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Microbiological Air Contamination in Some Educational Settings

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Abstract

The presence of bacteria and fungi in indoor air pose a serious problem from the point of view of health protection and environmental engineering. Precise determination of various groups of microorganisms indoors is necessary both to estimate the health hazard and to create standards for indoor air quality control. This is especially important in such densely populated facilities like education objects. In this study the level of microbial contamination in rooms of kindergarten, primary school and high school was estimated. A level of microbial air pollution was stated as a considerable high, compared with existing suggestions for microbiological standards and UE demands. The number of microorganisms (as CFU/m^3) ranged within 340-7530 for mesophilic bacteria, 5-35 for haemolytic bacteria, 25-475 for staphylococci, 0-45 for coli group bacteria and 30-785 in the case of moulds.

Keywords: educational settings, air quality, airborne microorganisms

Introduction

Most of our life is spent indoors. Therefore, indoor air pollution may present a greater risk to human health than exposure to atmospheric air contaminants.[10] One kind of indoor air pollutant is airborne microorganisms – bacteria and fungi [9]. They are factors of potential infectious, allergenic and immunotoxic effects. Indoor microflora is reported to be responsible for health problems, especially among children [3]. Bioaerosols decrease air quality and affect human health, also causing some diseases such as tuberculosis, diphteria, legionellosis, fever, rhinitis, nausea and asthma [12].

The activity of people and equipment within enclosed spaces is thought to be the principal factor contributing to the buildup and spread of airborne microbial contamination [6]. Another major emission sources of indoor microbiological pollutants are animals, plants, air conditioning systems, building materials, particles of soil and dust. A lot of these come from outdoor air, especially in summer and autumn [9].

School facilities are densely populated, so it's making the problem of maintaning good quality indoor environments more difficult [1]. Poor indoor air quality causes in many cases illness requiring absence from school or can cause acute health symptoms, decreasing performance while at school. Children are more likely to suffer the consequences of indoor pollutants than adults, because they are still developing physically [1,10].

It has been stated that especially the presence of moulds in indoor air of schools poses a serious risk to children. All moulds have the potential to cause health effects such as headaches, breathing difficulties, skin irritation, allergic reaction and aggravation of asthma symptoms [14]. Epidemiological data suggest that mould exposure may increase the risk for asthma up to five-fold

at school age [8].Richards noticed that asthma is the principal cause of school absences (up to 20% of lost school days in elementary and high schools)[1]. Taskinen et al.[19] proved that 14% of school children revealed a positive reaction to fungal allergens in skin prick tests and serum IgE reactions. Platt et al. revealed that elevated occurences of wheezing and fever in children was connected with high numbers of fungi in the air [9].

To estimate a hazard of microbiological air pollution a number of fungi and various groups of bacteria indoors should be determined, as precisely as possible. In this study the level of microbial contamination in some education objects was estimated using a MAS-100 air sampler.

Materials and Methods

Research work was carried out in some educational settings in Warsaw: kindergarten (a classroom for six-year-old children), primary school (two classrooms, a corridor, a cloak-room) and high school (laboratory room).

A characteristic of air sampling points is presented below (Table 1).

Table 1. Locations of air sampling.

Kind of room	Characteristic
cloak-room	Accomodation of primary school, about 150 m^2 , without people
school corridor	Primary school, second floor, about 20 children
Classroom 1	About 50 m^2 , during the lesson, 25 children
Classroom 2	About 50 m^2, 3 hours after lessons, without people
Kindergarten room	Classroom for six-year-old children, 60 m^2, 15 children
Laboratory room	High school microbiological laboratory, 18 persons

Microbiological studies covered the determination of the total number of mesophilic bacteria, mannitol+ staphylococci, coli-group bacteria, haemolytic bacteria and moulds.

Air samples were taken using an MAS-100 air sampler, based on the principle of the Andersen air sampler (corresponding to its 5th stage). Tested volumes of the air were 100 and 250 liters and the sampling rate – 100 l/min. Bacteria and fungi were collected and grown on standard culture media [2] as presented below in Table 2.

Colonies were counted after 48h of incubation at 37°C for bacteria and after 5 days at 26°C for moulds.

The average number of bacteria and fungi was calculated as colony forming units in 1 m^3 (CFU/m^3). Total microbial count was corrected using the conversion formula devised by Feller [5]:

$$Pr = N[1/N + 1/N-1 + 1/N-2+....+1/N-r+1]$$

Table 2. Culture media for microorganisms.

