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MICROBIOLOGICAL CONTAMINATION FROM AIR CONDITIONING SYSTEMS IN JAPANESE BUILDINGS

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Abstract

Fungal and bacterial particle contamination in air conditioning systems and supply air were investigated in four buildings in Tokyo area. At the steady state operation the concentration was very low but the turbulence such as starting the system, opening the service door or changing filters during operation of system caused significant increase. Fungi and bacteria were of human and earth origin.

Forward

Recently the indoor air pollution by microbiological particles in air-conditioned building is attracting the attention because of its potential source of infection, allergy, contamination and also as one of indice of environmental conditions.

The concentration of airborne bacteria or fungi dependent upon many elements such as occupants' density and activities, quantity existing in the space, and building elements among which the air-conditioning apparatus might have important role in modern buildings.

This paper is to report the results of measurement of microbiological contamination by the air-conditioning systems in four office buildings in Japan during summer and winter season operations.

Measurements

The outline of buildings investigated is shown in Table 1.Elements to be

measured and methods were as follows.

Airborne bacterial and fungal particles: slit-type air sampler (M/G 200J) and 6 stage type Andersen sampler with tripto-soy agar (for bacteria) and potato dextrose agar (for fungi).

Surface bacteria and fungi: swab with paper and incubation same to above mentioned agar.

Particulate matter: Light scattering type particle counter for 5 sizes (KC-01).

Bacteria and Fungi were isolated and identified to genus or species.

Incubation: for bacteria, 37 C 48 hours and for fungi 25 C 72 - 94 hours incubation was used.

Major parts of measurements were made at the air outlet or diffuser using skirt-like attachment, also the air conditioner itself was investigated of contamination along the air flow path. Swab samples were taken at appropriate positions.

Conditions of tests were as follows.

1. At the first start of air conditioner of the day and following intentional off and on operation.
2. Steady state operation.
3. Intentional turbulence by moving the role-type air filter, opening and closing of service port of the air conditioner or operation of damper adjustment all the air-conditioning system in operation.

Results of Measurements

The concentration variation of fungal particles, bacterial particle and total particulate matters of 0.3 - 5 m diameters were obtained at the above mentioned conditions as shown in Fig. 1 - 3.

Though the types and values changed by building, they showed same tendency. At the day's first start of the air conditioning systems the concentration of supply increased, as expected. However, secondary start gave very significant less increases (Fig. 1 - 2).

At the steady state operation, the concentration is, generally speaking, very low for both total particles, fungal and bacterial particles as shown in Table 2.

When turbulence such as opening of inspection port or changing air filters gave considerable increases in incentration of supply air, which is shown in Fig. 3.

The example of determination of bacterial and fungal particles to the genus is shown in Table 3.

Discussion

1. Generation at start and stop operation

The quantity of biological particles from the supply outlet at the starting and stopping of the operation showed the maximum value at the first one of the day and decreased or vanished at the subsequent trials. The amount changes by the building and system, but, generally speaking, the amount is less than expected.

The contamination accumulation in air-conditioning system depend upon many elements such as age and material, structure of the system, the the quantity of air transported, environmental condition for fungi or bacteria in system and cleaning method. The reason of less amount than expected was that these buildings were relatively new and that these particles which are loose enough to be removed have been blown off by the preceding routine operation of the system.

2. Generation by the turbulence

Of the turbulence tested the opening of the service port door showed most significant increase of generation. Especially when the downflow side one of the air conditioner was opened even visible particles were blown out through the diffusers.

The main mechanism of generation seemed to be the abrupt increase rate of air flow caused the take off of settled or attached particulate material in the chamber or air duct.

Also vibrations caused by the change of air pressure must be another reason. The movement of role type air filter release fairly large amount of particles deposited on it as shown in the Photo 1, which was an example of fungal particles and mainly consisted of Cladospolium in this case.

