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The microbiological environment in specific rooms of a university campus

P. Kic[1,*] and L. Růžek[2]

[1]Czech University of Life Sciences Prague, Faculty of Engineering, Kamycka 129, 16521, Prague 6, Czech Republic; [*]Correspondence: kic@tf.czu.cz
[2]Czech University of Life Sciences Prague, Faculty of Agrobiology, Food and Natural Resources, Kamycka 129, 165 21 Prague 6, Czech Republic

Abstract. The aim of this paper is to present the results of a microclimatic research focused on the microbiological contamination in different rooms of the campus of the Czech University of Life Sciences Prague with emphasis on bacteria and filamentous fungi, including presence of the allergenic genus *Cladosporium*. Attention is paid to the purpose of the rooms, ventilation or air-conditioning, and also to problems with the technological equipment installed and used in the rooms. In the frame of this research, were examined the indoor conditions in lecture rooms, the special breeding sections for laying hens and several parts of an experimental brewery. Different intensities of ventilation and air-conditioning influenced the quality of the indoor environment in the studied rooms during the year.

Key word: indoor air quality, bacteria, filamentous fungi, temperature, air humidity.

INTRODUCTION

The aim of this paper is to present the results of a microclimatic research focused on the microbiological contamination in different rooms at the Czech University of Life Sciences campus. The microbial contamination (bacteria and filamentous fungi including presence of the allergenic genus *Cladosporium*) as well as the main microclimatic parameters of the air (temperature and relative air humidity) were measured and evaluated in relation to the different performance conditions of the tested rooms. Attention is paid to the purpose of the rooms, ventilation or air-conditioning and also problems with the technological equipment installed and used in the rooms.

Many scientific and professional papers emphasize the influence of indoor climate on human health (Gorny & Dutkiewicz, 2002; Karwowska, 2003; Fisk et al., 2007) and on the comfortable feeling of inhabitants inside different buildings and rooms (Seppänen et al., 2006; Nõu & Viljasoo, 2011; Tint et al., 2012). There are also many research and scientific papers that have focused on the influence of microclimate on the health of animals and the efficiency of animal production (Chiumenti, 2004; Ledvinka et al., 2008; Rajaniemi & Ahokas, 2012; Sada et al., 2012). Majority of these papers pay the attention to the thermal conditions and the concentration of noxious gases. The problems of the welfare of laying hens are also emphasized in the EU Council Directive 99/74/EC; unfortunately, the issue of indoor air quality and ventilation are not mentioned.

Indoor environment can also play a rather important role in the relation to the quality and durability of a building (Sada et al., 2012). The effect and influence of moisture and air humidity as well as microbiological contamination by fungi is emphasized (Papez & Kic, 2013).

In the frame of this research, were examined the indoor conditions in lecture rooms, special breeding sections for laying hens and several parts of an experimental brewery. Different intensities of ventilation and air-conditioning influenced the quality of the indoor environment in the studied rooms during the year.

MATERIALS AND METHODS

This research work was carried out in different rooms of the campus of the Czech University of Life Sciences in Prague. In the frame of this research, were examined the indoor conditions inside a lecture room, special breeding sections for laying hens and several parts of an experimental brewery.

The lecture room M II has the capacity of 121 student places and is equipped with a comfortable air-conditioning (AC) system for ventilation, heating and cooling. It also includes a regenerative heat exchanger and humidifier for the winter period. The measurement was carried out during summer, autumn and winter periods, under different operational conditions.

Two sections of an experimental building for housing domestic animals were equipped with different technological equipment. The first section was equipped with a three-tier battery of cages housing 72 laying hens, and the second one (60 laying hens) with a typical floor housing technology of boxes on deep litter, corresponding with the alternative technology with nests etc. The microclimatic research covered all four periods of the year.

The brewery of the Czech University of Life Sciences in Prague, used for education and production of special traditional Czech beers according to the old traditional procedure, consists of separated rooms used for specific purposes, which need very special equipment and also require individual parameters of microclimatic conditions (Chladek, 2007). The microbiological conditions were controlled in the brew house, the section of wort cooling, the cellar room which is combined of the department of fermentation and maturation tanks, the energetic centre and a classroom for 32 students. The measurement of microbiological contamination was carried out during the winter.

