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Original scientific paper

Indoor Microbiological air Pollution in the Hospital

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Abstract: Microorganisms in the air of occupational indoor environments are associated with a wide range of adverse health effects with major public health impact. The aim of this study was testing the presence of microbiological parameters (bacteria and fungi) and microclimatic parameters (temperature and relative humidity) in the clinical hospital "St. Luke the Apostle" in Doboj, which is located in the Republic of Srpska (Bosnia and Herzegovina). Concentrations of bacteria ranged from 35 CFU/m^3 to 6,295 CFU/m^3. Maximum fungal concentration was 1,135 CFU/m^3, while the minimum was 10 CFU/m^3. The average levels of bacteria (1,113 CFU/m^3) and fungi (186 CFU/m^3) indicated that all hospital rooms were generally contaminated. Statistical analysis confirmed direct connection between the number of bacteria, fungi and microclimatic parameters, especially relative humidity.

Key words: bacteria, fungi, workplace, hospital

INTRODUCTION

The indoor air is a very dynamic system in which particles of biological and non-biological origin are distributed and displaced (Mandal and Brandl, 2011). Microorganisms suspended in the air of occupational indoor environments are now appropriately recognized and that exposures to them are associated with a wide range of adverse health effects with major public health impact (Shiaka and Yakubu, 2013). Biological air contaminants are basically constituted with bacteria, fungi, and viruses, and their distribution may vary according to environment, area within the environment, and location within a given area (Aguiar et al., 2014). Hospital buildings may be regarded as variable and vigorous environments affected by season, weather conditions, indoor ventilation system design and operation, intrusion of moisture, outdoor microbial load, the number of occupants and visitors, and by human activities. These factors can be related to a condition for microbial growth (Ilić et al., 2018). People, air currents, water, construction materials, and equipment bring microorganisms into hospitals. Aerial transmission is the most important route for many microbial pathogens in indoor environments, including hospitals. The concentration of biological agents inside a building depends not only on the amount of agent released, which determines the strength of the source, but on the rate of exchange between indoor and outdoor air through ventilation as well (Božić et al., 2019).

OBJECTIVES

The aim of this study was testing the presence of microbiological parameters (bacteria, fungi) and their association with microclimatic parameters (temperature and relative humidity) in the clinical hospital "St. Luke the Apostle" in Doboj, which is located in the Republic of Srpska (Bosnia and Herzegovina).

MATERIAL AND METHODS

Portable bio-impactor air sampler Sampl'air™ Lite, manufactured by BioMérieux S. A, Marcy-l'Étoile, France, for microbial air monitoring based on the principle of air impaction was used. Microorganisms were collected by air aspiration through a grid that was situated a few millimetres above a Petri dish. Viable organisms in the air were impacted on the agar. Airflow was adjusted at 200 L/min and directed over the surface of a Petri dish containing appropriate solid culture media (trypticase soy agar (TSA) and Sabouraud Dextrose Agar (SDA)). Before each sampling session, the head of the air sampler was properly sterilized. Thirty-five samples were obtained over 10 days (in February and March 2017). The microbial concentration for each temporal series was expressed as the mean value of colony-forming units (CFU) per m^3 of the air analysed. The most likely number was assumed by using the table of correspondence. A correlation between the values found and the temperature and humidity using the portable multifunctional Metrel MI 6401 Poly device with SensorLink PRO and professional PC software was established. Testing of microclimatic parameters (temperature and relative humidity) was performed according to methods IEC 60751:2008 and CEN - EN 12599. Estimation of airborne fungi was carried out by growth on agar medium. The sampled plates were incubated at 30-35 °C for 48 h in the case of bacterial analysis and at 28-32 °C for 72 h in the case of fungal sampling. After the incubation period, colony counting was performed with an EasyCount 2 colony counter with supporting software, and the plates were examined for manual CFU counting.

