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Composition and Size Variation of Airborne Fungal Spores in the Asian Dust Events (2000~2001)

Hwan-Goo Yeo* and Jong-Ho Kim

Department of Environmental Engineering, Hanseo University, Seosan, 356-706, Korea

Abstract - PM (Particulate Matter) samples contained fungal spores were collected in the ambient air of Seosan, west Korea, in springtime of 2000 and 2001. PM concentrations were 199.8 μg m^{-3} in the 1st Asian Dust Storm period (March, 23~24) and 249.4 μg m^{-3} in the 2nd period (April, 7~9), 2000. Compared with the concentrations in 2000, relatively low PM concentration (157.3 μg m^{-3}) was measured in the Asian Dust Storm period (April, 24~26) of 2001. Although there were somewhat differences for the total PM concentrations among the three periods, majorities of the PM were composed of coarse particles sized about 5~6 μm over the periods of the two years. Diverse molds grown from fungal aerosols were observed in the PM samples and identified at the genus level. All the genera, *Fusarium, Aspergillus, Penicillium, Basipetospora, Epicoccum* and *Monotospora* are hyphomycetes in the division Fungi imperfecti (Deuteromycota). Especially, morphologically more diversified mycelia of hyphomycetes were grown on the fine PM sample (1.1~2.1 μm) than coarse PM samples in the periods of 2000. Furthermore, some molds were grown on even the background PM sample less than 0.43 μm in the period of 2001. It was thought that some kinds of ultra fine sized fungal spores were transported by the Asian Dust Storm and suspended in the ambient air of study area during the events.

Key words : Asian Dust, fungal spore, Fungi imperfecti

INTRODUCTION

Asian Dust Storm (Yellow Sand Storm) blown from deserts in China and Mongolia caused much damage to the east China as it passed through and onto the middle region of the Korean Peninsula to record undesirable meteorological phenomenon due to the particles. The transport of Asian Dust from China to the North Pacific atmosphere was documented (Shaw 1980; Duce *et al.* 1980; Parrington *et al.* 1983; Uematsu *et al.* 1983; Merrill *et al.* 1989; Bodhaine 1995; Husar *et al.* 1997) and results in a maximum level of aerosol loading each springtime. Compelling geological evidence of global scale transport of Asian Dust emerged from the chemical analysis of samples in the Greenland ice core (Biscaye *et al.* 1997) and Hawaiian soil studies (Rex *et al.* 1969; Dymond *et al.* 1974; Kennedy *et al.* 1998; Chadwick *et al.* 1999). The chemical and radiological fingerprints of deposited dust at both locations were most consistent with the composition of the Asian Dust.

Husar *et al.* (2001) reported the formation, transport and other characteristics of two Asian Dust Storms in April 1998. The focus was on the dust storm that occurred on April 19, 1998 over Mongolia and North-Central China which crossed the Pacific causing aerosol concentrations near the health standard in USA (150 μg m^{-3}) over much of the West Coast of North America. Up to

* Corresponding author: Hwan-Goo Yeo, Tel. 041-660-1366, Fax. 041-660-1119, E-mail: yeohg@hanseo.ac.kr

now, several observers in Korea, Japan and North America have monitored the unusual dust cloud scrutinizingly. Although several papers in Korea include physicochemical characteristics of Asian Dust Storm (Shin and Kim 1992; Lee *et al.* 1993; Kim *et al.* 1995; Chun *et al.* 2001; Shin *et al.* 1999), hardly known bioaerosol concerned with the dust events.

This study was focused primarily on the collection and detection of fungal spores at PM samples, and intended to elucidate the difference of the passing of a year. Namely, our current study was undertaken to investigate the ambient fungal aerosol characteristics in relation to PM size distribution and Asian Dust events in west Korea.

MATERIALS AND METHODS

Samplings were performed four times (including three times of Asian Dust periods) on the roof of six story office building which were located 18 meters above ground level in Seosan (126° 35′E, 36° 42′N), mid-west coast of Korea, in the spring of 2000 and 2001. The three times of sampling of the dust events were done from 23 to 24 March (the first dust storm period), from 7 to 9 April, 2000 (the second period) and from 24 to 26 April, 2001 (the third period), respectively. To compare with the dust events, sampling of non Asian Dust period (from 12 to 16 May, 2000) was done at the same location.

