INDOOR AIR QUALITY OF THE OFFICE BUILDINGS

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Summary

Growing attention is being paid to indoor air quality as one of the main health and well-being factors, also in Slovakia. The Building and Environmental Engineering Institute is concerned to indoor sciences research work within indoor environmental engineering orientation of the structural architecture. The indoor air quality research activities are oriented to indoor architecture, indoor materials and indoor technologies. The main subject of the last period interest is and the materials emissions. It has become evident that building materials are the major source of indoor volatile organic compounds. The indoor air acceptability and indoor air quality in office building concerning to several types of interior materials are presented in this case study. Today's interior, however, take into account primarily aesthetics, durability, availability and economy. Comparing performed by chemical analysis and sensory tests using the test chamber. The results of these tests show negative proposals for the interior office space and to encourage favorable design solutions. The article presents variety combinations of materials, simulating that positively affect on the interior environmental quality.

Keywords: Indoor quality, materials, odors, TVOCs

1 Introduction

Indoor environment especially concerning to interior architecture affect us not only by their mass, surfaces, color and shapes. Indoor surfaces mostly emit the volatile organic compounds (VOCs) which have great impact on human beings. Therefore, the question of selection materials and surfaces plays an important role. Several office interior surfaces emissions are compared in this study. Results are reviewed related to current European standards. The impact of individual material surfaces and their interaction effect to the indoor air quality will be discussed within the paper. The materials combinations regarding to their emissions are reviewed to indoor air quality criteria. Research also points to indoor material combinations, which should not be used indoors.

Methodology of material comparison is based on the volume of volatile organic compounds (VOCs) in the air. In these chemical measurements testing of total volatile organic compounds (TVOCs) concentration and are carried. Total volatile organic compounds TVOCs from building materials may not bother the users of buildings but can cause serious health problems. Not only by various new materials, but also their suitable aimed combination the better indoor environmental quality can be achieved. The materials combinations regarding to their emissions are reviewed to indoor air quality criteria. Research also points to indoor material combinations, which should not be used indoors.

Nowadays, the buildings are divided into: very low-polluting, low polluting and not low polluting. The classification of buildings is affected by the approach in selecting low emitting materials and restricting activities that emit pollutants into the environment of buildings. The interior material emissions affect the indoor chemical concentrations level.

The buildings are divided by percentage of odor dissatisfied into: very low-polluting (percentage of dissatisfied is under 10 %) and low polluting (percentage of dissatisfied is under 15 %) [1, 2].

The impact of selected indoor surface materials for various offices on indoor TVOCs concentrations are observed in presented study. The office interior material surfaces (No 1) are fitted out with polyamide carpet flooring covering, the painted gypsum boards for walls and ceiling was used. Flooring layer surface covering of office interior surfaces (No 2) are presented by wooden parquet, walls and ceiling layer surface covering are presented by painted gypsum boards. The office interior material surfaces (No 3) are presented by PVC flooring covering, painted gypsum boards covering for walls and also for ceiling surface was used (**Tab. 1**).

Tab. 1 Selected office material surfaces

Interior	**Office 1**	**Office 2**	**Office 3**
Flooring	Polyamide carpet	Wooden parquet	PVC
Wall covering	Painted gypsum boards	Painted gypsum boards	Painted gypsum boards
Ceiling	Painted gypsum boards	Painted gypsum boards	Painted gypsum boards

2 Chemical measurement and sensory assessments

2.1 Methodology of sensory assessments

Methodology of sensory assessments is based on analysis the exhaust air from test chamber. An untrained sensory panel of 20 subjects analyzed through the diffuser exhaust air. Before the first assessment the panels were instructed how to use the scale and the exposure equipment. The age of sensory panel ranged between 24 and 54 years and average age was 30,06. Sensory untrained panel represented 65 percent nonsmokers, 35 percent smokers, 70 percent were women and 30 percent were men.

The sensory assessments of emissions from building material surfaces and their combinations was studied in a test chamber (volume of 240 l of dimensions 0,8 x 0,6 x 0,5 m). Air exchange rate 0,5 1/h and temperature 23 °C in test chamber was set. Before the tests, the chamber was cleaned and the background sensory assessment in an empty chamber operated under the same conditions as during the emission test was investigated. The impact of individual materials and their interaction effects to the perceived air quality will be discussed within the paper. After air samples analysis from the test chamber sensory panel evaluated two continuous scales regarding odour intensity (**Fig. 1**) and acceptability of the air (**Fig. 2**) [3].