Statistical analysis:

Statistical data processing, while determining the interdependence and relationship between microbiological parameters (bacteria and fungi) and microclimatic parameters (temperature and relative humidity), were calculated and displayed as frequency polygon charts and box plots. Descriptive statistical parameters, such as the mean, standard deviation, median, minimum and maximum, were applied to the data. Bivariate correlation studies (Spearman's, Pearson's and Kendall's correlation coefficient test) were used to evaluate the relationship between the concentration of airborne fungi and bacteria (as CFU/m^3) and microclimatic parameters (relative humidity and temperature). A significance level of a p-value < 0.05 was used. For statistical data processing, while determining interdependence and the relationship between bacteria and fungi and microclimatic parameters, EXCEL, JASP Computer software and Free Statistics Software were used.

RESULTS AND DISCUSSION

The assessment of indoor air quality is essential in determining microbial (bacterial and fungi) pollution. The values of the number of bacteria and fungi (in CFU/m^3) are measured together with the microclimatic parameters (temperature and relative humidity). In the Table 1, the concentrations of bacteria varied and ranged from 35 CFU/m^3 to 6,295 CFU/m^3.

Table 1. Descriptive statistical for bacteria, fungy, temperature and relative humidity

	Bacteria	Fungi	t	RH
Valid	72	72	72	72
Mean	1113	185.8	22.89	41.96
Median	905.0	127.5	23.35	42.20
Mode	655.0[a]	50.00[a]	23.50	43.20

Std. Deviation	932.6	179.5	1.906	5.029
Variance	8.697e+5	3.223e+4	3.634	25.29
Skewness	3.161	2.554	-0.3442	0.5567
Kurtosis	14.38	10.19	0.08303	1.012
Minimum	35.00	10.00	17.80	29.60
Maximum	6295	1135	27.10	56.60

Maximum fungal concentration was 1,135 CFU/m^3, while the minimum was 10 CFU/m^3. The average levels of bacteria (1,113 CFU/m^3) and fungi (186 CFU/m^3) indicated that all hospital rooms were generally contaminated. Similar values were obtained during earlier surveys at the same site (Ilić et al., 2018). Measured values fungi, or their spores, are a frequent cause of asthma, allergic alveolitis, vasomotor rhinitis and urticaria (Ilić, 2015).

The quality of indoor air is one of the most significant factors affecting the health and well-being of people who inhale at least 10 m^3 of the air every day and spend between 80-95% of their lives indoors (Dacarro et al., 2003; Shiaka and Yakubu, 2013). Quantitative standards/guidelines range are from less than 100 CFU/m^3 to more than 1,000 CFU/m^3 (total fungi) for fungi, as the upper limit for non-contaminated indoor environments, but during the study, the determined value was exceeded in most of the measurement points, and has exceeded the average value (Rao et al., 1996).

European Commission Report had recommended the following limits for bio-aerosols: 0 undetectable, 1-499 CFU/m^3 low, 500-999 CFU/m^3 medium and > 1000 CFU/m^3 high (CEC, 1994); the average value for bacteria in the research was 1,113 CFU/m^3, which indicates a medium level contamination, with the high values measured at a large number of measuring points. WHO has set the guidelines of bio-aerosols counts at 500 CFU/m^3 (WHO, 1990) and American Conference of Governmental Industrial Hygienists (ACGIH) with the culturable counts for total bacteria not to exceed 500 CFU/m^3 (Jensen and Schafer, 1998; Katiyar, 2013), which confirms the thesis that there is a high level of contamination in the hospital.

The type of species and number of organisms present in the air depends on physicochemical factors like the temperature, viscosity, lighting, suspension of organic and inorganic material and food availability (Kumari et al., 2011). The relationship between bacteria and fungi concentrations (CFU/m^3) and relative humidity in the study area was analysed using correlation analysis (Pearson, Spearman and Kendall). The results of the correlation analysis between bacteria and fungi concentration and relative humidity are shown for the level of significance $p < .05$, and $p < .001$ (Table 2). Correlation analysis indicated the relationship between bacteria, fungi and relative humidity (Table 2). Such results suggest that these pollutants might have similar sources or have been affected by similar factors. Values of correlation analysis for other pollutants are moderate positive (fungi and temperature) or negative (temperature and relative humidity) and not relevant significant results.

