

ASSESSMENT OF THE INTERNAL MICROCLIMATE USING THE QUESTIONNAIRES SURVEY

Abstract

This paper considers the subject of the applicability of survey research as an essential element for the assessment of the indoor microclimate. The results of the survey research are presented and compared with the experimental results performed in residential buildings.

Keywords: building physics, indoor air quality, indoor climate, questionnaire surveys

1. Introduction

Currently conducted studies to determine the quality of the indoor microclimate use systems based on advanced technological solutions. During the research, usually only a few basic parameters that describe the quality of the indoor environment are monitored and measured constantly. Additionally, measurements are used in a limited number of sensors that are placed at specific locations, and the measuring range is determined by the upper and lower detection limit. Therefore, each additional source of information about the state of the indoor environment can provide highly relevant data to analyze the quality of the indoor microclimate. Especially when it collects and analyzes data in a different manner than usually applied technological sensors (Table 1). One such source of information can be a questionnaire survey of flat-users. In conjunction

with the results of the measurement systems they create full spectrum of information on the quality of the internal microclimate. Surveys, in addition to the description of operation of the technical solutions used in the building, also give information on individual behavior and user experience [4].

2. Subject of research

The indoor microclimate affects thermal comfort of users [5] and, as a results, is a crucial factor. The study consisted of registration of changes of parameters describing the typical indoor climate. At the same time, among the dwelling users questionnaire surveys were performed. Then, the results of the study were compared with the results of measurement surveys. During a measurement study authors focused their attention on identifying the variability in parameters of indoor air. The measurements conducted during

Table 1. Comparison of the possibility of collecting information by users and sensors

Information source	
Buildings users	Sensors
It is possible to a large number of users	Number of sensors usually limited
Variable location	Fixed location
Receiving multiple signals at the same time	Limited number of measured parameters
A wide range of sensitivity	Fixed range
The possibility of mutual communication and exchange of information	The data transferred to the control or data recording
Possible large variation in sensitivity over time	The relatively small variation in sensitivity on time
The possibility of integration of multiple parameters	Usually ignore the impact of other parameters

the recording of the basic parameters describing the microclimate of premises: the concentration of carbon dioxide, temperature and relative humidity of the air. Measurements were carried out at the temperature of outside air -10°C to 0°C and the wind speed 0 to 6.5 m/s. In rooms where exhaust ducts were located the speed and direction of air flow through each ducts of the natural ventilation were also recorded. The analyzed parameters were measured for two weeks with measuring step of 30 minutes. For each apartment at least two series of measurements were done.

Buildings selected for the study were made in the traditional technology or big plates, which have walls warmed with styrofoam. All buildings are equipped with natural ventilation system. Based on the analysis of existing questionnaires sheets on indoor air quality (Table 2) the scope and subject of the questionnaire used in the study were defined. The survey contained 48 questions. It contained questions about thermal comfort, problems in the operation of natural ventilation and symptoms of SBS. Primary objective of the survey was to determine subjective assessment of indoor air quality. Also identified was the knowledge level of users on the development of indoor air quality and its impact on the mood of the inhabitants.

Table 2. The number of questions in each thematic groups in the questionnaires of air quality

Questions group	A	B	C	D	E
Basic questions	1	4	1	0	2
Background factors	4	5	4	3	4
Physical factors affecting the indoor environment	36	12	13	30	12
Psychosocial work environment factors	5	4	4	11	4
Questions about the disease	5	4	3	2	2
Symptoms of SBS	20	13	13	17	13
Comments	0	1	1	1	1
Number of all the questions	71	43	41	64	38

Comments :

A – Swedish Council for Building Research [8]

B – MM-Questionnaire Orebo Medical Center Hospital [8]

C – Nordtest Report 204 Indoor Climate Questionnaire [8]

D – Hong Kong Polytechnic Library Survey [8]

E – Kielce University of Technology

The analysis included 65 apartments and 21 single-family houses, which collected 177 questionnaires.

