IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 12, Issue 9 Ver. I (September. 2018), PP 39-45
www.iosrjournals.org

Bacteria and Fungi Levels in Crowded Indoor Areas

Sundri, M.I.
Department of Engineering Sciences in the Mechanical Field and Environment, Constanta Maritime University, Romania

Abstract: *The malls are places where we spend a few hours a week. Therefore, air quality inside these buildings is important for the health of individuals. The microbiological air quality assessment in two malls of Constanta, Romania, showed bacterial and fungal concentrations ranging from 52 CFU m^{-3} to 2018 CFU m^{-3} and from 52 CFU m^{-3} to 865 CFU $m^{-,3}$ respectively. According to EC sanitary standards for non-industrial premises, concerning bacterial level 1% of the samples have values within the limits of low pollution level, 52% for moderate, 46% for high and 1% for very high pollution level. For fungi contamination, 6% of the samples were within the limits of low pollution degree, 85% for moderate and 9% for high pollution degree. Highest levels of microbiological contamination have been found in fast food and gaming areas in both malls for both bacteria and fungi. There are differences in the level of microbiological contamination between samples taken in the morning and in the afternoon, as well as between samples taken in the working days and in the weekend days.*

Keywords: *airborne microbiological levels, bacteria, fungi, malls of Constanta, Romania*

Date of Submission: 26-08-2018 Date of acceptance: 06-09-2018

I. INTRODUCTION

The indoor environment has a major impact on human health, with effects on well-being, productivity and ultimately on the local economy (B1-B7). That's why its quality in the places where we spend a lot of our daily time is very important. Numerous studies highlight the negative impact of indoor air pollution on the quality of life [1], [2], [3], [4], [5], [6].

Nowadays, some of the most visited places by the people are shopping centers or malls. These are places where people can spend a whole day. In their buildings there are different type of shops, traffic halls, fast food areas, bars, cafeterias, entertainments areas. In the mall areas, with high density of population, people walk or spend long periods of time, hence a poor indoor air quality can greatly affect individuals and, at large scale, the public health. In an ICSC report based on a US study, Americans visit a shopping center six to seven times a week. For the other people the situation does not differ much. Therefore, air quality inside the mall is very important, and its monitoring and evaluation should be done in every such shopping center.

Many risks to indoor air quality have been identified for human health. Hazards in the internal environment are represented by different physical agents as well as chemical and biological contaminants [7], [8], [9], [10].

Among the main indoor air quality parameters, with a major effect on human health are airborne flora, which is associated with asthma development, respiratory infections and symptoms (wheeze, cough, dyspnea) [11], [12], [13], [14].

Location, design, structure of the building, ventilation system, have an important contribution to airborne flora level. Moreover, the indoor equipment like furniture stuffing, textile, plants, food stuff and people's activity like walking, talking, coughing, sneezing are major factors that influence the level and composition of airborne microorganisms [15], [16], [17], [18], [19], [20].

The aim of this study is to investigate the indoor air microbiological quality, bacteria and fungi level, in two building of malls in Constanta (Romania). The microbiological parameters have not the same values inside the entire building. For this reason, the spaces in each mall has been categorized and divided in sampling zones as function of their destination and how long the people are resting in these areas. The indoor spaces where people are resting or walking for more than 30 minutes are the halls, fast foods areas, cafeterias, bars, cinemas, gaming areas.

II. MATERIALS AND METHODS

This study was conducted in Constanta, a city in southeastern Romania with a population of approximately 300,000 people.

The evaluation is based on the sampling and measurements of bacteria and fungi concentration in 2 malls of the city: C-Mall and V-Mall. The malls are new construction having more than 30,000 m^2 of active surface for public access. Weekly, more than 20,000 individuals visit each of these shopping centers.

For each mall we assigned 7 sampling zone where people were expected to spend more than half an hour during a visits to the shopping center: 3 zones on the halls (H), 1 zone for fast food area (FF), 1 zone for cafeteria/bar (CF), 1 zone inside the cinema (CNM) and 1 zone for gaming area (GM). The choice of the sampling zones has been made using similarity judgments between the particularities of the spaces with the same destination in each mall.

