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Field Survey on Indoor Air Quality and Health in Japan

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Indoor air pollutant by indoor microorganism and house dust has caused asthma, allergy and atopic dermatitis of occupants. In order to make clear indoor air quality and health in houses, eight houses of Miyagi Prefecture in Japan have been investigated. As a result, the amount of floating mold was less than European guideline value. *Penicillium* sp. and *Cladosporium* sp. occupy more than 50% amount of total mold.Amount of mite was higher in the houses with dog or carpet than others.The number of particles in the air and amount of house dust on the floor in houses with dog and little child became higher than others. In addition, there was a lot of house dust on the floor in houses with large carpet area. DEHP was found in 7 houses. The concentration of DEHP was almost thesame as the medium obtained from previous study in Sweden.

Key words: House dust, Health, Indoor air quality, Microorganism, SVOC.

In recent years, air tightness and energy efficiency of residential buildings have been promoted, which has been a contribution to improvement of energy saving and comfortableness in the buildings. On the other hand, it is reported that indoor air pollutant by house dust such as mold and mite has caused the increase ofallergy, asthma and atopic dermatitis. House dust caused by insufficiency of ventilation volume and indoor high humidity is suspected as the source of the disease. Indoor house dust includes spore of mold, carcass and dung of mite and volatile organic compounds, which are suspected to be the cause of allergy, asthma and atopic dermatitis. The first report related to allergies that caused by mold can trace back to the early 30s of last century[1]. The majority of schoolchildren with asthma in the United Kingdom are sensitized to the house-dust mite by Burney *et al*.,[2]. Basagaña et alfound that the mean attributable fraction of adult asthma due to atopic sensitization was 30% and 18% for sensitization to house dust[3]. In the last 40 years a worldwide increase in the prevalence of allergy, asthma and unspecific hypersensitivities has been reported[4].

The final objective is to develop a high efficiency air ventilation system to prevent expansion of indoor air pollution caused by house dust and indoor microorganism such as mold and mite. As the first step of the research, field survey of house dust and health was practiced in eight houses of Miyagi prefecture in Japan from January to February in 2008. The purpose of this survey was to grasp the actual condition of house dust and health in actual residential houses. Temperature, humidity, concentration of air chemicals and ventilation volume were measured, and comprehensive indoor environment including

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the questionnaire survey on health condition and way of living of residents was also investigated.

Outline of the objective residential houses

The houses for the survey were selected through house building companies that were cooperative to this research. The building characteristics were described in Table 1. House E was multi-family house and others were detached houses. House C, D, F and G were comparatively new which were built after 2004 and they were air tight and high energy efficiency house. Twenty-four hour ventilation systemswere installed in these six houses except two comparatively old houses of House B and E. The ventilation systems in House A and H were forced exhaust ventilation system, while that in House C, D, F and G were forced supply and exhaust ventilation system with heat exchanger. The materials of the floor for house dust collection performance were carpets in House B and E (100%, 92%) and wood in House D, F, G and H (68~100%). In House A and C, wooden floor occupies about a half of the total floor space (64%, 55%) and the spaces occupied by carpets were also comparatively large (54%, 22%). The number of residential occupants was two to six. There were more occupants in House C as it holds two families. House C, D and F hold one or two infants. As a special feature, it should be noted that House A and B have pets inside of the houses.

Outline of measurement methods

Floating mold

Floating mold was collected by blowing fifty litters of sucked air with Air Sampler (Merck0MAS-100) to PDA culture plate. Figure 1 showed the collection by air sampler. After collected and cultured at 25°C for five to seven days, mold was counted, which the number of the mold converted in 1 m^3 of air. Measurement points wereLiving room, Another room (Room besides Living Room), Bathroom, Inside of wall in living room, Inside of wall in another room, Crawl space under floor and Outdoor. Inside of wall air was sucked through a wall socket box, and under floor air was through ventilation opening of under floor storage. It was not possible to practice the measurement of inside wall air and under floor air at some houses.