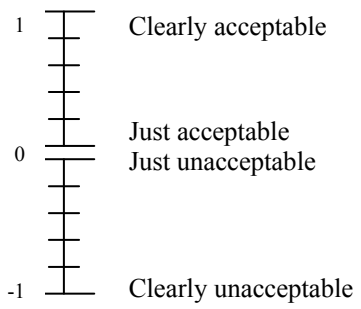

Fig. 1 Acceptability scale [3]

0	No odor
1	Slight odor
2	Moderate odor
3	Strong odor
4	Very strong odor
5	Overwhelming odor

Fig. 2 Odor intensity scale [3]

2.2 Methodology of chemical measurements

Methodology of materials comparison is based on the volume of total volatile organic compounds (TVOCs) in the air. The volume of emissions from building materials and their combinations was studied in a test chamber (volume of 240 l of dimensions 0,8 x 0,6 x 0,5 m). Air exchange rate 0,5 1/h and temperature 23 °C in test chamber was set. Before the tests, the chamber was cleaned and the background sensory assessment in an empty chamber operated under the same conditions as during the emission test was investigated [4].

Then, were subsequently evaluated the material surfaces combinations used in the interiors of three different offices, in the time interval 3 days. In this interval, there are significant changes in TVOCs concentrations in considered interior. First the material samples were collected from the administrative building interiors in low-emitting foil. Subsequently, the samples were deposited into research conditions into test chamber for 48 hours. After this time, we engage sorption tube and another 24 hours we collected air samples from the test chamber. Subsequently, air samples taken from the test chamber were processed in the laboratory and volume of individual pollutants were evaluated. The results were compared with European standards.

3 Chemical and sensory emissions measurements results

Perceived air quality is based on the odor scales considered acceptable, if the average assessed acceptability of indoor air is greater than 0 and odor intensity is less than 2. Both criteria are rated in the same time. Percentage dissatisfied and the perceived indoor air quality is determined by odor acceptability scale in the room and by Fangers and Gunnarsens formula (**Fig. 3**) [3].

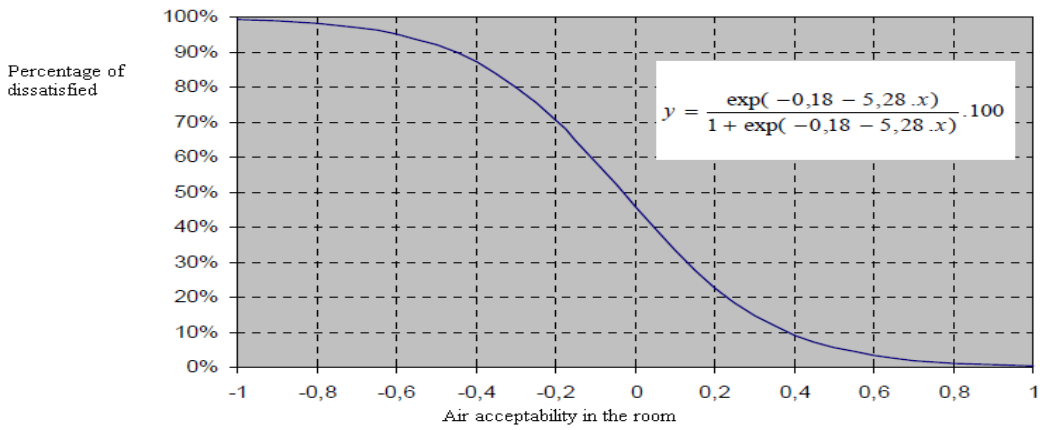

Fig. 3 Fangers and Gunnarsens graph and formula [3]

3.1 Sensory measurements results

Offices No.1 indoor air quality is represented by the percentage of dissatisfied by 60 %. This office interior thanks to higher percentage of dissatisfied does not meet the criteria of perceived indoor air quality. Odor acceptability -0,25 and odor intensity 1,0625 was achieved by polyamide carpet flooring covering (**Tab. 2**). Painted gypsum boards for wall and ceiling covering was presented by 0,1 odor acceptability and 2 odor intensity (**Tab. 2**).