In general, the physical methods including impaction, impingement, and filtration have been commonly applied to the collect bioaerosols. Although the impinger is widely used, the sampling performance of impingers was poorly characterized compared to impactors (Henningson and Ahlberg 1994; Eduard and Heederik 1998). According to the fact, impactor than impinger and filter is more commonly used for bioaerosol sampling because of direct collection without post-collection sample processing (Li and Lin 1999).

In this study, an eight-stage Cascade impactor (Andersen Instrument, Model 20~800, USA) and 0.22 μm pore size membrane filters (80 mm diameter, Hi-Fil Seoul Science Co.) were used for PM samples. Every PM impactor samples contained fungal spores and collected on the membrane filters were cultured on the M-endo Broth media, and some spores were isolated and culturred on malt extract agar plate for identification. Dark incubation of fungal spores continued 96 hours at 25°C, and light microscope (Nikon E600; maximum 1,000×) was used for examination and identification of grown molds.

RESULTS AND DISCUSSION

1. PM during the Asian dust events

The Asian Dust Storms have been studied for decades to understand their sources, mechanisms of transport, and aerosol characteristics, including the effects on radiation (Mizohata and Mamuro 1978; Iwasaka *et al.* 1979; Wang *et al.* 1980; Zhou *et al.* 1981; Zaizen *et al.* 1995; Zheng *et al.* 1998; Zhang and Lu 1999). However, quantitative understanding of individual dust events, e.g. the dust emission locations and rates as well as the details of long-range transport and removal, are still incomplete.

In this study, PM concentration, mean temperature and mean relative humidity were 199.8 μg m^{-3}, 5.1°C and 55.8% in the 1st Asian Dust event (March, 23~24, 2000), 249.4 μg m^{-3}, 6.5°C and 45.3% in the 2nd event (April, 7~9, 2000) and 157.3 μg m^{-3}, 10.6°C, 50.1% in the 3rd event (April, 24~26, 2001), respectively. On the other hand, reduced PM concentration (98.9 μg m^{-3}), risen temperature (14.4°C) and relative humidity (77.7

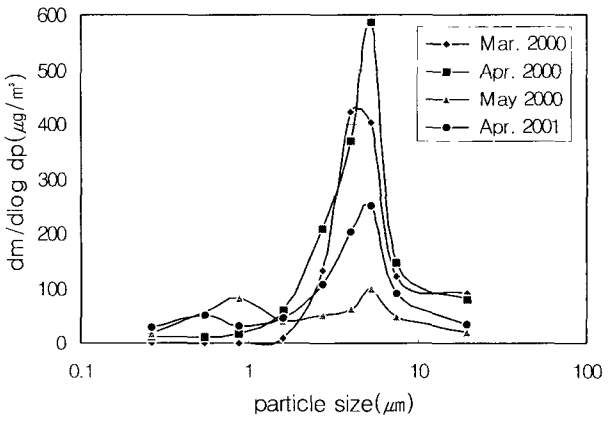


Fig. 1. Particle size distribution of PM in springtime, 2000 and 2001.

%) were detected in the non Asian Dust period (May, 12~16, 2000). Although there was somewhat difference for total PM concentration among the three Asian Dust events, majority of the total PM was composed of about 5 μm sized coarse particles over the three periods (Fig. 1). However, fine particles sized about 1 μm and coarse particles sized about 5~6 μm ultimately showed peaks, which is within typical bimodal pattern at the graph of PM size distribution in the non Asian Dust period.

Chun *et al.* (1999) measured PM size distribution on Anmyon Island, Korea in the Yellow Sand Period, 1998. The measured volume size distribution function showed a sharp peak between 1~5 μm, with a volume-mean diameter of 2 μm, and a logarithmic standard deviation of 1.6. Continuous monitoring of particle concentration in different size ranges exhibited a strong correlation between the particles in the PM peak size range (2~3 μm) and virtually no correlation with particles below 0.8 μm and above 10 μm. Hence, the size ranges below 0.8 and above 10 μm have different origins than the coherent PM size range between 1~10 μm (Chun *et al.* 2001). The absence of transported large particles implies that the PM above 10 μm were preferentially removed by gravitational settling during the 2~3 day atmospheric transport time from Gobi to Korea (Husar *et al.* 2001).