Kind of microorganisms	Culture medium
Mesophilic bacteria	MPA nutrient agar
Staphylococci	Chapman agar
Coli-group bacteria	Endo agar
Haemolytic bacteria	Blood agar
Fungi	Martin agar

where:
N= 400 (number of holes in perforated lid of the sampler)
r - number of CFU counted on Petri dish
Pr - statistically corrected total count of bacteria in tested air volume

Predominating isolates of fungi were identified using morphological criteria [4][15][16].

Parameters such as relative humidity, temperature and number of people in the object were determined simultaneously with each microbial sample.

Results

The research work was carried out in winter. The temperature of atmospheric air was about 1°C and temperature indoors- 18-21.5 °C. Relative humidity of the air was 46-56%, depending on sampling place. All examined buildings had traditional ventilation without air conditioning systems.

The results of microbiological determinations are presented in Figs. 1-5.

The highest level of bacteriological contamination was detected in the corridor and in rooms during lessons. After the lessons a number of microorganisms were much lower.

Haemolytic bacteria were most numerous in the kindergarten classroom and staphylococci – in laboratory room. Coli-group bacteria only in laboratory room, corridor and classroom with children were detected.

The higher amounts of fungi occured in primary school corridor and the cloak-room. Among moulds

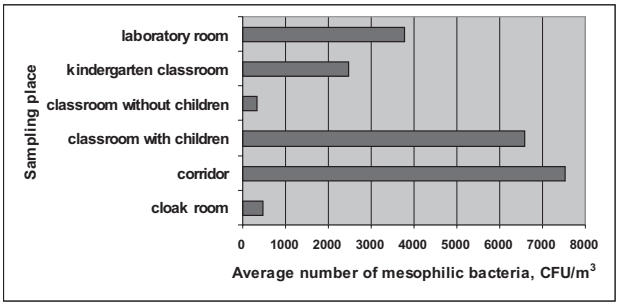

Fig.1. Number of mesophilic bacteria in various educational rooms.

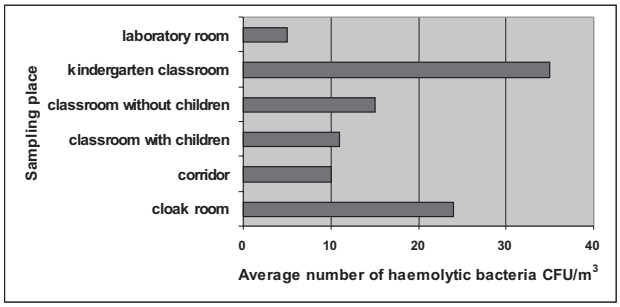

Fig.2. Number of haemolytic bacteria in various educational rooms.

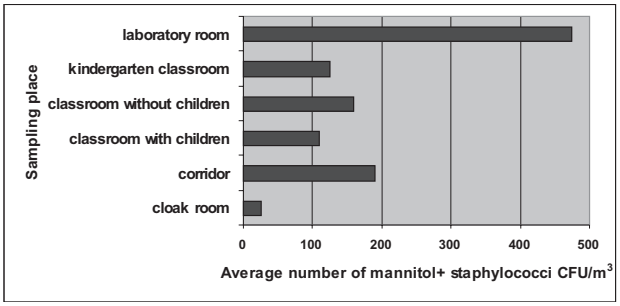

Fig.3. Number of mannitol+ staphylococci in various educational rooms.

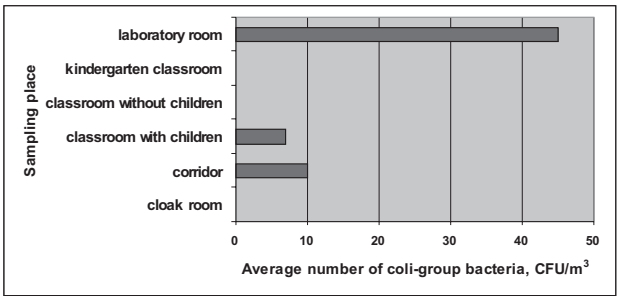

Fig.4. Number of coli-group bacteria in various educational rooms.

