Prof. dr hab. Marzenna R. Dudzińska,
Indoor and Outdoor Air Quality Department
Faculty of Environmental Engineering and Energy
Lublin University of Technology

Review

Review of the doctoral dissertation by Seyedkeivan Nateghi, M.Sc. Eng.
„Analyzes of selected methods of limiting the spread of air pollutants in the occupied ventilated rooms"

Formal basis

The basis for the review is the letter number RIE-BD.512.32.2025 dated 24/06/2025 (received on 30/07/2025) of the Chairman of the Discipline Council for Environmental Engineering, Mining and Power Engineering at the Silesian University of Technology.

The formal basis is the Act Law on Higher Education and Science of July 20, 2018 (Journal of Laws of 2018, item 1669) with amendments.

The importance of research topics

Understanding of environmental and human threats is constantly growing in societies of many countries, but the most common topics of discussion are climate changes, depletion of raw materials, degradation of water resources, atmospheric pollution (commonly referred to as smog), and, more recently, energy savings. These are the problems that affect the entire ecosphere and usually require solutions at the supranational level. However, the greatest and most direct impact on humans is the environment that they themselves create, often in an unskillful manner, because it is indoors, i.e. in the indoor environment, that humans spend over 90% of their lives.

In many countries, research into indoor environmental quality has a history spanning several decades. Since the publication of the first version of the WHO document "The Right to Healthy Indoor Air" (WHO, 2000), interest in research has grown worldwide, reaching its peak during the pandemic, when we spent more time indoors and realized that in indoor environment we are exposed not only to chemical pollution and thermal discomfort, but also to biological pollution—bacteria, fungi, and viruses.

However, it seems that the quality of the indoor environment is still an underestimated area of research in Poland.

Many thermal modernization measures have been undertaken in our country, as rising energy prices have generated interest in energy savings, including the simplest method which is sealing residential, office, and school buildings. With natural ventilation still being the most popular in Poland, this often causes problems with relative humidity in rooms and creates conditions conducive to the growth of mold fungi. However, poor air exchange and circulation also pose a problem with bacterial or viral bioaerosols, the main sources of which in rooms are humans.

The negative impact of indoor air pollution can be reduced by using appropriate ventilation systems, but mechanical ventilation, especially high air exchange rates, requires a lot of energy expenditure.

One indoor environment that is of great interest is educational facilities. Children and young people spend time there, and they are a population that is more sensitive to external factors, especially pathogenic threats. They spend several hours a day in groups where isolation is impossible, making them more susceptible to airborne or droplet-borne threats. Epidemiologists have also proven the impact of children on the spread of infectious diseases throughout the population; infected children are the main risk factor for parents and grandparents looking after them, and especially for elderly people, the effects of infection can be serious.

Therefore, any research aimed at minimizing the transmission of biological contaminants in educational buildings is of significant scientific and practical importance.

General characteristics of the dissertation

The reviewed dissertation is not a classic dissertation, but a summary of the results published by the doctoral student in six scientific articles, five of which he is the first author. The articles were published between 2023 and 2025 in journals listed by the Ministry, published by Elsevier (5 articles, with IF ranging from 6.7 to 10.5) and MDPI – 1 article, IF = 3.

These are:

1. Grygierek K., Nateghi S., Ferdyn-Grygierek J., Kaczmarczyk J., (2023), Controlling and limiting infection risk, thermal discomfort, and low indoor air quality in a classroom through natural ventilation controlled by smart windows, Energies 16, 592. IF = 3
2. Nateghi S., Kaczmarczyk J., (2023), Multi-objective optimization of window opening and thermostat control for enhanced indoor environmental quality and

Energy efficiency in contrasting climates, Journal of Building Engineering 78, 10617. IF = 6.7

