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Impact of Flats Features on Levels of Bioaerosol in Indoor Environments

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ABSTRACT: *People spend about 90% of their life in indoor environments. Therefore air of indoor environments has a great effect on public health. Indoor air pollution causes upper and lower respiratory tract diseases and pneumonia, especially in infants and children whose defense system is not yet developed. Indoor air pollution is one of the leading environmental factors that affect human health negatively and it has been reported that it is more effective than outdoor environments.*

This study undertaken in different districts of Ankara during winter and spring periods. Concentration and types of bacteria and fungi identified in inside of flats. Also some of factors that affect amount of bacteria and fungi in indoor environments of 119 dwellings were aimed. The method to measuring the concentration and type of bacteria and fungi in environments was NIOSH Method-0800. According to the obtained results, characteristics of building such as; age of building, materials used, type of paint and socio-demographic characteristics of families, lifestyle habits, physical characteristics of the environment and amount of salary, severely affect the concentration of bacteria and fungi in an indoor environments. After identifying the sources of pollutants, solutions have been presented which show how we can reduce or eliminate the concentration of bacteria and fungi that cause health problems in an indoor environments. As a result, statistical relationship between concentration of bacteria and fungi and characteristics of flats were found in indoor environments. According to the results obtained; the factors affecting bacterial and fungal concentration in indoor environments are, distance from traffic sources, area of flats, heating system, covering type, type of windows profile, wall painting, status of windows during sampling and existence of unusual odor inside flats.

Keywords:*Bacteria, Bioaerosol, Fungi,Indoor air*

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I. INTRODUCTION

People need clean drinking water, human rights and clean and healthy air for a good and quality life. For a long time, due to outdoor air pollution and climate conditions,indoor air is considered more reliable and healthy than outdoor environment. In the past, there was a view that being in an indoor environment protected people from polluted and unhealthy outdoor air [1]. In reality according to experts people are significantly affected by polluted indoor air [2]. Also the most interaction of allergenic substances, harmful gases, particulate matter, volatile organic compounds, bacteria and fungi occurs in the indoor environments. This particularly affects infants, children, women and people with heart and respiratory diseases in the negative direction [3]. Also, babies and children who are more biologically sensitive and have insufficient systems to turn toxins into harmless particles are more easily damaged [4]. According to the researches of Selcuk University polluted air affects lung growth of babies and children badly because children are breathing through the mouth instead of the nose where 90% of the dirty air is filtered [5].

Indoor air pollution sources are divided into two groups as biological and nonbiological resources. Bacteria, fungi, mold, viruses, pollen and their fragments are identified as biological pollution sources. Nonbiological resources are, gases generated during cooking, smoking, heating and cooling systems, construction materials,dust and particulate matter from furniture [6]. Bioaerosols include bacteria, fungi spores, viruses, pollen and biologically derived fragments and the general name of all organic dusts originating from air [7]. These biological organisms and their endotoxin, mycotoxin and volatile organic compounds can cause adverse health problems [8].

1.1. Importance Of Indoor Air Quality

People spend a large part of their time (more than 80%) in the indoor environments. For this reason indoor air has important impact on human health [10,11]. Infants, children and women who are cooking in the quarries with solid fuel are exposed to more adverse effects of indoor air pollution [12,13].

From the 1850s, indoor air is thought to be the most important factor affecting human life. Evidence suggests that, exposure to indoor air pollution is an important cause of morbidity and mortality [14]. The Environmental Protection Agency (EPA) has documented that human are exposed to air pollution in the indoor environment 2-5 times and sometimes 100 times more than outdoor air pollution. According to the World Health Organization report, 7 million people in the world died of air pollution in 2012. Half of this value (one in 8 deaths) died from indoor air pollution [15].

EPA states that air of 6 out of every 10 households are unhealthy due to pollutants [16]. According to scientific inquiry in America, a baby is exposed 4 cigarettes damage per day due to existence of bacteria and fungi in an indoor environment. The World Health Organization (WHO) has investigated the effects of air pollotion on global disease and found that, indoor air pollution is the eighth reason responsible for 2.7% of the global disease in the world [14]. About 3 million people die from air pollution every year in the world. This value constitutes 5% of the total death cases in the world [17]. Each person breathes an average of 400-500 million liters of air per year. So quality of breathing air is very important for human health [18].

1.2. Limit Values For Bioaerosols

The American Conference of Govermental Industrial Hygienists determined 100 CFU/m³ for level of bioaerosol in air [18]. This amount was removed in 1999 and the Canadian Government identified an unacceptable level of bioaerosol concentration above 500 CFU/m³. NIOSH (Occupational Safety and Health Administration) has determined that the upper limit value of total bioaerosol that can cause health problems is 1000 CFU/m³ [18].

II. MATERIAL AND METHODS

Air samples were taken from indoor air of flats and bioaerosol (bacteria and fungi) analyzes were performed. In the study, a total of 119 flats in Ankara were used for indoor and outdoor air sampling for 2 years during autumn-winter and spring-summer perios. Air samples were drawn on Plate, Blood and Sabouraud-Antibiotics agars for 4 minutes with the device for measuring bioaerosol in the indoor environments of the flats. Some socio-demographic characteristics of the families and life habits, the environment they live in, any changes in bedrooms and other roomswere analaysed.

For determination of the relationship between bioaerosol concentrations in indoor environments and bioaerosol sources, bioaerosol levels measured in indoor and outdoor environments and physical properties of environments, some socio-demographic characteristics of the families and life habits have been examined. Air of indoor environments was sampled 50 cm above the ground. Sampling of bioaerosols was carried out in accordance with NIOSH Method-0800 which is the indoor bioaerosol sampling standard methood and with SKC instrument. This sampling system consists of an impactor and a vacuum pump that collects bioaerosols in the impactor. Vacuum pump has a constant air flow rate of 28.3 L/min, that was checked with the DC-Lite Calibrator before each sample.

Sterile, ready-to-use agars have been used to determine the concentration and types of bacteria and fungi originating from ambient air. To determine the total number of bacteria; Plate Count agar, for the species identification of bacteria; Bloody agar and for determining the species and number of fungi; Sabouraud-antibiotic agar were used. At the end of the sampling, agars were taken to the laboratory and placed in the incubator. Bacteria were incubated for 48 hours at 37 ºC and for about 7 days at 25 ºC. Plate Count agars were placed in the incubator of the KORU Hospital microbiology laboratory. After incubating the Plate Count agars for 24 h at 37 ºC to determine bacterial counts, colony counting on the medium placed on the semi-automatic colony counter was performed under fluorescent light.