The sampling period of time was 4 days in each mall between 2018 April 20 and May 6. We choose two working days [WD] and the two last days of the week [WND] to observe the influence of the number of visitors which is greater in weekend. Measurements and sampling were performed for each day in two time periods: in the morning 2 hours after opening so between 10:00 and 12:00 and in the busiest period of the day, between 17:00 and 19:00.

From each zone mentioned above, air flora samples regarding bacteria and fungi were collected, using passive technique by sedimentation. For this purpose, 9 cm diameter Petri dishes were used. Plates were exposed for about 30 minutes at a distance of at least 1 m from the walls and about 1 m from the floor. The dishes with nutrient-agar for bacteria investigation were incubated for 24 hours at 37^0C, and dishes with sabouraud dextrose agar for fungal evaluation were incubated at 25^0C for 72-120 h. The results were expressed in colony forming units at 1 m^3 (CFU m^{-3}), using Omeliansky's formula:

N= 5a*104 (b*t)-1

where:

"N" represents microbial CFU m^{-3} of indoor air; "a" is the number of colony forming units per Petri dish; "b"- dish surface [cm^2] and "t" – the exposure time [min].

During microbiological sampling, temperature and humidity were measured from each sampling zone.

For statistical representations, Excel graphical functions were used, highlighting the maximum, minimum, P25, P75, mean and median values.

III. RESULTS AND DISCUSSION

Microbiological data analysis from two city malls revealed a bacteria average level of 656 CFU m^{-3} in the C-Mall and 594 CFU m^{-3} in the V-Mall. Bacterial concentrations range from 105 CFU m^{-3} to 2018 CFU m^{-3} in C-Mall and from 52 CFU m^{-3} to 1940 CFU m^{-3} in V-Mall (Tables 1 and 2).

Table 1. Airborne bacteria values in the C-Mall [CFU m^{-3}]

	Hour	C-H1	C-H2	C-H3	C-FF	C-CF	C-CNM	C-GM
WD1	10÷12	603	262	288	760	157	393	734
	17÷19	786	210	419	1442	419	446	865
WD 2	10÷12	393	288	183	891	183	315	498
	17÷19	603	393	550	1520	655	524	786
WND 1	10÷12	419	288	236	1337	105	446	1022
	17÷19	970	472	524	1913	498	760	1232
WND 2	10÷12	157	288	472	2018	498	629	1075
	17÷19	550	655	708	1573	708	472	1127

Table 2. Airborne bacteria values in the V-Mall [CFU m^{-3}]

	Hour	V-H1	V-H2	V-H3	V-FF	V-CF	V-CNM	V-GM
WD1	10÷12	288	236	52	865	131	288	367
	17÷19	472	655	498	1232	341	550	839
WD 2	10÷12	157	315	236	865	210	262	498
	17÷19	708	419	472	1363	288	734	865
WND 1	10÷12	210	367	393	1861	472	393	1048
	17÷19	472	603	524	1940	577	550	970
WND 2	10÷12	288	498	367	1127	367	183	996
	17÷19	419	524	446	1678	498	341	944

Considering the five types of areas where the measurements were made (halls, fast-food, coffee-bar, cinema and game area), the bacterial distribution is similar in the two malls. On average, the highest bacteria level was found on the fast-food restaurant areas: 1432 CFU m^{-3} in the C-Mall and 1366 CFU m^{-3} in the V-Mall, and the lowest bacterial level was recorded in coffee-bars: 403 CFU m^{-3} in the C-Mall and 360 CFU m^{-3} in the V-Mall. After fast-food, the gaming areas have the highest bacterial levels, with a value of 917 CFU m^{-3} in the C-Mall and 816 CFU m^{-3} in the V-Mall. An average, samples from hall and cinema have values with 4%÷23% higher than on the coffee-bars areas (Fig 1).

