ortamı toplam bakterilerin belirlenmesinde kullanılırken mantarlar için malt ekstrakt agar (MEA) kullanılmıştır. Bu periyodun sonunda oluşan koloniler sayılmış ve hacim başına düşen toplam bakteri ve mantar sayısı belirlenmiştir. Hava sıcaklığı, bağıl nem, rüzgar hızı ve yönü de aynı zamanda kayıt edilmiştir. Aktif örnekleme metodu sonuçlarına göre, en fazla bakteri sayısı 35^{0}C inkübasyon sıcaklığında Başaksehir istasyonunda 222 KOB (Koloni oluşturan birey)/m^3, en fazla mantar sayısı 20^{0}C inkübasyon sıcaklığında da 286 KOB/m^3 olarak belirlenmiştir. Belirlenen mikroorganizmalar için herhangi bir tür teşhis yapılmamıştır. Pasif örnekleme metodunda en fazla bakteri sayımı sonucu 35^{0}C 'da Bakırkoy istasyonunda 9250 KOB/m^3 olarak saptanmıştır.

Anahtar Kelimeler: Mikrobiyal fauna, dış ortam havası, sedimentasyon örnekleme, mikrobiyal yük

Investigation of Air Quality in Terms of Microbiological Density in Some Regions of the European Side of Istanbul Province

Abstract

Microbial fauna of the outdoor ambient air of Istanbul has been determined in European side of Istanbul province at four different districts (Bakirkoy, Fatih, Basaksehir and Esenler) by active and passive sedimentation sampling methods. In addition to meteorological factors, the effect of urbanization and traffic density for the air microbial load is also determined. Outdoor air sampling was performed between April 2014 and November 2015. The sedimentation method was done by standart plate count agar (PCA) opening the cover of the petri dishes containing a prepared medium. Standart plate count agar (PCA) medium was used for the determination of total bacteria while malt extract agar (MEA) was used for fungi. The colonies formed at the end of this period were counted and total number of bacteria and fungi per unit volume and area were determined. Air temperature, relative humidity, wind speed and direction were also recorded. As a result of the active sampling method, the most counted units of bacteria was determined at 350C in Basaksehir station as 222 CFU(Colony forming unit)/m^3, maximum fungal was determined as 286 CFU/m^3 at 20^{0}C incubation temperature. The maximum amount of bacteria in the passive sampling method results at 35^{0}C was in Bakirkoy station as 9250 CFU/m^3.

Keywords: Microbial fauna, outdoor air, sedimentation sampling, microbial load

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1. Introducion

Several studies have been conducted to determine the number and composition of atmospheric microorganisms. The atmosphere is not suitable for microbial growth due to high light intensity, extreme temperature changes, low organic matter concentration and low water content (Kuzyakov and Razavi, 2019). On the other hand, although the atmosphere is not suitable for the growth of microorganisms, it contains organism at a certain rate. Examples of airborne particles include pollens, microorganisms, and insects. Airborne microorganisms include algae, protozoa. yeasts, molds, rust, bacteria and viruses. The microbial load of air varies based on the amount of dust in the air and the human activities in the environment. Air on top of a fertile soil contains more microorganisms when compared to the air on sandy and muddy soil. Also, compared to the air on an area covered with meadows or forests, the air on a barren land, and compared to the sea air, terrestrial air contains more microorganisms. Air moisture also affects the quantitative status of microorganisms. The main factors behind the degree of bacterial contamination of air are the density of human and animal populations, vegetation, the structure of soil and the earth, the humidity and temperature of the atmosphere, the direction and length of the wind flow (Fujiyoshi et al., 2017).

In the upper layers of the air, aerobic bacilli are more abundant and in the lower layers, there are bacteria groups such as Achromobacter, Sarcina and Micrococcus. These organisms can be transported vertically and horizontally over long distances in the atmosphere. Although autotrophic bacteria could reproduce in clouds where particles that contain gases such as NH_3 and CO_2 and moisture are present, the growth of pathogenic microorganisms is not possible in the atmosphere (Brown et al., 2018). Bioaerosol is the general name for all airborne organic dust of biological origin such as bacteria, fungi, fungal spores, algae, viruses and pollen and their fragments. Exposure to these biological organisms and their microbial metabolites such as endotoxins, mycotoxins and VOC (Volatile Organic Compounds) leads to adverse health effects (Bennett and Inamdar, 2015). It was reported that in homes, where these types of pollutants are present, the frequency of the crises of asthma patients increases and the pollutants are associated with respiratory diseases (Kim et al., 2018).