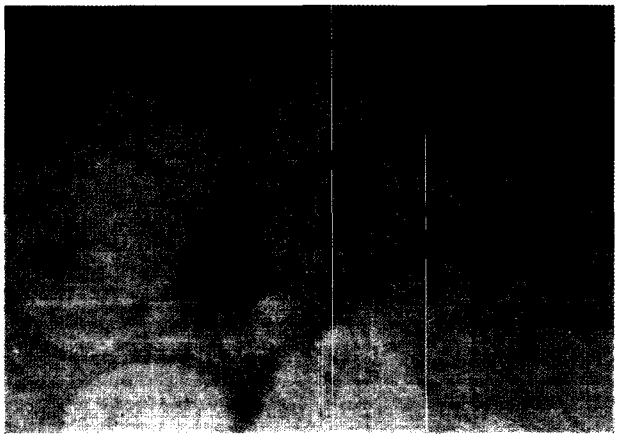
2. Characteristics of fungal spores in the storm periods

1) Composition of fungal spores

About 70,000 species of fungi have been described; however, some estimates of total numbers suggest that 1.5 million species may exist (Hawksworth 1991; Hawksworth *et al.* 1995). A division of Kingdom Fungi, Deuteromycota (fungi imperfecti) is divided into form-classes based upon morphological similarities. The criteria that are typically used are colour, shape, size and septation of the conidia (whether the spores are unicellular, or made up of multiple cells). An important fungi imperfecti group is the form-class hyphomycetes. Hyphomycetes are those fungi imperfecti which form a mycelium but lack a sporocarp and the spores are borne on conidiophores. Hyphomycetes are also called molds and a culture of hyphomycete can be recognized by the powdery or fluffy appearance of the colony. Many are also easily cultured so that more research has been conducted upon this group of fungi than for many other. The hyphomycetes genera, *Alternaria, Cladosporium, Curvularia, Drechslera, Epicoccum, Fusarium, Nigrospora* and *Stemphylium* were listed by Kendrick as the 'Big Eight' because of their allergenicity and frequency in the air (Kendrick 1990).

Four sorts of molds grown from fungal spores during the Asian Dust events were recorded in the authors' previous study (Yeo and Kim 2001). All the genera observed in 2000, *Fusarium, Aspergillus, Penicillium* and *Basipetospora* are hyphomycetes in the division Deuteromycota. Several species of the genera *Aspergillus, Penicillium* and *Fusarium* produce secondary metabolites such as aflatoxin, citrinin and trichothecenes that may be potent toxins and carcinogens

(a) *Monotospora* sp.(×40)



(b) *Epicoccum* sp.(×80)

Fig. 2. The molds grown on the PM aggregations (April, 2001).

(Deacon 1997), and *Basipetospora* sp. is frequent in arid soil environment. On the other hand, a total 6 sorts of molds were grown from the Asian Dust samples in 2001. The new observed taxa, *Epicoccum* sp. and *Monotospora* sp. (Fig. 2) were grown with the 4 taxa occurred in the previous year. These all the molds are thought to be a general composition of dry season in temperate region.

2) The size of fungal spores

Airborne fungal spores vary greatly in size, but most are in the range of 2~50 μm, which are larger than actinomycetes and other bacterial spores and generally smaller than pollens (Lin and Li 1998).

In this study, *Fusarium* sp. spores were formed fluffy molds at the relatively large sized SPM (>3.3 μm) aggregations. Lin and Li reported that large numbers of ambient fungus spores isolated were in the size range of 2.1~3.3 μm in Taiwan, a subtropical region (Lin and Li 1996). However, qualitatively more diverse hyphomycetes were grown on the sample contained 1.1~2.1 μm sized PM than on the other sized samples in the Asian Dust event of 2000 (Yeo and Kim 2002). The diverse mold species might be belonged to the genera, *Aspergillus, Penicillium* and *Basipetospora*.

