Field measurement of $PM_{2.5}$ concentration in office buildings

Naoki Kagi[1,*], *U Yanagi*[2], *Kenichi Azuma*[3], and *Hoon Kim*[4]

[1]Tokyo Institute of Technology, Tokyo, Japan
[2]Kogakuin University, Tokyo, Japan
[3]Kindai University, Osaka, Japan
[4]National Institute of Public Health, Saitama, Japan

Abstract. The characterization of indoor $PM_{2.5}$ has been concerned about health effects. $PM_{2.5}$ in indoor air is affected by not only indoor emissions but also penetrations from outdoor air. Therefore, it is important for indoor $PM_{2.5}$ to take into account of penetration factors of $PM_{2.5}$ through air conditioning units in buildings. This study aimed at investigating $PM_{2.5}$ concentrations and I/O ratios (indoor/outdoor concentration) in office buildings. As a result, the relationships between $PM_{2.5}$ concentrations or I/O ratios and building characteristics could be classified as the types of buildings, such as specific or non-specific, and air conditioning units, such as the individual or central system. The I/O ratio for the specific buildings, over 3,000 m^2 of total floor area and buildings that had the central air conditioning unit was relatively low because of medium performance filter in air conditioning units.

1 Introduction

The characterization and emission of indoor sub-micron aerosols have been of great interest. There are some previous studies reported about influences between indoor particles and health effects [1]. Indoor sub-micron aerosols are closely related to our health. There are few studies for indoor $PM_{2.5}$ compared with suspended particle matter, such as PM_{10}. $PM_{2.5}$ in indoor air is affected by not only indoor emissions but also penetrations from outdoor air. Therefore, it is important for indoor $PM_{2.5}$ to take into account of penetration factors of $PM_{2.5}$ through air conditioning units in buildings. This study aimed at investigating $PM_{2.5}$ concentrations and I/O ratios (indoor/outdoor concentration) in office buildings by field measurements.

2 Methods

The field measurements for indoor particle in office buildings were conducted in 2015 to 2018. This study focused on the relationship between $PM_{2.5}$ concentrations and air conditioning types of each building. The building information of the field measurements is shown in Table 1. The specific and non-specific buildings mean a more than 3000 m^2 floor area building or not, respectively. In this study, the air conditioning systems are classified in two types, the central air conditioning system and the individual air conditioning system. The mass concentrations of $PM_{2.5}$ were measured by TSI Dust Trak 8530 in indoor environments and outside buildings.

3 Results and discussions

The results of $PM_{2.5}$ concentrations and I/O ratios (indoor/outdoor concentration) of each building are shown in Figure 1. Because the buildings of T18, T19 and O08 used ultrasonic humidifiers and F04 had a smoking room, $PM_{2.5}$ concentrations and I/O ratios are relatively high. The other buildings of indoor $PM_{2.5}$ concentrations did not exceed 35 $\mu g/m^3$, which is the 24 hour standard of

Table 1. Building information.

ID	City	Type[1)]	AC[2)]	summer	autumn	winter
T05	Tokyo Kanagawa	S	C	2015-16	2015	2015
T06		S	I	2015-16	2015	2015
T17		S	C	2015-16	2015	2015
T18-1,2		S	I	2015-16	2015	2015
T19-2,3		S	C	2016	2015-16	2015
O02-1,7,9	Osaka	S	C	2016	2016	2015
O03-2L,2S,5		S	C	2016	2015-16	2015
O04		S	I	2015-16	2015	2015
O05-1,2,3,4,5		S	C	2016	2015-16	2015
O06		S	C	2015	2015	2015
O08-1,2,4,5		S	I	2016	2015-16	2015
E01	Tokyo Saitama	S	I	2018	—	2017
E02-1,2,3		N	I	2018	—	2017
E03		N	I	2018	—	—
E04		S	C	2018	—	—
E05		N	I	2018	—	—
W01	Osaka	N	I	2018	—	2017
W02		N	I	2018	—	2017
W03		S	C	2018	—	—
F01	Fukuoka	N	I	2018	—	—
F02		N	I	2018	—	—
F03		N	I	2018	—	—
F04		N	I	2018	—	—

1) S: specific building, N: non-specific building
2) C: Central air conditioning, I: Individual air conditioning

