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SIZE DISTRIBUTION OF AIRBORNE FUNGAL AND BACTERIAL PARTICLES IN JAPANESE BUILDINGS

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Abstract

The results of indoor enviromental measurement on the size distribution of airborne fungal and bacterial particles using Andersen air sampler (6 stage) which were carried out in 1978-82 in Tokyo area. The size distribution of fungal particles were similar to log-normal distribution with peaks(mode) around 3.5μm irrespective of seasons, spaces or concentration levels. Results of Cladosporium particles alone were almost same. Those of bacterial particles did not show definit distribution types. The difference of those size distribution characteristics seem to come from mechanism of liberation into air. The median of size were around 3.5μm for fungi and 5.5 - 6.5μm for bacteria.

Introduction

The characteristics and behavior of airborne fungal and bacterial particles have very strong influence to the mechanism and degree of contamination, control performance of control measures such as air filters, and also to the transport and diffusion by air flow.There are, however, not many quantitative information and studies about them especially on the size distribution at actual airborne state. Of course we have many data on the morphological size of fungal and bacterial particles, but the behavor of particles of airborne state must be quite different due to the differnce of density, agglomeration and co-existent materials.

If the aerodynamic size range and size distribution of airborne biological particles are determind,it is very muuch usful to the evaluation of samplers,the prediction of contamination levels of indoor enviroment, and the collection efficiencies of air-cleaning devices and establishment of control measures.

There are not many information of the aerodynamic size distribution of airborne fungal and bacterial particles in the field of engineering. On the other hand we have many studies of the Andersen samplers which were developed originally for the evalution of airborne bacterial particles; on their collection mechanisms, analyis of aerodynamic characteritis, and collection efficiencies (1, 2, 3, 4).

We would like to introduce the results of measurments on the concentration and size distribution of fungal and bacterial particles in Japanese building of several types mainly air-coditioned for the purpose of providing the basis of engineering control measures against indoor air pollution by airborne microbiological particles.

Experimental

Method of collection. For the collection of airborne fungal and bacterial particles, the six stage Andersen samplers of standard type used at 28.31/min flow rate, the sampling time being 5-15 minutes depending on the circumtances.

The samples were collected on agar media plate, the colonies were counted after the incubation of 96 hours at 25°c(fungi) and of 48 hours at 37°c(bacteria).

The colonies grown on the potato-dexistrose agar with chloramphenicol were counted as fungi and onthe triptosoya agar were as bacteria.

The long time (30-60minutes) slit samplers and light-scattering type airborne particle counters were also used simultaneously.

Type of buildings measured. Six air-conditioned buildings, undergroundshopping centers, subway stations and dweling house of natural ventilation were measured. Each measurements were made for one-three days. Most of the air-conditioned building were of office purpose.

The collection characteristics of Andersen sampler. The range of particles sizes collected on each stage of the Andersensamplers were determind according to the method in our revious report (4).

Using the relation of the impaction parameter and collection efficiency, we obtained the upper and lower limit of collection sizes, which were then plotted on the log-probability distribution paper.

The straight stage and the upper limit of preceeding stage is considered as the cumulative distribution curve of the collecti of the stage. The 50% value of these curves are taken as the aize ranges collected on each stage (Fig 1).

The size distribution of particles by the Andersen samplers were determind by the actual measurement of pore sizes by optical microscope and also these theoretical caluculation.

Method of evalution.
The colonies were counted, corrected according to Andersen's positive hole conversion table, divided by the range of size collected on each stage, obtained the size distribution at each 1μm range which were plotted in histogram(Fig 2).

Results of Experiments

Average concentration. The concentration of airborne fungal and bacterial particles are very much influenced by the characterstics of activities, type of buildings, seasons, state of maintenance services and also by the sampling method.

The average values of concentration in various buildings which were measured by us were as shown in Table 1.