2.1. Sampling Points

Sampling stations are: Keçiören, Etlik, Yenimahalle, Batıkent, Ostim, Etimesgut, Mamak, Dikmen, Pursaklar, Kazan, Bağlum, Sincan, Altındağ, Çankaya, Seyranbağları, Siteler, Gölbaşı, Akyurt, Demetevler and Çubuk.Sampling points in Ankara are given in Figure 1.

Fig 1. Sampling Points

In this study bioaerosol samplings were made in indoor environments of flats during different seasons. The first and second samples were made during spring-summer and autumn-winter periods of 2011. The third and fourth sampling were carried out in spring-summer of 2012 and autumn-winter of 2013-2014. Sampling dates and number of flats are given in Table 1.

Table 1. Sampling Dates and Number of Flats

Period	Date	Number of Flats
First	16.04.2011 26.07.2011	119
Second	24.10.2011 28.12.2011	94
Third	19.04.2012 11.07.2012	86
Fourth	28.11.2013 26.01.2014	67

Table 2. Flats properties affecting bioaeosol concentration

Distance From Traffic Sources	Flats near to traffic sources	%70	**Floor of Flats**	Third floor and below	%53
	Flats far from traffic sources	%30		Floors higher than third one	%46
Heating Systems	Central Heating System	%26	**Floor Covering**	Wood and Laminate	%60
	Wood and Coal Stove	%11		PVC	%9
	Gas Stove	%1		Others (Carpet or Rug, Concrete, Mosaic and Ceramics)	%31
	Combi Heating System	%62			
State of Windows During Sampling	Open	%57	**Wall Painting**	Whitewash	%33
				Plastic paint	%51
	Close	%43		Oil paint	%17
Type of windows profile	PVC	%49	**Unusual Smell Inside Flats**	There is smell	%65
	Wood	%51		There isn't any smell	%35
Flats Area	>100 m²	%61			
	<100 m²	%39			

2.2. Sampling and Analysis Method

Air samples were taken inside the flats in the study. Indoor air environment was performed in accordance with NIOSH Method-0800, a bioaerosol sampling standard. The samples were run with a system containing the Quick Take 30 pump attached to the SKC Bioimpacture. The air samples were collected inside agars during 4 minutes with 28.3 L/min constant flow rate by vacuum pump. The bioaerosol sampling system consisting of an impactor and a vacuum pump is shown in Figure 2.

Vacuum Pump	Impactor
	

Fig 2. Vacuum Pump and Impactor

Air samples were drawn on Plate, Blood and Sabouraud-Antibiotic agars for 4 minutes with the device for measuring bioaerosol in the indoor environments.At the end of the sampling agars which were immediately closed were taken to the laboratory and placed in the incubator. Bacteria were incubated for 48 hours at 37 ºC and for about 7 days at 25 ºC. After incubating the Plate Count agars for 24 h at 37 ºC to determine bacterial counts, colony counting on the agarsin the semi-automatic colony counter was performed under fluorescent light.

Statgraphics XV.I statistical package program was used to investigate differences in the evaluation of all sampling results, to examine thr differences between the measured value and the expected value and the differences between the two factors. The evaluation of the data was generally made at 95% confidence interval. Box whiskers, spearman rank correlation, ANOVA and correlation analyzes were used in Statgraphics program and beyond the evaluation of data.

III. CONCLUSION

Concentration and type of bacteria and fungi measured in indoor environments of sampled flats. As a result, statistical relationship between bacterial and fungal concentration and flats characteristics were found in indoor environment. According to the results obtained; factors affecting bacterial and fungal concentration in indoor environments are;distance from traffic sources, floor and area of flats, heating system, covering type, type of windows profile, type of wall painting, status of windows during sampling and existence of unusual odor in the flat. One-Way ANOVA Test, Kruskal-Wallis Test (KWT), Mood's Median Test (MMT) and Variance Check Test (VCT) were applied between the internal bacteria and fungus data and questionnaire studies. For each questionnaire study, differences between the groups were determined in the 95% confidence interval ($p < 0.05$).

3.1. Distance From Traffic Sources and Concentration of Bacteria and Fungi

A person needs 15 m³ of clean air per day and a single vehicle can convert it to dangerous and poulluted air in just 10 minutes. Urban traffic is an important source of pollutants because of the lack of adequate technical maintenance of vehicles, unconscious use and some of too oldvehicles [21].

In this study, it was determined that 70% of the flats sampled were close to the main street and trafficsources. According to the Variance Check test, there is a statistically significant correlation between bacterial and fungal concentration during spring-summer and fungal concentration in fall-winter period and distances of flats from traffic sources. The results of the tests and the P values are shown in Tables 3. Flats near to traffic sources (less than 100 meters away from the traffic sources) are shown in number 1 and the flats far from traffic sources (over 100 meters from the traffic sources) and main streets are shown in number 2 on the Box Whisker plot. In 92% of flats near to traffic sources fungal levels were measured more than 500 CFU/m³ during the fall-winter period. In addition the fungal concentration was found 1.5 times more in the flats near traffic sources during autumn-winter than other flats. The distance between the main street and the flats was found less than 100 meters in 72% of flats with bacterial conentration more than1000 CFU/m³ during spring period and 60% of flats with fungal level more than 500 CFU/m³ during spring-summer.

In the spring-summer period the bacterial and fungal concentration in the flats near the main street have increased about 2 times because the windows have been open for a long time. In fall-winter period concentration of fungi in flats near to traffic sources have measured about 2 times more than other flats. According to the results obtained, the air of the indoor environments is more affected from the outside environments during spring-summer period. Moreover in all sampling periods the concentration of bacteria in flats near to traffic sources and main streets was measured 4.5 times more than other flats. Box-and-Whisker Plot of bacteria-fungi concentration and distance from traffic sources are shown in Figures 3.

