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Appraisal of Indoor Microbial Pollutants at University Research Labs and Offices under Mediterranean Climate

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Abstract. Bacteria and fungi grow indoors when sufficient moisture is available. This study aims to determine the total viable bacterial count and fungi levels and to compare these levels among various science teaching laboratories and staff offices in Gaza city universities. A cross-sectional prospective study was conducted, sixty-five (65) air samples were collected from three local universities using Air Sampler. Auto Ranging Multimeter was used to record humidity and temperature. Air samples with counts of bacteria or fungi more than 500 Colony forming units "CFU"/m^3 were considered polluted according to the world health organization (WHO) standards. Among the 65 samples from the three universities, 48 sample (73.8%) had more than 500 colonies/100L. In term of fungal concentration, nine samples (13.8%) exceeded the WHO standards of 500 CFU/m^3. The highest percentage of bacterial load in air samples at the three universities (more than 500 CFU/m^3) was at IUG with 80.8% due to its old existence, more labs and lab activities. The lowest was at AQU with 61.5% due to less lab and lab activities. The highest percentage of fungal load in air samples at the three universities also were at IUG with 19.2 % and the lowest was at AQU with 7.7%.

1. Introduction

Quality of indoor air is an important element that influences the well-being of humans as they breathe 10m^3 air every day and generally spend 80–95% of the time indoors [1, 2]. Indoor environments contain a complex mixture of live and dead micro-organisms, fragments, toxins, allergens, volatile microbial organic compounds and other chemicals [3]. Bacteria, fungi and virus may form biological air contaminants and their distribution may vary according to the environment conditions. Heating, ventilation and air conditioning systems may also be microbial sources [4].

There is a growing evidence that exposure to biological agents in the indoor environment can have adverse health effects. Generally biological hazards to human arise from exposure to high concentrations of bio-aerosols; there are three main groups of diseases; infectious diseases, respiratory diseases and cancer [5]. A recent indoor air quality report by the World Health Organization (WHO) provided sufficient epidemiological evidence that inhabitants of damp or moldy buildings are at increased risk of respiratory symptoms, respiratory infections and exacerbations of asthma [6]. Moreover, the quality of indoor environments affects comfort and productivity [7].

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The presence of many biological agents in the indoor environment is due to dampness and inadequate ventilation where excess moisture may increase the chemical emissions from building materials and floor covers [3]. Micro-organisms including fungi and bacteria are important factors influencing indoor air quality. The variety of species may alter with nutrient source, water availability and temperature. Both fungi and bacteria numbers are seasonally influenced; where they have higher levels in summer and autumn [8, 6]. Several studies were conducted previously and shows the trends of indoor biological pollutants at different environments, while this research investigated the university indoor environment at a Mediterranean climate and examined the influence of weather parameters.

This research was carried out to determine the total viable bacterial count and fungi levels as well as to investigate the relationship between pollutants levels, humidity and temperature in the studied universities labs and offices.

2. Materials and Methods

2.1. Study Location

The study was conducted to assess bacterial and fungal counts in the indoor air of research labs and faculty offices of the selected universities (The Islamic University of Gaza "IUG", Al Azhar University "AZU" and AL Aqssa University "AQU") in Gaza City, Palestine. These universities are serving students' population 63000 and 4000 staff.

2.2 Sampling

Samples were collected from the labs and offices of IUG, AZU and AQU over one month (April-May 2013). Samples were collected from different labs at three selected universities. Twenty-six samples were collected from IUG, 26 samples from AZU and 13 samples from AQU. Samples from fifty-five labs of biology, chemistry, environment science, medical sciences and physics were used for the study. More so, 10 faculty offices were tested in this research.

2.3 Materials

Culture media used for counting of bacteria and fungi were as follows:
A - Dichloran Rose Bengal Chloramphenicol (DRBC) agar (Oxoide- UK) DRBC Agar was used for the enumeration of yeasts and molds, colonies of molds and yeasts should be apparent within 5 days of incubation. Colonies of yeast appear pink due to the uptake of rose Bengal.

2.4 Statistical Analysis

Chi square test was performed using SPSS 14.0 to examine the relationship between fungi and bacteria as criterion dependent variable, humidity and temperature as criterion independent variables. One-way analysis of variance (ANOVA) was performed to compare colonies count by concentration.

