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Indoor air quality – a key element of the energy performance of the buildings

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Abstract

The inadequate thermal performance of existing buildings and ventilation strategies in buildings are currently the biggest challenges for the housing sector in Central and Eastern Europe in the context of addressing the sustainability and health of the built environment. Lack of adequate ventilation of indoor spaces causes poor air quality and a higher incidence of sick building syndrome (SBS), which is manifested by affecting the comfort and wellbeing in the living space. Ensuring high energy performance buildings and indoor air quality is efficiently approached by limiting emissions from sources or by partial neutralization of the pollutants, an important stage being the establishing specific emissions levels by performing monitoring studies of indoor air quality. In this context, the paper presents experimental studies focused on monitoring the concentrations of volatile organic compounds, inorganic compounds and particulate matter, from indoor air in residential spaces located in the urban area of Bucharest, Romania. The obtained results highlight the fact that in analysed spaces there are concentrations of pollutants whose values should be considered to improve the indoor air quality while addressing effectively the upgrade of energy performance in buildings.

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Keywords: indoor air quality, energy performance, pollutants, residential spaces

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1. Introduction

Indoor Air Quality assurance is done mainly through the air exchange between interior and exterior. In addition to organic and inorganic pollutants in particulate matter (which have a direct impact on human health), the main problem affecting indoor environment of a building is water vapor and carbon dioxide (emissions from building occupants). The air permeability of a building / functional units is particularly important both in terms of energy (reducing consumption of energy in the operation of buildings by limiting the number of air changes) and to ensure conditions for thermal comfort and physiological occupant (ensuring air flow necessary to maintain concentrations of substances harmful to human health, within reasonable limits). Reducing air permeability of buildings through the use of very tight closure elements (especially insulated glazing and wall paneling material very slightly permeable to air and water vapor) has major implications for indoor air quality by increasing the concentration of water vapor and carbon dioxide produced by human metabolism etc. The users behavior in condominiums, while reducing the heat supplied through installation of central heating (closing the radiator thermostatic valves) and using the cooking appliances with open flame to increase the interior temperature, rise in the indoor air both the moisture content and the concentration of harmful gases, for example carbon monoxide and dioxide.

This will occur more frequent and with a stronger impact when the building envelope is airtight (having insulated glazing systems) and in the context of a poor standard of living, falling within the accepted definition of poverty to fuel (a household is in the situation of fuel poverty when thermal comfort inside the dwelling cannot be provided with affordable cost of family income).

In this case, lack of adequate ventilation of occupied spaces contributes to an increased incidence of sick house syndrome (SBS - sick building syndrome). In simple terms, SBS is manifested by affecting the comfort and wellbeing of living space. Basically, a sick building is also characterized by low energy efficiency, the result of flaws in design, implementation and use of the building and in particular of the building systems.

2. Materials and methods

The residential spaces that were investigated from the point of view of indoor air quality were selected based on the area where they are located, being selected a building located relatively far from the traffic and a building located next to a high traffic arteries. Interior spaces were chosen on the assumption that in the kitchen areas there are many sources of emissions and the rest area (bedroom) is most importance space, where emissions must be minimized. Pollutant concentration measurements were performed in situ, both in lack of any activity conditions and in the case of carrying out normal activities, while the space ventilation was of natural type.

Residential space no. 1 is unit from a building with ground floor plus three floors, located in an urban area. Indoor analyzed spaces are northern orientation relative to the cardinal points. Internal and external walls are made of hollow brick, the windows are made of PVC profiles with double glazing and the doors are wooden made. For the decoration of bedroom walls interior waterborne paint was used and the floor is made of solid wood flooring. The kitchen has both walls and floors finished with glazed ceramic tiles. Residential spaces no. 2 and no. 3 are located in a building next to high traffic streets, with East orientation, no. 2 at second floors and no. 3 at ninth floors of the building. Internal and external walls are made of a mixed structure, frames and diaphragm walls from reinforced concrete and closures from AAC (autoclaved aerated concrete) blocks. The windows are made from Al and PVC profiles and the doors are wooden made. The waterborne paints were used for decoration of wall bedrooms and the glazed ceramic tiles for walls and floors of kitchens.

The pollutants, selected based on their effects on human health, were monitored using a direct detection method and the portable data-logging detector - Gray Wolf Direct Sense IQ-610 equipment, a device with photo-ionization detector (PID) for VOCs [5], and Gray Wolf Direct Sense TG-501 equipment, based on electrochemical principle, for nitrogen oxides, sulfur dioxide, ozone and carbon monoxide. Carbon dioxide and the parameters of indoor air (temperature and relative humidity) have been recorded using sensors based on NDIR (Non-dispersive infrared) principle, by thermal resistance Pt100 and by capacitive principle, and a portable particle optical counter used for particulate matter, of which general principle of operation is based on the phenomenon of scattering. The equipment can display the concentrations in ppm, ppb and $\mu g/m^3$ units. The calibration of the equipment was performed before