The present study aimed to determine the number, composition and seasonal distribution of the total bacteria and fungi in domestic and outdoor atmospheres in Istanbul province and to determine whether the total number of bacterial and fungal colonies were associated with various meteorological factors.

2. Materials and Methods

2.1. Determination of the Stations

The samples were collected by sedimentation method in Fatih, Bakirkoy, Basaksehir, and Esenler districts in Istanbul (Figure 1) and by active sampling in Bakırkoy, Basaksehir, Esenler districts. The samples analyzed in the study were collected via the 4 stations in European side of Istanbul province between April 2014 - October 2015 in the determined regions for 18 months on certain intervals by active sampling. On September 2015, sampling was conducted by sedimentation method (1st station: Bakirkoy, 2nd station: Esenler, 3rd station: Basaksehir, 4th station: Fatih). In each station, total bacterial and fungal colony count were determined with 328 media via sedimentation and filtration methods.

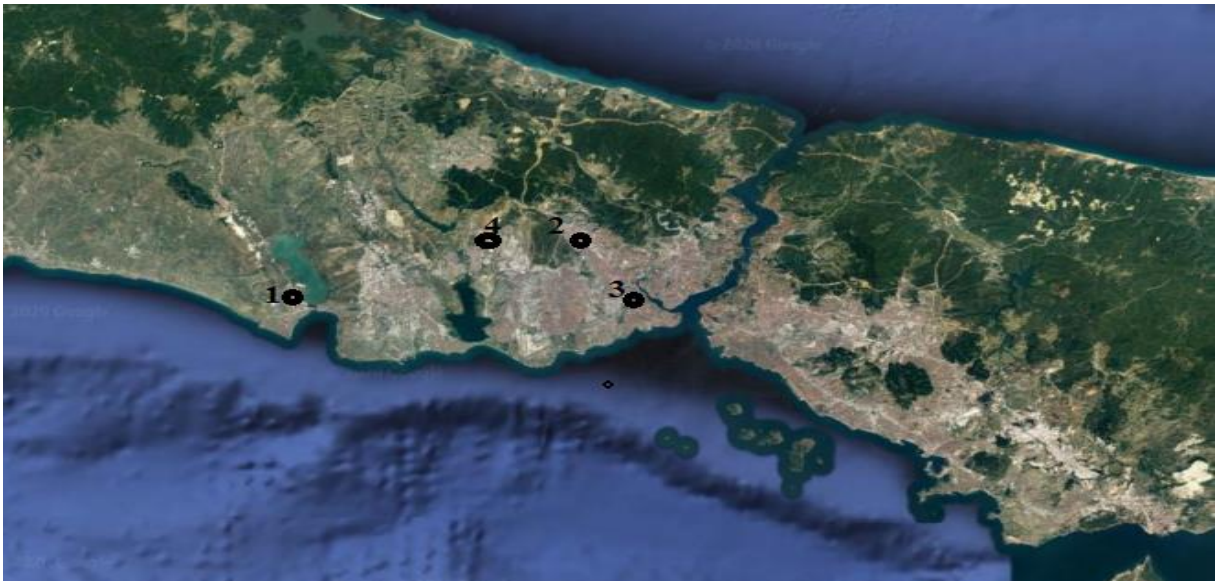

Fig. 1. Sampling stations (1. Station; Bakirkoy, 2. Station; Esenler, 3. Station- Fatih, 4. Station; Basaksehir)

Bakirkoy station was selected since the district is an urban settlement, urbanization and station transfer center with high traffic load and human population. Basaksehir station was preferred since the district is an organized industrial zone where several activities that cause air pollution are conducted and the district is urban and traffic-intensive center. Fatih station was selected due to high vehicle load and population, while Esenler-Davutpasa station was preferred due to dense plant flora and its windy character. The samples were collected from the outdoor atmosphere with sedimentation and filtration methods. In the present study, the sedimentation method initially developed by Pasteur was used with passive sampling.