3. Research results

The results of the measurement study showed that in majority of the analyzed dwellings problems with the system of natural ventilation occurred. These results were presented by the authors in detail in

the articles [7, 9, 10]. In short they are presented in Table 3. It shows percentage of the number of units, which reported incorrect microclimate values. The values above the recommended adopted minimum or maximum values were considered as incorrect.

Table 3. Percentage of dwellings with reported incorrect microclimate values – a method of measuring

Name of the parameter	Kind of building	
	Single family	Multifamily
Indoor temperature	37.3	51.2
Relative humidity	35.6	54.1
CO ₂ concentration	20.6	44.7
Air flow velocity	48.9	69.7
The direction of air flow in ventilation ducts	61.3	78.4

The analysis of the data presented in Table 3 shows that in the majority of the analyzed objects natural ventilation does not work properly. This causes abnormalities in the development of microclimate. In the majority of cases these abnormalities did not occur alone. A thorough analysis of the results indicates that the irregularities did not affect only 10–15% of all surveyed dwellings in each group of buildings.

Given such large-scale problems the authors have tried to analyze individual user experience of the surveyed dwellings based on questionnaire surveys.

The group of questions about physical factors affecting the indoor environment was 12 questions. Respondents could answer in the affirmative or negative way. The results have been provided in Figure 1. It presents the percentage of respondents confirming the existence of the parameter. Although the answers are dependent on the individual preferences in many areas they agree with measurements. This includes parameters which are easy to define by users such as temperature and feelings within. With some questions the respondents had some problem to answer (eg humidity).

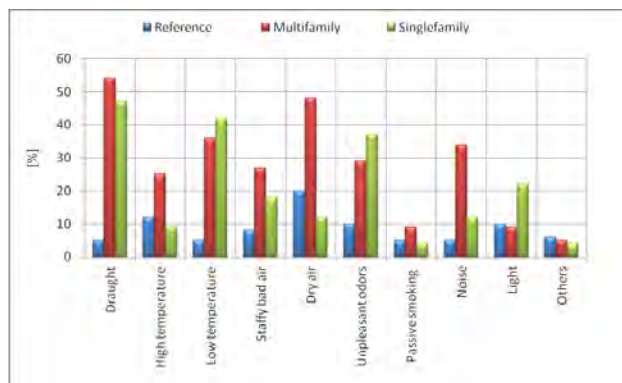


Fig. 1. Wrong assessment of the physical characteristics of microclimate by sensations of respondents, percentage

Another set of questions were questions regarding the occurrence of the sick building symptoms. In this part of the questionnaire users were asked 13 questions. Users could answer in the affirmative or negative way. The results are shown in the Figures 2–4. Figure 2 shows the percentages of members of apartments and houses, who declared the most common of SBS symptoms – separately for single-family and multi-family buildings. Figure 3 shows the percentages of users of the same objects declaring the presence of SBS symptoms according to gender, and age Figure 4 of the respondents.

4. Analysis of results

The results clearly show that the surveys are a source of additional information about the functioning of the building. In a large part they allow to determine the impact of unmeasured parameters (odors, cigarette smoke, etc.) on the users and medical symptoms of SBS.

A major problem in the analysis of the results of research based on questionnaires is to establish reference levels. Only for some parameters (temperature, draft) levels have been established [5] and can be determined by calculation (PMV, PPD, DR). Due to the lack of accepted reference levels authors indicated in Figures 1 through 4 levels of reference of available publications [1, 2, 3]. These levels have been established for different types of buildings and should be considered only as a guide. Also, the period of calculation of the values, the end of the last century, indicates the need for verification. The authors found, however, that it is sufficient for the execution of a preliminary assessment of the results.

Analyzing the negative assessment of the physical characteristics that describe climate (Fig. 1) it should be noted that they are consistent with results from a measurement study (Table 3), both for single-family dwellings and multi-family houses.

