Journal of Young Scientist, Volume III, 2015
ISSN 2344 - 1283; ISSN CD-ROM 2344 - 1291; ISSN Online 2344 - 1305; ISSN-L 2344 – 1283

INDOOR AIR QUALITY ASSESSMENT THROUGH MICROBIOLOGICAL METHODS

Silviu BADEA, Andrei Liviu CHIRIȚĂ, Cristian ANDRONE, Bianca Georgiana OLARU

Scientific Coordinators: Professor PhD Carmen CÎMPEANU, Lecturer PhD Constanța MIHAI

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania, Phone : + 4021. 318.25.64, Fax: + 4021.318.25.67

Corresponding author email: olaru_bianca1990@yahoo.com.au

Abstract

The aim of this study was to evaluate indoor-air microbiological contamination of the Land Reclamation and Environmental Engineering Faculty building from Bucharest. Samples were taken in May 2014, during both period of intense indoor activity (in the afternoon classes) and less indoor activity (during weekends). Total number of mesophilic aerobic bacteria, yeast and moulds from the air of selected rooms was determined using Koch sedimentation method. We used Petri plates filled with gelose medium to determine the total number of bacteria and Czapek-Dox Agar medium for the filamentous fungi identification. In many cases, a multiple growth bacteria and significant increase of filamentous fungi were observed, especially during intense indoor activity period. According to the standards of microbial air loading, the indoor air of the faculty is relatively clean.

Key words*: airborne bacteria, airborne fungi, indoor air, microbiological air quality.*

INTRODUCTION

The knowledge of microbial air contamination is an important criteria for assessment hygiene conditions. All around the world, the life style changes have resulted in a shift from open air environments to indoor environments at home and work places, where people spend a substantial time. (Chao et al, 2003, Molhave, 2011).

Healthy environment has a very strong connection with the human health (Botkin & Keller, 2007). Bacteria, fungi, pollen, viruses and mites can be sources of biological air contamination (Nevalainen and Seuri, 2005, Khan and Karuppayil, 2010). Clean air is what all living humans and animals needs for good health and well being. However, due to urban development, the air is continuously polluted. Urban ambient air is more polluted than overall atmosphere, due to high density of human population and their activities in urban areas. (Ling et al. 2012).

Human spend up to 80% of their lifetime either inside workplace or in their own homes. (Yang and al, 2007).

Some of the health effects of exposure to air pollution, such as the impact on the respiratory and cardiovascular systems, have been extensively studied, thus it is well-known that exposure to air pollutants leads to an increase in mortality and morbidity rates of the population (Baccarelli et al, 2008; Kunzli et al, 2000, 2004).

Poor indoor environment quality could negatively affect the profits of any organisation as the costs of workers absence due to medical reasons and low productivity most often exceed the cost of energy use associated with maintaining acceptable standards. (Wong LT, Mui KW, Hui PS., 2007). The atmosphere is not a favourable environment for long-term survival of microbes. Indoor air quality can be defined as the air quality inside a building that will lead to occupant comfort and health. Indoor air quality is influenced by gas, microbial contaminants or particles that conduct to poor health conditions. Physical, chemical and biological factors can change indoor air quality. The physical factors include a range of issues from temperature, humidity and air movement to dust, lighting and noise, while chemical factors include pollutants arising

from paint, carpets, furniture, environmental tobacco smoke, cosmetics, drapes. For the biological factors, microorganisms play the main role, because the inhalation of bacterial, fungal and micro algal spores can cause an allergic reaction. A poor indoor air quality can cause a variety of short-term and long-term health problems including allergic reactions, respiratory problems, eye irritation, sinusitis, bronchitis and pneumonia. (Marmot et al., 2006).

Fungal flora can be hazardous for health, particularly in rooms with heating, ventilation and air conditioning systems in place. (La Serna I. et al, 2002).

Biological contamination of indoor air is mostly caused by bacteria, moulds and yeast. They can be dangerous as pathogenic living cells but they can also secrete some substances harmful for health. These are different kinds of toxic metabolism products, for example mycotoxins (Daisey J.M., et al, 2003).