Table 3. Relationship Between Concentration of Bacteria-Fungi and Distance From Traffic Sources

Period	Biyoaerosol	Factor (Distance from traffic sources)	Average CFU/m³	Test	P-Value
Spring-Summer	Bacteria	Far from traffic sources	907	Variance Check	0.01
		Near to traffic sources	1076		
	Fungi	Far from traffic sources	143	Variance Check	0.00
		Near to traffic sources	241		
Autumn-Winter	Fungi	Far from traffic sources	150	Variance Check	0.00
		Near to traffic sources	240		
All samples	Bacteria	Far from traffic sources	852	Variance Check	0.03
		Near to traffic sources	1652		

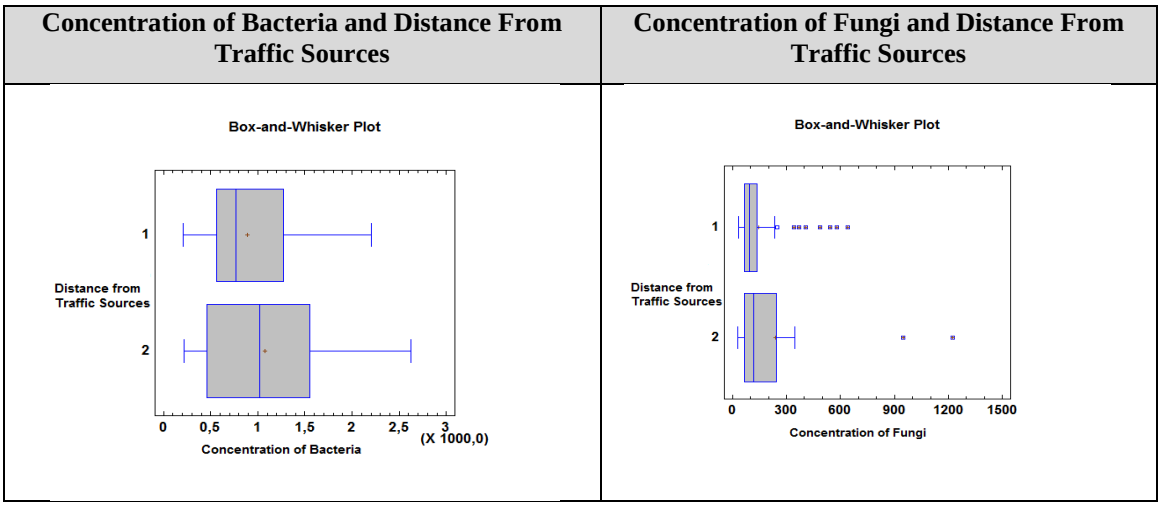


Fig 3. Box-and-Whisker Plot of Bacteria-Fungi Concentration and Distance From Traffic Sources

1: Flats far from traffic sources
2: Flats near to traffic sources

3.2. Floor of Flats and Concentration of Fungi

Since the lower floors are close to the main streets and pollution sources, they are exposed to dust, particulate matter and bacteria which are mostly in the air [23]. Fungal formation depends on the moistue of the building [24]. According to the results of this survey, 33% of the flats are flats in the basement or the ground floor, 20% are in the 1st or 2nd floor and 46% are in 3rd floor or above. According to the Variance Check test from the one way ANOVA test, the statistical relationship between the fungal level in the indoor environment and the floor of flats during the spring-summer period was determined (Table4). Concentration of fungi is measured 95 CFU/m³ in the upper floors (flats located on the 3rd floor and upper floors) and it was measured 174 CFU/m³ (2 times more) in the 3rd floor or below flats during spring and summer. During spring-summer period, 100% of the flats with a fungal leves more than 500 CFU/m³ were found in the 1st, 2nd or 3rd floors. In addition, the increase in the concentration of fungi has been found especially in the flats located on the third floor and below, mainly due to moisture and humidity penetrating from the floor of the building. Amount of fungi in the lower floors during all sampling periods was measured higher than 3rd and higher floors. The Box-and-Whisker Plot of the fungi level and floor of flats is shown in Figure 4.

Table 4. Anova Table of Floor of Flats and Concentration of Fungi

Period	Biyoaerosol	Factor	Average CFU/m³	Test	P-Value
Spring-Summer	Fungi	Third floor and below	174	Variance Check	0.00
		Floors higher than third one	95		
All samples	Fungi	Third floor and below	210	Variance Check	0.02
		Floors higher than third one	89		

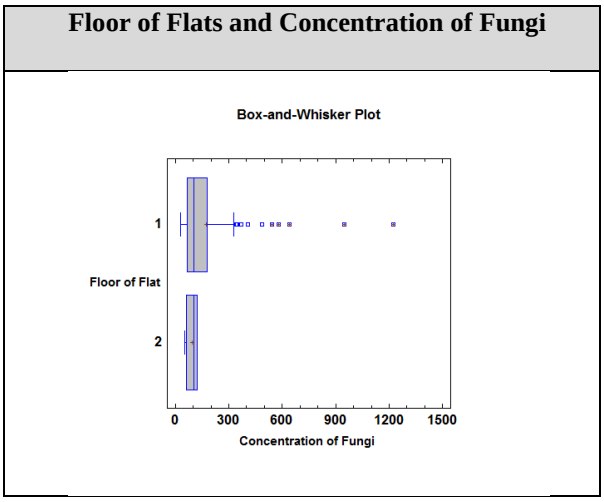


Fig 4. Box-and-Whisker Plot of Floor of Flats and Concentration of Fungi
1: Flats in third floor and below
2: Flats in floors higher than third one

3.3. Flats Area and Concentrarion of Fungi

According to the survey results; 61% of the flats sample have an area bigger than 100 m² and 39% have an area smaller than 100 m². According to Variance Check and one way ANOVA tests; statistically significant relationship was found between the levels of fungi in the flats and flats area. Concentrarion of fungi was measured 133 CFU/m³ in small flats and it was 200 CFU/ m³ in the flats with area of bigger than100 m². In addition during spring-summer period 73% of flats with fungal level more than 500 CFU/m³ have an area bigger than 100 m². The results of the test and the P value are shown in Tables 5. Flats with area bigger than100 m² are shown in number 1 and flats with area less than 100 m² are shown in number 2 on the Box-and-Whisker Plot. The fungal concentration and the Box-and-Whisker Plot of the residential area are shown in Figure 5.

Table 5. Area of Flats and Concentrarion of Fungi

Period	Biyoaerosol	Factor	Average CFU/m³	Test	P-Value
Spring-Summer	Fungi	Area<100m²	133	Variance Check	0.00
		Area>100m²	200		

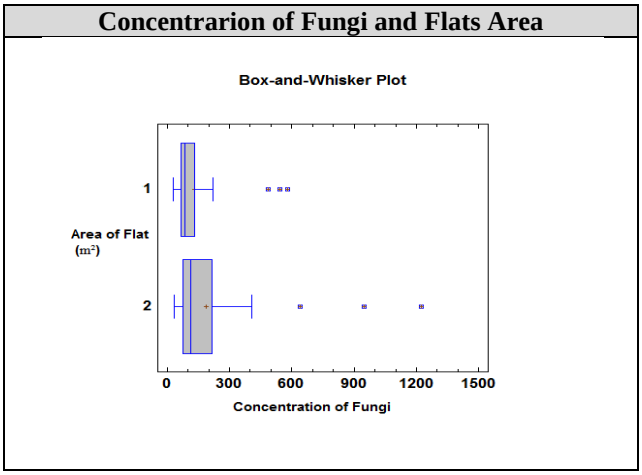


Fig 5. Box-and-Whisker Plot of Concentrarion of Fungi and Flats Area
1:<100 m²
2:>100 m²

3.4. Heating Systems and Concentrarion of Bacteria and Fungi Inside the Flats

About half of the people living in the world use wood and coal stoves which cause indoor air pollution as heating system inside their flats.1.6 million people per year (one person every 20 seconds) die by indoor air

pollution [22]. According to the International Energy Agency (IEA) survey in 2014 using of such harmful fuels is defined in the world as the 8th disease cause. According to the World Health Organization report; 2.7% of the diseases in the world are caused by the use of harmful fuels. In developed countries, 3.7% of diseases are caused by indoor air pollution and the use of wood fuels [109].

