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論文題目	Laboratory Simulation and Evaluation of Aerosol Particles Penetration, Deposition and Removal Processes in Sheltering Houses Equipped with Ventilation Systems (換気システムを備えた待避家屋におけるエアロゾル粒子の侵入、沈積および除去プロセスの実験室シミュレーションと評価)		

（論文内容の要旨）

This thesis presents in-depth information on the behavior and mechanism of aerosol particles in the process of penetration, deposition and removal in sheltering houses equipped with ventilation systems by laboratory simulation and evaluation. The thesis was divided into 7 chapters with each of the chapter cover various part as followed:

Chapter 1. Introduction

This chapter introduces the background of the accident at the Fukushima Daiichi Nuclear Power Plant and its impacts on the surrounding air. In addition, the objectives and the structure of this research are also introduced.

Chapter 2. A Review of Research on Aerosol Particles Penetration from Outdoor to Indoor

In this chapter, the referred properties of aerosol particles of this thesis are introduced. Moreover, literatures concerning the research progress of aerosol penetration are reviewed.

Chapter 3. Simulation and Evaluation of Sheltering Efficiency of Houses Equipped with Ventilation Systems

Experiments in this chapter investigate various elements that may affect the penetration factor, categorize particles (especially for UFPs) by the penetration characteristics for universal household sliding windows, reveal the most effective sheltering configuration for houses in air pollution emergencies, and compare the differences between the completely ideal state (uncharged/neutralized) and the actual situation through the particle charging state. The results illustrate that a high air exchange rate corresponds to a high penetration factor, and the concentration difference between outdoor and indoor affects ventilation efficiency. For universal household sliding windows, frames made of plastic coupled with an air exchange rate less than or equal to 1.20 h^{-1} can prevent particle penetration more effectively in air pollution emergencies. As the external particles gradually disperse and the concentration decreases, a ventilation system with a large air exchange rate may effectively purify the indoor air. However, UFPs of less than 69 nm are able to undergo penetrate in a large amount, especially when the air exchange rate is lower than 1.20 h^{-1}. Therefore, effective housing sheltering is still a challenge if the external source is primarily UFPs. The laboratory results of this work provide a reference for emergency evacuations and indoor air quality improvements when environmental air pollution accidents and extreme weather occur.

Chapter 4. Determination of the Optimal Penetration Factor for Evaluating the Invasion Process of Aerosols from a Confined Source Space to an Uncontaminated Area

Due to the outbreak and spread of COVID-19, SARS-CoV-2 has been proven to survive in

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aerosols for hours. To evaluate the invasion process of virus-containing aerosols from a confined source space to an uncontaminated area, based on the work in chapter 3 and a widely used concentration model, four numerical calculations of the penetration factor are proposed in this chapter. A theoretical time-correction P_{est} was applied to a size-dependent P_{avg} by proposing a correction coefficient r, and the error analysis of the real-time P(t) and the derived P_d were also performed. The results indicated that P_{avg} supplied the most stable values for laboratory penetration simulations. However, the time-correction is of little significance under current experimental conditions. P(t) and P_d are suitable for rough evaluation under certain conditions due to the inevitability of particles detaching and re-entering after capture. The proposed optimal P value and the error analysis could help provide insight into the penetration mechanism, and can also provide a rapid and accurate assessment method for preventing and controlling the spread of the epidemic.

Chapter 5. A Review of Indoor Particles: Behavior and Ventilation Technology

In this chapter, the behaviors of indoor particles, including deposition and coagulation, and the research progress of that under ventilation is reviewed.

Chapter 6. Assessment of Air Purification Effect in Sheltering Houses Equipped with Ventilation Systems after Air Pollution Incidents

A key issue in the later stage of an environmental emergency is indoor air purification. This chapter investigates a reasonable ventilation strategy for indoor air purification in the later stage of an air pollution accident. Using a closed test chamber to simulate a sheltering house with a ventilation system, the deposition rates of aerosol particles were measured under both ideal and non-ideal conditions. Additionally, the actual turbulence state can be inferred by querying the optimal K_e in the β-K_e diagram proposed by this work. The main removal mechanism for particles within the range of 53.3–371.8 nm at an air exchange rate less than 1.19 h^{-1} is deposition. A ventilation system based on a high-power exhaust pump causes a large turbulence, which results in the resuspension of particles outside the cumulative mode range with a ‘sudden drop’ in the deposition rate. In the later stage of an air pollution accident or in the case where outdoor particles do not contribute indoors, turning off other stirrers and fans and increasing the AER value of the ventilation system to more than 1.19 h^{-1} can achieve the desired air purification effect. This study provides a reference to improve the indoor air quality in the event of an air pollution accident. It also provides effective information for general household air purification. Additionally, it can support the construction of shelters in areas and countries prone to air pollution accidents or floating dust/hazy weather.

Chapter 7. Conclusions and Perspectives

The main findings and limitations of this study are summarized and emphasized.