3. Result and Discussion

A total of sixty-five air samples were collected from various locations at the selected three local universities and they are shown in Table 1. Twenty-six samples were collected from IUG and AZU respectively while 13 samples were selected from AQU. The samples were classified to two groups: Labs and faculty offices. At IUG, 22 labs and 4 faculty offices were selected for sampling while, at AQU, 10 labs and 3 offices were sampled. The total of sample size in all the universities was 65 samples (55 labs and 10 faculty offices).

3.1 Bacteria Counts

The average of bacterial counts for all sample population (n= 65) was 926 colony forming units "CFU"/m3 with a range of 160- 2420. This value exceeded the WHO standards of 500 CFU/m^3 for indoor bacteria concentrations. These values are consistent with the levels reported by Karwowska [9] with average bacteria in laboratory rooms in China ranged from 1600 – 2000 CFU/m^3 [10].

The highest mean of colonies of bacteria was at IUG with 1048 CFU/m^3 and the lowest was at AQU with 815 CFU/m^3 and an extreme bacterial count of 2420 CFU/m^3 was detected at a faculty office at

Table 1. Total bacterial count at the studied locations

Locations	N	Mean CFU/m^3	Std. Dev	Minimum CFU/m^3	Maximum CFU/m^3
University Level					
IUG	26	1048.08	624.481	190	2320
AZU	26	858.46	515.796	200	2000
AQU	13	815.38	630.933	160	2420
Total	65	925.69	584.201	160	2420
Labs Level					
Environment and Earth Science	14	1000	724.2	190	2420
Biology	14	694.3	288.2	320	1300
Chemistry	14	920.7	498.9	380	1920
Medical Sciences	13	1176.9	729.6	160	2280
Physics	10	826	534.7	240	1880
Total	65	925.7	584.2	160	2420
Labs vs Faculty offices					
Labs	55	884.55	561.284	160	2320
Faculty offices	10	1152.00	685.173	190	2420
Total	65	925.69	584.201	160	2420

AQU. The highest percentage of samples that exceeds the standards was at IUG which recorded 81% and this could be due to the crowdedness at the old university buildings which were built in the 80's. AQU had the lowest number of samples that exceeded the WHO standards with 62% and this could be due to less number of labs and less crowdedness. These differences were not statistically significant where the *p* value was 0.643.

The results show that the highest mean of bacterial counts was at Medical Sciences lab which has 1177 CFU/m^3 and the lowest count was at Biology lab with 694 CFU/m^3.These results agree with Bholah and Subratty [11] who found that the number of indoor bacterial bio-aerosol concentrations ranged between 3 and 1110 CFU/m^3.

3.2 Fungi

The average count for all samples was 313 CFU/m^3 with a range of 20- 1320 CFU/m^3. At the university level, the values are higher at IUG (348 CFU/m^3), slightly lower at AZU (317 CFU/m^3), and much lower at AQU (238 CFU/m^3). The higher concentrations at IUG labs may resulted due to labs locations at the basement and the poor ventilation. ANOVA results showed insignificant differences between universities with p-value of 0.884. When averaged by type of labs, the highest concentration was observed at Environmental and Earth Science Department Labs (430 CFU/m^3) and the lowest was at Physics Department Labs of 245 CFU/m^3.

Those average values are acceptable because they meet the WHO standards of 500 CFU/m^3 for indoor fungi. These results are consistent with that by Ross et al., [12]. They found fungal concentrations of 338 CFU/m^3 and 312 CFU/m^3 at a shopping center and a company respectively. While lower levels of 194 CFU/m^3 and 178 CFU/m^3 were observed at an auditorium and a hospital respectively. Karwowska [9] determined fungi in a lab rooms ranged between 160 and 780 CFU/m^3. Other studies have reported lower indoor fungal counts. For example, Bholahand and Subratty [11] reported concentrations ranged 0-196 CFU/m^3 at office buildings. Omoigberale et al. [13] observed fungal population from 3 to 45 CFU/m^3 in hospitals' indoor environments.