There is a non-significant and negative correlation between the fungi concentrations and relative humidity. However, no such correlation was discovered between fungi and relative humidity in researches by other authors (Aydogdu et al., 2005). Negative correlation may indicate the presence of a specific species of fungi.

Table 2. Correlation between analyzed parameters

			Pearson			Spearman			Kendall		
			r		p	rho		p	tau B		p
Bacteria	-	Fungi	0.135		0.260	0.237	*	0.045	0.167	*	0.041
Bacteria	-	t	-0.145		0.225	-0.012		0.920	-0.008		0.922
Bacteria	-	RH	0.073		0.542	0.092		0.443	0.067		0.411
Fungi	-	t	0.235	*	0.047	0.457	***	< .001	0.310	***	< .001
Fungi	-	RH	-0.015		0.901	-0.136		0.255	-0.088		0.278
t	-	RH	-0.538	***	< .001	-0.520	***	< .001	-0.371	***	< .001

* p < .05, *** p < .001

Figure 1. shows a frequency polygon of bacteria, fungi and total microorganism concentrations at the Hospital where the data are binned into regular intervals. Frequency of measured values bacteria, fungi and total microorganism clearly indicates that the largest number of samples has very high value of microorganism (WHO, 1990, CEC, 1994).

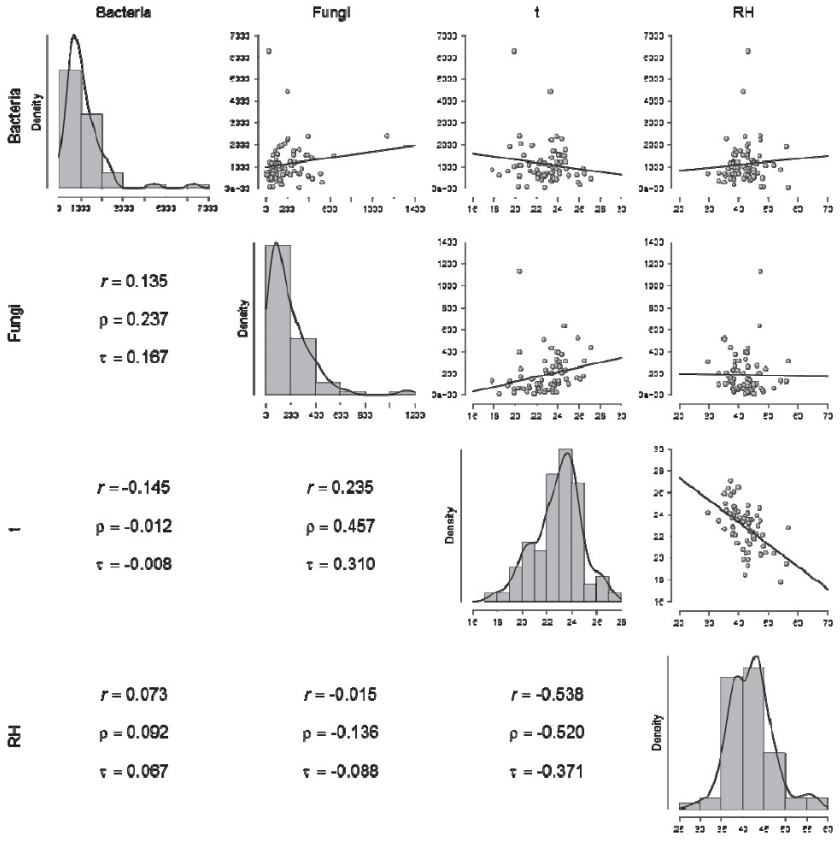

Figure 1. Correlation between the number of bacteria, fungi and relative humidity

There is a negative correlation between fungi and relative humidity and the it's necessary conduct further investigation on the effect of relative humidity in indoor environment in the medicinal institution.

