Assessment of the Microbial Occupational Work Environment in One Faculty of King Abdulaziz University in Jeddah

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Abstract. The presence of microorganisms in indoor air can pose serious health problems so; the purpose of the present work was to monitor the different groups of microorganisms including total viable bacteria, *Staphylococci*, total coliforms, *Salmonella* and fungi in different sites of the occupational environment (laboratories, offices, corridors and toilets) inside the Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia. The results showed that, the average of total viable bacterial counts in different work laboratories was ranged from 9500 to 23000, *Staphylococci* counts were ranged from 584 to 11000 and fungi counts were ranged from 383 to 2500 cfu/m³. On the other hand the total viable bacterial counts in work offices varied from 12700 to 26500 cfu/m³, meanwhile *Staphylococci* counts ranged from 5000 to 9500 cfu/m³ and fungi counts ranged from 1500 to 4833 cfu/m³. Also, the total viable bacterial counts in corridors ranged from 14340 to 23700 cfu/m³, *Staphylococci* counts ranged from 3167 to 10340 cfu/m³ and fungi counts ranged from 2830 to 5165 cfu/m³. Finally, the average of the total viable bacterial counts in toilets reached 22833 cfu/m³. Meanwhile, *Staphylococci* counts were 4920 cfu/m³ and fungi counts were 3010 cfu/m³. The highest average of total viable bacterial counts were found in toilets (22833 cfu/m³), the highest average of *Staphylococci* counts recorded (7811 cfu/m³) in corridors and the highest average of fungi counts were observed in laboratories (4516 cfu/m³). It is clear that the toilets had the highest average of total viable bacterial counts, the corridors had the highest average of *Staphylococci* counts and laboratories had the highest average of fungi. The microbial groups of coliforms, yeasts and *Salmonella* were not detected in all sampling sites (laboratories, offices, corridors and toilets). Finally, an attention must be given in the place to protect and enhance the occupational environment and keep health of students and workers well.

Keywords: Indoor air, microorganisms, airborne bacteria, health problems and occupational environment.

Introduction

In recent years, there has been a growing interest in indoor microbiological studies because long time of our life was spent indoors like houses, work offices, campus and schools.

Also, people inhale 10 to 14 m³ of the air every day and spend between 80 - 95% of their lives indoors (Abdel Hameed and Farag 1999 and Dacarro *et al.* 2003). Indoor air pollution in classrooms may increase the chance of short- and long-term health problems for

students and staff reducing teachers' productivity student's learning possibilities (Shaughnessy *et al.* 2012). Bioaerosols decrease air quality and affect human health, also causing some diseases such as tuberculosis, diphtheria, legionellosis, fever, rhinitis, nausea and asthma. Indoor air quality is becoming an increasingly important issue for occupational and public health because of 30 % of health problems is relevant to the indoor air pollutants (Reynolds, *et al.* 2001; Srikanth *et al.* 2008 and Dudzińska, 2011).

The air quality of indoor work environment is one of the main factors affecting health and one of main problems is the presence of microorganisms including bacteria, moulds and viruses (WHO, 2013 and Wamedo *et al.* 2012). The investigation of air quality contributes not only assessing indoor pollution levels, but also implementing corrective measures to improve air quality.

An indoor air pollution results from the combination of physical, chemical, biological factors and ventilation in the environment. Also, the other indoor sources of air pollution are heating, and air conditioning systems, building equipment, furnishings, and human activities (Jurado, *et al.*, 2014).

The bio contaminants sources of indoor air may enter indoor areas either by means of passive ventilation or by means of ventilation systems. Many genera are also emitted by indoor sources like animals, flowerpots and wastebaskets.

In most cases, normal flora is not harmful. However, growth conditions like excessive humidity and/or a high water content of building materials are encountered on more frequent basis, which in most cases can be described as the limiting factor for microbial growth (Dhanasekaran *et al.*, 2009). Moreover, Kalwasinska, *et al.* (2012) mentioned that, possible sources of biological contamination

of indoor air of working environment include peoples, organic fine dust, various materials found in the buildings, and the air inflowing from the ventilation and air conditioning closed systems.

The air inhaled by people is abundantly populated with microorganisms which form so-called bioaerosol. Bioaerosol is a colloidal suspension formed by liquid droplets and particles of solid matter in the air, whose components contain or have attached to them viruses, fungal spores and conidia, bacterial endospores, plant pollen and fragments of plant tissues (Karwowska, 2005 and Kalwasinska *et al.* 2012).

The sampling and analysis of microbial load in indoor air has attracted more attention. Indoor air contamination may present a great risk to human health. The most indoor air pollutants are airborne microorganisms including bacteria and fungi which are normal and essential components of all environments.

These microorganisms are reported to be responsible for many health problems, especially among children who are sensitive to indoor pollutants more than adults, because they are still developing physically (Karwowska, 2005; Kim and Kim 2007; Huttunen, *et al.* 2008 and Stanley, *et al.* 2008).