In this study, 26% of the flats use the central heating system, 11% use wood and coal stove, 62% use combi (natural gas) and 1% use natural gas stoveas as heating system inside the flats. According to ANOVA and Variance Check tests, statistically significant relationship was found between concentration of bacteria and fungi in the indoor environments and type of heating system during autumn-winter. Results of tests and P-values are shown in Table 6. The heating system is central system in flats with number 1, the heating system is wood and charcoal stove in flats with number 2, combi boiler is used in houses with number 3 and the heating system is natural gas in flats that are shown with number 4 in the Box-and-Whisker Plot. In the autumn-winter periods the highest bacterial level was measured 1251 CFU/m³ in flats with wood and coal stoves. The highest levels of fungi in this period was measured in flats using wood and coal stoves as heating system. During fall-winter period, 68% of flats with a bacterial level more than 1000 CFU/m³ were found with wood and coal stoves. As a result of this study indoor air pollution is related to use of wood and coal stoves in urban areas especially in rural areas and poorly financed. Indoor air pollution from heating system affects all people living in indoor environments. In a study conducted by Keles et al., in 1999, the percentage of allergic rhinitis cases before and after natural gas use in Stanbul was examined. At the beginning of 1994, 62.5% of the subjects complained of rhinitis, in 1996, this rate dropped to 51%. In addition it was emphasized that the change of the heating source in the indoor environments besides some factors such as: age, gender, and smoking status affect this ratio [61]. Box-and-Whisker plot of concentration of bacteria and fungi and type of heating systems inside the flats are shown in Fig 6.

Table 6. Concentrarion of Fungi-Bacteria and Type of Heating System

Period	Biyoaerosol	Factor	Average CFU/m³	Test	P-Value
Autumn-Winter	Bacteria	Central heating	746	Variance Check	0.03
		Wood and Coal Stove	1251		
		Combi Heating System	1050		
		Gas Stove	906		
	Fungi	Central heating	115	Variance Check	0.00
		Wood and Coal Stove	500		
		Combi Heating System	240		
		Gas Stove	220		

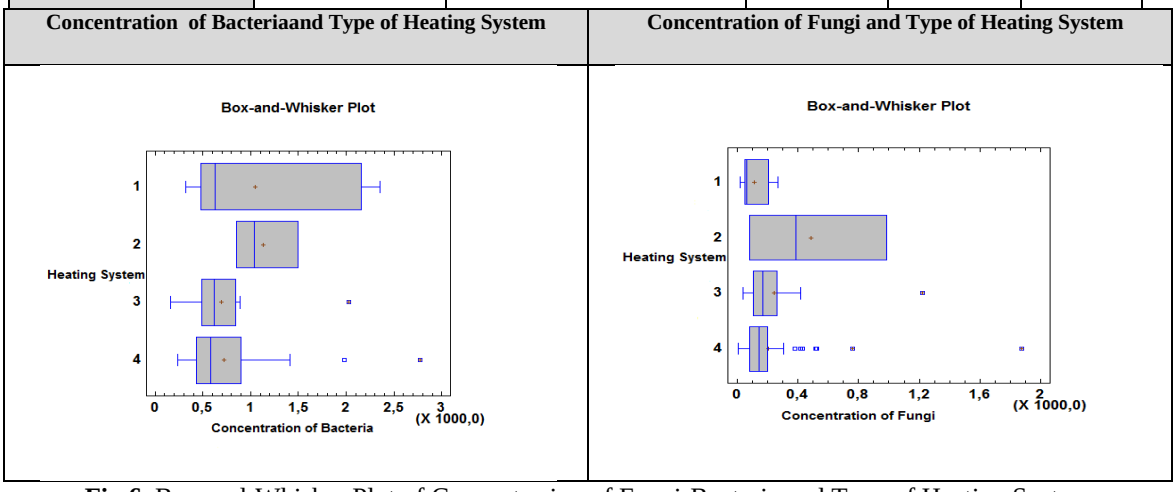


Fig 6. Box-and-Whisker Plot of Concentrarion of Fungi-Bacteria and Type of Heating System

1: Central heating System
2: Wood and Coal Stove
3: Combi Heating System
4: Gas Stove

3.5. Floor Covering of Flats and Concentrarion of Bacteria and Fungi

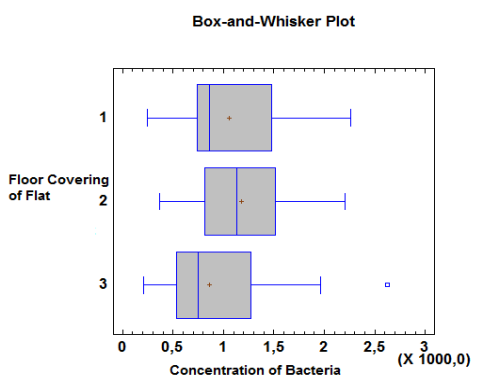
Linoleum, Wood, Laminate, Marley, PVC are classified as soft floor covering in the flats [121]. Marley floors were used in England in 1948 and polyvinyl chloride floors for the first time were used in 1930 after the second world war. Marley and polyvinyl chloride (PVC) consists of plastic material that used in indoor environment. Using of Marley is widespread in hospitals, schools, offices, factories, public buildings and most importantly in houses. The use of marley is prohibited all over the world due to existance of asbestos material in Marley [121]. Special adhesives are used in polyvinyl chloride (PVC) floors. Marley and PVC materials should be made softer and more flexible for indoor use (for reducing noise pollution). PVC identifies one of the most toxic plastics in the world and increases chlorine gas, ethylene dichloride, vinyl chloride, mercury, dioxins, PCB quantities in the air [121].