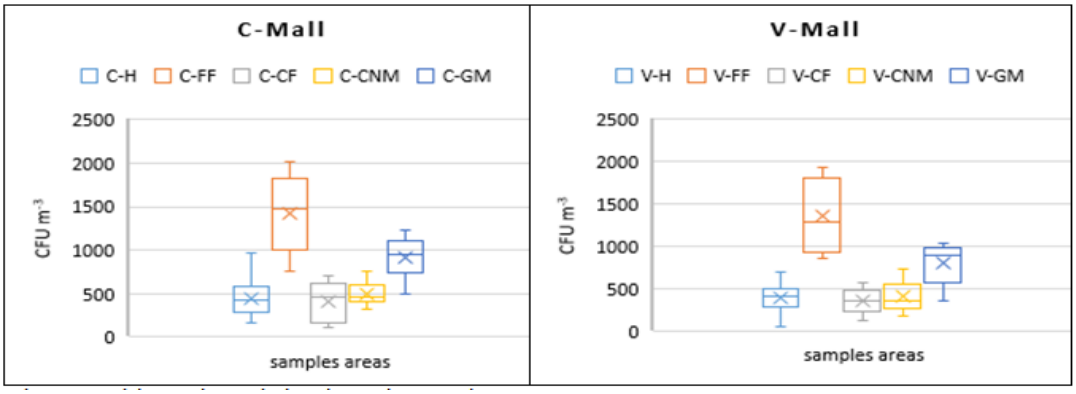

Figure 1. Airborne bacteria levels on the samples areas

According to EC sanitary standards for non-industrial premises, from halls, coffee-bar and cinema, most of the samples were in the moderate pollution degree: 62.5%, 75% and 62.5%, respectively for C-Mall and 70.8%, 87.5% and 62.5% for V-Mall. Gaming and fast-food areas are characterized by high levels of bacterial pollution: 87.5% of samples for C-Mall and 75% and 100%, respectively for V-Mall. For both malls a single airborne bacterial value is found within the limits of very high pollution level, over 2000 CFU m^{-3}, and a single value within the limits of low pollution level, below 100 CFU m^{-3} (Fig. 2).

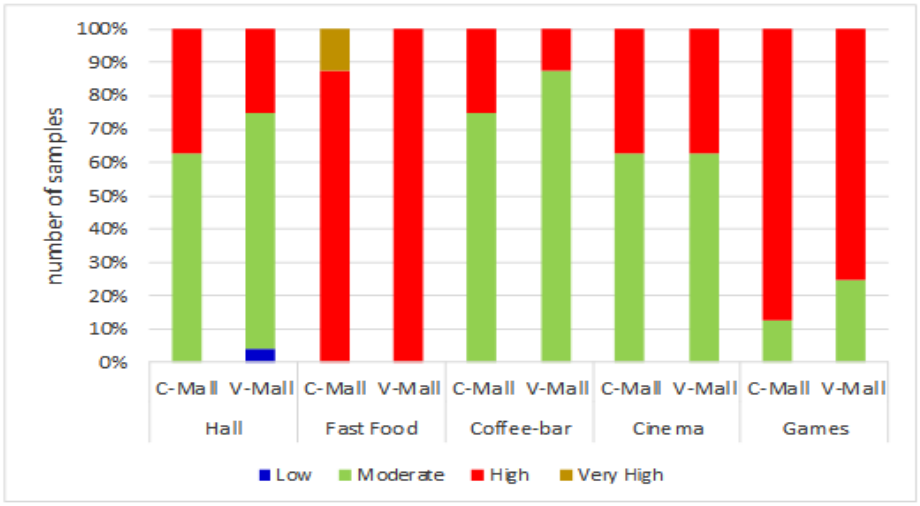

Figure 2. Airborne bacterial pollution degree

Concerning fungal concentration, the average level was 279 CFU m^{-3} in the C-Mall and 291 CFU m^{-3} in V-Mall, with values that range from 52 CFU m^{-3} to 839 CFU m^{-3} and 79 CFU m^{-3} to 865 CFU m^{-3}, respectively (Tables 3 and 4).

Table 3. Airborne fungal values in the C-Mall [CFU m^{-3}]

	Hour	C-H1	C-H2	C-H3	C-FF	C-CF	C-CNM	C-GM
WD1	10÷12	79	183	52	210	79	131	236
	17÷19	105	341	262	393	236	210	446
WD 2	10÷12	183	131	105	157	52	315	210
	17÷19	131	210	79	734	183	341	315
WND 1	10÷12	341	79	157	498	210	262	446
	17÷19	210	288	157	839	472	498	498
WND 2	10÷12	105	262	183	786	236	315	367
	17÷19	367	131	210	550	419	288	367

Table 4. Airborne fungal values in the V-Mall [CFU m^{-3}]