The aim of this study was to assess the microbial contamination of indoor air from the Land Reclamation and Environmental Engineering Faculty building, located in Bucharest (FIFIM). The study embraced a measurement of the concentration of bacteria and fungi in the air of selected rooms and microbial composition of the air.

MATERIALS AND METHODS

Total number of mesophilic aerobic bacteria, and filamentous fungi from the air of selected rooms was determined using Koch sedimentation method.

The Koch method do not require expensive instrumentation, it is fast and simple. Sedimentation method does not permit exact quantitative determination; some earlier observations reported that results of sedimentation method are usually higher than numbers obtained with the use of air samplers. (Fleischer M.,2006). However, data collected by sedimentation method allow the drawing of correct conclusions on types of microorganisms
present in the air and can give a good approximation of bacterial and fungal concentration.

Air microorganisms were settled gravitationally directly on the Petri plates filled with nutrient media and exposed in sampling points for a period of time. The number of microorganisms expressed as CFU/ m3 was estimated according to Omeliansky's equation:

$$CFU/m^3 = \frac{n \times 10000}{S \times T}$$, where:

n – number of colonies developed on the culture medium surface

S – surface of the Petri dish

T – exposure time of Petri dish in minutes

In order to assess the airborne bacteria and fungi from indoor FIFIM building, the samples were taken during two sampling periods, in May 2014. The first sampling period was on weekends and the second was during academic activity when the population density was found to be highest (academic staff, students and the public service requester), between 12-2 pm.

Figure 1. Thermostat for incubating samples (Microbiology lab CO3 – FIFIM)

The Petri dishes (108 plates) were exposed for 20 minutes on each sampling point. In each investigated room 2 Petri plates were placed, filled with nutrient medium as follow:

Gelose medium to determine the total number of bacteria, and

Czapek-Dox Agar for filamentous fungi identification.

Petri dishes were incubated for 24, 72, and 96 hours at 37°C to determine the total number of bacteria and for 3 days at 28°C to determine the fungal growths (figure 1).

Bacteria were identified by two arrays. The first one was the macroscopic estimation through description of colony and the second one was by microscopic estimation using

Gram dyeing. Diagnosis of filamentous fungi was based on estimation of morphological features of growth on Czapek medium.
The investigated places of the building encompass main halls, dean's office, lecture rooms, laboratories, library and toilets (table 1).

Table 1. Investigated rooms of the faculty (* means the rooms with ventilation systems)

Rooms	Mark	Area (m2)	Cubature (m3)
A - building			
Ground floor hall	H_{0A}	60	240
Laboratory*	A_{04}	28	98
Toilets	T_0	9	27
First floor hall	H_{IA}	45	180
Dean office*	D	25	100
Board staff room*	BR	100	350
Second floor hall	H_{IIA}	45	180
Lecture room*	$A_{II\,1}$	120	400
Third floor hall	H_{IIIA}	45	180
Lecture room*	$A_{III\,4}$	36	108
Fourth floor hall	H_{IVA}	45	180
Lecture room*	$A_{IV\,2}$	36	108
B- building			
Library*	L	100	350
Hall	H_{B-C}	30	120
Toilet	$T_{II\,B}$		
Prof office*	O_B	25	120
C- building			
Ground floor hall	H_{C0}	40	160
Laboratory*	C_{03}	40	140
First floor hall	H_{C1}	30	120
Men Toilet	MT	4	12
Women Toilet	WT	4	12
Second floor hall	H_{CII}	30	120
Men Toilet	MT	4	12
Women Toilet	WT	4	12

RESULTS AND DISCUSSIONS

Quantitative variation of Microorganisms from indoor air of the Faculty
As expected, the air samples taken during afternoon academic activity have recorded in most cases higher values of germs total number in comparison with the samples taken on weekends. Strong relationship between
Indoor air filamentous fungi contamination
The results concerning the average number of airborne filamentous fungi from different occupant density, human activity and microorganisms concentration of the indoor air was reported in several other papers (Chao et al., 2003, Daisey et al., 2003, Khan and Karuppayil, 2011, Fleischer, 2006, Künzli et al., 2000).