3. Average concentration

The average concentration of supply air at stage operation showed very low concentration as shown in Table 2. The main cause of indoor concentration development seems to be the indoor generation. The influence of starting must be very small. However, some fungi or bacteria is found by surface swabbing of air conditioning apparatus even we do not find airborne ones and these would become airborne if some conditions develop.

4. Biological phase

At the start of system we get Aspergillus and Cladospolium and decrease abruptly afterward. In steady state operation many colonies of grampositive cocci which are to be human origin and of Corynebacterium which are to be earth origin were found.

At fresh air intake of a skyscrape many Bacillus subtilis and Corynebacterium which seems to be earth origin were isolated.

in Changing filters many Cladospolium colonies were found. On coils no bacteria nor fungi was isolated.

Table 1. Outline of Buildings Measured

Names of Building	Above Ground / Basement	Year of Construction	A. C. System	Air volume Supplied
M	7 / 2	1965	Single Duct	4.3×10^2 m^3/h
T	32 / 3	1977	Zone Single Duct	2.6×10^2
H	6 / 1	1966	Floor Single Duct	1.4×10^2 * $- 4.7 \times 10^2$ **
S	9 / 2	1973	Floor Single Duct	

* interior zone, ** perimeter zone

Table 2. Average Concentration of Supply Air (Steady State Operation)

Season	Name of Binding	Fungi(P/l)		Bacteria(P/l)	
		S. S.	A. S.	S. S.	A. S.
Winter	M	0.002	–	0.005	–
	T	0.03	0.005	0.007	
	H	0(0.006)*	0.005	0.005(0.02)*	0.004
	S	0	–	0	–
Summer	M	0.12	–	0.004	–
	T	0.014	0.016	0.004	0.005
		0.016			
Inter-mediate	S	0.006	0.01	0.001	0.004

S.S. : Slit Sampler, A. S. : Andersen Sampler
* Perimeter zone

Table 3-1 Geuns of Airborne Bacteria (Intermadiate Season, Building S)

Genus	Colonies
Bacillus	47
Corynebacterium	70
Streptomyces	29
Kurthia	13
Staphylococcus	10
Micrococcus	69
Aerococcus	25
Yeast Fungi	50
Others	11

Number of Samples : 7 sets

Table 3-2 Genus of Airborne Fungi (Winter, Building H)

Genus	Colonies
Aspergillus	17
Penicillum	10
Scopularisis	1
Paecilomyces	2
Acremonium	1
Moniliella	140
Monillia	1
Chaetomiun	1
Stachybotrys	1
Cladosprium	102
Yeast	1
Others, unknown	22

Number of samples : 4 sets

Table 1. Transfer Rate to Other Stages

	Stage	Collection Efficiency to Each Stage(%) — Particle Pertaining Stage 7	6	5	4	3	2	1	Apparent Collection Efficiency
Collecting Stage	7	92.5	12.5						%
	6	7.5	66.0	16.0	1.0				97.4
	5		21.0	66.0	12.0	0.5			100.2
	4		0.5	17.7	63.0	19.0	0.7		109.4
	3			0.3	23.3	63.0	15.4	0.8	98.0
	2				0.7	16.5	61.0	9.1	101.8
	1					1.0	22.9	90.1	97.4
		100	100	100	100	100	100	100	
Range of Particle Diameter μm		—	0.75 -1.4	1.4 -2.25	2.25 -3.5	3.5 -5.5	5.5 -8.0	8.0 -15	