Tab. 2 Office No. 1 odor charakteristic

Constructions	Material	Odor acceptability (-1/+1)	Odor intensity (0-5)
Flooring	Polyamide carpet	-0,25	1,0625
Wall covering	Painted gypsum boards	0,1	2
Ceiling	Painted gypsum boards	0,1	2
Combination		-0,123	1,6154

Office interior emissions (No. 1) of material surfaces constitute an unacceptable perceived indoor air quality conditions. Odor acceptability -0,123 and odor intensity 1,6154 were evaluated in the case of this interior (**Fig. 4**, **Fig. 5**).

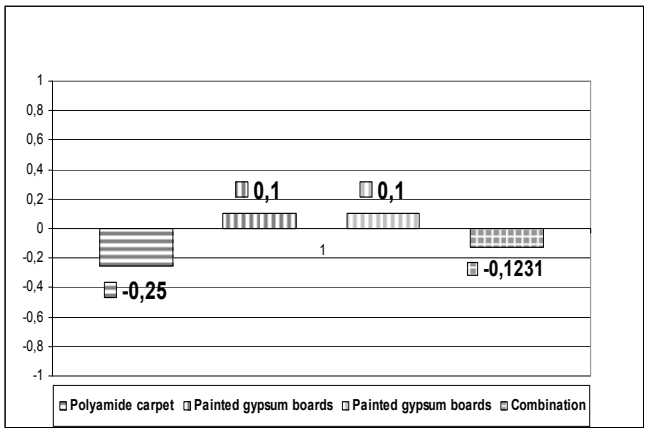

Fig. 4 Office No. 1 odor acceptability

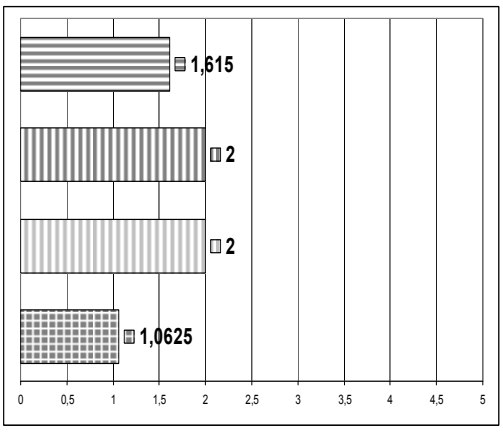

Fig. 5 Office No. 1 odor intensity

Offices No.2 indoor air quality is represented by the percentage of dissatisfied by 25 %. This office interior thanks to higher percentage of dissatisfied does not meet the criteria of perceived indoor air quality. Odor acceptability 0,667 and odor intensity 1,4167 was achieved by wooden parquet flooring covering (**Tab. 3**). Painted gypsum boards for wall and ceiling covering was presented by 0,1 odor acceptability and 2 odor intensity (**Tab. 3**).

Tab. 3 Office No. 2 odor charakteristic

Constructions	Material	Odor acceptability (-1/+1)	Odor intensity (0-5)
Flooring	Wooden parquet	0,667	1,4167
Wall covering	Painted gypsum boards	0,1	2
Ceiling	Painted gypsum boards	0,1	2
Combination		0,18	1,3

Office interior emissions (No. 2) of material surfaces constitute an acceptable perceived indoor air quality conditions. Odor acceptability 0,18 and odor intensity 1,3 were evaluated in the case of this interior (**Fig.6**, **Fig. 7**).

