I-CUB: 'Indoor Climate-Users-Buildings': Relationship between measured and perceived indoor air quality in dwellings

I-CUB: 'Indoor Climate-Users-Buildings': Relationship between measured and perceived indoor air quality in dwellings

Sarka Langer[1,2], Theofanis Psomas[2] and Despoina Teli[2]

[1]IVL Swedish Environmental Research Institute, P.O. Box 53021, SE-400-12 Göteborg, Sweden
[2]Division of Building Services Engineering, Department of Architecture and Civil Engineering, Chalmers University of Technology, SE-412 96, Göteborg, Sweden

sarka.langer@ivl.se

Abstract. Assessment of indoor environmental quality has recently moved to a combined methodology of both measurements and questionnaire surveys. In this study, we have used data from the national survey of the Swedish housing stock, BETSI, conducted in 2007/2008, during the heating season. The study included, among others, measurement of selected indoor air pollutants and an extensive questionnaire survey on the occupants' perception of their dwellings. Measured concentrations of the air pollutants NO_2, TVOCs and formaldehyde were aggregated into one Indoor Air Pollution Index (IAPI) on a continuous scale between 0 (excellent Indoor Air Quality; IAQ) and 10 (poor IAQ). The perceived IAQ was assessed by the occupants on a 5-point category scale from very good to very poor. On the entire scale of IAPIs, 92% of the respondents in single-family houses perceived the IAQ as very good or good and 8% as acceptable, while in the apartments, the ratings 'very good' and 'good' accounted for 58%, acceptable for 33% and 9 % for 'poor' and 'very poor', respectively. In both building types, the tendency of IAPIs was shifted to lower values (good IAQ). Analysis of IAPI-medians showed no statistically significant differences between and among the air quality perception ratings.

1. Introduction

The Swedish National Board of Housing, Building and Planning (Boverket) performed a national survey of the Swedish housing stock BETSI (Buildings, Energy consumption, Technical Status and Indoor environment). The survey consisted of inspections of almost 1,400 dwellings divided to single-family houses and apartments in multi-family houses in the heating season of 2007/2008, as well as a questionnaire survey about the occupants' perception of their homes and health symptoms later in the spring of 2008. Results of the technical aspects and overall summary of the responses from the questionnaires were compiled [1,2]. All data from the survey were made available for in-depth analysis to interested researchers and various correlations were examined and the results were published, e.g. [3-6].

In this study, the research team investigates the association, not previously considered, between the measured concentrations of the indoor air pollutants NO_2, TVOCs and formaldehyde, aggregated into one index, and the occupants' responses on perceived indoor air quality (IAQ) in their homes.

2. Methods

The concentrations of the air pollutants (continuous scale) were aggregated into one Indoor Air Pollution Index (IAPI) in a similar way as described in [7]. The IAPI is a unitless number which can score values between 0 (best IAQ) and 10 (worst IAQ).

The questionnaires were sent separately to randomly selected inhabitants of Sweden two months after the BETSI survey took place, with some overlap with the surveyed dwellings. The question about the perceived IAQ: What do you think, in general, about air quality in your dwelling? was answered on a five-point category scale: very good - good – acceptable – poor – very poor.

The index was divided into bins separated by one (e.g. (0-1), (1-2), ..., (9-10)) and the frequency of every response was calculated within each bin, for the five categories of responses. All data distributions were treated statistically to find if the differences between the samples were significant or not. Mann-Whitney U-test for equal medians was used for the statistical analysis.

3. The sample

From the total number of 1,400 surveyed dwellings, the measurements of the indoor air pollutants were conducted in a subsample of 157 single-family houses and 148 apartments in multifamily houses. The questionnaires, 156 from the single-family houses and 338 from the apartments, were filled in by 1 or 2 adult occupant(s) per dwelling. Missing values of the concentrations of one or more air pollutants and inconsistencies between the dwellings with measurements but without responses, and vice versa, reduced substantially the size of the sample available for the analysis. The sample of valid pairs of measurements and responses finally consisted of only 145 responses from 77 single-family houses and 76 responses from 58 apartments.

4. Results and discussion

Figure 1 shows the frequency distributions of the IAPI in the index bins for the five assessment categories of perceived IAQ in the dwellings. Analysis of the relationship between the IAPI and the perception showed that 92% of the respondents in single-family houses perceived the IAQ as very good or good and 8% as acceptable, regardless the IAPI value. In the apartments, the ratings ‘very good’ and ‘good’ accounted for 58% of the responses, 33% voted ‘acceptable’ and 9 % for ‘poor’ and ‘very poor’. For both types of dwellings, the distributions of IAPIs were shifted to lower values (good IAQ). This means that the aggregated indoor air quality indicator, based on the individual measured pollutants from the national survey, cannot represent the occupants’ perception in their homes.