In this study in 60% of the flats wood and laminate, in 9% PVC and inside the 31% of flats others (carpet, concrete, mosaic, ceramic) are used. According to Variance Check and Mood's Median tests of one-way ANOVA test; concentration of bacteria and fungi during spring-summer period were found more in flats with marley and PVC floor covering than other flats. The results of the tests and the P values are shown in Tables 7. Flats with wood and laminate parquet floor covering are shown in number 1, flats with PVC and marley floor covering are shown in number 2 and flats with other floor covering types (carpet, concrete, mosaic and ceramic) are shown in number 3. During spring-summer period flats with PVC and marley have the highest concentrationof bacteria of 1175 CFU/m³ and fungal level of 180 CFU/m³. Bacterial and fungal growth and proliferation arises especially in the humid and rainy seasons [18]. In the fall-winter period concentration of fungi was found high in flats with wood and laminate and other (carpet, concrete, mosaic and ceramic) floor coverings. The Box-and-Whisker Plot of concentration of bacteria and fungi and floor covering is shown in Fig 7.

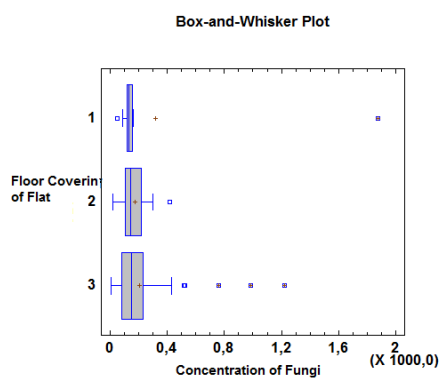
Table 7. Floor Covering of Flats and Concentrarion of Bacteria and Fungi

Period	Biyoaerosol	Factor (Floor Covering of Flats)	Average CFU/m³	Test	P-Value
Spring- Summer	Bacteria	Wood and Laminate	1052	Mood's Median	0.03
		PVC, Marley	1175		
		Others	861		
	Fungi	Wood and Laminate	118	Variance Check	0.04
		PVC, Marley	180		
		Others	172		
Autumn-Winter	Fungi	Wood and Laminate	318	Variance Check	0.00
		PVC, Marley	176		
		Others	210		

Floor Covering and Concentrarion of Bacteria in Spring-Summer



Floor Covering and Concentrarion of Bacteria in Autumn-Winter



Floor Covering and Concentrarion of Fungi in Autumn -Winter

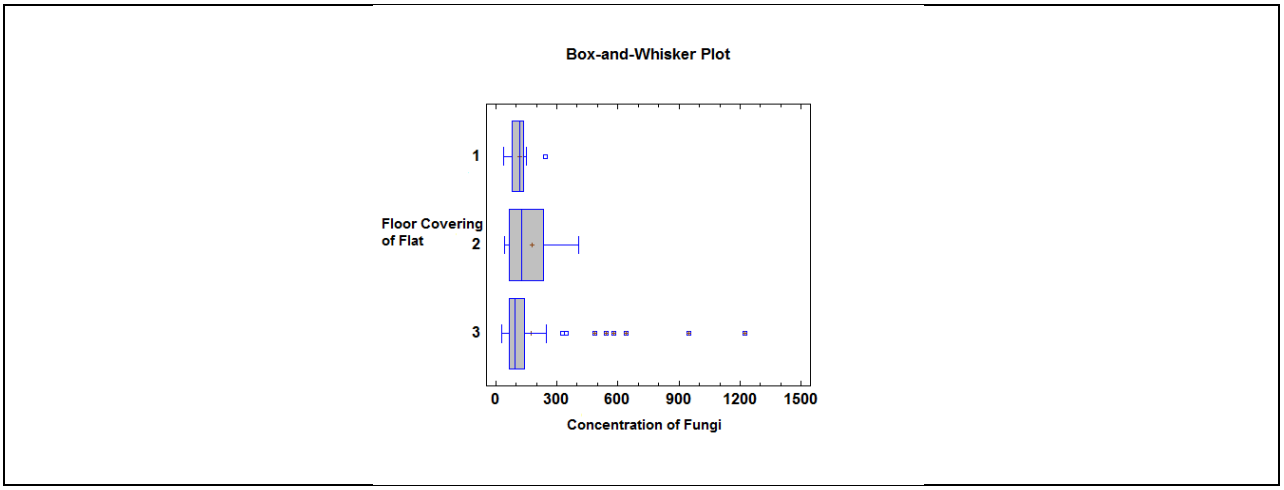


Fig 7. Box-and-Whisker Plot of Concentrarion of Fungi and Bacteria and Floor Covering of Flats

1:Wood and Laminate
2:PVC, Marley
3:Others (Carpet or Rug, Concrete, Mosaic and Ceramics)

3.6. Type of Wall Painting and Concentrarion of Bacteria and Fungi

Choosing the paint for the indoor environments is one of the most important decisions we should make to choose a kind of paint that is friendly to human health. The least harmful chemical containing type of paint should be preferred in indoor environments. This is important especially for infants, children, mothers who are breathing air for at least 15-20 hours every day without interruption in indoor environments. Wall paintings that do not produce bacteria and fungi are the least harmful to health [38].

Water-thinned paints do not cause much problems for human health, as compared to othersHowever synthetic paints and thinners reduce the oxygen in the air as they vaporize and causing asthma, shortness of breath, heartbeat and other respiratory problems in human.Unleaded and flavorless products should be preferred especially for baby and children's rooms [38].

In this study, whitewash is used in 33% of the flats, plastic paint is used in 51% of flats and oil paint is used in 17% of flats. According to the one way ANOVA and Variance Check tests; statistically significant relationship was found between the concentration of bacteria-fungi and type of wall paintingin inside the flats during spring-summer period and the concentration of fungi and wall painting in the fall-winter period. The results of the tests and the P values are shown in Tables 8. The flats with whitewashed wall painting are shown in number 1, the flats with plastic paint as wall paint are shown in number 2 and the flats with oily paint are shown in number 3 on Box-and-Whisker Plot. In the spring-summer period the highest concentration of bacteria and fungi were found in the flats where oil and whitewash were used and in the fall-winter period the highest concentration of bacteria and fungi were found in the flats with plastic paint. In another study conducted in Ankara, toluene, octane, nonan and naphthalene levels were found higher in plastic and oil painting flats than in other flats, as the result of our study[11]. Because of the high temperature and humidity in the spring and summer and thikness of plastic paints,theyprovide a very suitable environment for fungal and bacterial growthin the indoor environment.Oil and plastic paints are thinned with solvent (thinner). Box-and-Whisker Plot of concentration of bacteria and fungi and type of wall painting are shown in Fig 8.