3. Nateghi S., Behzadi A., Kaczmarczyk J., Wargocki P., Sadrizadeh S., (2025), Optimal control strategy for cutting-edge hybrid ventilation system in classrooms: Comparative analysis based on air pollution levels across cities, Building and Environment 267, 112295. IF = 7.1.
4. Nateghi S., Kaczmarczyk J., Zabłocka-Godelwska E., Przystaś W., (2025), Investigating the Impact of Physical Barriers on Air Change Effectiveness and Aerosol Transmission Under Mixing Air Distribution, Building and Environment 272, 112676. IF = 7.1.
5. Nateghi S., Kaczmarczyk J.,(2024), Compatibility of integrated physical barriers and personal exhaust ventilation with air distribution systems to mitigate airborne infection risk, Sustainable Cities and Society 103, 105282. IF = 10.5
6. Nateghi S., Marashian S., Kaczmarczyk J., Sadrizadeh S., (2025), Resource-efficient design of integrated personal exhaust ventilation and physical barriers for airborne transmission mitigation: A numerical and experimental evaluation, Building and Environment 268, 112336. IF = 7.1.

In two publications, the doctoral student's declared contribution is over 50% (80% and 70%, respectively), in one it is 50%, and in three publication it is 35% each. This constitutes more than half of the total contribution.

The full texts of the articles are included as appendices to a 60-page study containing a summary in Polish and English, a list of abbreviations used, and five chapters. Chapter one is an introduction, research objectives and hypotheses, chapter two – summary of research published in articles 1-3, chapter 3 – summary of research from articles 4-5). Chapter 4 contains research not published in the presented articles, and chapter 5 – summary. Therefore, this is not a typical work based on a series of publications, as it also contains additional research conducted in the last year that has not been published at the time of submission of the dissertation. However, the structure of the work is clear and logical, with individual articles describing successive stages of research, which are interrelated and follow on from one another. This is interestingly presented graphically (Fig. 1), showing the connection between the individual stages of research described in successive publications.

The bibliography attached to the discussion contains 97 items from the years 2000-2025, with the vast majority being works from the last 6 years. Unfortunately, the list is in citation order (Vancouver system) rather than in alphabetical order (Harvard or

APA system), which makes it difficult to check to what extent it contains items other than those cited in the attached publications.

Substantive assessment

In the chapter entitled "Objectives and scope," the doctoral student does not formulate a single objective for the work, but lists three basic objectives:

- Evaluating different ventilation strategies in maintainig IAQ and reducing airborne infection risks in densely occupied spaces
- Investigating localized mitigation measures such as physical barriers, personal ventilation, mask and portable air cleaners in controlling aerosol transmission in densely occupied space.
- Analysing energy and comfort impacts with various IAQ improvement and infection control strategies.

The wording of the second objective is debatable, as "investigation" itself is not really an objective, it is rather a stage of research meant to serve the objective of evaluating various "*mitigation strategies*."

Although the main objective, which every dissertation usually has, has not been formally formulated, the "sub-objectives" provided are logically related and have allowed for consistent research to be carried out, corresponding, as it seems, to the main objective, which could be formulated as follows: assessment of the minimization methods for air pollution dispersion in ventilated rooms.

For the three objectives he had planned, the doctoral student presented five questions (research problems) and, in line with them, put forward five hypotheses in an attempt to answer the above questions.

The reviewer is not a supporter of hypotheses that are often obvious, formulated on the basis of premises derived from the literature or even after the problem has already been solved. However, regardless of personal preferences, the hypotheses should be considered correctly formulated.

The first chapter, entitled "*Introduction*," contains presumptions for conducting research, basic information about indoor environmental pollutants, and mitigation methods. The information on pollutants – VOCs, PM, bioaerosols, and CO_2 – is general, but supported by literature sources and sufficient as an introduction to the research. Subchapter 1.4: "*Methods to mitigate spread of indoor pollutants*" contains a synthetic summary of the literature on methods based on ventilation techniques, including hybrid, mixed, personal, and displacement ventilation, individual protective measures, physical barriers popular in the early stages of the pandemic, and filtration and air purification techniques. These are the methods discussed in individual publications that comprise the doctoral thesis submitted for evaluation.

The following subsection links these issues to thermal comfort and energy consumption.