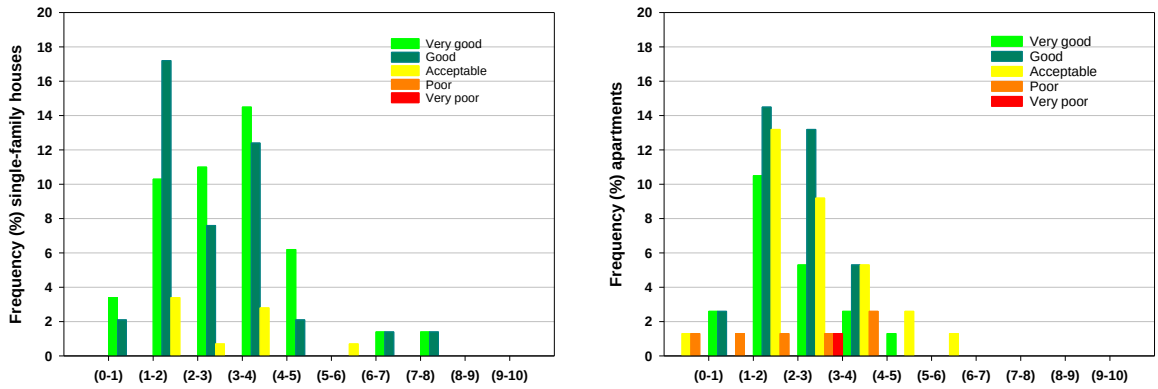

Figure 1. Frequency histograms of IAPIs with occupants’ perceptions for single-family houses (left) and apartments (right).

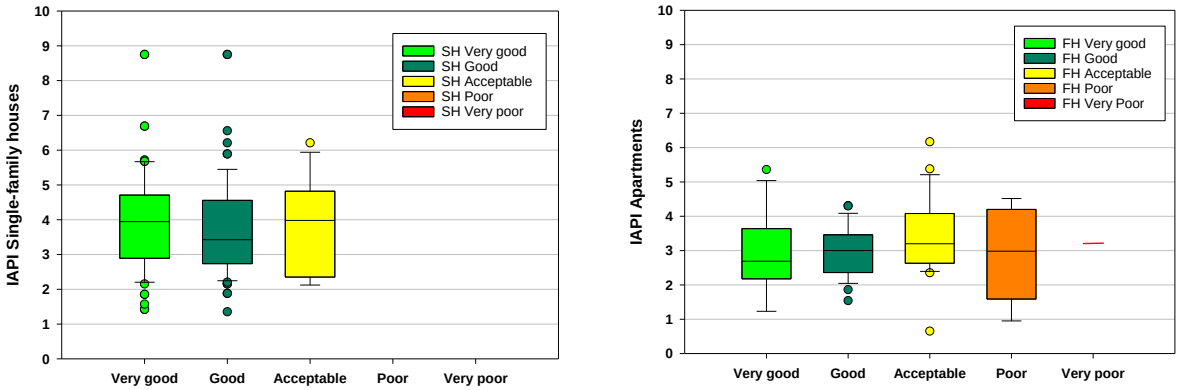

Figure 2. Boxplots showing the IAPI for single-family houses (left) and apartments (right) according to the rating categories.

The differences in the medians of IAPIs for each rating category were tested for statistical significance, separately for the single-family houses and apartments, figure 2. The p-values returned from the Mann-Whitney test were all in the range of 0.14 – 0.99. Analysis of IAPI-medians showed no statistically significant differences among the air quality perception ratings.

5. Conclusions

Occupants of apartments perceived the air quality worse than those in single-family houses. It was not possible to explain the occupants' rating of IAQ in their homes with the help of the Indoor Air Pollution Index. Possible reasons for the inconclusiveness may be the small size of the sample, the selected measured air pollutants (outside the authors' control), the inconsistent study design of the BETSI survey (measurements and questionnaires separated in time) or there are other aspects related to the occupants' perception of IAQ. In a similar extended French study [8], the occupants' perception of IAQ was affected by the presence of other indoor air pollutants (e.g., acrolein, tri- and tetrachloroethylene and PM_{10}) than those measured in BETSI.

References

[1] Boverket 2009 *The status of our houses. Så mår Våra Hus. Redovisning av Regeringsuppdrag Beträffande Byggnaders Tekniska Utformning m.m.* (in Swedish). Karlskrona, Sweden. ISBN pdf: 978-91-86342-29-6

[2] Boverket 2009 *Questionnaire survey about the occupants' perceived indoor environment and health symptoms. Enkätundersökning om boendes upplevda inomhusmiljö och ohälsa* (in Swedish). Karlskrona, Sweden. ISBN pdf: 978-91-86342-45-6

[3] Langer S and Bekö G 2013 Indoor air quality in the Swedish housing stock and its dependence on building characteristics. *Build Environ* **69** 44–54

[4] Zalejska-Jonsson A and Wilhelmsson M 2013 Impact of perceived indoor environment quality on overall satisfaction in Swedish dwellings. *Build Environ* **63** 134–44

[5] Mata É, Sasic Kalagasidis A and Johnsson F 2013 Energy usage and technical potential for energy saving measures in the Swedish residential building stock. *Energy Policy* **55** 404–14

[6] Wang J, Engvall K, Smedje G, Nilsson H and Norbäck D 2017 Current wheeze, asthma, respiratory infections, and rhinitis among adults in relation to inspection data and indoor measurements in single-family houses in Sweden - The BETSI study. *Indoor Air* **27** 725–36

[7] Moschandreas DJ and Sofuoglu SC 2004 The Indoor Environmental Index and Its Relationship with Symptoms of Office Building Occupants. *J Air Waste Manage* Assoc **54** 1440-51

[8] Langer S, Ramalho O, Le Ponner E, Derbez M, Kirchner S, Mandin C 2017 Perceived indoor air quality and its relationship to air pollutants in French dwellings. *Indoor Air* **27** 1168–76