Survey results indicate a much smaller percentage of people dissatisfied with the microclimate parameters in single family houses. They also less frequently complained about the typical symptoms associated with the syndrome SBS. This is due to the smaller number of observed disturbances in the operation of natural ventilation system, which was confirmed by measurements. It should be remembered that the assessment of some of the physical characteristics is dependent on individual preferences of residents. In some cases, we could be dealing with a „habit” of users to specific microclimate parameters. An example would be a smaller number of people complaining about the low temperature in houses even though tests have shown that it is on average up to 2 to 4°C lower as compared to apartments in multifamily buildings. Another important factor is the size of the facilities per inhabitant. In the case of single-family houses space per user is several times larger than the area of multi-family buildings. In this situation the concentration of indoor air pollution is more complex and, thus the negative feeling by the respondents is limited.

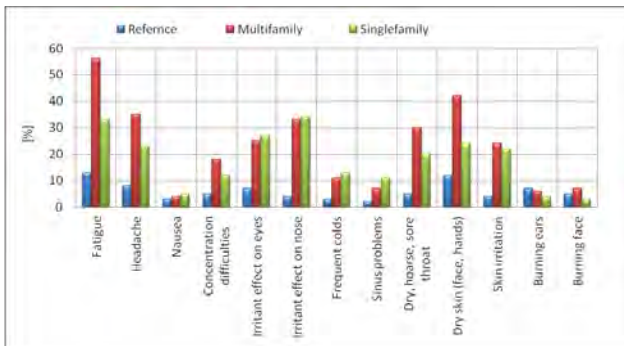


Fig. 2. The occurrence of SBS symptoms in the analyzed users' apartments and single-family households

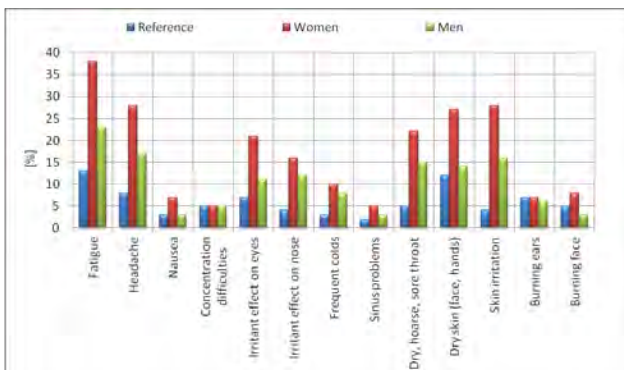


Fig. 3. The occurrence of SBS symptoms in relation to sex

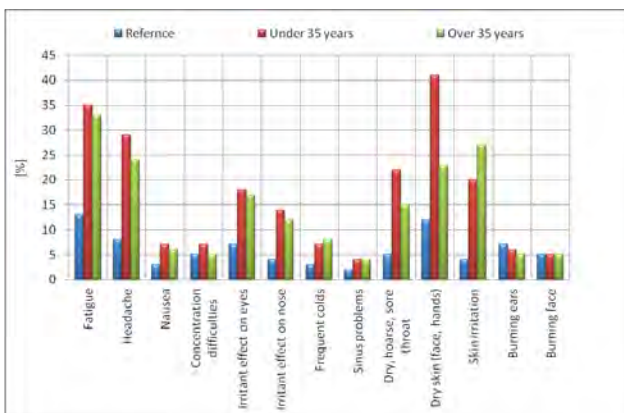


Fig. 4. The occurrence of SBS symptoms in relation to age

Very interesting part of the questionnaire concerns the presence of the symptoms associated with SBS. Number of people complaining about the various symptoms has been presented Figure 1 and amounts from a few to several dozen percent of respondents. It should be noted that a large number of respondents complained about more than one symptom. Over 40% of houses users complained about at least one of the symptoms of SBS, in apartment buildings, it was over 45% of users. Undoubtedly, these opinions should be verified by medical research. But the cost of execution and delivery time are not comparable to the method used in the questionnaire. Therefore, it must be held that the questionnaire surveys can be an instrument for the quick assessment of indoor air quality.