	Hour	V-H1	V-H2	V-H3	V-FF	V-CF	V-CNM	V-GM
WD1	10÷12	210	288	183	183	105	183	288
	17÷19	236	157	367	393	367	315	315
WD 2	10÷12	157	105	236	341	131	183	236
	17÷19	183	236	367	524	183	524	498
WND 1	10÷12	131	236	262	865	341	210	315
	17÷19	105	183	498	288	262	288	393
WND 2	10÷12	157	288	262	629	236	79	262
	17÷19	105	262	183	708	288	393	577

Compare with bacteria levels, there is a similar fungal distribution, the highest values being found in areas of fast-food (with a mean of 521 CFU m^{-3} in C-Mall and 491 CFU m^{-3} in V-Mall) followed by gaming areas (with an average of 360 CFU m^{-3} in both malls). On average, the smallest values of fungi were recorded on halls (181 CFU m^{-3} in C-Mall and 225 CFU m^{-3} in V-Mall) (Fig. 3).

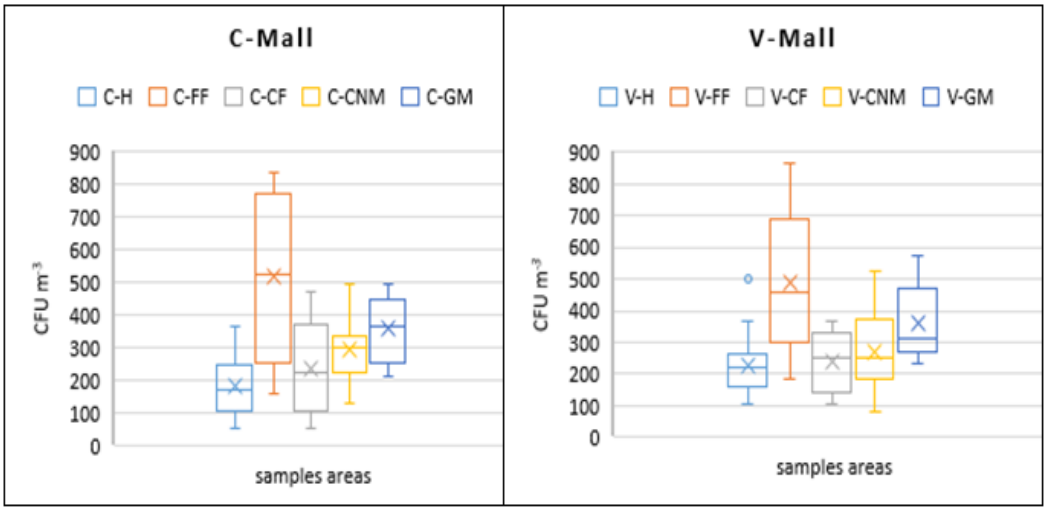

Figure 3. Airborne fungal levels on the samples areas

Excepting fast-food area, more of the samples have values for fungal concentration within a moderate pollution degree (according EC sanitary standards for non-industrial premises). For fast-food areas half of samples have values that means a moderate pollution and half a high pollution. In the V-Mall, in the cinema and the gaming areas one value was found higher than the limit of moderate pollution level. Some samples had low pollution degree of airborne fungal contaminations (Fig. 4).