Table 1. Building characteristic

ID	House Type	Total Floor Area [m^2]	Year of completion	Ventilation System	Air change rate [h^{-1}]
A	detached	105	1988	E	-
B	detached	109	1984	-	-
C	detached	150	2004	S&E	0.25
D	detached	153	2006	S&E	0.12
E	multi-family	68	1979	-	-
F	detached	127	2005	S&E	0.35
G	detached	165	2005	S&E	0.33
H	detached	150	1993	E	0.19

S&E: forced supply and exhaust ventilation system with a heat exchanger
E: forced exhaust ventilation system

Table 2. Amount and kind of mold glowing on the wall or floor (Part of results)

ID	Sampling point	Mold glowing on the wall or floor
A	Wash room (Wall)	*Cladosporium* sp.(+++), *Yeast* (+++)
B	Wash room (Wall)	*Cladosporium* sp.(+++)
	Toilet (Wall)	*Cladosporium* sp.(+++), *Penicillium* sp.
	Living room (Floor, Center of room)	*Phoma* sp., *Yeast* (+++)
G	Living room (Floor, Near wall)	*Phoma* sp., *Yeast* (++)

Amount of mold: (+++) more than 10 cfu/m^3 (++) 5-10 cfu/m^3 (unmarked): small amount

Adherent mold

Adherent mold was collected by wiping off 0.01m^2 of Wall and Floor with measurement absorbent cotton (Cotton swab II). The collected mold was transferred to PDA Culture Plate with measurement absorbent cotton, and then separated for morphological identification. Measurement points were Living Room, Another room, Entrance (wall), Washroom (wall). In Living Room and Another room, four measuring points were selected, which were floor center, floor edge, at the height of 10cm and 150cm of the wall as shown in Figure 2.

Mite

Mite was collected by vacuuming 1m^2 of the floor for thirty seconds with a mite collecting filter installed vacuum cleaner. Collected dust was fixed into the laboratory dish and dyed, and then the number and identify the varieties was counted. Measurement points were Living Room and Another room as shown in Figure 3. To grasp the distribution area, two different points were collected in each room, which were the center and the edge of the rooms.

Particles

The number of particles was measured with particle counter (LD-3K2) at one-minute intervals for three days. The point of 150cm high from the floor in Living Room was measured, which wasshown in Figure 4.

House dust

The floor was cleaned with a vacuum cleaner before the measurement and then three days after the accumulated house dust was collected

Fig. 1. Collection by air sampler

Fig. 2. Collection by cotton swab

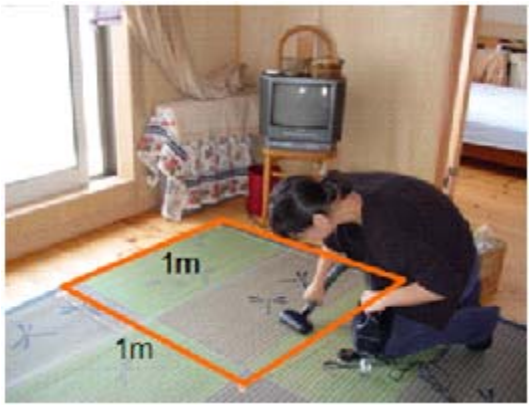

Fig. 3. Collection by cleaner

Fig. 4. Measurement by particle counter

with the vacuum cleaner with the same kind of filter (CPA225D) as shown in Figure 5. The weight difference of the filter was considered as the weight of dust. For the measurement precision electronic scales was used. Dust with less than 63¼m diameter was sifted and SVOC concentration included in the dust was detected at chemical analysis.High effective strains were identified according to the following three methods:

Measurement results

Measurement results of floating mold

Measurement Results of floating mold wereshown in Figure6. The numerical values of indoor (Living Room, Another room and Bathroom) were below the guideline of European Indoor Air Quality Standard (500cfu/m^3) and the number of mold was small. The number of mold inside of wall and under floor was larger than that of indoor. Especially inside of Living Room Wall of House A was very large, 1380cfu/m^3. The cause was not identified but there was a possibility of the growth