Indoor air bacterial contamination
The maximum level of mesophylic bacteria loading for clean air is less than 1500 CFU/m3 and for infested air is greater than 2500 CFU/m3 (SC 2009-16219/16.07.2009).
As can be observed in Figure 2, the bacterial growth of indoor air did not exceed the limit for fresh (clean) air quality (1500 CFU/m3) in any of the samples taken during weekends. In addition, the samples taken during the academic activity (in the afternoon classes) have not exceeded the bacterial load level in most cases.
However, there are some exceptions, especially in the central building (the A building). For instance, the lobby, the first, the second and the third floor halls (H0A, HIA, HIIA, HIIIA) and also the toilet from the ground floor (T0A) recording air bacterial loads that exceed the indoor air limit of infestation (> 2500 CFU/m3). The highest level of bacterial air infestation was recorded in the ground floor toilet (2 times higher than infestation limit), followed in descending order by the lobby (1.8 times), second floor hall (1.7 times), first floor hall (1.4 times) and the third floor hall (1.1 times). The reason for these exceeds is especially due to the poor natural ventilation of those rooms correlated with intensive traffic.
Five from the 24 selected rooms have had exceed of air bacterial load, which means that 24.2% from total cubature of indoor air investigated are infested with pathogenic mesophilic bacteria.
The remaining 75.8% is accounted for clean air. All the lecture rooms from the central building, the boardroom stuff, the library, and the whole investigated rooms from the B and C building of the Faculty did not counted bacterial growth values higher than 1500 CFU/m3, (the admissible value for clean air).

rooms of the building, sampling both on weekends and during academic activity are present in figure 3.

The admissible level for air fungi loading is 550 CFU/m3 (SC 2009-16219/16.07.2009).

Sampling during afternoon academic activity reveals that only 36.1% from overall investigated rooms are proper regarding fungal air loading (e.g. the library, the boardroom stuff, the environmental sciences and microbiology laboratories, the first and the second floor halls of C building and the toilets from the second floor of the C building).

In all the other selected rooms the fungal growths exceed the air infested limit. From the total cubature 63.9% was infested with filamentous fungi. The worst quality of indoor air was in the toilet from ground floor (T0A), where the level of air filamentous fungi exceeds over 14 times the admissible limit. Also, in the halls from A building (H0A and HIA) the fungal air contamination exceed the limit by 4 times, respectively by 6 times.

The fungal indoor air loading from the Dean office (D) and the amphitheatre (AII 1) exceeds twice time the admissible limit.

As can be observed the samples taken during weekend emphasize more clean indoor air than samples taken during student classis. However, the fungal air contamination of the Faculty buildings was higher than bacterial air contamination.