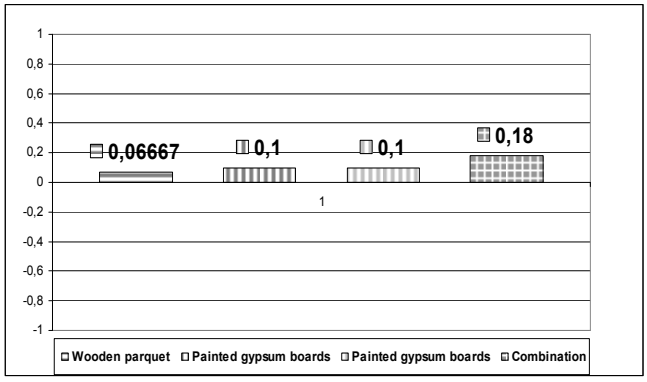

Fig. 6 Office No. 2 odor acceptability

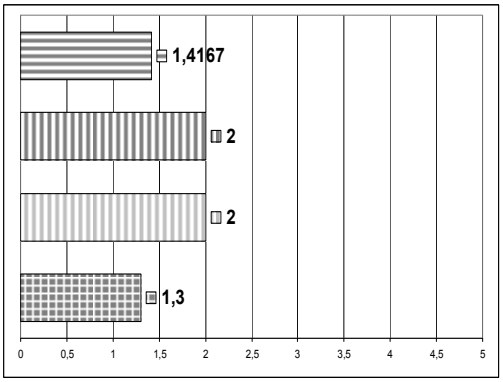

Fig. 7 Office No. 2 odor intensity

Offices No.3 indoor air quality is represented by the percentage of dissatisfied by 48 %. This office interior thanks to higher percentage of dissatisfied does not meet the criteria of perceived indoor air quality. Odor acceptability 0,0875 and odor intensity 1,125 was achieved by PVC flooring covering (**Tab. 4**). Painted gypsum boards for wall and ceiling covering was presented by 0,1 odor acceptability and 2 odor intensity (**Tab. 4**).

Tab. 4 Office No. 3 odor characteristic

Constructions	Material	Odor acceptability (-1/+1)	Odor intensity (0-5)
Flooring	PVC	0,0875	1,125
Wall covering	Painted gypsum boards	0,1	2
Ceiling	Painted gypsum boards	0,1	2
Combination		-0,072	1,727

Office interior emissions (No. 3) of material surfaces constitute an unacceptable perceived indoor air quality conditions. Odor acceptability -0,072 and odor intensity 1,727 were evaluated in the case of this interior (**Fig. 8, Fig. 9**).

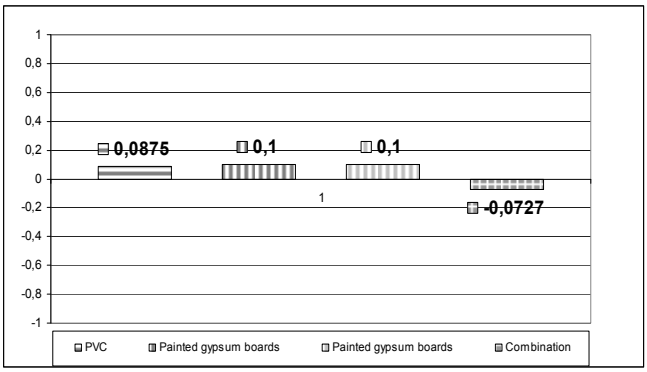

Fig. 8 Office No. 3 odor acceptability

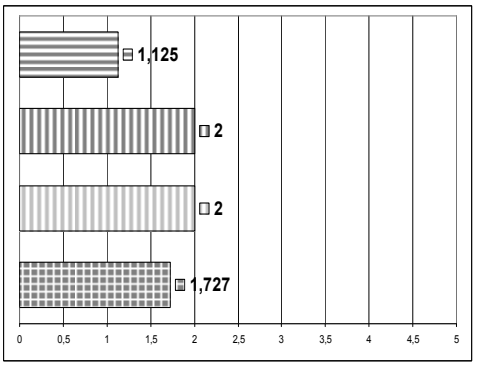

Fig. 9 Office No. 3 odor intensity

3.2 Chemical measurements results

Measured TVOCs emissions of office interior (No. 1) material surfaces met the criteria of very low-polluting materials. The emissions concentration was below estimated limit 0,1 mg/m^{2}h. The highest emissions concentration 0,013 mg/m^{2}h of painted gypsum boards were measured and the emissions 0,007 mg/m^{2}h of polyamide carpet flooring covering were obtained. TVOCs emissions concentration of this interior combinations under air change rate 0,5 1/h represent value 0,008 mg/m^{2}h (**Tab. 5**).