Even though coarse particles sized about 5 μm were most part of total PM in the Asian Dust periods (Fig. 1), much more diverse molds were grown from fine PM sample (1.1~2.1 μm) than coarse samples. However, no molds observed on the sample contained from 1.1~2.1 μm sized PM in the non Asian Dust period. On the other hand, at the third sampling period, Asian Dust event of 2001, some molds were grown even on the back up filter which contained particles less than 0.43 μm of aerodynamic diameter (Fig. 3). From these results, it was evident that very fine sized fungal spores, not attached to the coarse Asian Dust particles (Yellow Sand), were suspended freely in the ambient air of this study area during the Asian Dust events.

The periods for all four samplings were in spring and the weather conditions were similar, the only difference is whether the period is in Asian Dust events or not. Non Asian Dust period samples were collected May 12~16, 2000 after the Asian Dust Storm. There was a rain after. And to obtain a measurable PM sample, it took

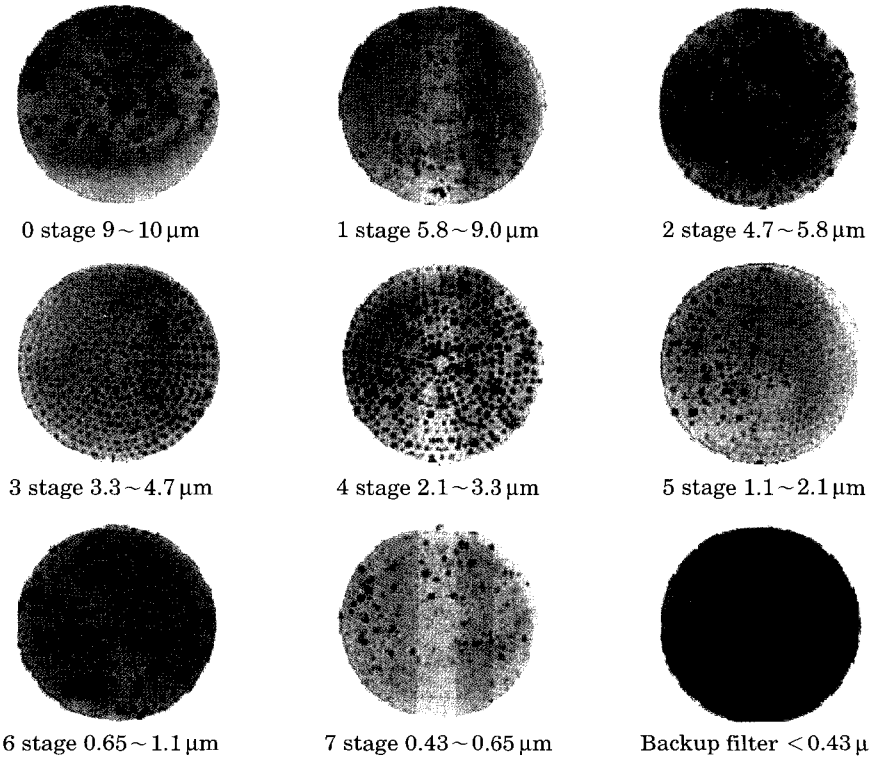


Fig. 3. Fungal colonies grown from PM samples (April, 2001; Asian Dust Storm period).

for four days. However, it was not any grown molds at the fine PM samples less than 2.1 μm. From the results, it was thought that a large amount of several kinds of fine fungal spores in the ambient air of this study area were originated from China and Mongol by the Asian Dust Storms.

CONCLUSIONS

High PM concentrations (157.3~249.4 μg m^{-3}) were detected in west Korea during the Asian Dust events, 2000 and 2001. Majority of the total PM was composed of coarse particles over the periods. However, fine particles sized about 1 μm and coarse particles sized about 5~6 μm showed bimodal peaks at the graph of PM size distribution in the non Asian Dust period.

Fungal spores at the PM samples were cultured and identified. Full-grown colonies from the Asian Dust (2000-2001), *Fusarium, Aspergillus, Penicillium, Basipetospora, Epicoccum* and *Monotospora* are hyphomycetes in the division Fungi imperfecti (Deuteromycota). Morphologically more diversified mycelia of hyphomycetes were grown on the sample captured 1.1~2.1 μm sized PM than on the other sized samples in the events of 2000. On the other hand, during the event of 2001, some molds were grown on the fine sized PM and even on the back up stage contained PM less than 0.43 μm as well. It was thought that a few sorts of ultra fine sized fungal spores were transported by the Asian Dust storm.

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