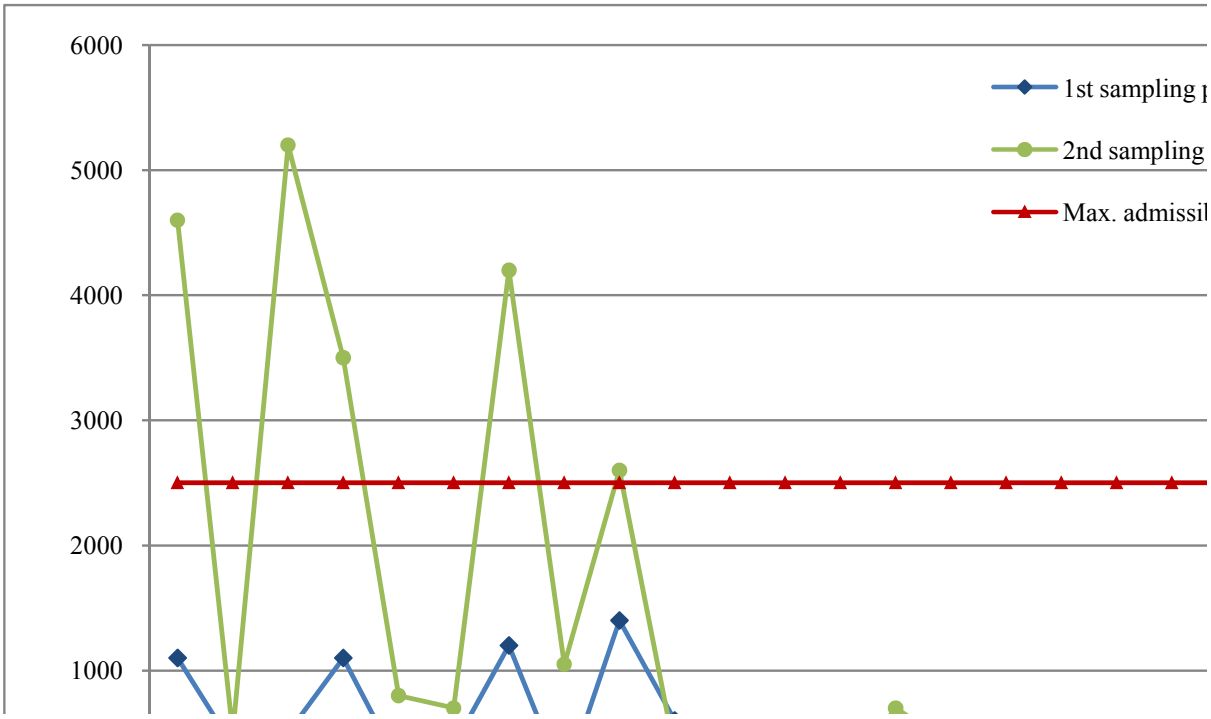

Figure 2. Bacterial load of indoor air from the Faculty building (CFU/m3)

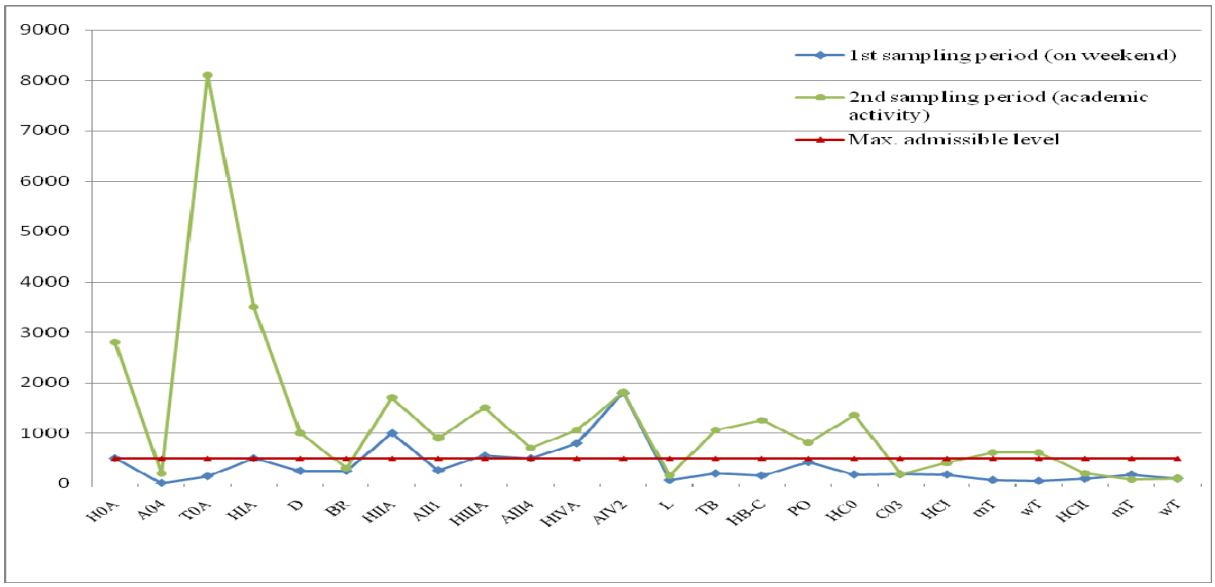

Figure 3. Fungal load of indoor air from the Faculty building (CFU/m3)

