

PhD Theses

Researching and measuring the indoor air quality in
passive and low energy (wooden frame) houses

Csilla Patkó

University of West Hungary

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**Researching and measuring the indoor air quality in
passive and low energy (wooden frame) houses**

Written by:
Csilla Patkó

Consultant:
Dr. Zoltán Pásztory

University of West Hungary
Faculty of Wood Engineering
József Cziráki Doctoral School of Wood Sciences and Technologies
Sciences of Wood Technology

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1. The subject of the dissertation

Indoor air quality, which is the main research area of the current dissertation, is a new scientific area. In this work, an alternative approach has been presented that considers buildings as a whole system whose main goals are providing people with high indoor comfort conditions and lessening the environmental impacts. Indoor air quality cannot be examined separately from the connecting scientific fields, which are building biology, building ecology and human ecology.

The main research areas of **human ecology** are the global impacts of human activities and the motivations behind them. The adverse chemicals, which are the result of human activities, are not only effecting the natural environment, but also have a great influence on human health through the built environment.

On the field of **building ecology** there are many studies researching the ecological impacts of building materials. The conclusions showed that the *Life Cycle Assessment (LCA)* of the materials is not providing proper information about these impacts and about the human health risks.

There are several case studies and measurements in the field of **building biology**, which are analyzing the adverse chemicals in the indoor air, the emissions from the building materials, and the health conditions of the occupants.

Indoor air quality has been influenced by many different factors: climate conditions, economical growth, culture, building regulations, and more importantly by human activities. By choosing the right building materials (low-emitting materials) and technologies can these adverse impacts on the indoor air quality be avoided. For this, there must be a regulated and up-to-date database of low-emitting materials accessible for designers and building contractors.

This work focuses on researching wood as a low-emitting building material. Many studies showed that by regulating the emission of adverse chemicals from pressed wood products, they could be recycled as low-emitting materials.

The aim of the literature survey was to determine those trans-disciplinary principles necessary for designing ecologically "healthy" buildings. The conclusion showed, that sustainability, ecological thinking and adaptation have essential impacts on health and natural environment. Through this holistic approach, a new way of behavior can be developed in the society, which will create a new base of living environment.

2. The case study of the dissertation

The presented case study, which is the first made in Hungary, shows the measurements of the indoor air quality in a passive, low-energy, wooden, light frame house. Concentrations of Volatile Organic Compounds (VOC) and formaldehyde were measured and compared with data from other case studies made in this subject, and with the current Hungarian and international regulations of adverse chemicals.

Six measurements were taken throughout one year. The results of the measurements showed the changing concentrations of adverse chemicals, from that the following conclusion were drawn:

1. The total volatile organic compounds (TVOC) were influenced by indoor temperature, indoor relative humidity, and air exchange rate. Human activities and the furniture had the greatest impacts on the concentrations.
2. The concentrations of benzene, toluene, naphthalene, and styrene were not deviant from the average values measured in other case studies, and from the current Hungarian and international regulations of adverse chemicals. They did not pose a health risk.
3. The concentration of formaldehyde did overpass the values of the current international regulations in one measurement, but it was just temporary. The main sources were the wooden materials cut into peaces in the living room. By the following measurements the concentration of formaldehyde was slightly increased because of the rise of the indoor temperature.
4. The rate of the wooden clothing in each room had a great influence on the concentrations of alpha-pinene and 3-carene. These chemicals are not toxic, therefore they did not pose a health risk.

The measurements were compared with data from other case studies made in this subject. This gives just referential information because of the variety and difference of the measurements found in literature. For a detailed analysis a further research work is needed.

The conclusion of analyzing indoor air quality showed a great number of new information about the correlation of building materials, the use of the building and indoor air quality. The measurements of indoor air quality are providing the designers and the building occupants with essential information about the state of the building and the health impacts. They can be used in many types of the architectural processes, e.g. in building diagnostics for renovations, in measuring the health impacts of a newly built house, and in finding the main sources of adverse chemicals of buildings with "sick building syndrome".

3. Theses of the dissertation

Thesis I.

My conclusion of the literature survey was that building biology and building ecology determine the trans-disciplinary principles necessary for designing ecologically "healthy" buildings.

I have found that these connecting scientific areas are just the "effects" in the "cause-and-effect" relation. Thereby, it was necessary to search for the "cause" in the area of human ecology. Through this holistic approach, which gives first an overview of the "whole" system and from that determines the "parts", new principles of scientific knowledge can be synthesized and implemented in designing "healthy" buildings.

I.1.