However, 6 out of 55 labs and 3 out of 10 offices tested exceeded the standards. Two labs at IUG and another lab at AZU had fungal counts over 1000 CFU/m^3. Further investigation of fungi sources in those places and corresponding clean-up measures are warranted. As shown in Table 2, the highest mean fungal concentration was detected at faculty offices (405 CFU/m^3) while the labs had an overall mean of 299 CFU/m^3. However, the difference in the mean values of office and labs are statistically significant due to large variability within each group. Also, 30% of the samples collected from the faculty offices exceeded the WHO standard of 500 CFU/m^3, while only 11% of the samples collected from labs did not fulfill with the same standard. The high level of Fungal in offices could be due to higher level of humidity (67%) and temperature (24.5°C**)** which exceeded the ASHARE Standards.

Table 2. Total fungal count at the monitored locations.

Locations	**N**	**Mean CFU/m^3**	**Std. Dev**	**Minimum CFU/m^3**	**Maximum CFU/m^3**
University Level					
IUG	26	347.69	263.747	60	1120
AZU	26	316.54	254.919	60	1320
AQU	13	238.46	186.451	20	660
Total	65	313.38	246.369	20	1320
Labs Level					
Environmental and Earth Science	14	430	423.1	100	1320
Biology	14	268.6	146.8	60	480
Chemistry	14	311.4	182.4	100	680
Medical Sciences	13	290.8	188.08	20	600
Physics	10	245	127.9	140	540
Total	65	313.4	246.3	20	1320
Labs vs Faculty offices					
Labs	55	296.7	216.1	20	1120
Faculty offices	10	405	374.8	100	1320
Total	65	313.38	246.3	20	1320

3.3 Influence of Temperature and Humidity

The overall average of temperature was 24.3ºC and this range acceptable for indoors environment. The temperature at labs level with the w that the highest temperature was at Physics Labs with 25.6ºC and the lowest was at Environment Science labs with 22.9ºC. In terms of temperature, the relationship between labs was statistically significant where *p* value was 0.001. The difference of temperature between labs and faculty offices, where the mean of temperature at faculty offices was 24.5ºC while it was 24.2ºC at the labs. The difference between labs and faculty offices has no statistical significance where *p* value was 0.681.

As shown in Table 3 also, the highest level of humidity was at AQU with 66.8% and the lowest level was at IUG with 65.1%. There is statistical significantt relationship between IUG and AQU where the *p* value was 0.047.

Regarding the humidity on the labs level, it can be noticed from Table 3 that the highest humidity level was at Environment Science labs with 66.7% while the lowest level was at Chemistry labs with 64.9%. Moreover, there was a statistical significance between the levels of humidity in the different labs where p value was 0.037, which means that the humidity varies from one lab to the other due to differences in size, occupancy or layout. Humidity level at the faculty offices was greater than the levels at the labs, where humidity was 67.06% at the offices and 65.6% at the labs. The relationship between the two groups was statistically significant, where the *p* value was 0.032.

Table 3. Humidity trends

Location	N	Mean (%)	Std. Deviation	Minimum	Maximum
Universities Level					
IUG	26	65.1	2.05	61.3	68.7
AZU	26	66	2.1	62.4	69.4
AQU	13	66.8	0.73	65.9	68.9
Total	65	65.8	1.9	61.3	69.4
Labs Level					
Environmental and Earth Science	14	66.7	1.5	63.7	68.7
Biology	14	65	1.1	63.4	66.5
Chemistry	14	64.9	1.6	62.4	67.1
Medical Laboratory Sciences	13	66.5	3.2	61.3	69.4
Physics	10	66.1	1.4	64.2	68.9
Total	65	65.8	1.9	61.3	69.4

4. Conclusion

It can be concluded that the highest mean of bacterial count was detected at the Medical Sciences labs with an average of 1177 CFU/m^3 and the lowest was at Biology labs with an average of 94.3 CFU/m^3. In term of bacterial counts, chemistry labs were considered the most polluted where 86% of the samples exceeded the WHO standards of 500 CFU/m^3 while physics labs were the least polluted with 60% of the samples. Environment Science labs were considered to be the most polluted with fungi and the lowest was at biology labs with 0%. Faculty offices had the highest counts of bacteria with an average of 1152 CFU/m^3 and 405 CFU/m^3 of fungal counts. The overall humidity level was 65.8% and this is higher than the ASHARE Standards of 40 %- 60%. The highest humidity percentage was at faculty offices with a level of 67.1%. In order to improve the indoor environment quality, it is recommended to perform a periodical monitoring of indoor quality and laboratory disinfection along with good ventilation. Separation of labs from faculty offices, organize awareness programs for staff and students on indoor pollution.

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