The air samples for microbiological analyses were taken by the instrument Merck Mas-100 Eco, a microbial air sampler with the volume of 0.200 m^3 of air, and cultivated by PDA (potato-dextrose agar OXOID CM 139; 100%) and NA (nutrient agar OXOID CM 003; 100%). Colonies of microorganisms were evaluated after 5 days of incubation. Yeast and filamentous fungi were cultivated at 22°C, bacteria at 29°C. The captured microorganisms, which formed colonies on the culture media, were expressed as colony forming units per m^3 ($CFU \cdot m^{-3}$).

The temperature and humidity of surrounding air were measured by the sensor FH A646–2 including the temperature sensor NTC type N with an operative range from – 30 to +100°C with accuracy of ± 0.1 K, and air humidity by a capacitive sensor with an operative range from 5 to 98% with accuracy of ± 2%. The sensors were connected to the data logger ALMEMO 2690–8.

RESULTS AND DISCUSSION

The principal results of the microclimate measurement and microbiological evaluation for different AC levels are summarized in Tables 1, 2, and 3. Table 1 contains the results about the microbiological contamination and air temperature (T) and relative humidity (Rh) in the lecture room during several periods of the year and with different operational conditions.

Table 1. Results of measurements in a lecture room at the Faculty of Engineering

Period	AC	Students	Fungi	*Cladosporium*	Bacteria	T	Rh
-	-	persons	CFU m^{-3} ± SD	CFU m^{-3} ± SD	CFU m^{-3} ± SD	°C	%
Summer	no	0	408 ± 19	293 ± 26	207 ± 28	23.3	39.4
Summer	yes	0	444 ± 126	356 ± 133	121 ± 45	22.2	43
Autumn	no	34 to 55	356 ± 93	48 ± 16	884 ± 149	25.3	50.4
Autumn	yes	17 to 55	324 ± 36	104 ± 15	308 ± 103	23.1	34.5
Winter	no	5 to 47	77 ± 23	9 ± 4	860 ± 121	22.3	32
Winter	yes	5 to 47	28 ± 7	7 ± 3	312 ± 61	22.9	20.2

SD – Standard deviation.

The summer measurement was in an empty lecture room without students. The concentration of bacteria was low and the air–conditioning (AC) was decreased. On the other hand, the concentration of filamentous fungi was increased by the AC operation, which is especially true for the allergenic fungi *Cladosporium* which the air conditioner brought into the internal environment from the outdoor air. There was a similar situation during the autumn.

The quality of indoor air in the classroom with students and without the function of AC during the autumn measurement was rather low, which is obvious from the high level of average temperature (25.3°C) and the strongly increased relative humidity to the average 50.4%., as none of the metabolic products of the persons surviving inside (energy, vapour, noxious gases, etc.) were ventilated out. Contamination of indoor air by bacteria was also rising with the number of students present to the average value of 884 CFU m^{-3} when the AC in the lecture room was out of order.

A positive influence of AC was recognised in the autumn measurement, when the AC was switched on. The indoor temperature was decreased to the optimum 23.1°C and the relative humidity was lower as well (average 34.5%). Thanks to the function of the AC the average concentration of bacteria also decreased from 884 CFU m^{-3} to 308 CFU m^{-3}. Unfortunately, the average concentration of the allergenic *Cladosporium* increased from 48 CFU m^{-3} to 104 CFU m^{-3}. The filtration of inlet air is not sufficient and this fungus was brought into the internal environment from outdoor air with inlet air.

There was a completely different situation in winter. As the day of the winter measurement was rather cold with snow, all surrounding surfaces including the area of air inlet were covered with snow and clean, without a source of fungi. It resulted in a very low concentration of all kinds of fungi inside the lecture room. The range of the quantity of fungi was between 30 and 785 CFU · m^{-3} in various educational rooms (Karwowska, 2003). Our results are in accordance with this author's.

From the measurement of bacteria, it is obvious that students are the main source of bacteria inside the lecture room. Gorny & Dutkiewicz (2002) reported a normal range of bacteria concentration between 88 and 4,297 CFU m^{-3}. Our results are in accordance with these authors. The AC which was installed in our lecture room significantly reduced the bacteria concentration inside the lecture room in autumn and winter as well.