My conclusion of the literature survey was that passive houses are not necessarily equal with "healthy" buildings. The design methodology behind them are based on "by-components" principles, which means that the ecological affects of the building is determined by its parts and it does not take into consideration the cumulative affects of the parts. I have found that the design of energy-conscious and passive houses is not giving a proper answer for the following question: Can these buildings – designed in accordance with the current international, architectural trends – be compared in ecological aspects with the conventional but still standing buildings, which are incorporating the durability and adaptiveness of the former architectural periods?

I.2.

I have found that the current regulations of building materials are not taking into consideration the health impacts. It is a fundamental human right to be able to live in a healthy environment. Referring to the precautionary principle of the *Általános környezetvédelmi törvény 6-12.§* (General Environmental Bill, Section 6-12.§), I indicate to extend the regulations to low-emitting building materials to be categorized into a database constraining the manufacturers and developers to launch only ecologically "healthy" products into the market, which do not pose adverse impacts to the environment and human health during their life cycle.

After the literature survey, I have found that the *Life Cycle Assessment (LCA)* of the materials is not providing proper information about the adverse impacts of building materials.

Thesis II.

As a conclusion of my measurements, I have found that the analysis of indoor air quality provides a great number of new information about the correlation of building materials, adverse chemicals, the indoor air quality and their health impacts.

My present case study is putatively the first made in Hungary, which measured the indoor air quality in a passive, low-energy, wooden, light frame house.

This new information about indoor air quality can be used not only for new buildings but for building renovations as well, and can be compared with data from other case studies made in this subject. I have found that in the literature of indoor air quality there are not many case studies made in Hungary. I suggest to proceed with further surveys in the field of indoor air quality in order to get a better and more detailed view of the current state of the buildings in Hungary. Furthermore, I suggest to implement the measurements into the stages of architectural design, e.g. in building diagnostics for renovations, in measuring the health impacts of a newly built house, and in finding the main sources of adverse chemicals of buildings with "sick building syndrome".

Thesis III.

The conclusion of the literature survey and the results of my case study showed that the applied wooden materials can be considered as low-emitting building material, which do not have adverse impacts on indoor air quality and the health of the occupants.

I have found as a conclusion of the present case study, that the total volatile organic compounds (TVOC) of the indoor air during the one-year measurements had been changed only slightly and they did not pose a health risk.

The concentration of the TVOC were influenced by indoor temperature, indoor relative humidity and air exchange rate. Human activities and the furniture had the greatest impacts on the concentrations.

Thesis IV.

The conclusions of my measurements showed that the concentrations of benzene, toluene, naphthalene, styrene did not exceed the values of the current Hungarian and international regulations of adverse chemicals. They did not pose a health risk. The sources of these chemicals are not only the building materials but the furniture as well.

The concentration of formaldehyde did overpass the values of the current international regulations in one measurement, but it was just temporary. The main sources were the wooden materials cut into peaces in the living room. By the following measurements the concentration of formaldehyde was slightly increased because of the rise of the indoor temperature.

Thesis V.

The conclusions of my measurements showed that the rate of the wooden clothing in each room had a great influence of the concentrations of alpha-pinene and 3-carene.

These chemicals are not toxic, therefore, they did not pose a health risk. They are naturally emitted in high concentrations from air-dried spruce wood, which was applied in the building. The emission rate depends on the age of the wood, and the time of the cutting. I have found that the rate of spruce wooden materials are correlating to the concentrations of alpha-pinene and 3-carene.

3. Major publications in the field of the research work

Patkó Cs. (2013):

Evaluation of volatile organic components of indoor air of a newly-built wooden frame house in the last four seasons.

Conference Proceedings Part (A) 4th INTERNATIONAL CONFERENCE “TO PROTECT OUR GLOBAL ENVIRONMENT FOR FUTURE GENERATIONS” ICEEE-2013, 20 – 21 November 2013, Óbuda University Budapest, Hungary, 229-237pp

ISBN: 978-615-5018-93-0

Patkó Cs., Pásztory Z. (2013):

Formaldehid koncentráció egy újjépítésű, vázszerkezetes épületben.

Faipar, LXI 213/3:23-29

Patkó Cs., Pásztory Z. (2013):

Fa és faalapú építőanyagok emissziója.

Faipar, LXI. 2013/4:12-21

Patkó Cs., Patkó I., Pásztory Z. (2013):

Indoor Air Quality testing in Low-Energy wooden houses: Measurement of formaldehyde and VOC-s.

Acta Polytechnica Hungarica, Volume 10, Issue Number 8/ 2013, 105-116pp

DOI: 10.12700/APH.10.08.2013.8.6

IF:0,58

Patkó Cs., Patkó I., Pásztory Z. (2013):

The presence of volatile organic compounds (VOCs) indoors during the heating season: in situ emission study of a frame-house.

Acta Mechanica Slovaca, Volume 17, Issue Number 3/ 2013, 70-79pp

DOI: 10.2478/mecslo-2013-0031