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THE CONCENTRATION LEVELS AND CHARACTERISTICS OF INDOOR AIRBORNE MICROBIOLOGICAL PARTICLES IN JAPANESE BUILDINGS

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ABSTRACT

This is to report on results of field measurements of the level and their characteristics of airborne microbiological particles in buildings in Tokyo area.

The results show that the concentration in air-conditioned buildings were low, around 0.1-0.2 cfu/l for bacterial particles and 0.02-0.03cfu/l for fungal ones.

From the diurnal variation of concentration and occupants density, the concentration had high correlation with occupant density andtheir activities.

INTRODUCTION

Though the microbiological contamination in office envirements are generally considered to be one of the causes of alergy or malodour which might induce the sick building symptoms, they can result in grave cases of such as outbreak of tuberculoses infection in offices.(1) Much more considerations are required in measures against microbiological contamination in especially high-rise buildings with the increasing demands for energy saving and for higher tightness which lead to the more artificial environment.

At present, however, thereare no regulations on this point, nor the optimum for allowable levels of concentration of airborne microbiological particles or settle plate counts.

Besides the method of measurement itself is still the subject of discussion and no definit method is established.

The first requirement to control biological contaminant in indoor environment is to understand the status and characteristics of contamination in actual buildings.

We have been working on the behavior and chararistics of airborne biological particles in various indoor environments for these years and would like, in this report, to introduce some of the results of measurements on bacterial and fungal particles in office buildings with air-conditioning systems in Tokyo area.

THE OUTLINE OF MEASUREMENTS

Three of six buildings measured were of relatively new-built ones with modern air-conditioning systems, two of which were sky-scrapers, remaining two were privately owned office buildings of 8 - 10 floors. One building was a rather old office building and the other one was the kind of building with packaged air-conditioner which was intermittently operated in summer days.

To measure the time variation of airborne microbiological particle concentration, long-time slit samplers (M/G 200J) were used, and other apparatus were utilized for specific purposes; Andersen samplers for particle size distribution, settle plate counts, Leuter Centrifugal Samplers, Pin-hole samplers, and light scattering type particle counters for determination of concentration and sizes of total particulate materials.

As for collection media, Tryptosoya agar at 37 C for 48 hours for bacteria and Potato-dexist-rose agar with chloramphenicol at 25 C for 72-96 hours were used.

The sampling time was 10 minutes for Andersen samplers, 60minutes for slit samplers and 5 minutes for settle plate counts. Data with total particle counter were recorded in tape and analysed later.

The colonies grown on media plates were visually counted after the incubation mentioned above. No determination of species were made during countin except apparent fungal colonies growing on bacterial media which were excluded.

THE RESULTS OF MEASUREMENT

Diurnal variation of airborne microbiological particle concentration are shown in Figs. (Figl -5) which were constructed from the data obtained by dividing the number of the slit sampler sample into 2 minutes values.

From the variation characteristics of bactrial particle concentration in D buildings(Figl), vary significant low concentration before the office hours and lunch recess can be seen. (2) Since the main origin of generation of indoor bacteria is considered to be from man, its concentration get strong influences from the occupant density. FromFig2 the sharp rise of the fungal particle concentration is seen when sweeping activities wer performed which show that indoor activities would make the fungal particles airborne which had been grown on the various surfaces of buildings.

The diurnal concentrations of DMbuilding, F building and SC building in Fig 3-5 respectively. From Fig.3 the sharp rise of concentration at the time of power source suspention and after the air conditioning system was stopped, and decrease dur lunch time are clearly shown which are the effect of occupant density and operation of air-conditioningsystem. (1) (3) (4)

The F building showed the low concentration bacterial particles before the office begans after the air-conditioning started which implies

tne strong effect of occupants. Though during the lunch recess the air-conditioning was stopped, the concentration did not change became of low occupancy. After 17.00 hours, with air-conditioning stopped, the bacterial concentration gradually increased despite of low occupancy.

With SC building, wich was skyscreper and the rooms measured were for architectural design business, showed the occupant density and bacterial concentration has propotional tendency and fungal particle are rather constant and not much relation with the changes of occupancy.