In air-conditioned office the concentration varies from 0.1 cfu/1-0.3 for bacterial particles,0.02-0.05cfu/1 for fungal particles. Incases of subway stations we have much seasonal variation of order of 0.5-1.4cfu/1 for bacteria and 0.2-1.2cfu/1 for fungi.

Size distribution. The example of size distribution histogram of collected particles is shown in Fig 2.

Incases of fungi we almost definitly have specific curve, but in cases of bacteria we obtained a variety of types without any definit tendency. If the cummulative distribution of fungal particles were potted in log-probability paper, they fit straight line farely well, especially when the average values of 50 samples are plotted (Fig. 3).

Disscusion

The log-probability curve. The size distributions were fitted in the log-probability curves and we obtained the results that almost all the fungal particle sample showed the log-normal distribution with peaks around 3.5μm. The fungal particles showed this size characteristics irrespective of seasons, place, or kind of facilities.

On the other hand, with bacterial particles, we obtain various curves in the log-probability paper and not fit the log-normal curves (Fig 4). From the type of histogram of bacterial particles, we usually observe two peaks around 2μm and 5μm or maximum value at the largest potion of size range, depending on sample without any definit tendencies.

Median values. As representative values we might be able to use the median values. The fungal particles show 3-3.5μm and bacterial particles 5.5-6.5μm. The form coincide with the peak valus, but latter not necessarily with peaks.

Formation of log-normal curve. In case of fungi, from the mechanism of liberation, spores become airborne not always alone but in chaines or in branch of 2-3 spores to 20- 30 spores which we acertaind through the microscopic observation. There is also the size differences of spore itself. Therefore, these distribution are the resurts of product of size distribution of spores itself and also of the distribution of number of spores agglomerated.

In case of bacteria, they usually do not have mechanism of liberration for themselves but become airborne through the drying up of droplet or crushing into powder state with rather high energy. Therefore, the bacterial particles consequently contain foreign materials and aerodynamic characteristics are stronglyinfluenced by these materials other than bacteria.

Size distribution of Cladosporium particles. Of the samples obtained in subway station enviroment (5) of which determination of species were made, the size distribution of Cladosporium particles was plotted on log-probability paper(Fig 5). The plots fit straight line rather well which show the distribution is similar to log-normal ones. There seem to be strong possibility that many kind of species have similar size distribution characteristics.

Conclusion

1. The size distribution of airborne fungal particles is similar to log- normal distribution.
2. We cannot see definit distribution curves for airborne bacterial particles.
3. Median of airborne fungi is around 3.5μm and coincide with the peak (mode). In case of bacteria the median is 5.5-6.5μm and does not coincide with peaks.
4. The size distribution of airborne Cladosporium particles is similar to log-normal ones.
5. The concentration of airborne bacterial particles is air-conditioned offices were 0.1-0.3 cfu/1, fungal particles were 0.02-0.05 cfu/1, in subway stations 0.5-1.4 cfu/1 for bacteria, 0.2-1.2 cfu/1 for fungi.

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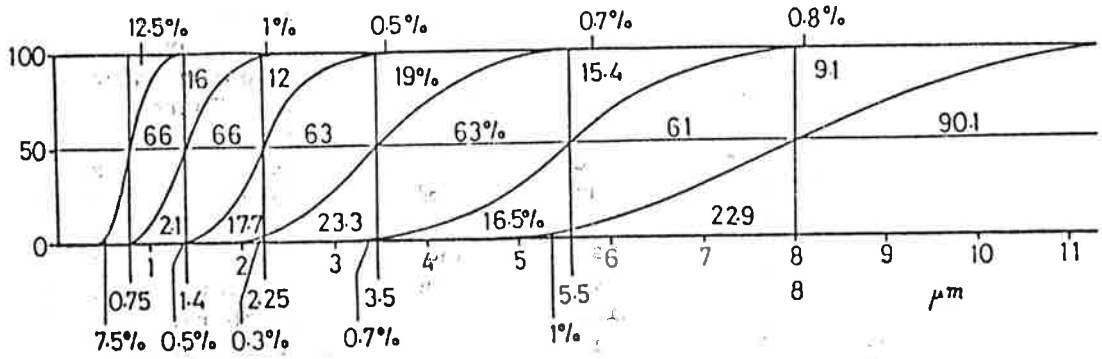


Fig. 1. collection characteristics of stages of Andersen sampler.

