

# Indoor air quality and job satisfaction in open plan offices with textile flooring

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## SUMMARY

The popularity of open plan offices has contributed to the increased use of textile flooring. Studies considering novel textile flooring materials are scarce. In this study, indoor air quality (volatile organic compounds, formaldehyde, and inhalable dust) was monitored, and a job satisfaction survey was conducted in the open plan offices with textile and hard flooring during summer and winter. The indoor air measurements showed low concentrations in both types of offices. Regarding the job satisfaction survey, the respondents in the offices with textile flooring reported to be more satisfied with their workspace, whereas in the offices with hard flooring, the respondents were more satisfied at their work.

## KEYWORDS

carpet, dust, emission, VOC, well-being at work

## 1 INTRODUCTION

In recent years, open plan offices have become more common, which has led to an increased use of textile flooring. There is a lack of research regarding novel textile flooring materials. In this work, the aim was to investigate whether there are differences in indoor air quality (volatile organic compounds, formaldehyde, inhalable dust) and the job satisfaction of employees in open plan offices with modern textile flooring compared to offices with hard flooring.

## 2 MATERIALS/METHODS

This study included four open-plan offices: two with modern textile flooring (recently renovated) and two with hard flooring (older offices). Indoor air measurements (volatile organic compounds (VOCs), formaldehyde, inhalable dust) and job satisfaction survey were conducted in the offices twice (winter and summer). The VOCs were collected with Tenax TA adsorbent tubes and pumps (SKC 3000 and 222). The samples were analysed with a gas chromatograph equipped with a mass selective detector connected to a thermal desorber (TD-GC-MS). The VOCs were determined as toluene equivalents. Formaldehyde samples were collected with DNPH samplers. The analysis of the samples was conducted with a liquid chromatograph equipped with a tandem mass spectrometer (LC-MS/MS). Inhalable dust samples were collected gravimetrically using IOM samplers. The job satisfaction questionnaire was based on two previous studies (Sakellaris et al. 2016; Otterbring et al. 2018) and included questions about satisfaction at work (feeling at an office) and a workspace. Rating scales were the same as the ones used in the previous questionnaires: -4...+4 and 1-7 (+4 and 7 corresponding to "very satisfied").

## 3 RESULTS/DISCUSSION

The total volatile organic compound (TVOC) concentrations ranged 20–250  $\mu\text{g}/\text{m}^3$  and 20–180  $\mu\text{g}/\text{m}^3$  in the offices with textile and hard flooring, respectively. The most common compounds in the offices with textile flooring were  $\alpha$ -pinene, carboxylic acid esters,

caprolactam, decamethylcyclopentasiloxane (D<sub>5</sub>), nonanal, and decanal. In the offices with hard flooring, D<sub>5</sub>, nonanal, and decanal were the most common compounds. Plausible sources for these compounds were, e.g., cleaning/personal care products and building materials. The formaldehyde concentrations were low in the offices; 6–30 µg/m<sup>3</sup> (textile flooring) and 5–16 µg/m<sup>3</sup> (hard flooring). The Finnish limit value for annual average formaldehyde concentration indoors is 50 µg/m<sup>3</sup> (Finnish Ministry of Social Affairs and Health 2015). A slight difference in the formaldehyde concentrations during summer and winter was observed, which might be attributed to seasonal variation in oxidation reactions in the atmosphere and indoors (Viskari et al. 2000; Lui et al. 2017). The inhalable dust concentrations were also low in the offices, 3–27 µg/m<sup>3</sup> (textile flooring) and 2–24 µg/m<sup>3</sup> (hard flooring). The Finnish limit value for respirable dust (PM<sub>10</sub>) in residential buildings during a 24-hour measurement is 50 µg/m<sup>3</sup> (Finnish Ministry of Social Affairs and Health 2015).

A total of 28 and 20 responses were received for the job satisfaction questionnaire from the offices with textile and hard flooring, respectively. Regarding satisfaction at work and the workspace, over 60% of the respondents were at least “rather satisfied” (corresponding to the ratings of +2 and 5) in both types of offices. The respondents in the offices with hard flooring reported to be more satisfied at their work (higher percentage of the ratings of 2–4 on average), which is likely attributed to a situation at a workplace (mood, work tasks, etc.). On the contrary, the respondents in the offices with textile flooring were more satisfied with their workspace (higher percentage of the ratings of 5–7 on average), which might be explained by more modern office facilities. The results did not differ greatly between summer and winter.

#### 4 CONCLUSIONS

There were no significant differences in the TVOC concentrations between the office types. However, the composition of the TVOCs differed. In the offices with textile flooring, greater number of compounds at slightly elevated concentrations were observed, which might be attributable to the fact that the offices with textile flooring were recently renovated. The formaldehyde and inhalable dust concentrations did not differ greatly between the office types. The higher percentage of the respondents were satisfied at their work in the offices with hard floor covering, whereas the respondents in the offices with textile flooring reported to be more satisfied with their workspace.

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