Fungal particles, in general, are low in air-conditioned buildings both in concentration and settlements which imples that the generation rate at normal state is low and some tubulences introduced by the strong activities would cause the shedding of them. Since the rate would be proportional also to the amount exist indoors and more work to be done to clarify how much and where we have the reservoirin building components and in air conditioning systems, and also their changes by years elapsed.

DISCUSSION

1 Average Concentration.

The results of measurements in these buildings are summarized in average values in Table 1.

The average bacterial concentration of airborne colony forming units in office buldings with modern air-conditioning systems were around 0.1cfu/l. The rather old buldings with air-conditioning showed similar results.

In the building which used intermittent operation showed 0.3 cfu/l, where well over 1.0cfu/l values were observed when air-conditioning system was stopped.

The concentration of airborne fungal particles were low and around 0.02- 0.03 cfu/l.

The bacterial settle plate counts were also low for buildings with low concentration and around 1.2-1.5 cfu/petri.d. 5min which were 1/6 of outdoor values.

Fungal settle plate counts were lower than bacterial ones and showed 0.1-0.15 cfu/petri.d. 5min which were for lower than the outdoor values of 45cfu/petri.d 5min.

The low values came from the low concentration and the slow settling velocity as mentioned later.

These values were much far lower compared with values given by previous reports.

For example in ordinary office buildings they had 30-50 cfu/petri d 5min of bacterialsettle plate counts and 1.0 cfu/l of concentration in 1950-1955.(5)

The progress of architectural and air clearning technology, the widespread of maintenance practice of indoor sanitation and also tightening of building shells from the demand of energy saving occurred.

We would have to keep up with the changes of the building enviroment. For example, one scientific society, which is one of very few that touches the problem of airborne bacterial particles, recommends 30cfu/petri.d 5min for indoor enviroments. whichis far much high values to be applied for ordinaly air-conditioned buildings.

2. On the variability

The timely fluctuation of concentration is one of the most characteristic features of airborne microbiological particles and considered to be caused by the fluctuation of generation rate and the mechanism of diffusion and transport.

We have expressed the variability by the coefficient of variation in terms of averaging time. In case of bacterial particles, at the concentration level of 0.3cfu/l, the coefficients of variation were0.3,0.1 0.08 for averaging time of 2,5,and 10 minutes respectively. In case of fungal particles the coefficients were 0.25, 0.15, for same pampling time length. (6)

If we do not have distinguished activities or climatic changes which would give a grave effect on the concentration, the sampling time of indoor microbiological particles are disirablly 5 minutes or longer to stabilize the values.

3. Size distribution

The size Distribution of fungal particles collected by Andersen samplers were very similer to the log-normal distribution with the median at 3.5 μ and the bacterial particles did not show identical distribution types as were previously reported by us. (7)

From the size distribution, we can easily for see that it is rather difficult to collect the fungal settle plate counts for enough numbe in the ordinary sampling time of 5 minutes. With bacterial particles the larger portion of size distribution contribute very much to the total number of settle plate counts that lead to enough values for statistical comparisons.

4.Correlation with Occupant Density

Coefficients of correlation between occupants density and fungi, bacteria and various sizes of total particles are shown in Table2.

Since the concentration is determined by the balance of generation rate and cleaning or air-conditioning capacity, it is easily expected that the bacterial concentration would have the correlation with the occupant density. The relation between occupant density and concentration of fungal and bacterial particles are shown in Fig.6. The coefficient of correlation for bacterial particles is 0.7 and for fungal particles 0.03, showing the governing factor for fungal particles is other than occupant density.(4)

The total number of particles or any sizes had high coefficient of correlation to occupant density.

SUMMARY

1. The average concentration of bacterial particles in air-conditioned buildings were around 0.1cfu/l and the settle plate counts were around1 1.2-1.5 cfu/petri d 5min. The fungal particle showed lower values of 0.02-0.03cfu/l in concentration and settle plate counts were 0.1-0.15cfu/ petri d 5min.

2. The bacterial particle concentration indoors in office buildings has correlation with occupant density and also influenced by activities. The fungal particle concentration get strong influences by the indoor activities but not by the occupant density.