Fig. 5. Collection by cleaner

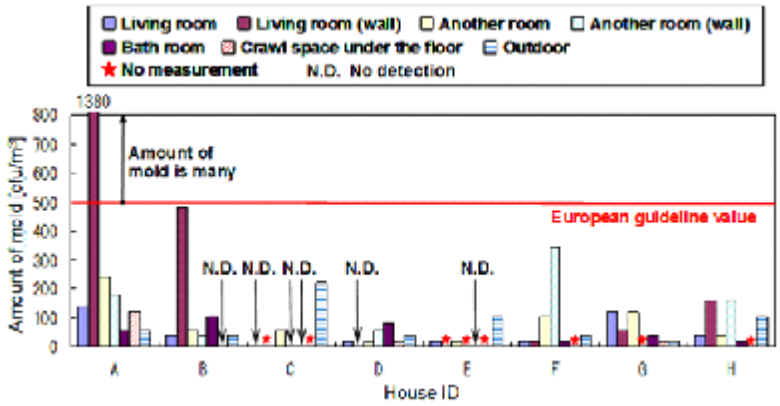

Fig. 6. Amount of floating mold

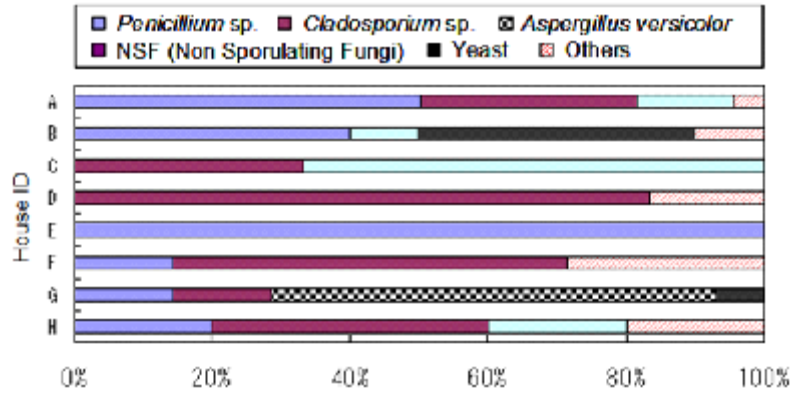

Fig.7. Percentage of every kind of indoor floating mold

of mold at the building structure inside of wall. Mold was detected outdoor of all houses, but there is no mold detected at some measurement points of indoor, inside of wall and under floor.

Fig. 7 shows the percentage of each kind of mold measured Indoor (Living Room, Another room, Bathroom). On the whole, *Penicillium* sp. and *Cladosporium* sp. which were thought to be the allergen of asthma and nasal inflammation were detected in large number, more than 50%. In the Bathroom of House D, *Fusarium* sp. that was thought to be the cause of infectious symptoms and mold poison was detected and it was included in the item of "Other".

Measurement results of adherent mold

A measurement result of adherent mold is shown in Table 2. There was hardly any damage caused by mold in the houses. The amount of collected adherent mold was very small in all houses. Mainly *Penicillium* sp. and *Cladosporium* sp. were detected, same as floating mold. A large number of *Cladosporium* sp. was detected on the surface of the wall in Washroom of House A and in Toilet of House B, where mold was visible.

Measurement results of mite

Mite was collected by vacuuming 1m^2 of the floor for thirty seconds and the number and varieties of Mites was analyzed. Figure 8 shows the number of Mites and it is 0^ÿ28 mites/m^2 at each measuring point. There was no Mite detected at any measuring points in House G. There were more Mite detected from another room of House A and House B and E. All three houses were comparatively old and measuring points were carpet floor. It should also be stated that House A and B have pets inside. Two points were measured

