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Technical note

Concentration of culturable bioaerosols during winter

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ABSTRACT

Concentrations of fungal and bacterial bioaerosols were measured during winter. Environmental parameters such as temperature, relative humidity, ultraviolet irradiation intensity, and the amount of snowfall precipitation were also measured with bioaerosol concentrations. Experimental results show that significant amounts of culturable fungal bioaerosols exist in the air during winter. The amount of fungal bioaerosols present in winter is comparable with that recorded in summer. In contrast, few culturable bacterial bioaerosols were detected in the air during winter. This quantitative result can be used to explain patterns of diseases that occur in winter. In addition, the effects of environmental factors on bioaerosols in winter were analyzed.

1. Introduction

Airborne microorganisms, termed bioaerosols, can influence human health and quality of life (Douwes, Thorne, Pearce, & Heederik, 2003; Hinds, 1999). For example, bacterial bioaerosols have been found to be related to human diseases, such as pneumonia, tuberculosis, brucellosis, anthrax, and Q fever (Arancibia et al., 2002; LaForce, 1986). Fungal bioaerosols are known to be etiological agents of respiratory diseases, such as allergic rhinitis, asthma (Bush & Portnoy, 2001; Cockcroft, Ruffin, Dolovich, & Hargreave, 1977; Fiegel, Clarke, & Edwards, 2006; Fung & Hughson, 2010; Zuskin, Schachter, Kanceljak, Mustajbegovic, & Witek, 1994), chronic obstructive pulmonary disease (COPD) (Lacey & Crook, 1988; Matheson et al., 2005; Olenchock, Christiani, Mull, Ye, & Lu, 1990). Therefore, due to the relevance of bioaerosols to human diseases, the concentration of bioaerosols present can be an important parameter in predicting the occurrence of such diseases. To date, bioaerosols have been measured in indoor environments, such as public restrooms (Lee et al., 2012), public hospitals (Li & Hou, 2003; Pastuszka, Marchwinska-Wyrwal, & Wlazlo, 2005), houses (Jeon et al., 2010; Jo & Seo, 2005; Lee & Jo, 2006; Ren, Jankun, & Leaderer, 1999; Roberts et al., 2006), and work places (Chang, Chung, Huang, & Su, 2001; Lacey & Crook, 1988; Law, Chau, & Chan, 2001; Kalogerakis et al., 2005; Kim, Park, Jang, Kim, & Lee, 2007). However, the quantitative measurements of the concentration of bioaerosols in outdoor environments have been rare and the data remains insufficient (Menetrez et al., 2007; Yeo & Kim, 2002) despite the importance of outdoor bioaerosol concentrations in the prediction and analysis of human diseases. In particular, quantitatively measured data for specific seasons, such as winter, are scarce.

Until recently, it was believed that very few microorganisms are present in external air environments during winter. The dry and cold weather conditions of winter are believed to be too harsh for the growth or survival of microorganisms; therefore, the air during winter is considered to be free of airborne microorganisms. However, few recent studies practically

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support this general hypothesis with scientific and quantitative data obtained from bioaerosol measuring protocols. Recently, the results of one survey of the concentration of bacterial bioaerosols during winter were reported (Lee et al., 2012). Their preliminary results showed the concentration of bacterial bioaerosols in air environments outside public restrooms with limited environmental parameters. Bioaerosols, which are different from ordinary water-born micro-organisms, have unique physical characteristics as aerosol particles, that should be considered in the undertaking of their measurement (Hinds, 1999; Lee, 2011).

In this study, the assumption that air during winter is bioaerosol-free has been tested with quantitative and extensive ways. The concentrations of fungal and bacterial bioaerosols in air in winter were measured over a period of three months. In addition, environmental parameters such as temperature, relative humidity, ultraviolet ray irradiation intensity, and the amount of snowfall precipitation were recorded in order to analyze any effect that these environmental parameters may have on bioaerosols. The measurement data, for the concentration of fungal particles and bacterial particles, show very different patterns. There were significant concentrations of fungal bioaerosols present in winter air; however, almost no bacterial bioaerosols were detected during the same season. This experimental result will prove useful in the understanding and prediction of air quality and human disease in winter.

2. Experimental methods

The bioaerosol measurements were carried out during the winter seasons of 2014 and 2015 in the Seoul Metropolitan Area. This area has a population of ten millions. In outdoor air environments, there are several types of bioaerosol present, such as airborne fungi, bacteria, pollen, viruses, and biological fragments. Fungal and bacterial bioaerosols were selected as the subjects of this study because they are known to be the most abundant and representative bioaerosols present in ordinary environments in the Korean peninsula (Lee, 2011). In particular, a parameter for total airborne bacteria was also selected as a legal bioaerosol standard for indoor air quality in the Republic of Korea and Malaysia. The sampling of airborne fungal and bacterial bioaerosols was carried out using a culturable bioaerosol sampler (Bio-culture sampler, Buck bio-culture, Model B30120, A.P. Buck, Inc., Orlando, FL, USA). This sampler which had been used in previous studies on bioaerosol concentrations (Heo, Kim, & Lee, 2014), was an impaction-type sampler with a flow rate of 100 L per minute. In each case, this sampler was used for 5 min to sample the surrounding bioaerosols (Jo & Seo, 2005; Jones & Harrison, 2004; Lee & Jo, 2006).

The sampled mixture of air and particles was directed onto an agar plate inside the sampler after passing through 400 nozzles. The culturable fungal aerosol particles were incubated at 25 °C for 48 h after being deposited on the agar which contained MEA (maltose 12.75%, dextrin 2.75%, glycerol 2.35% peptone 0.75% and agar 15%). The culturable bacterial aerosol particles were incubated at 37 °C for 24 h after being sampled on the agar which contained nutrient agar (beef extract 3%, peptone 5%, and agar 15%). The concentrations of culturable fungal and bacterial bioaerosols in the air were expressed in units of CFU/m^3, following the enumeration of the number of colonies present using a positive-hole correction table to adjust colony counts from a 400-hole impactor to allow the collection of multiple particles through a single hole (Macher, 1989).

Environmental parameters, during the winter season, were measured at the same time as the bioaerosols were measured. Temperature and relative humidity were measured during the measurement campaigns. In particular, the intensity of ambient ultraviolet irradiation was measured using a UV light meter (Model YK-35UV, Lutron Electronic Enterprise Co., Ltd., Taipei, Taiwan) in order to analyze any effect that UV irradiation may have on bioaerosols. In addition, the amount of snowfall that occurred during the campaign was also measured.

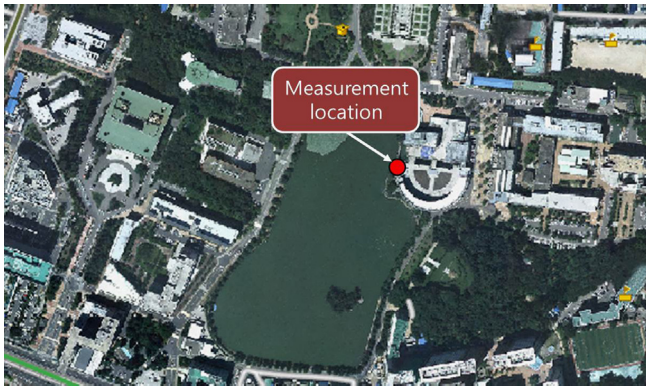

Fig. 1. The locations (N37°32′26.0″/E127°04′35.0″) of bioaerosol measurement campaign (sky view) in winter (Heo et al., 2014).