The subsequent chapters of the dissertation contain a summary of the research and a synthetic discussion of the methods and results. The repetition of "*This chapter summarizes...*", "*This section presents...*", "*This chapter employs...*" in almost every chapter and subsection is somewhat annoying but the structure of the paper is consistent and correctly combines the results published in individual articles.

The first three publications, according to the list presented, rather than the chronology in which they were published, (Grygierek K., Nateghi S., Ferdyn-Grygierek J., Kaczmarczyk J., (2023), Nateghi S., Kaczmarczyk J., (2023), Nateghi S., Behzadi A., Kaczmarczyk J., Wargocki P., Sadrizadeh S., (2025)), are devoted to various ventilation techniques, and the studies published in them are summarized in Chapter 2 (*Chapter 2: Ventilation strategies and smart control*). The papers concern the possibility of optimizing natural ventilation (window opening system) in combination with the optimization of heating control in a school classroom, taking into account the outdoor air quality and outdoor temperature. Cases of using only natural or mechanical ventilation, as well as masks or masks and air purifiers, were studied. In all cases studied, the impact of the proposed optimization on energy consumption was analysed. These papers include the results of computer simulations.

The most important conclusion seems to be that optimizing ventilation may be sufficient to maintain the desired thermal conditions and CO_2 levels, but not when it comes to preventing infections. On the other hand, the statements about improving both air quality and reducing the risk of infection with a reduced number of people in the room seem obvious and were formulated on the basis of a single case where the number of users in the room was reduced by 50%. However, it is interesting to link the results for this case with the impact on carbon dioxide concentration and increased energy consumption in the absence of an air purifier.

The next chapter (*Chapter 3: Local strategies for infection control*) summarizes the research presented in the following three publications (Nateghi S., Kaczmarczyk J., Zabłocka-Godlewska E., Przystaś W., (2025); Nateghi S., Kaczmarczyk J., (2024); Nateghi S., Marashian S., Kaczmarczyk J., Sadrizadeh S., (2025)), devoted to the impact of physical barriers (screens) and personal exhaust ventilation on the spread of contaminants. Due to the widespread use of barriers during the recent pandemic, this is an important issue. Barriers are simple solutions that do not require high investment costs and do not interfere with the structure of the building, and can therefore be widely used. However, their role is limited and they may affect the movement of particles, such as bioaerosols, rather than air quality. Studies have shown that even in the case of particles, the effect of barriers is limited and depends on the ventilation used. However, combining exhaust ventilation with physical barriers can significantly reduce exposure to pollutants. The research described in two publications (papers 3-4) was conducted in a model chamber, where heated dummies simulated students. The chamber was designed to test various ventilation systems and distribute controlled, generated amounts of aerosols, i.e. to conduct the experiment under controlled conditions. In the latest publication from this part of the research, the impact of barrier height and ventilation air flow rate was confirmed using CFD simulation.

Chapter 4 (*Chapter 4: Life cycle assessment of infection control strategies*) contains an unpublished (at least at the time of writing this dissertation) environmental assessment using LCA methods of various proposed strategies for controlling the spread of infection. Barriers, personal protective equipment (masks), and barriers combined with exhaust ventilation were considered. The estimation of costs and energy consumption was also influenced by the assumption, in each scenario considered, of mechanical mixing ventilation providing 148 L/s of atmospheric (outdoor) air.

This is an interesting aspect, resulting not only from the costs of the solutions used (materials, raw materials, energy), but also from the need to manage waste (spent masks, screens), including medical waste that is contaminated or potentially contaminated. At a time of rising infection rates and the spread of the pandemic, these are not costs that are taken into account, but when assessing the minimization of bioaerosol spread during seasonal infections, it is obviously significant, and the conclusion that an integrated system of physical barriers and local displacement ventilation is the solution that best balances the risk of infection and environmental impact is relevant for practical application. However, from a social point of view and as part of the pressure on decision-makers, these aspects should be weighed against the costs of treating infections.