3. The variability of airborne microbiological particle concentration can be expressed in coefficient of variation and sampling time isdesirally longer than 5minutes for the stability of measured values.

4. The size distribution of airborne fungal particle concentration were, as previously reported by us, log-normal distribution with peaks around 3.5 m. The bacterial particles had no definit tendencies.

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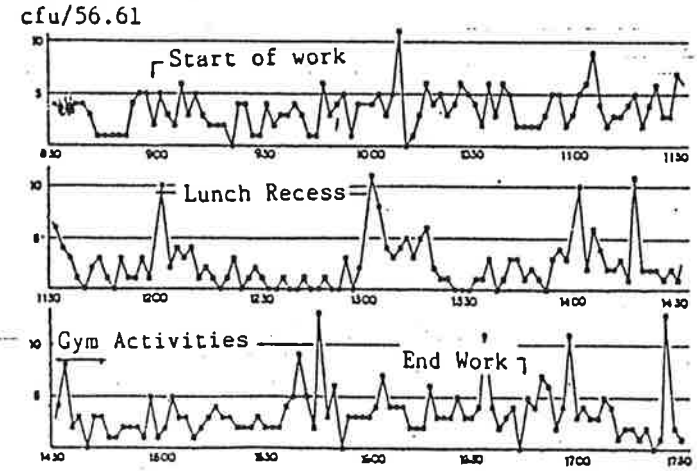
Table1. Average Concentration and Settle Plate Counts
(average one working day)

Building	Scale	Air-Conditioning	Settle Plate Counts (cfu/petri d.5min)		Concentration (cfu/l)	
			Bacteria	Fungi	Bacteria	Fungi
T	9floor	central	0.12	0.02	0.96	0.33
S	sky-scraper	central	o.115	0.02	1.89	0.11
D	10floor	central	0.069	0.035	1.95	0.15
DM	7floor	packaged	0.326			
SB1	sky-scraper	central	0.199	0.036	2.33	0.096
SB2			0.216	0.084	2.0	0.089
F	9floor	central	0.099			

Table 2 Coefficients of Correlations (SB Building)

	Occup.D	Bacteria	Fungi	Total Particulates				
				>5μm	>2μm	>1μm	≥5μm	>.3μm
Occup.D	1	.69935	.03366	.74499	.75326	.67433	.72994	.87345
Bacteria	.69935	1	.31143	.70038	.76656	.72056	.71677	
Fungi	.03366	.31143	1	.23421	.22676	.29269	.26894	.1261
Total Particulats (μm) >5	.74499	.70038	.23421	1	.95507	.65755	.62521	.66607
Total Particulats (μm) >2	.75326	.76656	.22676	.95507	1	.75059	.69392	.72151
Total Particulats (μm) >1	.67433	.72856	.29269	.65755	.75059	1	.96052	.87349
Total Particulats (μm) ≥5	.72994	.71677	.26894	.62521	.69392	.96052	1	.91881
Total Particulats (μm) ≥3	.87345	.72817	.1261	.66607	.72151	.87349	.91881	1