The aim of the present study is to estimate the indoor microbial air quality in four different sites (laboratories: 13 locations, offices: 10 locations, corridors: 7 locations and toilets: 2 locations) in Faculty of Metrology, Environment and Arid Land Agriculture, King Abdu-Aziz University, Jeddah, Saudi Arabia.

Materials and Methods

In this study the research work was carried out in some different sites including offices, laboratories, corridors and toilets for counting of total viable bacteria, *Staphylococci*, total coliform bacteria, *Salmonella* and fungi.

Triplicate samples were taken from all different sites in the morning at 8 to 10 am.

Cultural media

Standard plate count agar (Oxoid) a medium was used for counting the total viable bacteria, Rose Bengal Chloramphenicol agar (HiMedia) was used for enumerating fungi, Baird parker egg yolk tellurite emulsion agar was used for counting of *Staphylococci*, Violet red bile agar (HiMedia) was used for counting total coliforms and Brilliant green agar base with sulphamethoxazole supplement (HiMedia) was used for enumerating *Salmonella*.

After air sampling, the plates were incubated at 37°C/24-48 h for bacteria and at 27°C/3-5 days for fungi (Karwowska, 2005; Stryjakowska Sekulska, *et al.* 2007 and Hayleeyesus and Manaye 2014).

Air sampling

The high-efficiency microbial air sampler (Sampl'air® Lite AES CHEMUNEX, France) was used for enumerating the counts of microorganisms directly in elevated convex petri plates loaded with different media depending on the tested microorganisms in sampling points for 10 minutes.

The numbers of microorganisms were expressed as colony forming unit/cubic meter of air using the following equation (Stryjakowska Sekulska, *et al.* 2007).

$$\text{CFU/m}^3 = a \cdot 10000/p \cdot t \cdot 0.2$$

Where: a – The number of colonies on the Petri plate

p – The surface area of the petri plate

t – The time of petri plate exposure

Fig. 1. The microbial air sampler (Sampl'air® Lite AES CHEMUNEX, France).

Results and Discussion

The microbial groups of coliforms, yeasts and *Salmonella* were not detected in all sampling sites (laboratories, offices, corridors and toilets). The microbial counting results were varied depending on sampling locations. The data in Figure (2) shows the colony forming unit (cfu) of the detected groups in laboratories. The counts of total viable bacteria, *Staphylococci* and fungi (cfu/m³) were ranged from 9500 to 23000 cfu/m³, 584 to 11000 cfu/m³ and 383 to 2500 cfu/m³, respectively.

Figure (3) illustrates the counts cfu/m³) of the same microbial groups in offices. The counts of these groups varied from 12700 to 26500 cfu/m³ for total viable bacteria, 5000 to 9500 cfu/m³ for *Staphylococci* and from 1500 to 4833 cfu/m³ for fungi.

The results in Figure (4) shows, the total viable bacterial, Staphylococcal and fungal counts (cfu/m³) in corridors. The recorded counts ranged from 14340 to 23700 cfu/m³ for total viable bacteria, 3167 to 10340 cfu/m³ for *Staphylococci* and 2830 to 5165 cfu/m³ for fungi. The total viable bacteria were recorded 22500 and 23166 cfu/m³ in toilet one and two, respectively.

Also, the counts were 5500 and 4340 for *Staphylococci* and 2833 and 3187 for fungi in

the same 2 locations, respectively (fig 5). The obtained results showed that the highest general means of total viable bacterial counts (22833 cfu/m^3) was observed in the samples taken from toilets followed by the samples taken from corridors (19435 cfu/m^3).

Also, the means of total viable bacterial counts detected in the samples taken from laboratories were 17548 cfu/m^3 and the lowest total viable bacterial counts were detected in the samples taken from offices 17168 cfu/m^3 . Whereas, the general means of *Staphylococci* counts (cfu/m^3) in corridors, offices, laboratories and toilets were found to be 7811, 6668, 5750 and 4920 cfu/m^3 , respectively (table 1). The obtained results indicated that, the counts of fungi were 4516, 4046, 3010 and 2567 cfu/m^3 in laboratories, corridors, toilets and offices respectively.

Data revealed that higher prevalence of microbial load was detected in toilets and corridors. Our results are in agreement with those obtained by (Kalogerakis, *et al.* 2005; Karwowska, 2005; Di Giulio, *et al.* 2010; Hayleeyesus and Manaye 2014; Jurado, *et al.* 2014 and Mohan, *et al.* 2014).

Moreover, the higher concentrations could be attributed to personal activities (talking, sneezing, walking and coughing), flower pots, equipments, outside air and closed conditioning systems (Kalogerakis *et al.* 2005).

Therefore, the ventilation rates can be very essential to protect the occupant's health and decrease the indoor microbial load.

In conclusion, almost all the sampling sites were heavily contaminated with bacteria and fungi. Thus, attention must be given to control the environmental factors which favor the cross contamination in indoor occupational environment to prevent adverse health effects.