2.2. Active Sampling and Membrane Filtration

In this method, the outdoor air was collected in the isotonic solution in the gas washing bottle using a vacuum pump. Prior to sampling, the equipment used such as the gas washing bottle, fasteners, isotonic solution, pure water, strainer set, and pipettes were sterilized in an autoclave (Figure 2). Sampling was conducted outdoors at human respiratory level of 1.5 meters. To research the quality of bacteria and fungi present in the air and to determine the suspended solid (SS) content, temperature, humidity, conductivity, samples were collected for 30 minutes in the morning and in the evening at each station at predetermined measurement points. The samples were transported to the laboratory with an ice battery thermos and isolated from the outdoor temperature. Once a specific air volume passed through the filter, the filter that retained all airborne microorganisms was placed on an agar medium. After the membrane filtration and incubation processes, the microbiological load in the ambient air was determined.

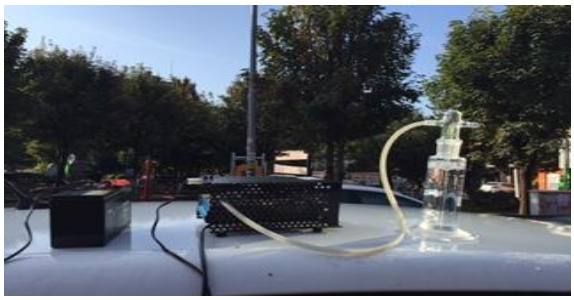

Fig. 2. Active sampling method

2.3. Sedimentation

Four petri dishes for total bacteria and for fungi determination were left with the lids off at 1.5 meters high in the sampling area about 30 minutes. Then, the lids were wrapped with stretch film and transferred to the laboratory in an ice battery thermos for incubation. Petri dishes were allowed to incubate for 48 hours at 25°C and 35°C. The colonies that grew at the end of the incubation period were counted.

2.4. Analysis

The strainer set was sterilized under a fume hood to prevent contamination. The agar saturated cardboards were placed in the strainer set. The media used are special cardboards saturated with a solution that is precisely formulated for microorganism growth with optimum parameters and could be stored for a long time and could be used by wetting with 3.5 ml sterile water. Standard PCA was used for total bacteria and MEA was used for mold and yeast determination.

The 250 ml samples in the gas washing bottle, 2 bacteria (37^0C-20^0C) in 50 ml, 2 fungi (37^0C-20^0C) were recorded for bacterial and fungi growth in the media in the air samples exposed to incubation for 2 days. The air temperature was also recorded during air quality measurements.

3. Results

3.1. Bacteria and Fungi Colony Counts Determined with Active Sampling Method

The total organism and fungal colonies obtained by the active sampling method are presented in Tables 1, 2 and 3. After the sampling and incubation conducted in Davutpasa station between April and November, the results of bacteria and fungi colony count are presented in CFU/m^3. In September, it was recorded that bacteria growth was higher as a result of the sampling and analysis conducted during the morning hours. The air temperature was 25ºC on 02.09.2014 when the sampling was conducted. The counting result conducted for the medium for the bacteria that underwent 30 min sampling and incubation at 30ºC was 7431 CFU/m^3. 833 CFU/m^3 colonies were counted in the fungi medium. The air temperature was 21°C and the incubation temperature was 35°C.

In April-November period, it was recorded that bacteria and fungi growth was higher as a result of the sampling and analysis conducted in June during the morning hours. The air temperature was 25ºC on 15.06.2014 when the sampling was conducted. The counting result conducted for the medium for the bacteria that underwent 30 min sampling and incubation at 20ºC was 7500 CFU/m^3. The count and analysis conducted on the fungi medium sampling collected on the same date and morning hours and incubated in 20ºC revealed 1528 CFU/m^3 fungi colonies.

Table 1. Colony counting results at Bakirkoy-Incirli stations via active sampling method.