Figl. Bacterial Concentration in D Building

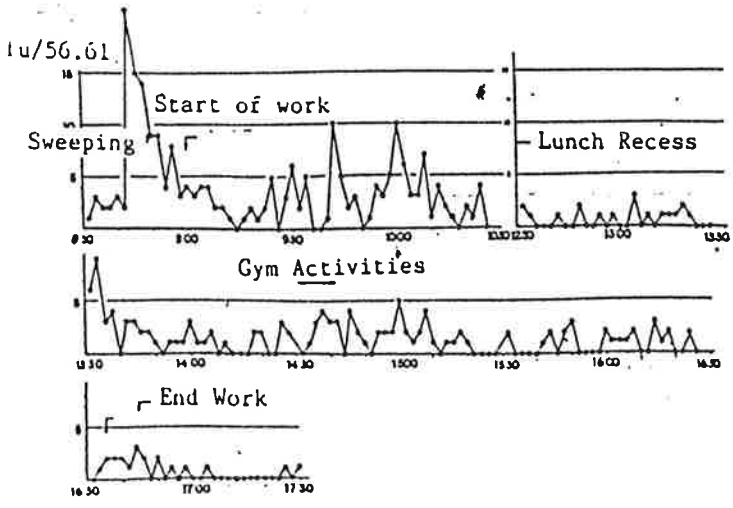


Fig2. Fungal Concentration in D Building

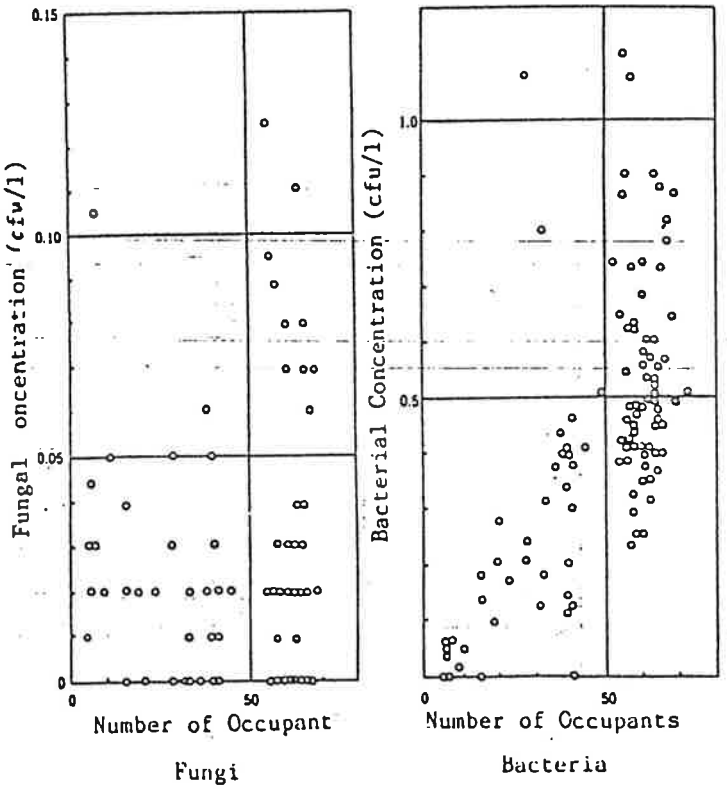


Fig6. Correlation with Occupant Density

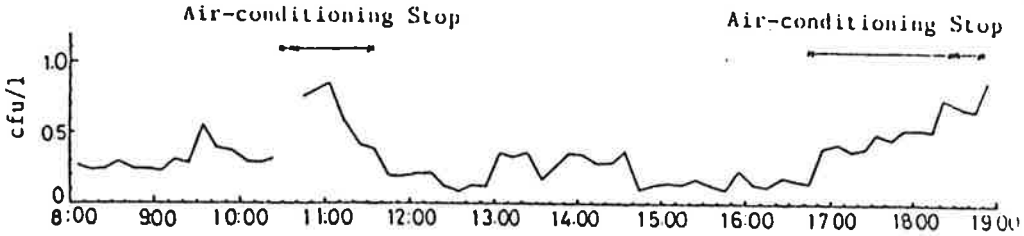


