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Brief Report

Dust Storms from Degraded Drylands of Asia: Dynamics and Health Impacts

Shinji Otani [1,*], Yasunori Kurosaki [2], Youichi Kurozawa [3] and Masato Shinoda [4]

[1] International Platform for Dryland Research and Education, Tottori University, Tottori 680-0001, Japan
[2] Arid Land Research Center, Tottori University, Tottori 680-0001, Japan; kuro@alrc.tottori-u.ac.jp
[3] Division of Health Administration and Promotion, Faculty of Medicine, Tottori University, Yonago 683-8503, Japan; kurozawa@med.tottori-u.ac.jp
[4] Graduate School of Environmental Studies, Nagoya University, Nagoya 464-8601, Japan; shinoda.masato@g.mbox.nagoya-u.ac.jp
* Correspondence: otanis@alrc.tottori-u.ac.jp; Tel.: +81-857-30-6316

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Abstract: Asian dust events are massive meteorological phenomena during which dust particles from Chinese and Mongolian deserts are blown into the atmosphere and carried by westerly winds across Northeast Asia. Recently, there has been steady increase in both the frequency and the severity of Asian atmospheric dust events. Concern has been expressed regarding the potential health hazards in affected areas. The principal nature of the damage associated with Asian dust events differs between the emission (sandstorm) and downwind (air pollution) regions. In the emission region, the health impacts of dust storms are reflected in the high prevalence of respiratory diseases and severe subjective symptoms. Extreme dust storm events may cause a disaster to happen. In downwind regions such as Japan, analysis of Asian dust particles has shown the presence of ammonium ions, sulfate ions, nitrate ions, and heavy metal compounds that are considered not to originate from soil. Asian dust particles have been thought to adsorb anthropogenic atmospheric pollutants during transport. Therefore, Asian dust events coincide with increases in daily hospital admissions and clinical visits for allergic diseases such as asthma, allergic rhinitis, and conjunctivitis. Although the effect of Asian dust on human health in each region is influenced by a variety of different mechanisms, human activities are partly responsible for such negative effects in many situations. We therefore need to address these environmental problems.

Keywords: Asian dust; human health; Mongolia; Japan

1. Introduction

Dust storms originate in many dryland areas. Estimates of the relative magnitudes of dust emissions in different parts of the world indicate the Sahara contributes >50% of the global total, followed by China and Central Asia (about 20%) [1]. Dust events often affect human life and health not only in the originating drylands but also in downwind regions. Although the Sahara is the most important source of dust globally, approximately 60% of windblown Saharan dust moves southward toward the Gulf of Guinea across areas where few people live [2]. Asian dust events involve the long-range transport of atmospheric particulate matter originating from dryland areas, which is carried by westerly winds across Northeast Asia (Figure 1). Such events can affect large numbers of people because East Asia is the one of the most densely populated areas of the world. According to Kurosaki and Mikami [3], both the frequency and the severity of Asian atmospheric dust events have been increasing, raising concern regarding consequent health hazards in affected areas. The principal nature of the effects of Asian dust events on human health differs between the emission and downwind regions [1]. Here, we describe the health effects in each of these regions.

