INDOOR AIR QUALITY IN PRIMARY SCHOOLS

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ABSTRACT

The objective of this paper was to verify that problem of indoor air pollution is present in primary school in Yugoslavia.Indoor air pollutant levels of sulfur-dioxide, soot, nitrogen dioxide, carbon monoxide and formaldehyde, and air-microflora was determined in different places of school environment.The average indoor level of sulphur dioxide and soot in primary schools were comparatively high. Determined average levels of carbon monoxide were from 13.2 - 31.8 mg/m^3, levels of nitrogen dioxide were 20 - 62 μg/m^3 and levels of formaldehid : 0.01 - 0.83 μg/m^3 . Most frequently identified pathogenic microorganisms were *E. coli, Staphilococcus aureus*, *Streptococcus haemoliticus* and fungi and molds . In both schools more than 50% of the samples contained innumerable bacteria in m^3 of the air.Indoor air pollution in Yugoslav primary schools can be hazardous to pupils' health in regard to microbiological and chemical agents. It is necessary to establish Yugoslav standards of indoor air quality.

KEYWORDS: IAQ assessment, formaldehyde, nitrogen dioxide, carbon monoxide, sulphur dioxide, schools

INTRODUCTION

Children's exposure to air pollution are likely to be much greater than adult's for several reasons [2] and according to air quality monitoring network , most of the urban inhabitants in Niš breath air which is not clean [4]. We also know that the air quality in an indoor space depends on the outdoor air quality [6,7] . Unfortunately, there are no Yugoslav indoor air quality criteria and guidelines and only a few studies were investigated indoor air quality and health aspects of this.
The objective of this paper was to determine the exposure of schoolchildren to different air pollutants in primary schools in order to assess of the adverse health effects associated with them.

METHODS

Investigation was done in two primary schools in the town of Niš . The first school is placed in the industrial zone, near the busy street and this place is Niš' "black point" of air pollution. School number 2 is placed out of industry and traffic, enclosed with vegetation, with levels of ambient air pollutants below the limit values.
The samples of the air were taken in classrooms, passages and schoolyards. In the first school they use central heating, and in the second school - tile stoves. The sampling lasted continually 20 days in the cold period in winter.
We determinated the levels of sulphur dioxide, soot, carbon monoxide, nitrogen dioxide and formaldehyde in indoor air, and microbial air quality also.

The concentration of sulphur dioxide in the air was determined by acidimetry and ambient level of soot in the air was obtained by refractometry. Nitrogen dioxide, carbon monoxide and formaldehyde were determined by spectrophotometry.
The results of the measurements are presented as mean values of 24-hour concentrations.
Microbial growth was determined after the aspiration of the air through the liquid dextrose bouillon by standard microbical techniques.

RESULTS

The results are shown on the tables 1-5.

Table 1. Average daily levels of sulphur dioxide in two primary schools

Place of measurement	C_{avg} ($\mu g/m^3$)	SD	Min	Max	N
Classroom[1]	25	49.7	0	121	20
Classroom[2]	0	1.16	0	11	20
Schoolhall[1]	45	62.8	0	130	20
Schoolhall[2]	0	4.7	0	23	20
Schoolyard[1]	188	68.4	10	416	20
Schoolyard[2]	17	14.2	0	61	20

C_{avg} = average concentration
[1]school number 1 in polluted area
[2]school number 2 in non-polluted area

Table 2. Average daily levels of soot in two primary schools

Place of measurement	C_{avg} ($\mu g/m^3$)	SD	Min	Max	N
Classroom[1]	39	51	0	131	20
Classroom[2]	5	13.8	0	29	20
Schoolhall[1]	51	93.9	0	210	20
Schoolhall[2]	4	16.5	0	41	20
Schoolyard[1]	85	44.9	0	196	20
Schoolyard[2]	1	11.5	0	29	20

[1]school number 1 in polluted area
[2]school number 2 in non-polluted area

Table 3. Average daily levels of carbon monoxide in two primary schools

Place of measurement	C_{avg} ($\mu g/m^3$)	SD	Min	Max	N
Classroom[1]	15.7	9.3	6	27.6	20
Classroom[2]	13.2	7.6	25	43	20
Schoolhall[1]	31.8	7.4	24	42	20
Schoolhall[2]	31.5	9.1	10.2	26.7	20
Schoolyard[1]	19.9	11	10.1	24.7	20
Schoolyard[2]	0	0.2	0	1	20