Table 2 contains a summary of the results of the microbiological measurements and the air temperature and relative humidity in the building with two rooms used for the breeding of laying hens during several periods of the year. The levels of indoor contamination by microbes are very high; there are differences between both sections and also in the course of the year.

Table 2. Results of measurements in two sections for breeding of laying hens

Period	Housing	Fungi	Bacteria	T	Rh
		CFU m^{-3} ± SD	CFU m^{-3} ± SD	°C	%
Winter	Cages	32,476 ± 8,591	116,810 ± 14,457	19.0	45
Winter	Boxes	56,571 ± 14,875	194,333 ± 34,152	17.0	65
Spring	Cages	6,952 ± 1,238	73,892 ± 15,834	20.2	52
Spring	Boxes	10,190 ± 571	100,282 ± 11,876	19.1	61
Summer	Cages	5,036 ± 3,572	9,840 ± 8,625	22.3	68
Summer	Boxes	4,923 ± 3,661	76,435 ± 28,768	22.0	69
Autumn	Cages	5,869 ± 1,274	11,297 ± 2,708	20.4	50
Autumn	Boxes	4,310 ± 691	72,714 ± 2,786	19.6	64

SD – Standard deviation.

The situation was the worst in the winter, which was mainly due to little ventilation. During other periods of the year, at increasing outdoor air temperatures, contamination with bacteria and fungi occurs due to intensive reduction of ventilation of the indoor air. It is obvious from the results of the measurements that the situation in the section of the laying hens housed in the boxes on the floor was constantly worse. As the people working in the building are usually inside the building only for a very short time for housing the laying hens, the measurement of *Cladosporium* was not provided in these sections.

Table 3 contains the results of the microbiological contamination and the air temperature and relative humidity in five main parts of the experimental brewery. The lowest contamination by bacteria was in the brew house, where there is quite intensive ventilation due to removal of the excess heat generated during brewing. Intensive ventilation on the other hand causes an increased incidence of filamentous fungi, including *Cladosporium*.

Table 3. Results of measurements in five sections of the brewery

Room	Fungi CFU m^{-3}	*Cladosporium* CFU m^{-3} ± SD	Bacteria CFU m^{-3} ± SD	T °C	Rh %
Brew house	785 ± 25	150 ± 30	760 ± 90	21.2	31.7
Whirpool	500 ± 70	90 ± 20	1,135 ± 25	19.1	37
Cellar	685 ± 65	95 ± 5	1,120 ± 270	7.8	100
Energy centre	360 ± 160	60 ± 10	815 ± 155	20.5	75.1
Classroom	545 ± 105	95 ± 5	840 ± 40	22.1	29.4

SD – Standard deviation.

But the brewing process can also be the source of fungi. The highest incidence of fungi and bacteria in the brewery was in the cellar and whirlpool, which was caused by the technological processes. The concentrations of fungi and bacteria in both of these rooms are similar; although there are significant differences in temperature and relative air humidity.

The concentration of fungi and bacteria in the classroom was worse than in the studied lecture room, because this room is permanently connected to the brew house and the internal environment is directly influenced by its microclimate. More intensive ventilation of the special classroom connected to the brew house could, in this case, also improve the indoor microclimate.

CONCLUSIONS

The comparison of the results obtained from the measurements in different parts of the university campus shows that ventilation and air-conditioning also have a decisive influence on the quality of the indoor environment, in addition to the technological equipment and purpose of the room.

The indoor environment in the lecture room would be greatly improved by the use of better filters, which are able to capture finer particles, particularly allergenic *Cladosporium*. It is also important to ensure the necessary maintenance, especially well- timed replacement of filters after pollution.

The higher movement of the laying hens on the floor and the more complicated ventilation in the part of the housing section used for living (especially near the floor) cause permanently higher concentration of microbes than in the case of housing in cages. More intensive ventilation of the building would help to improve the quality of the indoor microclimate.

The brewery is a very special technology, which needs different rooms and very different microclimatic conditions. The results of the measurement show that different technological needs are respected in the operation of heating, cooling or air-conditioning in all sections of the brewery.

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