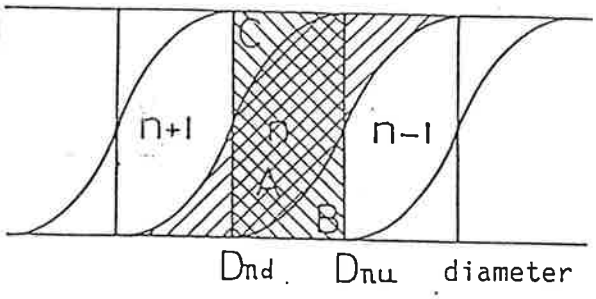

Fig 1. Toransport of Perticles to Other Stages

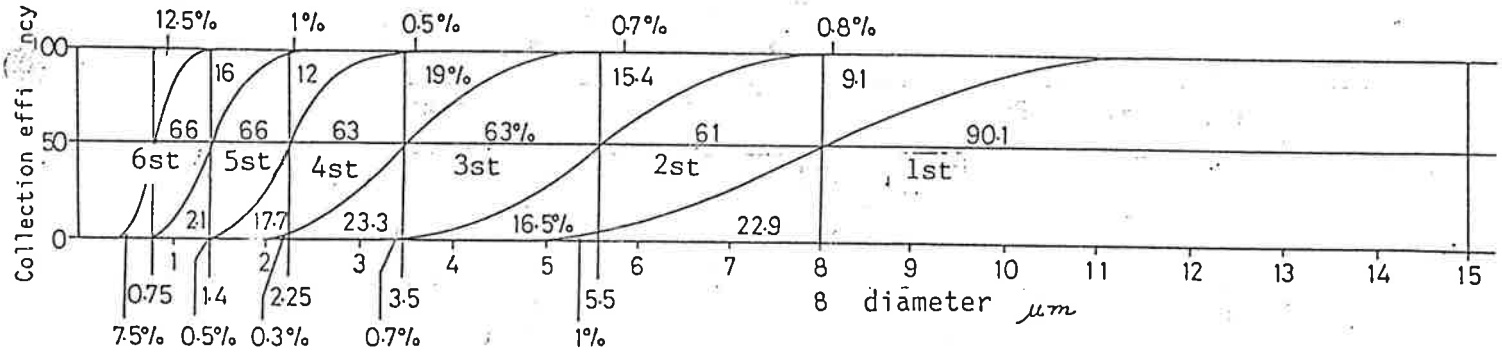

Fig 2. Collection Efficiency and Transfer Rate of Perticles to Other Stages