5. Conclusions

1. A well planned and carried out questionnaire survey can be relatively inexpensive, but could also be a good indicator of the quality of the microclimate just like the research using a complicated measuring equipment.
2. Questionnaires allow to collect large amounts of data in a relatively short period of time.
3. Proper preparation of the questionnaire and the analysis of results is an interdisciplinary task and requires the cooperation of specialists from many fields.
4. The advantage of survey research is to assess by the users an almost infinite number of indoor air parameters at the same time.
5. The movement of the people makes it possible to cover the entire studied area for the tests and not just certain areas characteristic for recording with the measurement apparatus.

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Badania nad jakością mikroklimatu wewnętrznego z zastosowaniem kwestionariuszy ankietowych

1. Wprowadzenie

Autorzy prowadzonych obecnie badań nad jakością mikroklimatu wewnętrznego wykorzystują w swoich pracach systemy oparte o zaawansowane technologicznie rozwiązania. Jednak w trakcie realizacji badań analizie poddawanych jest tylko kilka podstawowych parametrów opisujących jakość środowiska wewnętrznego. Pomimo, że dostępna obecnie aparatura pomiarowa daje możliwość monitorowania parametrów IAQ w sposób ciągły, to do pomiarów stosowane są ograniczone ilości czujników. Umieszczane są w określonej lokalizacji, a ich zakres pomiarowy jest ograniczony. Dlatego też badania takie warto uzupełnić dodatkowymi danymi, zwłaszcza jeśli sposób odbierania i monitorowania parametrów IAQ jest zgoła odmienny. Źródłem takich dodatkowych, bardzo istotnych, informacji o stanie środowiska wewnętrznego mogą być badania ankietowe użytkowników mieszkań. Wyniki badań ankietowych w połączeniu z danymi zebranymi przez systemy pomiarowe tworzyć będą pełny obraz jakości mikroklimatu wewnętrznego. Dodatkowo odpowiednio przeprowadzone badania ankietowe, poza opisem działania zastosowanych rozwiązań technicznych, pozwalają uzyskać informacje na temat zachowań oraz indywidualnych odczuć użytkowników.

2. Charakterystyka badań

Badania polegały na rejestracji zmian parametrów opisujących mikroklimat wewnętrzny oraz porównanie otrzymanych wyników pomiarowych z wynikami wykonanych, równoległe z pomiarami, badań ankietowych.

Analizą objęto 65 mieszkań i 21 budynki jednorodzinne, z których łącznie korzystało 177 osób. Ankieta zawierała 38 pytań koniunktywnych zawierających pytania dotyczące komfortu cieplnego, zaburzeń w działaniu wentylacji grawitacyjnej oraz występowania symptomów SBS. Głównym celem przeprowadzenia ankiety było sprawdzenie subiektywnej oceny jakości powietrza wewnętrznego przez użytkowników pomieszczeń.

3. Analiza wyników

Uzyskane wyniki badań jednoznacznie wskazują, iż wykorzystanie ankiet jest źródłem dodatkowych informacji na temat funkcjonowania budynku. Ich niezaprzeczalną zaletą jest fakt, że pozwalają na określenie oddziaływania na użytkowników parametrów niemierzalnych (zapachy, dym papierosowy itp.) oraz medycznych objawów SBS.

4. Wnioski

1. Odpowiednio zaplanowane i przeprowadzone badania ankietowe mogą być relatywnie tanim, ale równie miarodajnym wskaźnikiem co badania z wykorzystaniem skomplikowanej aparatury pomiarowej.
2. Zaletą badań ankietowych jest możliwość oceny przez użytkowników praktycznie nieskończonej ilości parametrów powietrza wewnętrznego w tym samym czasie.
3. Przemieszczanie się mieszkańców daje możliwość oceny całej rozpatrywanej przestrzeni.
4. Testy ankietowe pozwalają na zebranie dużej ilości danych w stosunkowo krótkim przedziale czasowym.
5. Prawidłowe przygotowanie kwestionariusza oraz analiza wyników jest zadaniem interdyscyplinarnym i wymaga współpracy specjalistów z wielu dziedzin.