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3)
BakİrkoyIncirli	25.4.2014	09:00-10:00	25	Bacteria	20	222
					35	150
				Fungus	20	45
					35	27
	25.4.2014	18:00-19:00	27	Bacteria	20	66
					35	51
				Fungus	20	33
					35	23
	25.5.2014	09:00-10:00	27	Bacteria	20	4
					35	10
				Fungus	20	4
					35	3
	25.5.2014	18:00-19:00	30	Bacteria	20	12
					35	5
				Fungus	20	14
					35	6
	25.6.2014	09:00-10:00	27	Bacteria	20	6
					35	8
				Fungus	20	6
					35	4
	25.6.2014	18:00-19:00	30	Bacteria	20	5
					35	3
				Fungus	20	6
					35	3
	25.7.2014	09:00-10:00	24	Bacteria	20	4
					35	4
				Fungus	20	8
					35	2
	25.7.2014	18:00-19:00	28	Bacteria	20	2
					35	2
				Fungus	20	2
					35	2
	25.8.2014	09:00-10:00	19	Bacteria	20	21
					35	14
				Fungus	20	4
					35	27
	25.8.2014	18:00-19:00	20	Bacteria	20	47
					35	27
				Fungus	20	2
					35	2
	25.9.2014	09:00-10:00	15	Bacteria	20	5
					35	2
				Fungus	20	7
					35	3
		18:00-19:00	15	Bacteria	20	11
					35	4
				Fungus	20	286
					35	2
	25.10.2014	09:00-10:00	16	Bacteria	20	49
					35	58
				Fungus	20	19
					35	6
	25.10.2014	18:00-19:00	18	Bacteria	20	47
					35	49
				Fungus	20	8
					35	6
	25.11.2014	09:00-10:00	9	Bacteria	20	14
					35	6
				Fungus	20	24
					35	11
	25.11.2014	18:00-19:00	10	Bacteria	20	4
					35	3
				Fungus	20	2
					35	2

Table 2. Colony counting results at Davutpasa-Esenler stations via active sampling method.

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3)
Davutpasa-Esenler	2.4.2014	09:00-10:00	15^0	Bacteria	20	0
					35	2
				Fungus	20	23
					35	19
	2.4.2014	18:00-19:00	17^0	Bacteria	20	0
					35	0
				Fungus	20	12
					35	6
	2.5.2014	09:00-10:00	16^0	Bacteria	20	0
					35	0
				Fungus	20	0
					35	0
	2.5.2014	18:00-19:00	19^0	Bacteria	20	10
					35	14
				Fungus	20	6
					35	2
	2.6.2014	09:00-10:00	23	Bacteria	20	103
					35	72
				Fungus	20	6
					35	4
	2.6.2014	18:00-19:00	24	Bacteria	20	119
					35	126
				Fungus	20	10
					35	6
	2.7.2014	09:00-10:00	25	Bacteria	20	25
					35	33
				Fungus	20	2
					35	2
	2.7.2014	18:00-19:00	29	Bacteria	20	3
					35	1
				Fungus	20	2
					35	2
	2.8.2014	09:00-10:00	27	Bacteria	20	5
					35	2
				Fungus	20	2
					35	2
	2.8.2014	18:00-19:00	29	Bacteria	20	11
					35	3
				Fungus	20	18
					35	6
	2.9.2014	09:00-10:00	25	Bacteria	20	177
					35	220
				Fungus	20	21
					35	8
	2.9.2014	18:00-19:00	29	Bacteria	20	2
					35	8
				Fungus	20	4
					35	4
	2.10.2014	09:00-10:00	21	Bacteria	20	51
					35	119
				Fungus	20	6
					35	25
	2.10.2014	18:00-19:00	23	Bacteria	20	60
					35	126
				Fungus	20	12
					35	5
	2.11.2014	09:00-10:00	14	Bacteria	20	3
					35	4
				Fungus	20	5
					35	6
	2.11.2014	18:00-19:00	17	Bacteria	20	7
					35	8
				Fungus	20	9
					35	10

Table 3. Colony counting results at Ikitelli-Basaksehir stations via active sampling method.