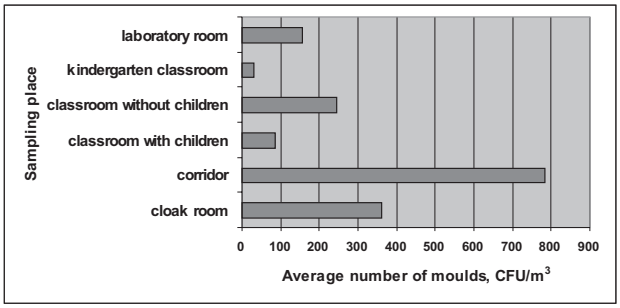

Fig.5. Number of moulds in various educational rooms.

isolated from the air strains from genus *Aspergillus* (*A. ochraceus, A. flavipes, A. nidulans, A terreus and A. niger*) and *Penicillium* (*P. notatum, P. brevicompactum, P. implicatum*) predominated.

Discussion

Air quality in schools, including microbiological pollution, has been an object of much research. Literature data concerning the number of microorganisms in school accomodations are presented in Table 3.

Number of bacteria and fungi determined in this research work is presented in Table 4.

It has been stated, that the number of microorganisms was higher during the occupation of the objects by people. A correlation between bacteria and number of persons in a room has been previously suggested by Nevalainen et al. [20] and Stobinska and Skrzycka [18].

The most contaminated sites were rooms during lessons and the corridor in the primary school. Staphylococci and haemolytic bacteria were found in all areas, but coli-group bacteria only in some of them.

Up to now in Poland there have been no standard regulations concerning permitted levels of microbiological contaminants in indoor air. According to Topley [21], the total number of microorganisms (determined by sedimentation method) in school accomodations shouldn't exceed 2825 CFU/m^3. As Krzysztofik suggested, the total number of bacteria should be lower than 1500-2000 CFU/m^3, haemolytic bacteria - 50-100 CFU/ m^3 and fungi - 200 CFU/m^3 [2][7][18]. In our research, the levels mentioned above were exceeded in many cases. Comparing our results with UE demands [18] for indoor air (maximum 500 microbial cells in 1 m^3) it should be stated that the degree of microbial contamination in a tested area was exceptionally high (up to 16-fold higher than permitted levels).

A very important group of microbiological contaminants in schools are moulds, due to their allergenic and toxic influence. Meklin et al. [13] found that in schools most often occured such fungi as: *Penicillium sp., Cladosporium sp., Aspergillus sp.* and yeast. Wurtz et al.[20] isolated some strains of *Aspergillus* (*A. versicolor*) and *Penicillium* from the indoor air of some Danish schools. Dotterud et al. [9] noticed that in Norwich schools most commonly occured moulds belonging to the genera: *Penicillium*, *Aspergillus*, *Cladosporium* and *Mucor*. Stobińska and Skrzycka [18] detected some strains from genera: *Fusarium*, *Penicillium* and *Rhizopus* in university rooms.

Results of this research prove that most common in schools are moulds from genera *Aspergillus* and *Penicillium*.

Poor biological air quality may be connected with some non-biological aspects. The air exchange rate was determined as an important factor in air quality. Based on the tests of 28 school rooms, Sowa [17] stated that air exchange rate was 1.2-9.6 m^3/h per 1 person (it should be about 20 m^3/h), and inefficient ventilation systems may be responsible for this. During the winter the situation gets

Table 3. Number of bacteria and fungi in the air of educational settings, according to literature data.

Place of sampling	Number of bacteria (CFU/m^3)	Number of fungi (CFU/m^3)	Reference number
Corridor	7700-8200		[18]
Laboratory room	1600-2000	160-780	[18]
School rooms	100-1000		[11]
Lecture room		493	[7]
Laboratory room		450	[7]
Corridor		1415	[7]
Classrooms	75-56,000	23-1400	[20]
School rooms	0-5900 (11,000*)	0-550 (950*)	[13]

* moisture-damaged schools

Table 4. Range of quantity of bacteria and fungi in various educational rooms (results from this study).

Kind of microorganisms	Number of microorganisms (CFU/m^3)
Mesophilic bacteria	340-7530
Staphylococci	25-475
Coli-group bacteria	0-45
Haemolytic bacteria	5-35
Fungi	30-785

worse because of the lowered air exchange in classs-room due to thermal comfort prevention.

Results of this study confirm the considerable microbial contamination of most investigated school settings. It should be emphasized that a real hazard of such pollution levels may be more serious because there are suggestions that in some cases the level of total bacteria may be even up to 5-times higher then the number of culturable bacteria determined as CFU/m^3 [20]. Numbers of bacteria from various groups (coli-group, haemolytic, staphylococci) may be different in individual objects, which should be considered in the scope of microbiological analyses.

It's clear that high contamination of indoor air at schools poses a serious problem both from the point of view of health protection and environmental engineering. It proves that it's necessary also to develop the standards of indoor air quality related to microbial pollution for educational settings.

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