Fig3 Bacterial Concentration in DM Building

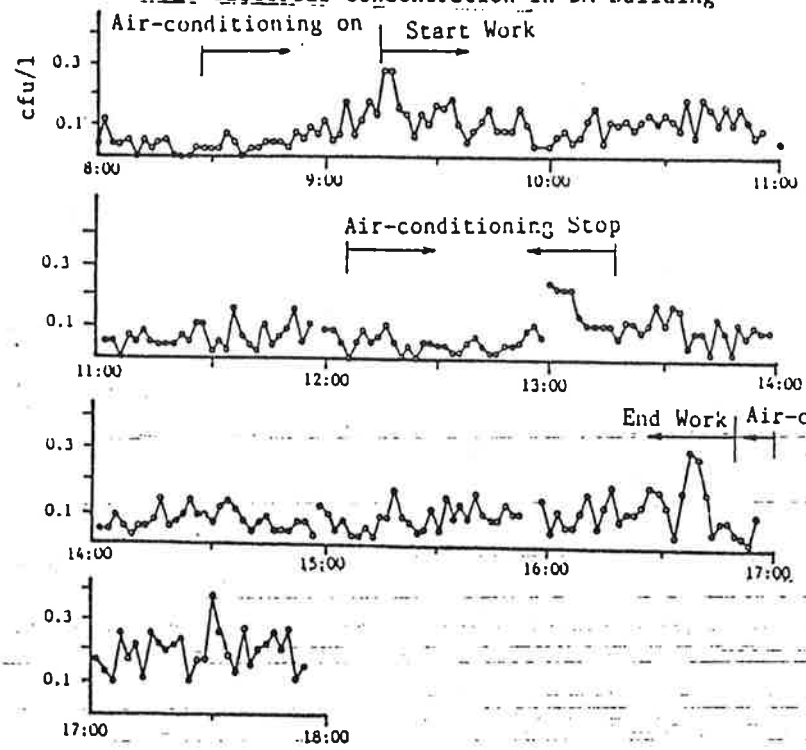


Fig4 Bacterial concentrationin fF Building

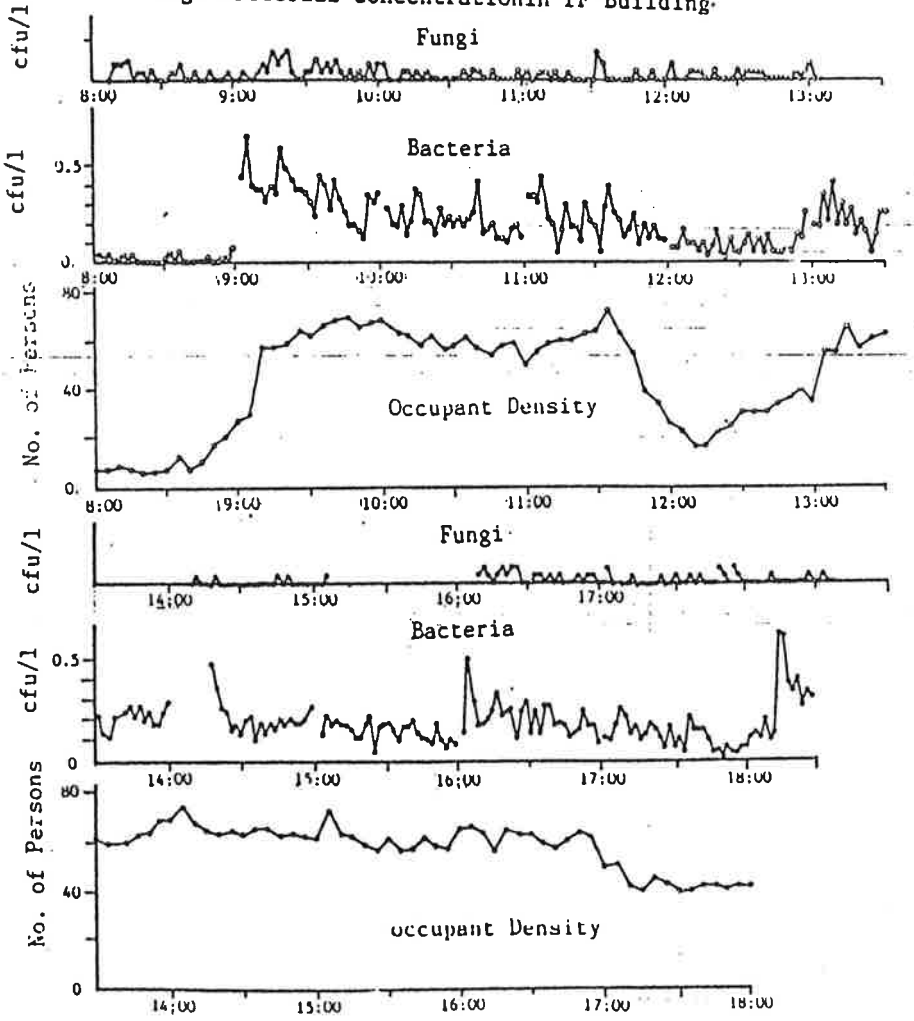


Fig5 Diurnal Variation of Concentration in SB Building