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3)
Ikitelli-Basaksehir	15.4.2015	09:00-10:00	12	Bacteria	20	6
					35	4
				Fungus	20	4
					35	4
	15.4.2015	18:00-19:00	13	Bacteria	20	10
					35	16
				Fungus	20	6
					35	10
	15.5.2015	09:00-10:00	19	Bacteria	20	37
					35	41
				Fungus	20	8
					35	4
	15.6.2015	09:00-10:00	25	Bacteria	20	222
					35	150
				Fungus	20	45
					35	27
	15.6.2015	18:00-19:00	27	Bacteria	20	66
					35	51
				Fungus	20	33
					35	23
	15.7.2015	09:00-10:00	27	Bacteria	20	4
					35	10
				Fungus	20	4
					35	2
	15.7.2015	18:00-19:00	30	Bacteria	20	19
					35	7
				Fungus	20	24
					35	9
	15.8.2015	09:00-10:00	27	Bacteria	20	6
					35	8
				Fungus	20	6
					35	2
	15.8.2015	18:00-19:00	30	Bacteria	20	5
					35	2
				Fungus	20	11
					35	3
	15.9.2015	09:00-10:00	24	Bacteria	20	4
					35	4
				Fungus	20	8
					35	2
	15.9.2015	18:00-19:00	28	Bacteria	20	2
					35	2
				Fungus	20	2
					35	2
	15.10.2015	09:00-10:00	19	Bacteria	20	21
					35	14
				Fungus	20	4
					35	27
	15.10.2015	18:00-19:00	20	Bacteria	20	47
					35	27
				Fungus	20	2
					35	2
	15.11.2015	09:00-10:00	15	Bacteria	20	16
					35	7
				Fungus	20	2
					35	2
	15.11.2015	18:00-19:00	15	Bacteria	20	9
					35	2
				Fungus	20	286
					35	2

3.2. Bacteria and Fungi Colony Counts Determined with Sedimentation Method

The total bacteria and fungi colony counts obtained with sedimentation method in Basaksehir- Ikitelli, Davutpasa-Esenler, Fatih-Aksaray, Bakirkoy-Incirli stations are presented in Tables 4, 5, 6 and 7.

Table 4. Colony counting results at Basaksehir-Ikitelli stations via sedimentation method

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3)
Basaksehir-İkitelli (sedimentasyon)	13.9.2015	15:00-16:00	25	Bacteria	20	2563
					35	1938
				Fungus	20	250
					35	250
	16.9.2015	16:00-17:00	25	Bacteria	20	313
					35	1063
				Fungus	20	324
					35	63
	17.9.2015	15:00-16:00	27	Bacteria	20	233
					35	1063
				Fungus	20	411
					35	67
	21.9.2015	14:00-15:00	26	Bacteria	20	125
					35	250
				Fungus	20	750
					35	156
	23.9.2015	12:00-13:00	23	Bacteria	20	34
					35	11
				Fungus	20	438
					35	313
	30.9.2015	17:00-18:00	16	Bacteria	20	250
					35	188
				Fungus	20	313
					35	63

The sampling conducted with sedimentation method was carried out in September at all stations. The highest value was recorded for the samples collected before 23:00 in Bakirkoy station on 23.09.215. For the fungi, the air temperature was recorded as 25^{0}C before noon on 21.09.2015 for the samples collected in Esenler station. The highest value obtained in total organism colony count was 9250 CFU/m^3 and the highest value obtained in total fungus colony count was 875 CFU/m^3.

Table 5. Colony counting results at Davutpasa-Esenler stations via sedimentation method

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3)
Davutpasa-Esenler(sedimentasyon)	7.9.2015	15:00-16:00	25	Bacteria	20	125
					35	94
				Fungus	20	188
					35	438
	17.9.2015	16:00-17:00	26	Bacteria	20	220
					35	42
				Fungus	20	34
					35	8
	21.9.2015	11:00-12:00	25	Bacteria	20	125
					35	94
				Fungus	20	188
					35	438
	29.9.2015	11:00-12:00	21	Bacteria	20	3450
					35	1125
				Fungus	20	540
					35	250
	21.9.2015	13:00-14:00	26	Bacteria	20	36
					35	250
				Fungus	20	438
					35	625
	23.9.2015	11:00-12:00	25	Bacteria	20	3000
					35	9250
				Fungus	20	750
					35	250
	30.9.2015	19:00-20:00	15	Bacteria	20	250
					35	3000
				Fungus	20	438
					35	125

Table 6. Colony counting results at Fatih-Aksaray stations via sedimentation method.