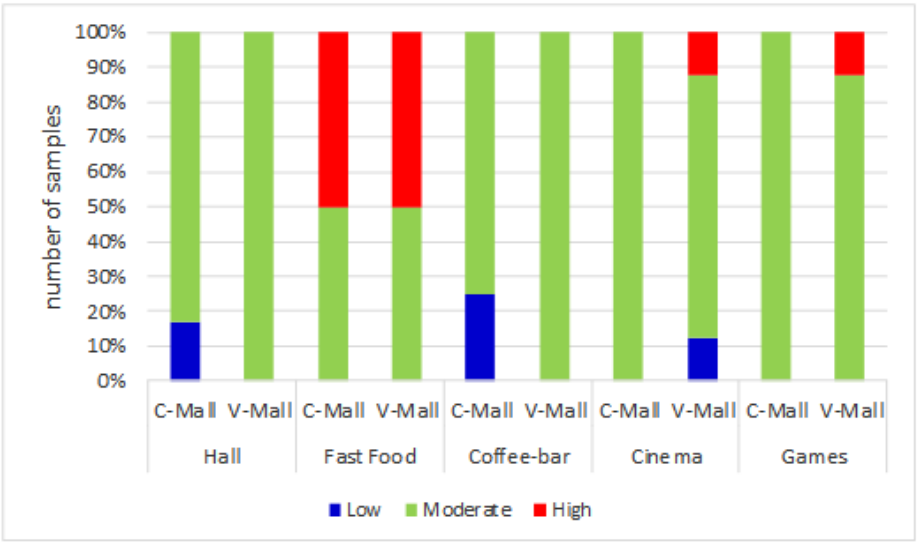

Figure 4. Airborne fungal pollution degree

Considering all samples from both malls, in the morning the bacterial concentration is lower than in the afternoon; thus, the values obtained from the samples taken in the first 2 hours after the opening of the malls represent 68% of the value recorded in the samples between 17:00 and 19:00 (Fig. 5). Also, the concentration of the fungi in the morning samples was, on average, 73% of the concentration recorded in the afternoon. (Fig. 6).

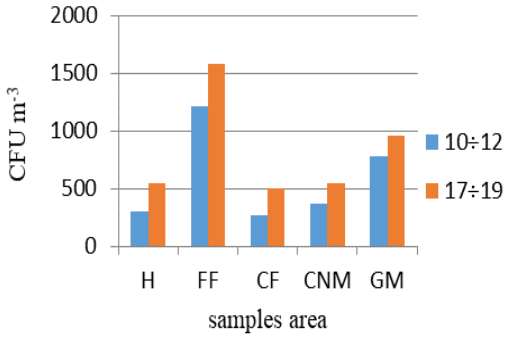

Figure 5. Bacteria level in function of day period

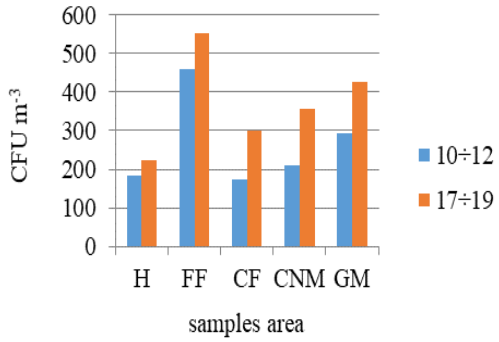

Figure 6. Fungi level in function of day period

Compared to workdays, a 35% higher level for both bacteria and fungi was recorded in the weekend days (Figures 7 and 8).

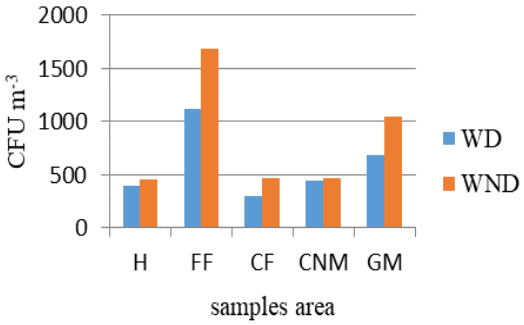

Figure 7. Bacteria level in WD and WND

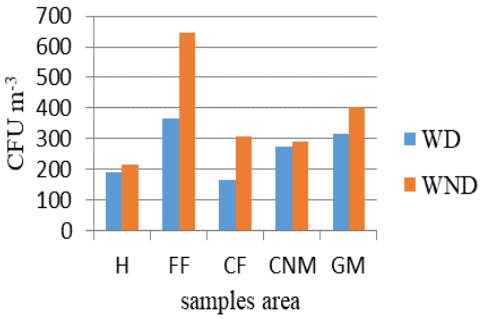

Figure 8. Fungi level in WD and WND

There is a high correlation between bacteria and fungi concentrations, with a positive linear association: regression coefficient R^2=0.55 (n=112) (Fig. 9).