Tab. 5 Office No. 1 TVOCs emissions

Constructions	**Material**	**TVOCs (mg/m^{2}h)**	**TVOCs (µg/m^3)**
Flooring	Polyamide carpet	0,007	9,7
Wall covering	Painted gypsum boards	0,013	18,1
Ceiling	Painted gypsum boards	0,013	18,1
Combination		0,008	11,1

Emissions of office material surfaces (No. 1) also met the limit value 200 µg/m^3. TVOCs emissions concentration under air change rate 0,5 1/h represent value 11,1 µg/m^3. The highest emissions concentration 18,1 µg/m^3 of painted gypsum boards were obtained, the emissions 9,7 µg/m^3 of polyamide carpet were measured (**Fig. 10, Fig. 11**).

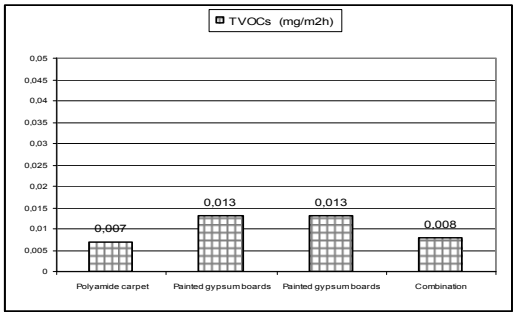

Fig. 10 Office No. 1 TVOCs (mg/m^{2}h) emissions

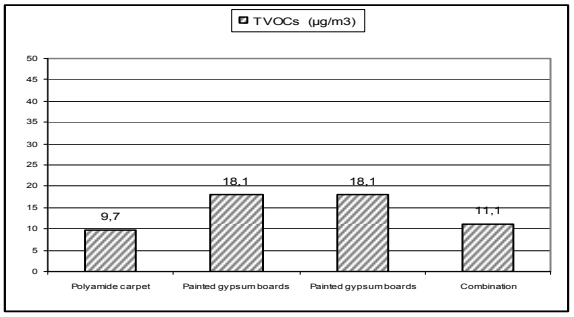

Fig. 11 Office No. 1 TVOCs (µg/m^3) emissions

Measured TVOCs emissions of office interior (No. 2) material surfaces met the criteria of very low-polluting materials. The emissions concentration was below estimated limit 0,1 mg/m^{2}h. The highest emissions concentration 0,013 mg/m^{2}h of painted gypsum boards were measured and the emissions 0,005 mg/m^{2}h of wooden parquet flooring covering were obtained. TVOCs emissions concentration of this interior combinations under air change rate 0,5 1/h represent value 0,007 mg/m^{2}h (**Tab. 6**).

Tab. 6 Office No. 2 TVOCs emissions

Constructions	**Material**	**TVOCs (mg/m^{2}h)**	**TVOCs (µg/m^3)**
Flooring	Wooden parquet	0,005	7,5
Wall covering	Painted gypsum boards	0,013	18,1
Ceiling	Painted gypsum boards	0,013	18,1
Combination		0,007	9,7

Emissions of office material surfaces (No. 2) also met the limit value 200 µg/m^3. TVOCs emissions concentration under air change rate 0,5 1/h represent value 9,7 µg/m^3. The highest emissions concentration 18,1 µg/m^3 of painted gypsum boards were obtained, the emissions 7,5 µg/m^3 of wooden parquet were measured (**Fig. 12, Fig. 13**).

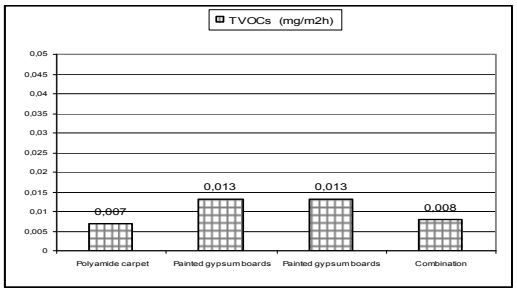

Fig. 12 Office No. 1 TVOCs (mg/m^{2}h) emissions

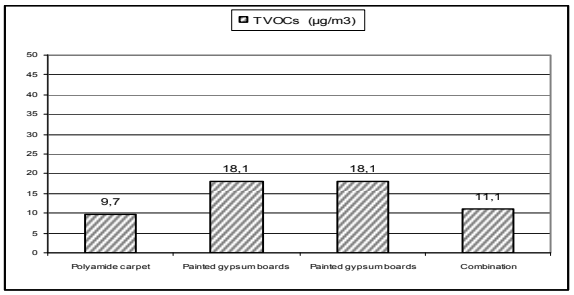

Fig. 13 Office No. 1 TVOCs (µg/m^3) emissions

Measured TVOCs emissions of office interior (No. 3) material surfaces met the criteria of very low-polluting materials. The emissions concentration was below estimated limit