Table 8. Type of Wall Painting and Concentrarion of Bacteria and Fungi

Period	Biyoaerosol	Factor (Wall Painting)	Average CFU/m³	Test	P-Value
Spring- Summer	Bacteria	Whitewash	1080	Variance Check	0.02
		Plastic paint	888		
		Oil paint	1006		
	Fungi	Whitewash	171	Variance Check	0.03
		Plastic paint	180		
		Oil paint	110		

Autumn -Winter	Fungi	Whitewash	151	Variance Check	0.00
		Plastic paint	210		
		Oil paint	310		

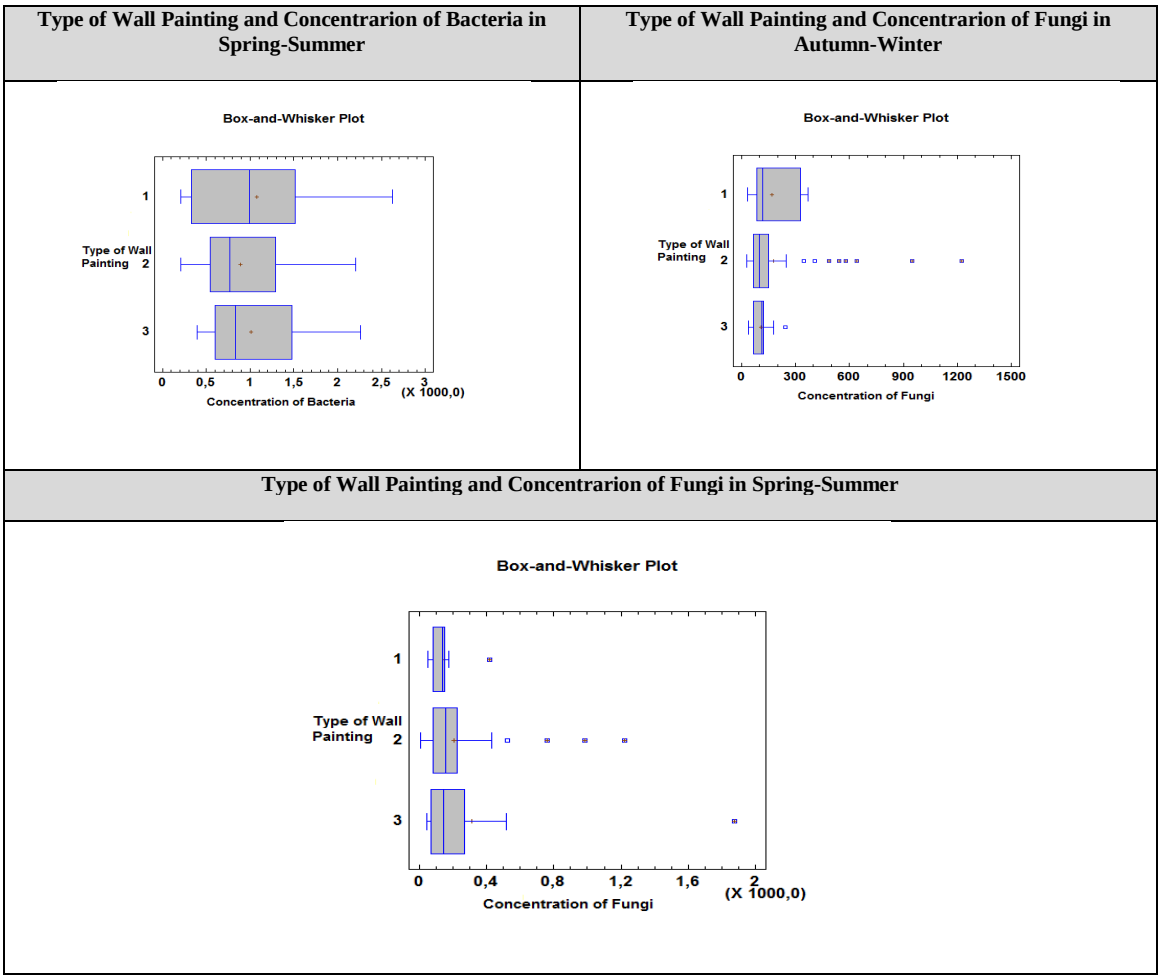


Fig 8. Box-and-Whisker Plot of Concentrarion of Bacteria and Fungi and Type of Wall Painting
1: Whitewash
2: Plastic paint
3: Oil paint

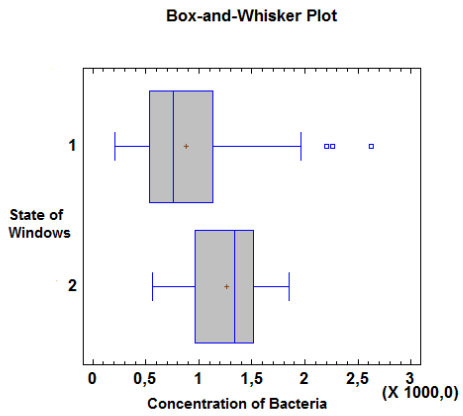
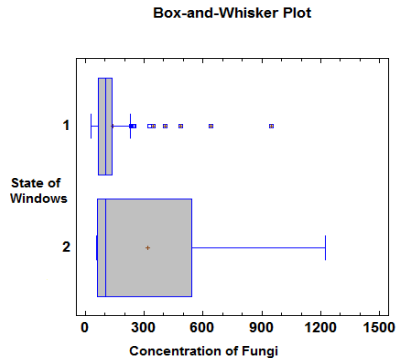
3.7. State of Windows During Sampling and Concentrarion of Bacteria and Fungi

Ventilation of the flats is very important to reduce bacteria, fungi and harmful microorganism levels in an indoor environment, to prevent the oxygen decreasing, to reduce carbon dioxide gas, body odors, cigarette smoke, moisture increasing and to remove moisture. The windows are the basic ways of natural ventilation and the basic forces that make up the aeration are wind power and thermal forces. In this study, 57% of the windows in the flats we sampled were open and 43% were close during sampling perriods. According to the Variance Check, Mood's Median, Kruskal Wallis and ANOVA Table from one way ANOVA tests, statistically significant relationship was determined between the concentration of bacteria and fungi and the state of the windows during sampling in spring-summer and autumn-winter periods in the indoor environment. The results of the tests and P values are shown in Table 9. The flats with open windows during sampling are shown in number 2 and the flats with close windows during sampling hours are shown in number 1 on the Box-and-Whisker Plot. In the spring-summer period, concentration of bacteria in flats with close windows measured 880 CFU/m³ and it was measured 1366 CFU/m³ (1.5 times greater) in flats with open windows during sampling hours. In this period fungi concentration was measured as 143 CFU/m³ in flats with closewindows and 319 CFU/m³ (2fold more) in flats with open windows.During the spring-summer period, windows and doors are open for a longer time than other seasons so in this period the concentration of bacteria and fungi were measured about 2 times higher than other seasons. In the spring-summer period the outdoor air influences the air of indoor