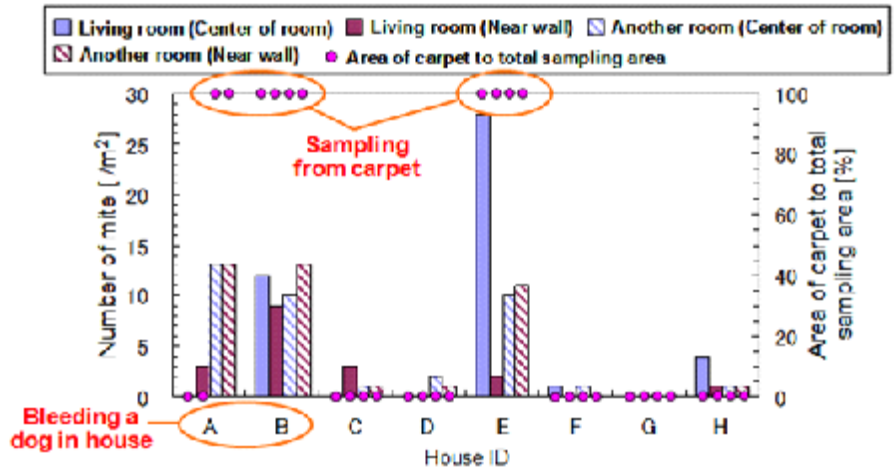

Fig. 8. Amount of mite

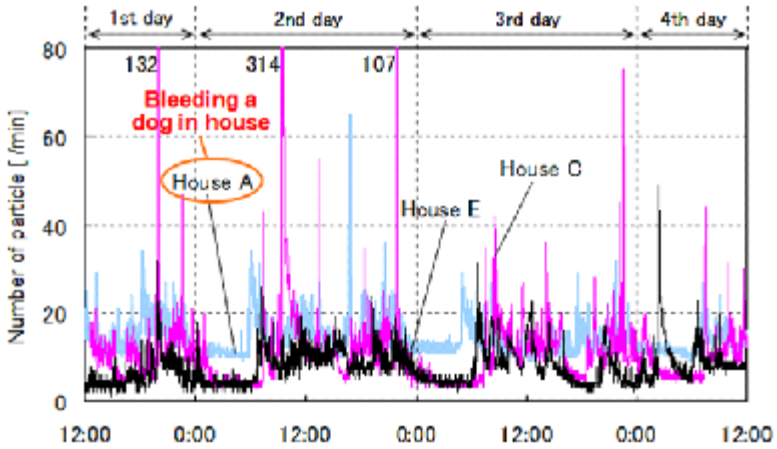

Fig. 9. Amount of particles in the air

in each room, floor center and floor edge, to grasp the distribution of Mite in the rooms. It was anticipated that House Dust settled on floor surface would move toward the edge, which would steer Mites to assembly at floor edge. However, any remarkable resultswere not obtained. It was inferred that the pleasant environment for Mite was involved with not only the amount of House Dust but also with humidity, varieties of House Dust and others.

Measurement results of particles

The number of particles was measured in one minute at one-minute intervals for three days in Living Room. Figure 9 shows the movement of the number of floating particles in House A, C and E, where the way of life and the structure of family were different. All houses showed a tendency to have less number and movement of the particles while they were away for their bedtime than that while they were in the room. The specific characteristic of the way of life in House A was that there was a big dog staying inside. From the results it can be said that there were more floating particles, with average of 12/min in the House A during bedtime than other two houses where there were no pets in the houses. The specific characteristic of House C was that it held two families with more occupants (6 people), there were more people in Living Room during the daytime and there were two active infants. Compared with House E with three adults, House C had about the same number of particles during bedtime but more during other period, and the number of the particles at its peak was large.