Figure 2 shows box Predictive region for bacteria and fungi in correlation with relative humidity and temperature.

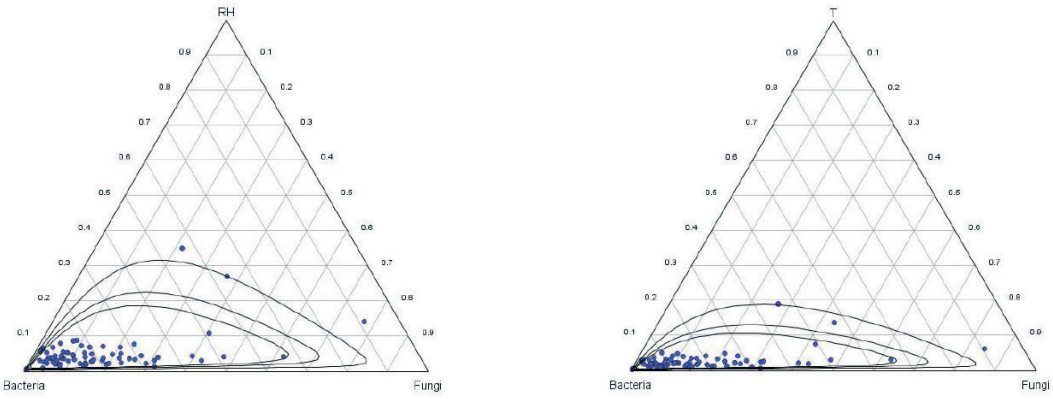

Figure 2. Predictive region for bacteria and fungi in correlation with relative humidity and temperature

Consistently implemented control strategies decrease the risk of bacteria and fungi associated infections among health-care workers and immune-compromised patients, with the greatest risk of infection caused by airborne microorganisms. Certainly, the poor IAQ issues represent only a portion of the total circumstances leading to infections. Safety and comfort of patients and medical staff are the top priority in all hospitals. Architects and other engineers manage the function and design of hospitals, but epidemiologists and infection-control professionals with specialized meters and techniques are required in order to maintain hospital buildings (Božić et al., 2019).

CONCLUSIONS

Bacteria show higher growth comparing to fungi which is slow growing. The results of the present research study reveal various degrees of contamination in all of the environments examined. The results indicate high level of microbiological contamination of the air.

Statistical analysis confirms direct connection between the number bacteria and fungi and microclimatic parameters, especially relative humidity. Considering that there is a negative correlation between fungi and relative humidity, the need for further investigation on the effect of relative humidity in indoor environment is suggested.

When there are traces of pathogenic microorganisms, certain measures of sanation need to be taken (determining the root cause of the contamination, disinfection and ventilation etc.).

Although it's only saprophytic microorganisms in this case, because of personal safety reasons, employees are advised to:

- Lime and dry all the rooms and remove any unnecessary items (flowers, carpets, etc.) which could contain mold and bacteria.
- Remove all heating appliances and maintain all air condiotioning units as well as clean and disinfect all ventilation devices if any.
- Mandatory airing out of the workstations.
- Doors and windows must be wide open for 4-5 minutes. The air will completely change, if only the window is opened, 10 minuted will be required several times during an 8 hour period.
- Cleansing of the workstations must be done regularly with vacuum cleaners and wet cleaning, with disinfective chemicals.
- Keeping a good personal hygiene. In case protective or work uniforms are worn washing them regularly is mandatory.
- Any consumption of food in the workstations should be strictly prohibited (Special rooms for

this purpose should be provided).
- Regular cleaning and disinfection from time to time of the workstations.

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