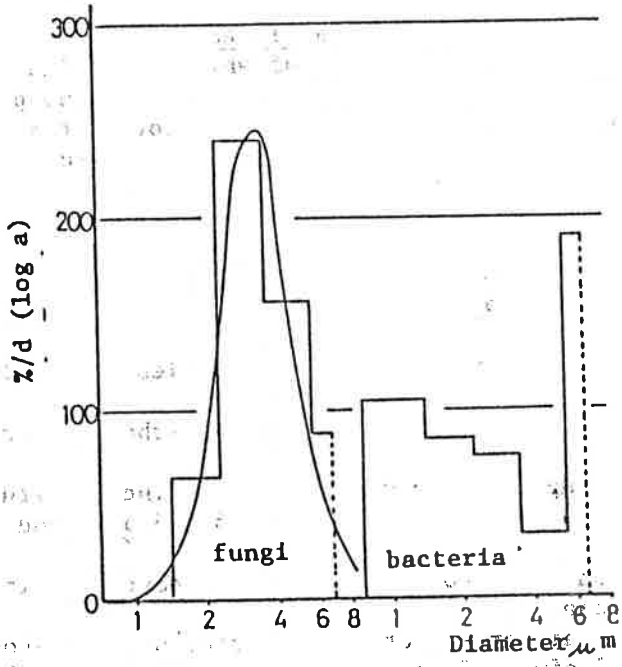
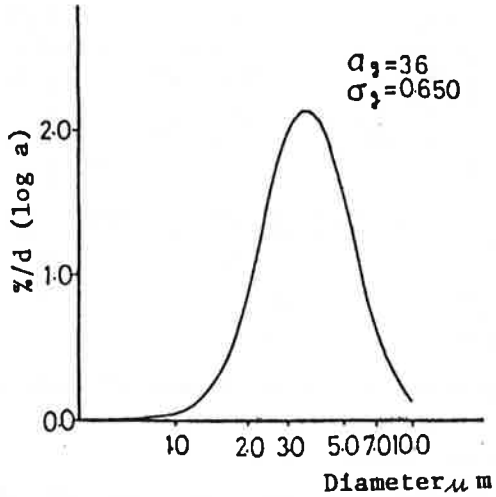


Fig 2. Size distribution histogram of fungal and bactarial particles.

Fig 6. Example of Cladosporium particles collected of Andersen sampler (x640).

Table 1. Average concentration and settle plate counts.

Facility		Settle plate counts (cfu/petri d.5min)		Concentration (cfu/l)	
		Bacteria	Fungi	Bacteria	Fungi
Office Building	A in aircond.	1.72	0.61	0.170	0.062
	B	2.50	0.39	0.140	0.020
	C	1.83	0.11	0.110	0.020
	D	4.50	0.17	0.120	0.060
	E			0.180	0.010
	F			0.082	
	G	3.33	0.33	0.144	0.030
	H W.O.aircond.	6.0	0.33	0.44	0.019
Underground Shopping Center		19.13	4.01	2.42	0.29
Subway Stn.	A Summer	27.39	7.0	1.254	1.32
	A Winter	30.88	1.38	1.95	0.487
	A Fall W.aircond	9.8	2.0	0.385	0.279
	A WinterW.aircond	21.8	1.96	0.92	0.20
	B Fall	36.4		1.18	1.04
	B Fall W.aircond	13.9		0.39	0.53