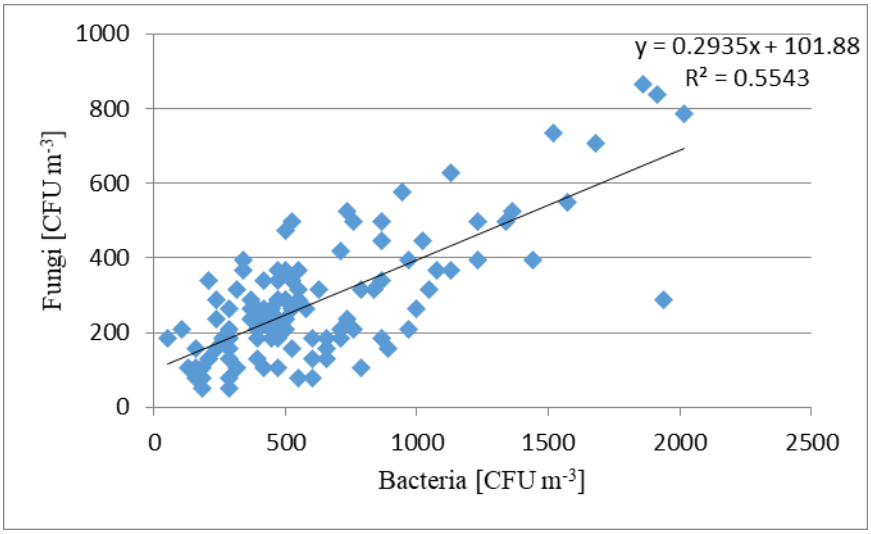

Figure 9. Fungal concentration against bacteria concentration in the malls

In more than 80% from samples the bacteria found included species of Micrococcus, Bacillus, Staphylococcus and Streptococcus.

Aspergillus, Penicillium and Cladosporium were the fungi found in 90% from samples.

The temperature on the samples areas range from 21.6^0C to 25^0C in C-Mall and from 21.7^0C to 24.6^0C in V-Mall. In C-Mall the average temperature was 23^0C in the morning and 23.8^0C in the afternoon. In the V-Mall was registered an average temperature of 23.1^0C in the morning and 23.4^0C in the afternoon.

The humidity range from 57% in the both mall to 71% in C-Mall and 70% in V-Mall. In the morning the average humidity was 62.7% in C-Mall and 62.3% in V-Mall, and in the afternoon the average humidity was 67.7% and 66% respective.

The same average temperature, 23.4^0C, was registered in C-Mall in the work days and weekend days. In V-Mall the temperature was 23.2^0C in the WD and 23.3^0C in the WND. Concerning humidity, the average values in C-Mall were 63.7% in WD and 67.7% in WND and in V-Mall were 63.8% and 64.5% respectively.
There is a weak correlation between bacteria concentrations and humidity in the C-Mall and between bacteria concentration and temperature in the V-Mall (Pearson correlation coefficient = 0.38 and 0.35 respective). Moderate correlations between bacteria level and temperature in C-Mall and between bacteria level and humidity in V-Mall were found (PCC = 0.53 and 0.41). Also moderate correlations between fungi level and temperature and humidity were found in the both mall (PCC values range from 0.43 to 0.49).

IV. CONCLUSION

Analysis of indoor air microbiological quality into investigated areas of two malls shows that half of airborne bacteria levels from samples were in the limits of low and moderate pollutions level and half (excepting one sample with a very high pollution degree registered)) in the limit of high pollution.

More than three quarters of samples fungi concentrations were in the limit of moderate pollution degree. There were samples with low level and some with high level degrees of pollution.

There is a high correlation between bacteria and fungi concentrations and there are weak and moderate correlations between airborne microbiological levels and temperature and humidity in both malls.

Both bacteria and fungi level from the afternoon samples have higher concentrations than in the morning. Also higher microbiological levels were found in the weekend days than in the week days. Differences in fungal and bacterial contamination between the two periods of the day and between the two weekly periods can be attributed to the variation in the number of visitors and the intensity of anthropogenic activity in the mentioned areas.

This study highlighted the existence of increased pollution in certain areas and during certain periods of time, which draws attention to the frequencies and duration of visits to malls, especially for people at risk (the elderly, children).

These results require an air quality monitoring in malls in general and in the two investigated malls in particular, not only from a microbiological point of view, but also for physical-chemical parameters, knowing that there are correlations between them, with impact on human health.