Figure 10 shows the average of the floating particles in each house. The number in House A with a big size dog was the largest. And that of House C was the second largest, as there

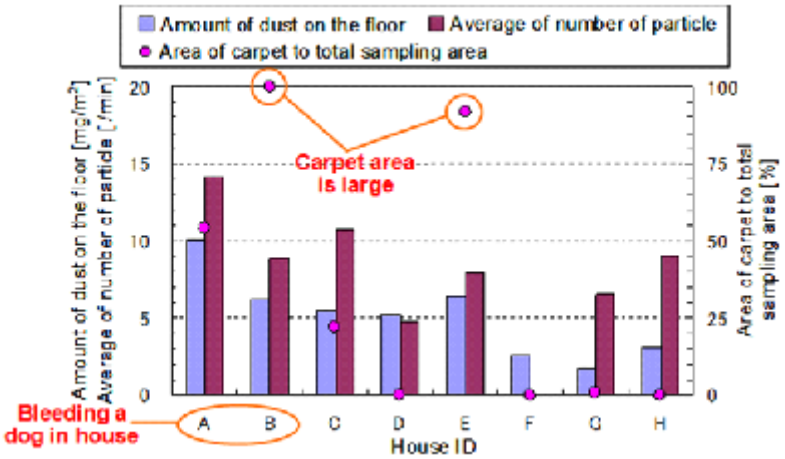

Fig. 10. Amount of house dust and particles

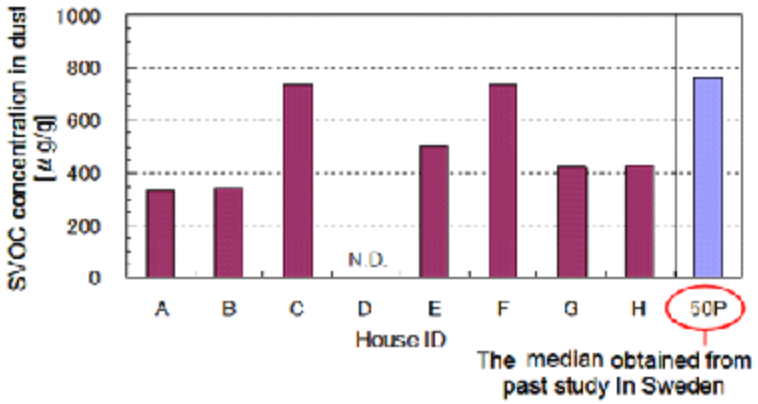

Fig. 11. SVOC concentration of house dust

were more occupants staying in the room longer period of time and two active infants. The measurement in House F was canceled because of breakdown of measuring equipment during the survey.

Measurement results of house dust

After vacuuming accumulated House Dust on floor for three days with the vacuum cleaner, its weight was measured. Figure 10 shows the result. House A with a big size dog inside had more dust same as floating particles. House B and E, where carpets occupied a large space, had more dust than House F, G and H that hadlarge wooden floor spaces. Although House C had a small carpet floor (22%) and House D had only wooden floor (100%), they had more dust collected than House F, G and H, where large space of the floors were also wooden. Itwas consideredthat both House C and D had two infants and House D kept a dog inside of the front door at night. The way of life and the structure of the occupants affected more than the floor material.

Concentration of SVOC in House Dust is shown in Figure 11. Object compounds for analysis were 2E1H, D6, BHT, DEP, C16, TBP, TCEP, DBA, DBP, C20, TPP, DOA and DEHP[5]. The only compound detected was DEHP. Figure 12 shows the amount of DEHP in 1g of House Dust. The amount of each house was 334~737μg/g. In the Figure 11, 50 percentile value of previous survey held in Swedenwas also shown[6]. The value of each house was smaller. The concentration of DEHP of House D was below limitation.

CONCLUSIONS

This paper is to report the results of survey of House Dust and health in eight houses of Miyagi Prefecture in Japan.The following conclusions have been drawn:

1) Amount of indoor mold in all houses was smaller than European guideline value.*Penicillium* sp. and *Cladosporium* sp. occupied more than 50% of total mold.
2) Amount of mold in the wall was more than indoor mold.*Cladosporium* sp. was found on the wall of wash room and toilet.
3) Amount of mite was higher in the houses with dog or carpet than that in the houses without dog or carpet.
4) Amount of particles in the air was higher in the houses with dog or carpet.
5) Amount of house dust was affected by the number and kind of occupancy or life style of them.
6) DEHP, one of SVOC, was found in 7 houses.Concentration of DEHP was almost the same as the medium obtained from past study in Sweden.

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