Fig. 2. Total viable bacteria, *Staphylococci* and fungi counts (cfu/m3) of air samples taken from laboratories.

Fig. 3. Total viable bacteria, *Staphylococci* and fungi counts (cfu/m3) of air samples taken from offices.

Fig. 4. Total viable bacteria, *Staphylococci* and fungi counts (cfu/m³) of air samples taken from corridors.

TVBC = Total viable bacterial count

Fig. 5. Total viable bacteria, *Staphylococci* and fungi counts (cfu/m³) of air samples taken from toilets.

Table 1. Means of bacteria and fungi counts (cfu/m³) in different sampling sites.

Sampling sites	Number of samples	Bacteria and fungi counts (cfu/m ³)		
		TVBC*	<i>Staphylococci</i>	Fungi
Laboratories	117	17548	5750	4516
Offices	90	17168	6668	2567
Corridors	63	19435	7811	4046
Toilets	18	22833	4920	3010

TVBC* = Total viable bacterial count.

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التقييم الميكروبي لبيئة العمل المهنية في إحدى كليات جامعة الملك عبدالعزيز بجدة

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المستخلص. إن تواجد الكائنات الحية الدقيقة في هواء الأماكن المغلقة يمكن أن يسبب العديد من المشكلات الصحية الخطيرة. لذلك كان الهدف من إجراء هذا العمل هو تتبع بعض مجموعات الكائنات الحية الدقيقة مشتملةً على العدد الكلي للبكتيريا، والبكتيريا العنقودية، ومجموعة بكتيريا القولون والسالمونيلا والفطريات في مواقع مختلفة من بيئة العمل المهنية في كلية الأرصاد والبيئة وزراعة المناطق الجافة.

أظهرت النتائج المتحصل عليها أن متوسط العدد الكلي للبكتيريا الحية في المختبرات كانت مختلفة حيث تراوحت الأعداد من ٩٥٠٠ إلى ٢٣٠٠٠، وتراوحت أعداد البكتيريا العنقودية من ٥٨٤ إلى ١١٠٠٠ والفطريات من ٣٨٣ إلى ٢٥٠٠ وحدة مكونة للمستعمرة/م^٣. على الجانب الآخر سجل العدد الكلي للبكتيريا الحية في المكاتب ١٢٧٠٠ إلى ٢٦٥٠٠ وأعداد البكتيريا العنقودية من ٥٠٠٠ إلى ٩٥٠٠ وحدة مكونة للمستعمرة/م^٣ وبلغت أعداد الفطريات من ١٥٠٠ إلى ٤٨٣٣ وحدة مكونة للمستعمرة/م^٣ ووجد أيضاً أن العدد الكلي للبكتيريا الحية في الممرات تراوح من ١٤٣٤٠ إلى ٢٣٧٠٠، وأعداد البكتيريا العنقودية تراوح من ٣١٦٧ إلى ١٠٣٤٠ وأعداد الفطريات من ٢٨٣٠ إلى ٥١٦٥ وحدة مكونة للمستعمرة/م^٣. ووجد أيضاً أن متوسط العدد الكلي للبكتيريا الحية في دورات المياه وصل إلى ٢٢٨٣٣ وحدة مكونة للمستعمرة/م^٣. وفي الوقت نفسه كانت أعداد البكتيريا العنقودية ٤٩٢٠ وحدة مكونة للمستعمرة/م^٣ وأعداد الفطريات ٣٠١٠ وحدة مكونة للمستعمرة/م^٣. وخلصت الدراسة إلى أن أعلى معدل من العدد الكلي للبكتيريا الحية وجدت في دورات المياه (٢٢٨٣٣ وحدة مكونة للمستعمرة/م^٣)، كما وجدت أعلى أعداد للبكتيريا العنقودية في الممرات (٧٨١١ وحدة مكونة للمستعمرة/م^٣). لوحظ أن أعلى معدل لأعداد للفطريات قد سجل في المختبرات (٤٥١٦ وحدة مكونة للمستعمرة/م^٣). كذلك خلصت النتائج إلى أعلى متوسط للعدد الكلي للبكتيريا الحية كان في دورات المياه وكان أعلى متوسط لأعداد البكتيريا العنقودية في الممرات وأعلى معدل للفطريات في المختبرات. من نتائج البحث لم يتم اكتشاف بعض المجموعات الميكروبية مثل: بكتيريا القولون والخمائر والسالمونيلا في جميع مواقع أخذ العينات (المكاتب والمختبرات والممرات ودورات المياه). وأخيراً، لا بد من الانتباه لتوفير البيئة المهنية السليمة في المكان للحفاظ على صحة الطلاب والعاملين أيضاً.

الكلمات المفتاحية: الهواء الداخلي، الكائنات الدقيقة، البكتيريا المتواجدة بالهواء، المشاكل الصحية والبيئة المهنية.