environment strongly. In the same way in the fall-winter period concentration of fungi in indoor environments were measured 184 CFU/m³ in flats with close windows and it was measured 360 CFU/m³ (about 2 times more) in flats with open windows.The highest concentration of bacteria and fungi were found in the flatswith open windows during the sampling period in both periods.In all sampling periods, the level of bacteria was found 952 CFU/m³ inflats with close windows during sampling and it was measured 2005 CFU/m³ (2 times) in flats with open windows.When the windows are openit is possible to assume that, the air circulationfrom outdoor into indoor environment causes airborne bacteria and fungus movement into indoor environments. Box-and-Whisker Plotand concentration of bacteria and fungi and state of the windows during sampling are shown in Fig 9.

Table 9. State of Windows During Sampling and Concentrarion of Fungi and Bacteria

Period	Biyoaerosol	Factor	Average CFU/m³	Test	P-Value
Spring- Summer	Bacteria	Close	880	ANOVA Table	0.02
		Open	1366	Kruskal-Wallis	0.00
				Mood's Median	0.02
	Fungi	Close	143	ANOVA Table	0.00
		Open	319	Variance Check	0.00
Autumn -Winter	Fungi	Close	184	ANOVA Table	0.00
				Variance Check	0.03
		Open	360	Kruskal-Wallis	0.00
				Mood's Median	0.01
All Samples	Bacteria	Close	952	Variance Check	0.05
		Open	2005	ANOVA Table	0.00

State ofWindows and Concentrarion of Bacteria in Spring-Summer	State of Windows and Concentrarion of Fungi in Spring-Summer
	

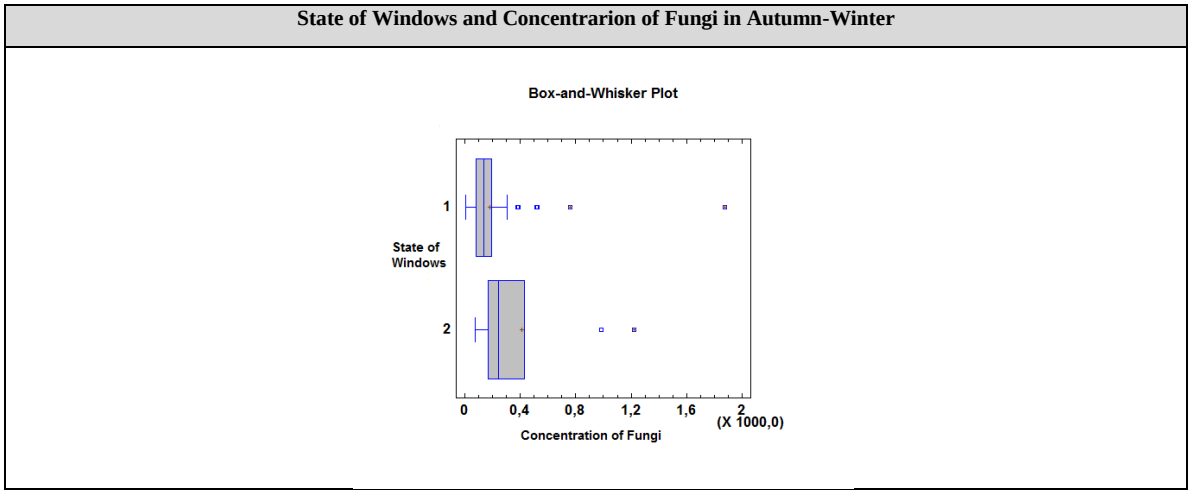


Fig 9. Box-and-Whisker Plot of State of Windows During Sampling and Concentrarion of Bacteria and Fungi

1:windows were close during sampling.
2:windows were open during sampling.

3.8. Type of Frame of Windows and Concentrarion of Fungi

As a building material, PVC is cheap and easy to install. So that it is used more than concrete, wood and kilnin recent years. Among the most common uses of PVC are doors and windows profile.

In this study, 49% of flats have PVC windows profile and 51% of them have wood windows profile. According to Kruskal-Wallis, Mood's Median and one-way ANOVA tests, statistically significant relationship was found between the fungi levels and the types of windows in the flats during autumn-winter period. The results of the tests and the P values are shown in Table 10. Flats with PVC windows are shown in number 1 and the flats with wood windows are shown in number 2 on Box-and-Whisker Plot. In autumn-winter period the concentration of fungi was 153 CFU/m³ in flats with wood-frame windows and it was 283 CFU/m³ (2 times more) in flats with PVC-frame windows. In the fall-winter period, PVC windows prevent air circulation in indoor environmentsand causing more moisture and humidity in indoor environments and finally causing fungus reproduction and reproduction. During this period, 75% of flats with PVC windows have fungal level of more than 500 CFU/m³. The Box-and-Whisker Plot of the type of windows profile and fungal concentration inside flats is shown in Figure 10.

Table10. Type of Windows and Concentrarion of Fungi

Period	Biyoaerosol	Factor (Pencere türü)	Average CFU/m³	Test	P-Value
Autumn -Winter	Fungi	PVC	283	Kruskal-Wallis	0.01
		Wood	153	Mood's Median	0.03

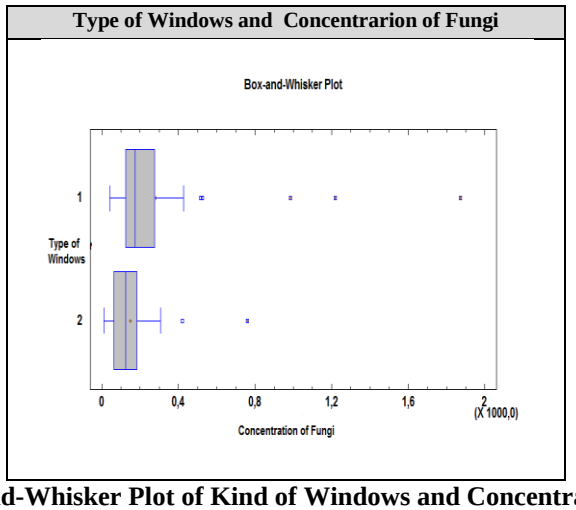


Fig 10. Box-and-Whisker Plot of Kind of Windows and Concentrarion of Fungi

1:PVC
2:Wood

3.9. Unusual Smell Inside Flats and Concentrarion of Bacteria and fungi

According to the results of the survey conducted in this study, in the fall-winter and spring-summer periods in 65% of the flats there was unusual smell inside flats. According to the Variannce Check test, statistically significant relationship was found between the levels of fungi in the indoor environments and the smell formed in the indoor environments. The test result and P-value are shown in Table 11. Flats without any unusual smell are shown in number 1 and flats with unusual smell are shown in number 2 on the Box-and-Whisker Plot. The test results and P-value are shown in Table 11. When we look at the average of all the sampling periods the concentration of fungi in flats without any unusual smell is 114 CFU/m³ and there is 320 CFU/m³ (2.8 times) in flats with unusual smell. Indoor unusual smell affect concentration of fungi found in the indoor environments. The Box-and-Whisker Plotof concentration of fungi and excistance of smell in the indoor environments are shown in Figure 11.