The dissertation concludes with Chapter 5, entitled "Conclusions," (*Chapter 5: Conclusions*) as is customary in a traditional dissertation. Chapter 5 contains a brief summary (once again briefly describing what was done in the research) and seven conclusions. In this section, the doctoral student refers to the hypotheses presented at the beginning and critically assesses their accuracy, which is an advantage of the work. All conclusions are quite general and formulated qualitatively, not quantitatively, although they are confirmed by the research, and this research and calculations, in some cases, would allow for quantitative conclusions. Some of the conclusions, for example those concerning opening windows in the absence of mechanical ventilation, should be disseminated beyond the scientific community.

In conclusion, the doctoral student presented proposals for future research directions (subsection 5.1.), which is in line with current trends in dissertation writing, but from an editorial point of view, the chapter should not have only one highlighted subsection. However, the suggested directions for future research were accurately identified, as there is an urgent need to take actions to improve the quality of the indoor air we breathe for most of our lives.

Comments and questions:

The dissertation consists mainly of publications that have already been reviewed and edited by acknowledged publishers, so there are no significant editorial shortcomings. The language of the paper is understandable and the terminology is correct.

The most important editorial comments concern the bibliography attached to the doctoral student's publication (pages 56-62), where the format has not been standardized, e.g., the year of publication is sometimes in bold and sometimes not. The order of explanations of abbreviations may also raise concerns, as it is neither alphabetical nor consistent with the order in which they appear in the text.

The following questions are not objections to the presented dissertation, but rather reflect the Reviewer's curiosity.

1/ Why, assuming a baseline level of carbon dioxide at 400 ppm (paper 1/Chapter 1), was 1200 ppm set as the optimization threshold? Of course, 400 ppm is currently (in the 21st century) considered the level for clean air. Warsaw was chosen as the city from the Polish climate zone, not Gliwice, however, is the concentration of CO_2 in the atmospheric air in Warsaw or Gliwice at the level of 400 ppm?

2/ In publication 5 (Nateghi S., Kaczmarczyk J., (2024), Compatibility of integrated physical barriers and personal exhaust ventilation with air distribution systems to mitigate airborne infection risk, Sustainable Cities and Society 103, 105282), the description of the method mentions 6 dummies simulating students, and the results for them are presented in Fig. 2. However, the photograph in Fig. 1 shows many more objects simulating students. Please explain the method in more detail.

3/ The objects (dummies) simulating students were intended to simulate people with low physical activity (heat load 60W), i.e., working at a desk. However, children rarely sit still, and their body temperature may also be different after a break spent running around than when sitting with a smartphone. Do you think that possible heat gains "from people", or assuming higher temperatures, or taking into account a larger number of students would affect the results?

4/ Among the proposed further studies, you rightly mention studies in real-life conditions. Do you expect confirmation (only clarification) of the results of simulations and laboratory studies, or do you think that due to the limitations of the models used, the results may differ significantly?

Summary

Regardless of a few critical comments and questions, it should be noted that the doctoral student demonstrated the ability to: formulate and solve a scientific problem, correctly present the obtained results, critically analyze them, and draw conclusions. The research conducted was well documented, and the correct research methods were used. The analytical methods and procedures were verified and documented.

Based on a reading of both the descriptive part of the dissertation and the published works, it can be concluded that the research conducted by the doctoral student and the discussion of its results make a significant contribution to research on indoor air quality and methods of improving it, and contain elements of scientific novelty.

Final conclusion

Taking into account all elements of the assessment, it should be concluded that the doctoral dissertation contains original scientific research and meets the statutory criteria for doctoral theses. Therefore, I recommend that the Discipline Council for Environmental Engineering, Mining and Power Engineering at the Silesian University of Technology in Gliwice approve the dissertation: “Analyses of selected methods of limiting the spread of air pollutants in occupied ventilated rooms” by Seyedkeivan Nateghi, M.Sc. Eng., for public defense.

Analysing the scope of the research, the documentation of the results, and their publication in recognized scientific journals, it can be concluded that the presented paper qualifies for distinction.

Lublin, August 30th, 2025. ....