[1]school number 1 in polluted area
[2]school number 2 in non-polluted area

Table 4. Average daily levels of nitrogen dioxide in two primary schools

Place of measurement	C_{avg} ($\mu g/m^3$)	SD	Min	Max	N
Classroom[1]	25	44.3	1	141	20
Classroom[2]	20	10.5	0	38	20
Schoolhall[1]	62	45.6	0	160	20
Schoolhall[2]	37	31.9	0	56	20
Schoolyard[1]	35	15.8	0	75	20
Schoolyard[2]	25	13.7	1	44	20

[1]school number 1 in polluted area
[2]school number 2 in non-polluted area

Table 5. Average daily levels of formaldehyde in two primary schools

Place of measurement	C_{avg} ($\mu g/m^3$)	SD	Min	Max	N
Classroom[1]	0.8	9.3	0	27.6	20
Classroom[2]	0.03	7.6	0	0.1	20
Schoolhall[1]	0.01	14.2	0	0.2	20
Schoolhall[2]	0.02	4.7	0	0.1	20
Schoolyard[1]	0.1	5.3	0	0.5	20
Schoolyard[2]	0.03	5.6	0	0.1	20

[1]school number 1 in polluted area
[2]school number 2 in non-polluted area

DISCUSSION

The average daily concentration of sulphur dioxide and soot were significantly higher in the school which is placed in the industrial zone than in the school from non-polluted area. The correlation in daily air pollution concentrations were high between indoor and outdoor ambient. It is at first surprising that the level of soot tended to be higher in the classroom and hall than in schoolyard in school from non-polluted area. A possible reason could be using the tile stoves for heating.

The mean indoor daily level of nitrogen dioxide was 25-62 $\mu g/m^3$ in the polluted area and 20-37 $\mu g/m^3$ in non-polluted area.These results give further evidence that indoor influences nitrogen dioxide are 40-50% of outdoor concentrations in the absence of additional indoor sources [1].Higher levels of nitrogen dioxide were not determined in the schoolyard, but in the hall of the school number 2 because the tile stoves fireboxes are placed there. These levels could slight changes in lung function in asthmatic children or play a role in causes of the "sick" building syndrome [1].

The indoor level of carbon monoxide presented in this study (13.2-318 $\mu g/m^3$) were higher than expected . The level of carbon monoxide > 29 $\mu g/m^3$ during 2-hour exposure increases the level of carboxi-haemoglobin in blood [1,3] and could endanger pupils' health. The level of carbon monoxide is high in school which gets warm by tile stoves, as well as in the first school, because of busy street and could affects childrens' health..

The level of formaldehyde in the schools was below the critical values, maybe because there was no new construction materials and furnishing. However,the concentrations over 0.1 $\mu g/m^3$ could influence nose nad throat irritation in children [1].

The results present that there are high level of microbial pollution in both schools.Health risks from microbiological contamination of the air are related to the contageous and allergenic consequences [1,3]. Since there are no regulations in this field, those samples which contained pathogenic microorganisms , as well as samples with innumerable microorganisms in m^3 , inspite their pathogenic qualities, were considered incorrect.

Most frequently identified non-saphrophit bacteria were *E. coli, Staphilococcus aureus, Streptococcus haemoliticus, Streptococcus faecalis and B. subtilis.* There were also identified fungus and mold *Aspergillus, Candida , Mucor, Phoma* and *Rhizopus sp.*
In both schools more than 50% of the samples contained innumerable bacteria in m^3 of the air.

They were too high taking in consideration the fact that children are more sensitive to harmful particles from the air than adults and that they spend a few hours a day at school. Former studies have suggested that air pollution is associated with respiratory health, especially among children who suffer from asthmatic symptoms [5]. It is advisable to install modern air devices in classroom facing busy streets.

Although the number of samples was small, the results certainly indicate that there is a problem of indoor air pollution in Yugoslav primary schools and that it is necessary for this problem to be legally regulated . For analysing health effects , the incidence and prevalence of respiratory symptoms and morbidity is further information on these is of the primary importance.

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