REFERENCES

[1]. Ranjit Kaur, Indoor Pollution and Human Health, International Journal of Engineering Technology Science and Research, 4(4), 2017, 79-81.
[2]. P. Wolkoff , Indoor air humidity, air quality, and health – An overview, International Journal of Hygiene and Environmental Health, 221(3), 2018, 376-390.
[3]. A.P. Jones, Indoor air quality and health. Atmos Environ, 33(28), 1999, 4535-4564.
[4]. J. Mandal, H. Brandl, Bioaerosols in indoor environment-a review with special reference to residential and occupational locations. Open Environ Biol Monit J, 4(8), 2011, 83-96.
[5]. Komalkirti Apte and Sundeep Salvi, Household air pollution and its effects on health, F1000 Research, 2016. PMID: 27853506
[6]. W.T. Kwok, Indoor air quality and its effects on humans—A review of challenges and developments in the last 30 years. Energy and Buildings, 130, 2016, 637–650.
[7]. O.Velentza, Particular matters: a threat for human health, Scientific Chronicles, 21(3), 2016, 233-244.
[8]. A. Valavanidis, K. Fiotakis, T. Vlachogianni, Airborne particulate matter and human health: toxicological assessment and importance of size and composition of particles for oxidative damage and carcinogenic mechanisms, Journal of environmental science and health. Part C, Environmental carcinogenesis & ecotoxicology reviews, 26(4), 2008, 339-62.
[9]. S. Nandasena, AR. Wickremasinghe, N. Sathiakumar, Indoor air pollution and respiratory health of children in the developing world, World Journal of Clinical Pediatrics. 8(2), 2013, 6-15.
[10]. E. Zuskin, E Neil Schachter, J. Mustajbegovic, J. Pucarin-Cvetkovic, J. Doko-Jelinic, B. Mucic-Pucic, Indoor air pollution and effects on human health, Periodicum Biologorum, 111, 1, 2009, 37–40.
[11]. S. F. Hayleeyesus and A. M. Manaye, Microbiological Quality of Indoor Air in University Libraries, Asian Pacific Journal of Tropical Biomedicine, 4(Suppl.1), 2014, 312-317.
[12]. Kirti Bomala, Geetha Saramanda, Byragi Reddy. T and Jyothi Kaparapu, Microbiological indoor and outdoor air quality of selected places in Visakhapatnam city, India, International Journal of Current Research, 8(4), 2016, 29059-29062.
[13]. E. Bragoszewska, A. Mainka and J. S. Pastuszka, Concentration and Size Distribution of Culturable Bacteria in Ambient Air during Spring and Winter in Gliwice: A Typical Urban Area, Air Quality, Atmosphere & Health, 11(6), 2018, 729-740.

[14]. C. Pasquarella, O. Pitzurra and A. Savino, The index of microbial air contamination, Journal of Hospital Infection, 46(4), 2000, 241–256.
[15]. Aaron J. Prussin II, Ellen B. Garcia, and Linsey C. Marr, Total Virus and Bacteria Concentrations in Indoor and Outdoor Air, Environ Sci Technol Lett, 2(4), 2015, 84–88.
[16]. M.F. Yassin and S. Almouqatea, Assessment of airborne bacteria and fungi in an indoor and outdoor environment. Int. J. Environ. Sci. Tech., 7 (3), 2010, 535-544.
[17]. H.S. Brightman, D.K. Milton, D. Wypij, H.A. Burge and J.D. Spengler, Evaluating building-related symptoms using the US EPA BASE study results, Indoor Air, 18, 2008, 335-345.
[18]. A.A. Haleem Khan, S. Mohan Karuppayil, Fungal pollution of indoor environments and its management, Saudi Journal of Biological Sciences, 19(4), 2012, 405-426.
[19]. D. Hospodsky, J. Qian, W.W. Nazaroff, N. Yamamoto, K. Bibby, H. Rismani-Yazdi, J. Peccia, Human occupancy as a source of indoor airborne bacteria. PLoS One, 7(4), 2012, e34867.
[20]. T. Zorman, B. Jeršek, Assessment of Bioaerosol Concentrations in Different Indoor Environments, Indoor and Built Environment, 17(2), 2008, 155-163.

Sundri, M.I. "Bacteria and Fungi Levels in Crowded Indoor Areas " IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT) 12.9 (2018): 39-45