* Corresponding author: kagi.n.aa@m.titech.ac.jp

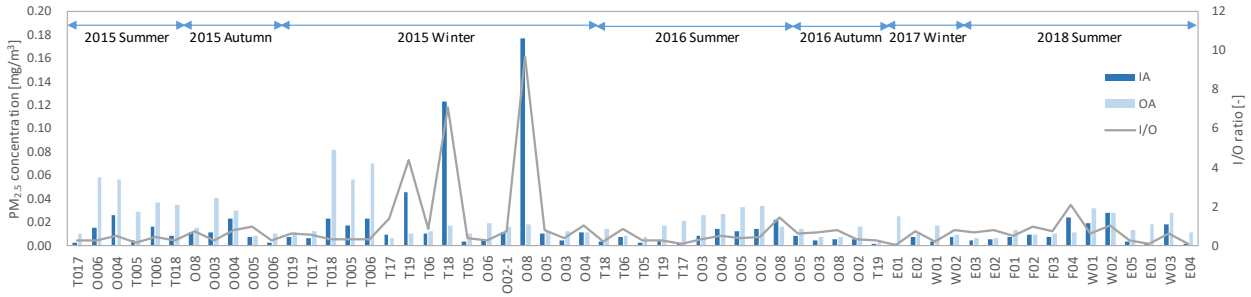
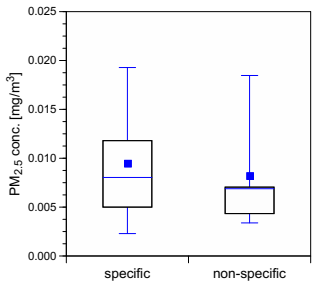


Figure 1 $PM_{2.5}$ concentration and I/O ratio for each building

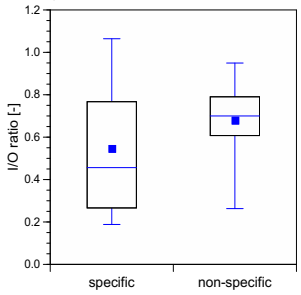
ambient air in Japan (Department of Environment, 2008) and I/O ratios were also lower than 1.

The box plots of $PM_{2.5}$ concentrations and I/O ratios are shown in Figure 2 and 3, when classified into specific, non-specific buildings and central, individual air conditioning systems, respectively. Note that buildings of T18, T19, O08 and F04 in winter are excluded from the data for the above reasons.

The average of I/O ratios of the specific buildings is lower than one of non-specific buildings. Both the $PM_{2.5}$ concentration and the I/O ratio in the central air conditioning were lower than in the individual air conditioning system. This is because the medium performance filters that were usually used in specific buildings and central air condition system could remove airborne particulate matters. The individual air conditioning systems usually only have rough filters. The filter in the central air conditioning system can efficiently remove fine and ultrafine particles from outdoor air and emitted in indoor environments [3]. The difference of the air filter in the air conditioning system could affect $PM_{2.5}$ concentration and I/O ratio.

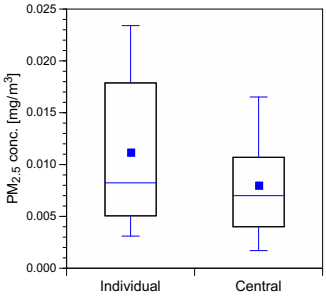


a) $PM_{2.5}$ concentration

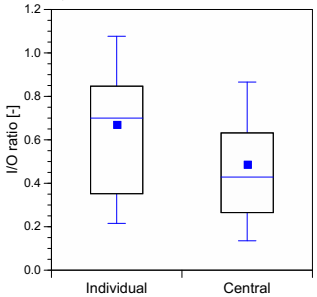


b) I/O ratio

Figure 2 Relationship between building types



a) $PM_{2.5}$ concentration



b) I/O ratio

Figure 3 Relationship between types of air conditioning units

4 Conclusions

This study conducted the field measurement for $PM_{2.5}$ in office buildings.

1. If there is no dominant particle source in the room, the I/O ratios of $PM_{2.5}$ were generally less than 1. The indoor $PM_{2.5}$ could be affected by outside particulate matters.
2. Both $PM_{2.5}$ concentrations and I/O ratios in the individual air conditioning system were higher than in the central air conditioning system.
3. The filter installed in the air conditioning system depends on the type of the air conditioning system. The difference of the air filter in the air conditioning system could affect $PM_{2.5}$ concentration and I/O ratio.

References

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