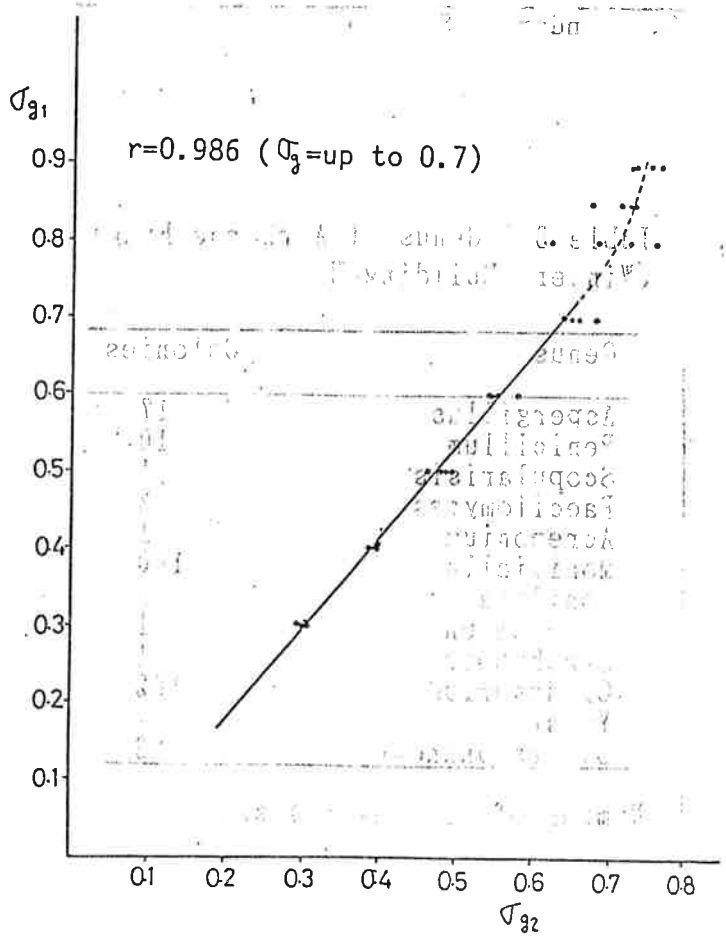

Fig 4. Correlation of σ_{g1} and σ_{g2}

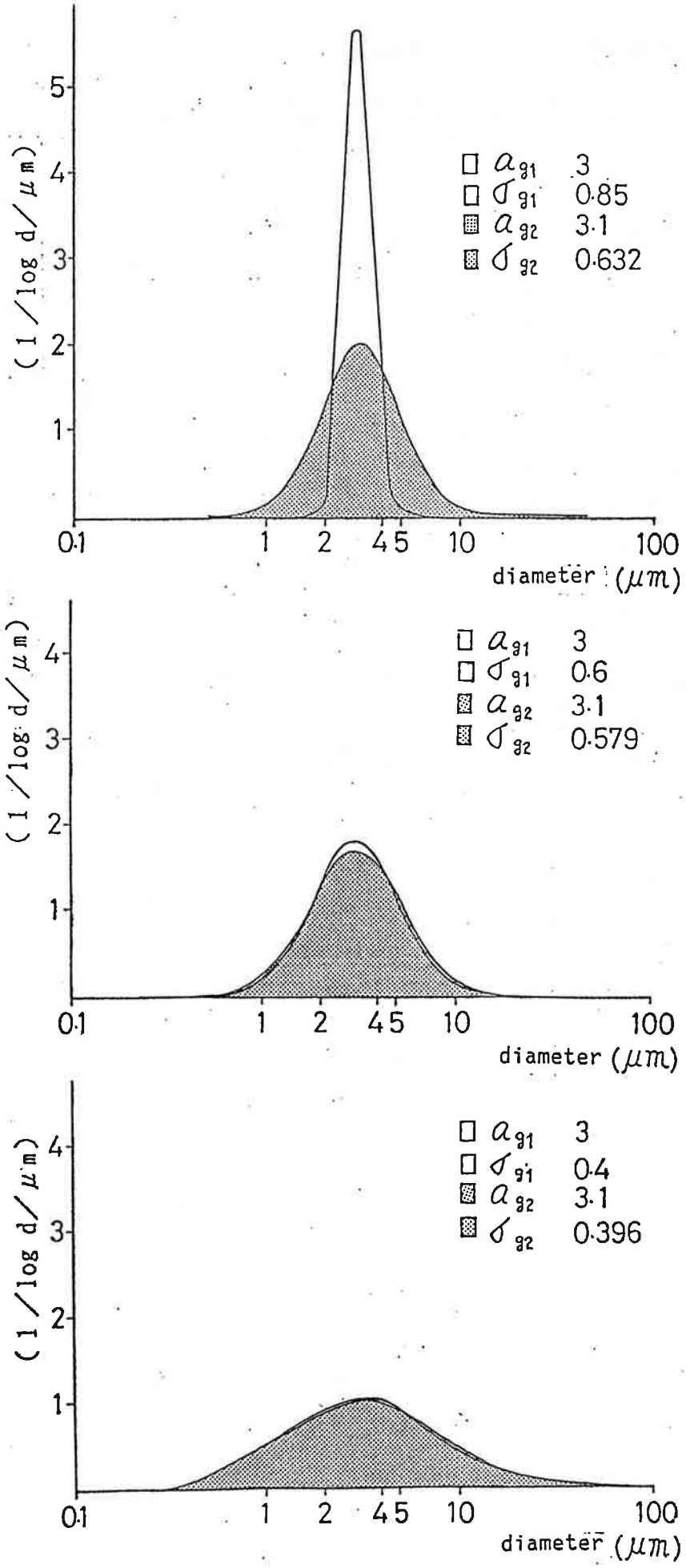

Fig 3. Comparison of Distribution Curves of Various σ_{g1} and σ_{g2}