Station	Sampling date	Sampling time	Air temperature	Air pollutants	Incubation temperature	Toal colony number (CFU/m^3 min.)
Fatih-Aksaray	16.9.2015	18:00-19:00	24	Bacteria	20^0	125
					35^0	313
				Fungus	20^0	250
					35^0	31
	21.9.2015	11:00-12:00	24	Bacteria	20^0	177
					35^0	245
				Fungus	20^0	264
					35^0	44

Table 7. Colony counting results at Bakirkoy-Incirli stations via sedimentation method.

Station	Sampling date	Sampling time	Air Temperature	Air Polltants	Incubation temperature	Toal colony number (CFU/m^3 min.)
Bakirkoy-Incirli	21.9.2015	13:00-14:00	26	Bacteria	20^0	63
					35^0	250
				Fungus	20^0	438
					35^0	625
	23.9.2015	11:00-12.00	25	Bacteria	20^0	3000
					35^0	9250
				Fungus	20^0	750
					35^0	250
	30.9.2015	19:00-20:00	15	Bacteria	20^0	250
					35^0	3000
				Fungus	20^0	438
					35^0	125

4. Discussion

In this study, there is no test for characterization of bacteria/fungus to identify the specific types but ony the approximately number of microorganisms counted for four stations. Studies on determination of bacteria and fungi in indoor/outdoor environments increased significantly during recent years. There are several studies that investigated the presence of bacteria and/or fungi in different types of indoor air, especially in Istanbul, Edirne (Sarica et al., 2002; Asan et al., 2004; Aydogdu et al., 2005; Okten and Asan, 2012) Eskisehir (Asan et al., 2004; Ceylan et al., 2006),Adana (Inal et al., 2007), Manisa (Kalyoncu and Ekmekci, 2008), Isparta (Asan et al., 2004; Unlu et al. (2003), Afyon (Cetinkaya et al., 2005), Denizli (Ovez et al., 2012) and Ankara (Mentese et al., 2012) provinces in Turkey.

In a study conducted at McGill University, it was determined that the correlation between air density and microbial concentration was similar in Montreal and London. Samples were collected from the oceans and islands up to 2700-3000 meter elevations. The analysis of these samples demonstrated that bacteria and fungi could live up to an elevation of 3000 meters. *Micrococcus, Sarcina*, Gram (-) and Gram (+) bacilli were determined among the aerobic bacterial spore forms. They examined the microbiological flora in the bedroom, living room, kitchen and bathroom of a newly built apartment and in the garden of the same apartment building. For this purpose, both air and surface samples were collected. The air samples were collected at 400 locations in the garden and in each room in the apartment at 2 locations with the petri dishes prepared with Tryptic Soy Agar (TSA) and left open for 10 minutes (Pelczar and Reid, 1965).

In one of the other study, the mycoflora in indoor and outdoor air in the six different districts of the city of Istanbul were investigated at two monthly intervals from November 15, 2001 to September 15, 2002. The aim of that study was to find out the densities of airborne fungal spores that can cause an allergic response on inhalation and/or asthma. The most widespread fungal spores were identified as those of the genus *Cladosporium* and *Penicillium* (Colakoglu, 2004). Colakoglu (1996), took outdoor air samples from the Marmara University campus area and a crowded street over a year long period using a volumetric spore trap.

