論文の要旨
Summary of the Dissertation

論文題目
Dissertation Title

Study on Indoor Air Quality and Its Effect on Health in Urban Houses of Indonesia
(インドネシアの都市住宅における室内空気質とその健康への影響に関する研究)

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In Indonesia, sick building syndrome (SBS) and related health problems are suspected among the residents in dramatically emerging new urban houses constructed of modern building materials without sufficient material standards or minimum ventilation rates. This doctoral thesis aims to gather all the data and information regarding the current conditions of existing indoor air and the health of urban houses in Indonesia, particularly in the middle-class high-rise apartment and to propose a comprehensive focus and method to improve the indoor air quality (IAQ) and health of the urban houses of Indonesia towards the air quality guidelines.

The literature review in Chapter 2 focused on indoor air quality and sick building syndrome in developing countries, particularly in urban houses and hot-humid climatic regions. As reviewed, there are few studies of indoor air quality and health in urban houses of developing countries in the tropics. Most studies are focused on public buildings and more on efficiency and working performance rather than health conditions. Most research in urban houses was done in four seasons countries with different climatic conditions, which leads to different heating, cooling, and ventilation systems. Moreover, the guidelines and awareness of indoor air quality and health in residential buildings are still lacking. Therefore, it is essential to study indoor air quality and health in urban houses of the tropics, to improve further the current awareness and guidelines of indoor air quality in developing countries.

Chapter 3 explained the current conditions of indoor air quality and health of urban houses in Indonesia, particularly in newly built high-rise apartments and traditional landed houses, Kampong. Three major cities of Indonesia, Surabaya, Jakarta, and Bandung, where the growth of new apartments coexist with Kampong, are chosen as the location of the study. Results of the questionnaire survey revealed that the self-reported sick building syndrome, based on multiple chemicals sensitivity (MCS) risks, in the apartment are significantly higher, nearly doubled, compared to the risk in Kampong's respondents. Moreover, the results of indoor air quality field measurements, formaldehyde concentration, and TVOC in the apartment are also significantly higher compared to Kampong. The average concentration of mean formaldehyde in the apartment is close to the WHO standard value of 0.08 ppm, while the average maximum value exceeds the standard in the apartment. In Kampong, the average concentration of formaldehyde is lower than the standard, but similarly, with apartments, several peaks of concentration in maximum value exceed the WHO standard. Similar to formaldehyde, TVOC concentration is also significantly higher in apartment houses. Furthermore, respondents with higher MCS risk were found to be exposed to a higher concentration of TVOC and formaldehyde. Other than the IAQ, several influential factors affect MCS risk and sensitivity of occupants in the newly constructed apartments. In Kampongs, the share of high MCS risk groups was relatively low. However, more than 80% of the measured houses were categorized within the highest fungal index, D, at an alarming rate. In fact, the survey results showed they suffered from mold and dampness. This implies that there are other IAQ problems even in Kampongs, which cannot be measured by the degree of chemical intolerance.

Chapter 4 discussed the results of further analysis using a mathematical model of factors affecting multiple chemical sensitivity and indoor air quality in urban houses in Indonesia, which later can be used as the base to improve air quality and health. The results showed that apartment respondents are likely to be affected by more factors than those living in Kampong. In Kampong, the age of the building was observed to increase the dampness, after that was possibly causing allergies conditions and MCS among residents. The results of this study implied that higher MCS in apartments is majorly affected not only by their allergic

conditions but also by additional factors concerning building conditions and occupant behavior. Therefore, chemical contaminants are more prevalent in the apartment, and biological contaminants are in Kampong. Furthermore, the windows-opening pattern of occupants in apartments and Kampong are analyzed to find the most suitable opening pattern for Indonesian in their urban residentials. It was found that the longer duration of windows opening does not always result in a lower concentration of chemical contaminants. Further study of the house's exterior condition is necessary to find the best opening pattern.

Chapter 5 explained the key findings extracted from the field measurements and household surveys on the severity of indoor mold risk and its impact on respiratory health, particularly cough symptoms, across a typical unplanned neighborhood of Kampung in Bandung, Indonesia. It is found that most houses suffered severe mold risk, primarily due to extremely humid weather conditions, especially during the rainy season. The TSP and PM2.5 concentrations exceeded WHO standards in most Kampung houses. Around 66% of houses recorded higher outdoor mean PM2.5 concentrations than indoors. Moreover, respiratory health problems increased in dry and rainy seasons, particularly among children. Further path analyses showed that the indoor environment directly impacted children's respiratory health, whereas window-opening, smoking behavior, and exposure to outdoor air pollution affected respiratory health among adults.

Chapter 6 discussed the results of detailed and specific cup measurements in selected apartment units using passive sampling, DSD-DNPH, and passive gas tube for organic solvent, where the sample was analyzed by Gas Chromatography–Mass Spectrometry (GCMS). As expected, the results showed that newly built apartments tend to have higher concentrations of chemical compounds. Several cup measurements found the possible source of pollution in the ambient air coming from materials. These contaminants were found to be emitted by wallpaper and wallboard materials used in the interior of the building. On the other hand, emission rates from several materials are relatively low, resulting in no contaminants detected in the ambient air but in the cup measurement.

Chapter 7 discussed further ventilation modification study cases in selected apartment units to observe the effect of air change flow in the room to the chemical concentration. The modification was followed by long-time observation of daily cooling and ventilation activities. Installing an exhaust-fan to improve the ventilation rate of the apartment was found to lower the IAQ concentration in the long term. Finally, chapter 8 concluded and summarized the main finding of this study and recommended key areas for further study based on the limitations of this thesis.

備考　論文の要旨はＡ４判用紙を使用し，4,000字以内とする。ただし，英文の場合は1,500語以内とする。

Remark: The summary of the dissertation should be written on A4-size pages and should not exceed 4,000 Japanese characters. When written in English, it should not exceed 1,500 words.