Table11. Existance of Unusual Smell Inside Flats and Concentrarion of Fungi

Period	Biyoaerosol	Factor	Average CFU/m³	Test	P-Value
Spring-Summer	Fungi	There is smell	180	Variance Check	0.00
		There isn't smell	150		
Autumn-Winter	Fungi	There is smell	250	Variance Check	0.01
		There isn't smell	215		
All Samples	Fungi	There is smell	320	Variance Check	0.00
		There isn't smell	114		

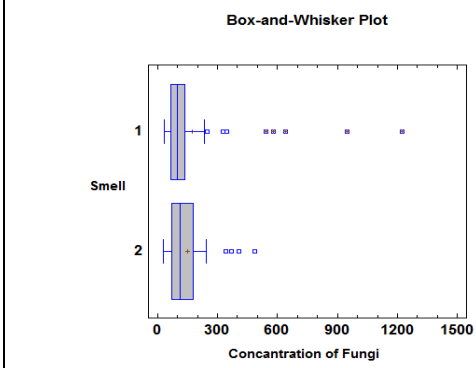
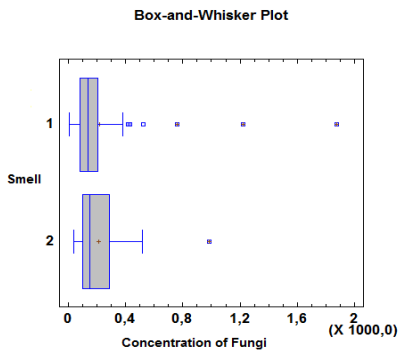
Unusual Smell Inside Flats and Concentrarion of Fungi During Spring-Summer	Unusual Smell Inside Flats and Concentrarion of Fungi During Autumn-Winter
	

Fig 11. Box-and-Whisker Plot of Unusual Smell Inside Flats and Concentrarion of Fungi

1: There is smell inside flats.
2: There isn't any smell inside flats.

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REFERENCES

[1]. Ahmet Soysal, Yücel Demiral, IndoorAirPollution, 2007.
[2]. 5.Ulusal hava kirliliği ve kontrolü sempozyumu, Ankara, 25-27 Ekim, 2010.
[3]. Hava kirlenmesi araştırmaları ve denetimi kirlenmesi araştırmaları ve denetimi Türk milli komitesi, Orta Doğu Teknik Üniversitesi, pp. 25-27,2010.
[4]. M. Gomzi, Indoor air and respiratory health in preadolescent children, Atmospheric Environment, vol. 33, pp. 4081-4086, 1999.

[5]. Eray Yurtseven, İki farklı coğrafi bölgedeki ilköğretim okullarında iç ortam havasının insan sağlığına etkileri yönünden değerlendirilmesi, 2017.
[6]. Sibel menteşe, İç ortam biyolojik kirliliğin mekansal değişimi ve dış ortamın etkisi, 2012.
[7]. Sibel Menteşe, Bina ve dekorasyon malzemelerinin iç hava kalitesine etkisi, 12. Ulusaltesisat mühendislik kongresi,2015.
[8]. Kalogerakis et al.,Human Exposure to Pollutants via Dermal Absorption and Inhalation, 2005.
[9]. Türkiye Sağlık Raporları,2010.
[10]. Rachel I. Adams and SeemaBhangar, et al., ChamberBioaerosolStudy: Outdoor airand human occupants as sources of indoor airborne. Microbes, 2015
[11]. Feyza Erdoğmuş, Arzu Özkara, S. Elif Korcan, Yavuz Bağcı, Hüseyin Dural, Ekstrelerinin AntimikrobiyalAktivitesinin Belirlenmesi, Afyon Kocatepe Üniversitesi, Fen Edebiyat Fakültesi, Biyoloji Bölümü,2002.
[12]. Gülizar Çakır Sümer, Hava kirliliği kontrolü:Türkiye'dehavakirliliğini önlemeye yönelik yasal düzenlemelerin, 2014.
[13]. Türkiye'nin hava kirliliği ve iklim değişikliği sorunlarına sağlık açısından yaklaşım, Sağlık bakanlığı temel sağlık hizmetleri, Genel Müdürlüğü, Eylül, Ankara, 2010.
[14]. Firouz demir yaşamış, Çevresel ölçüt ve standartlar, 29-42, 1994.
[15]. Halk sağlığı uzmanları derneği Türkiye halk sağlığı raporu,2012.
[16]. 16.Ulusal halk sağlığı kongre kitabi, Halk sağlığı uzmanları derneği, Antalya, 2013.
[17]. RüknettinKüçükçalı, Yüksek yapılarda tesisat ve pratik bilgiler, 1999.
[18]. Dilşad Akal, İç ortam hava kirliliği ve çalışanlara olumsuz etkileri, 2013.
[19]. Menteşe ve Güllü, İç ortam biyolojik kirliliğin mekansel değişimi ve dış ortamın etkisi, 2006.
[20]. Eskişehir il çevre durumu raporu, T.C. Eskişehir valiliği çevre ve şehircilik il müdürlüğü,2011.
[21]. Case Study: Healtheffects of traffic-relatedairpollution in a smallcommunity, 2015.
[22]. Sevda Hatun Altın, İç ortam hava kirliliğinin doğurabileceği sağlık etkileri, Aralık, 2015.
[23]. Marcel Sabin Popa, Binalarda mantar kontrolü ve rutubet problemleri, 2005.
[24]. http://www.wikipedia.org

Elham AGHLARA Impact of Flats Features on Levels of Bioaerosol in Indoor Environments." American Journal of Engineering Research (AJER), vol. 6, no. 11, 2017, pp. 268-281.