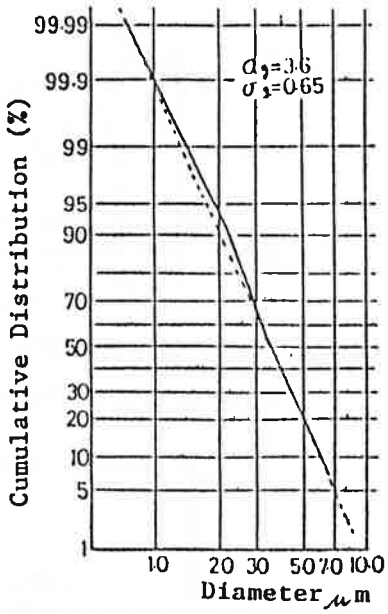
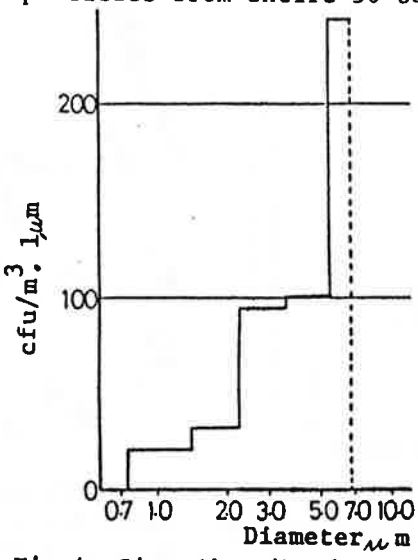


Fig 3. Size distribution of fungal particles from entire 50 samples.



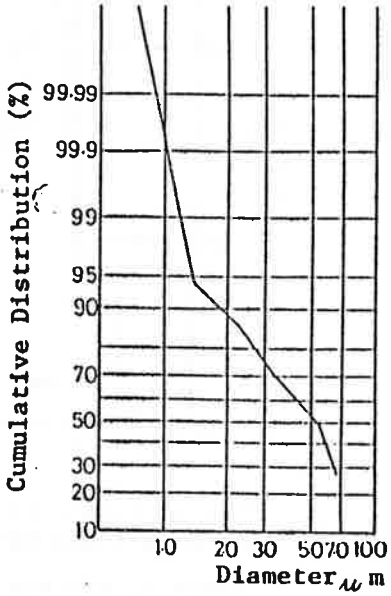
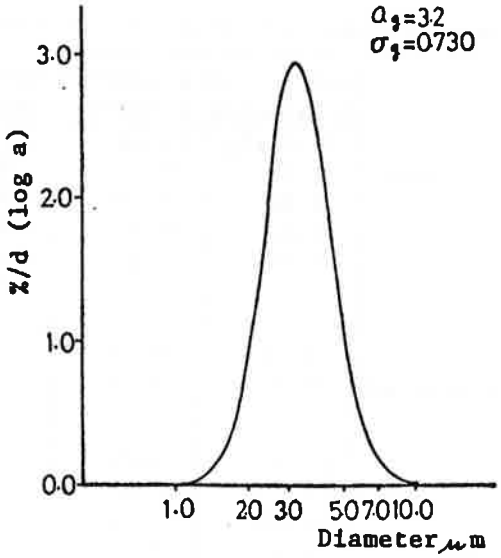


Fig 4. Size distribution of bacterial particles.



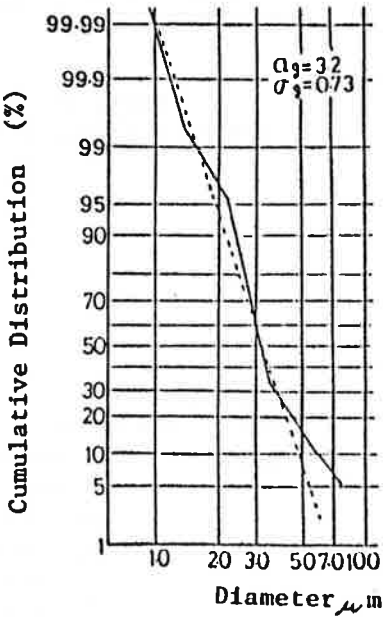


Fig 5. Size distribution of Cladosporium particles obtaind rom subway station samples.