Colakoglu (2004) studied indoor and outdoor mycoflora in the different districts of the city of Istanbul. According to the results, a total of 504 samples were observed by using the Petri Plate Gravitational Method; fungi were isolated from these samples and 2198 colonies were counted. *Penicillium* was found in greatest abundance followed by *Aspergillus, Cladosporium, Alternaria, Rhizopus* and *Fusarium* and *Cladosporium and Alternaria*. At the end of the study, it was conducted that, there was a high density of the fungi *Penicillium* and *Aspergillus* in the indoor air while in the outdoor air, *Cladosporium* and *Alternaria* population were high. It is understood that there were differences in the distribution of other fungal species between the indoor and outdoor air samples (Colakoglu, 2004). A similar was study about gravimetric sampling was carried out in Belgrad Forest by Colakoglu, (2003). According to the study, outside the city center, over the course of a year, finding that *Aspergillus* and *Penicillium* were the most populated types of fungi.

The average concentration of bacteria in indoor air was 73 CFU/m^3 in the bathroom, 116 CFU/m^3 in the bedroom, 140 CFU/m^3 in the living room and 144 CFU/m^3 in the kitchen. The mean bacteria count in the house was similar to the outdoor mean bacteria count. There were statistical differences between outdoor bacteria concentrations in the studies conducted on the 1st and 2nd year. Gram (-) bacilli were found on moist surfaces such as kitchen faucets and wash basins, Gram (+) cocci were found on kitchen faucet, bathtubs and faucets. Gram (+) bacilli were found to be higher in both moist and dry surfaces (Marcher and Flores, 1991). The increase in air pollution in Turkey and abroad in recent years and resulting increase in respiratory system diseases especially in humans led to an increasing number of studies on the topic. Khan et al. (1999) conducted a year-long study to investigate the aerial distribution of *Aspergillus* and other molds in domestic and outdoors air environment. They utilized Andersen sampler and Rose-Bengal Agar. They compared the fungal species found in indoor and outdoor atmosphere. They investigated whether airborne particles pass through filters based on their density and size. Removal of bacterial and fungal contaminants from the air was succeeded with a rate of 98.7% in bacteria and up to 67% in fungi. They reported that the *Penicillium* species were dominant after removal and 4 µm particles passed through the filters. Sapan et al. (1991) investigated the indoors fungal flora in the province of Bursa. It was found that reproduction was observed in 1014 out of the 1188 media and *Penicillium, Cladosporium, Rhizopus ehrenberger, Aspergillus, Absidia tiegh and Mucor mich.* Sapan et al. (1993) conducted a study to investigate the fungal flora in the homes of children with bronchial asthma in Bursa. In this study, samples collected at 6 stations for 12 months using Gravity-Based Petri plate method to determine the airborne fungi in Edirne province and determined that the dominant species were *Alternaria, Penicillium,* and *Cladosporium*. They also examined the correlation between the number of fungal spores, air pollutants and meteorological factors using statistical analyzes, and found that the correlations between the number of spores and SO_2 concentration in the air and temperature were statistically significant. Although this finding contradicted with the findings reported by Bicakci et al. (2001), it was considered that the increase in the temperature, precipitation and humidity provided the optimum conditions for the growth of fungi. The density of microfungi is also high in humid environments.

5. Conclusions

In the study, it was observed that in November, although the humidity rate and rainfall were high, the spore count decreased significantly as a result of the decrease in temperatures. The findings of the present study in these months were similar to those reported by other studies. In April and May, it was observed that the spores started to decrease in the atmosphere. It is suggested that this decrease was due to the increasing temperatures and related decrease in relative humidity despite the increase in precipitation in these months. The optimum conditions may vary based on the geographic conditions and climate. In May, temperatures, precipitation and humidity reached suitable levels for these spores to grow and mean monthly temperature was observed as 14.2°C. It was reported that during the days after the rain, the increase in temperatures and wind speed increase the spore count. It is understood that sampling areas of Istanbul City has a problem about fungal and bacterial load for human health. It is necessary to control microorganism populations in for protect people health from allergic diseases. Those with allergies to fungal spores are recommended not to leave home unless they used to, because organic plant waste concentrations are high and so fungal development is much higher. Scientists are advised to study the range of seasons described above when considering their treatments.

6. Acknowledge

This study was produced from master thesis and supported by Yıldız Technical University Scientific Research Projects Coordinator (Project No: 2012-05-02-YL-02).

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