One method for evaluation of the contribution of outdoor air to indoor bioaerosols is rank order assessment. Individual taxa are listed in descending order of abundance for indoor sites and outdoor controls. It may be obvious at this point whether or not the indoor and outdoor populations differ, and if amplification of certain taxa has occurred indoors. For saprophytic fungi the proportion of taxa found in outdoor and indoor collections should be qualitatively similar, if outdoor air is the only source of fungal bioaerosol.

Recommendations for Remedial Actions

Effective remedial action for controlling saprophytic bioaerosols most often involves interruption of the transmission of microorganisms from reservoirs and amplifiers to the occupant. A basic requirement for microbial growth is the availability of water. One very effective remedial action which involves the disruption of microbial amplification is to remove sources of water in the indoor environment or in the HVAC system which provides air to occupied space. Specific remedial measures that can be taken include the following: Remove and prevent the accumulation of stagnant water in HVAC system mechanical components. Maintain relative humidity in indoor spaces at levels less than 70% (<50% where cold surfaces are in contact with room air). Remove and discard porous organic materials that are obviously contaminated (e.g., moldy ceiling tiles). Wash with dilute bleach (1 cup per gal of water) all smooth surfaces that have been contaminated by microorganisms. When this recommendation is carried out for HVAC system components, make certain that disinfection occurs while the system is decommissioned. An excellent preventive maintenance program is essential for humidifiers, water spray systems, and other HVAC system components that may become wet. Replace filters at scheduled intervals and depending on the HVAC system fan capacity upgrade the collection efficiency of filters.

Affected personnel should not be returned to the environment until the source of the problem has been identified and corrected. If illness persists in the workplace even after remedial actions, affected personnel need to be permanently reassigned to another area. Whenever possible, the sampling protocol should be followed (as originally done) after remedial actions have been taken to demonstrate effectiveness.

Reference

1. American Conference of Governmental Industrial Hygienists, Committee on Bioaerosols. Airborne Viable Microorganisms in Office Environments: Sampling Protocol and Analytical Procedures. Applied Industrial Hygiene (1986) 1, R19-R23.

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 * - 4.7×10^2 **
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) S. S.	Fungi(P/l) A. S.	Bacteria(P/l) S. S.	Bacteria(P/l) 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

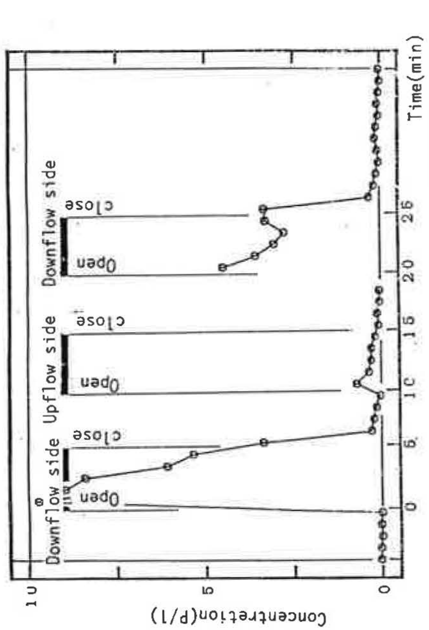

Fig 3. Effect Opening Service Door (Fungi)

Photo1. Release by Movement of Air Filter

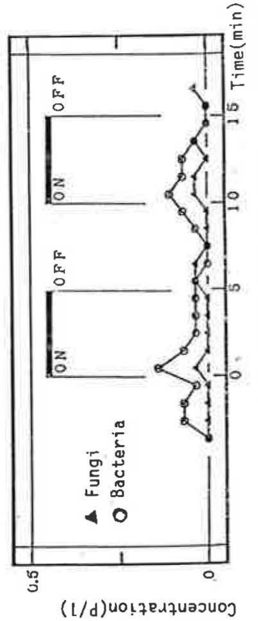

Fig 1. Efffect of Starting Air Conditioning System

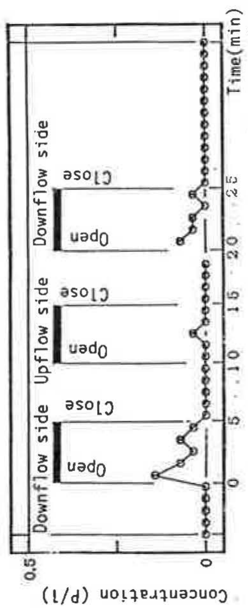

Fig 2. Effect of Opening Service Door (Bacteria)