0,1 mg/m^{2}h. The highest emissions concentration 0,029 mg/m^{2}h of PVC flooring covering were measured and the emissions 0,013 mg/m^{2}h of painted gypsum boards were obtained. TVOCs emissions concentration of this interior combinations under air change rate 0,5 1/h represent value 0,015 mg/m^{2}h (**Tab. 7**).

Tab. 7 Office No. 3 TVOCs emissions

Constructions	**Material**	**TVOCs (mg/m^{2}h)**	**TVOCs (µg/m^3)**
Flooring	PVC	0,029	40,3
Wall covering	Painted gypsum boards	0,013	18,1
Ceiling	Painted gypsum boards	0,013	18,1
Combination		0,015	22,5

Emissions of office material surfaces (No. 3) also met the limit value 200 µg/m^3. TVOCs emissions concentration under air change rate 0,5 1/h represent value 22,5 µg/m^3. The highest emissions concentration 40,3 µg/m^3 of PVC flooring covering were obtained, the emissions 18,1 µg/m^3 of painted gypsum boards were measured (**Fig. 14, Fig. 15**).

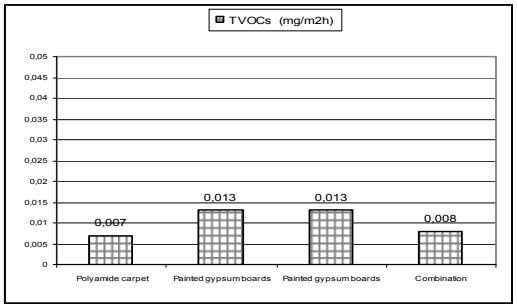

Fig. 14 Office No. 1 TVOCs (mg/m^{2}h) emissions

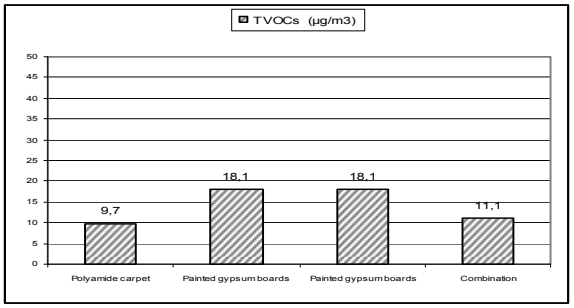

Fig. 15 Office No. 1 TVOCs (µg/m^3) emissions

4 Conclusions

The results demonstrate the sorption ability of material combinations and different chemical reactions in the indoor offices air. In the case of painted gypsum boards odor acceptability and odor intensity represented more acceptable results than the results of chemical testing. Odour acceptability of polyamide carpet and office material surfaces combination (No. 1) did not reach acceptable values. In the case of office (No. 3) PVC flooring covering meet the odor acceptability criteria but office material surfaces combination did not reach acceptable values. Chemical measurement tests confirmed the results of the least acceptable office material surfaces combination (No. 3). Results of sensory assessment of various materials and the office material surfaces combination has been confirmed by the chemical measurements.

The most acceptable TVOCs emissions concentration meet Office interior (No. 2) with wooden parquet floor covering, painted gypsum boards walls and ceiling covering.

The most unacceptable TVOCs emissions concentration reached Office interior (No. 3) with PVC floor covering, painted gypsum boards walls and ceiling covering.

It is better to be exposed with high TVOCs concentrations for short time that with low concentrations in long time period from health and well-being aspect. Therefore, the decisive factor for healthy interior architecture is not actual TVOCs concentration, but predicted TVOCs concentrations for long indoor using time.

Nowadays, research of these and other effects of the TVOCs combination concentrations in the interior will help us in ensuring better indoor air quality and allowed to set limits, which will guarantee the environment quality limits of indoors.

References

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