Qualitative Analysis of Microorganisms from indoor air of the Faculty

Microbial indoor air quality was determined not only by quantitative variation of bacteria and fungi but by the presence of some particular microorganism species, which are very important for the people health occupying the Faculty rooms. Microscopic estimation with Gram dyeing showed that gram positive bacteria are dominated (e.g. Bacillus spp, Streptococcus spp, Staphylococcus spp.) (Figure 4).

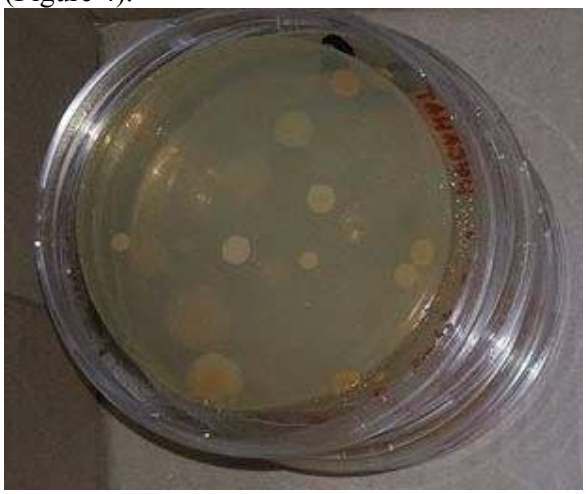

Figure 4. Bacteria colonies from indoor air of Faculty

Quality characteristics of fungal flora isolated from the air of selected rooms showed domination of fungi genus like: Penicillium, Aspergillus, Alternaria, Mucor, and Rhizopus (Figure 5).

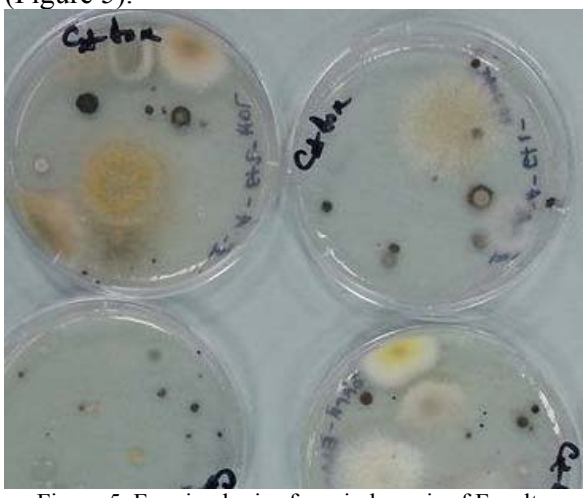

Figure 5. Fungi colonies from indoor air of Faculty

CONCLUSIONS

The total number of germs growing from the air samples taken during afternoon academic activity have recorded in most cases higher values in comparison with the germs growing from the samples taken on weekends. Strong relationship between occupant density, human activity and microorganisms concentration of the indoor air was observed. In general, the fungal air contamination was higher than

bacterial air contamination. From the total investigated cubature of the Faculty buildings the statement of air quality is present as follow:
- for the A building
16,4 % represent clean air
14,9% relatively clean
59,7 % infested air
- for the B building
59% clean air
61% relatively clean air
0% infested air
- for the C building
68,7% clean air
31,3 % relatively clean air
0% infested air.

ACKNOWLEDGEMENTS

This paper is part of the graduation projects presented in July 2014 by Badea Silviu, Chiriţă Liviu Andrei and Androne Cristian. The work took place in Microbiology and Environmental Sciences laboratories from the Land Reclamatin and Environmental Sciences Faculty (C03 and A04).

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