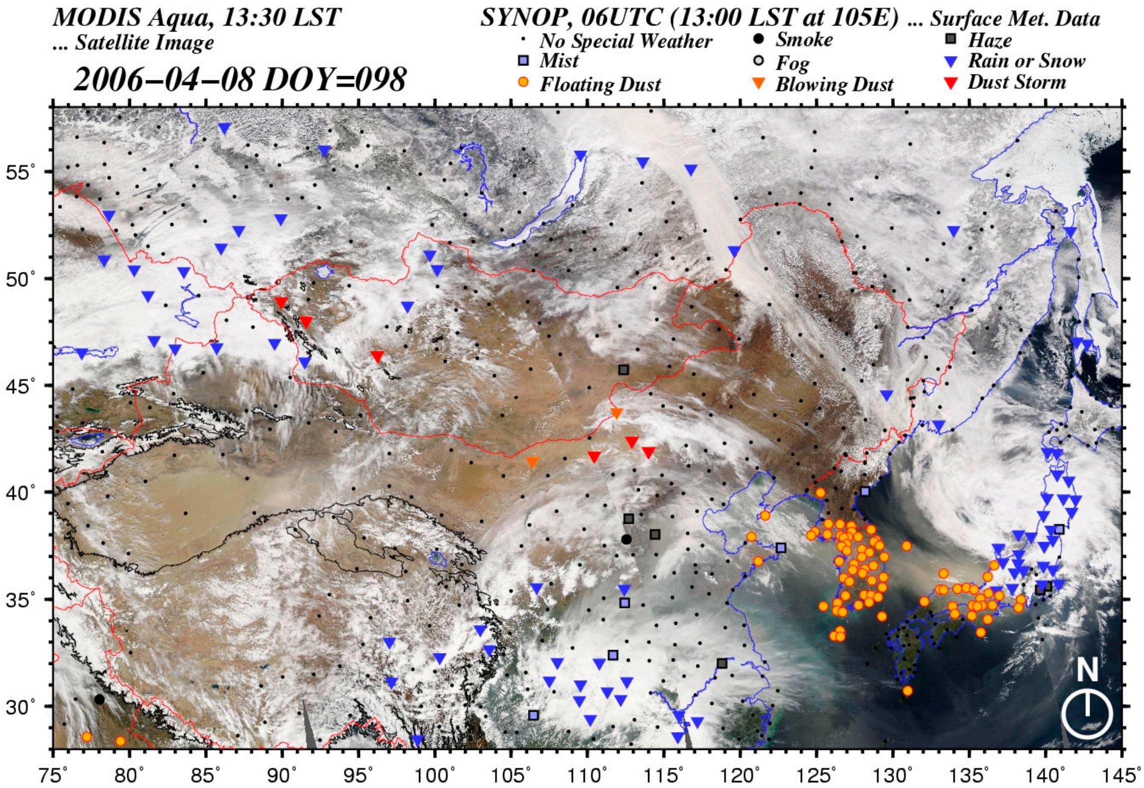

Figure 1. Typical Asian dust event. MODIS: Moderate Resolution Imaging Spectroradiometer true-color images with surface weather conditions on 8 April 2006 (NASA: National Aeronautics and Space Administration/GSFC: Goddard Space Flight Center, Rapid Response).

2. Impacts of Asian Dust on Health in Emission Regions

In Mongolia, during 17–20 April 1980, and on 5–6 May 1993, between nine and 16 people and 100,000–675,000 head of livestock died because of severe snow and dust storms [4]. Most recently, because of an intense dust storm that occurred across a broad area of Mongolia on 26–27 May 2008, 52 people lost their lives and 320,000 animals were killed. In an emission region such as Mongolia, severe dust storm events constitute major disasters.

We have previously documented subjective symptoms of the eyes and of the respiratory system, as reported by inhabitants (n = 123) in urban and desert areas of Mongolia immediately after this latest dust storm. The data collection method adopted in that study involved face-to-face interviews with a questionnaire. A detailed description of the survey has been published elsewhere [5]. The prevalence of eye symptoms was higher among those subjects living in the desert area than among the urban area subjects. Dust storms have been associated with a high prevalence of eye symptoms in Mongolia. We also performed a cross-sectional survey on Health-Related Quality of Life (HRQOL) using a 36-item short-form health survey (i.e., an index of health condition) and livestock loss data one year after this dust storm event. Our results provide preliminary evidence that livestock loss has long-term effects on HRQOL; some HRQOL markers (general health and vitality) were lower among people who had lost livestock than among those who had not. Therefore, saving lives, maintaining animal husbandry, and ensuring medical health support after dust storm disasters (e.g., medical care patrols and psychological consultations) are primary requirements. Moreover, the development of an appropriate early warning system to prevent dust storm damage is also needed [6].

Exposure to dust particulates irritates the respiratory tract and is associated with respiratory disorders such as asthma, pneumonia, and nonindustrial silicosis [1]. In fact, the outpatient morbidity associated with diseases of the respiratory system in provinces with high frequency of occurrence of dust events has remained stably high [3,7] (Figure 2). For example, the morbidity rate of respiratory diseases in Omnogovi Province, located in the Gobi Desert, was 2157.61 per 10,000 inhabitants in 2011, i.e., about twice the national average (1048.17) [7]. It is suggested that populations particularly vulnerable to airborne particulate matter and associated respiratory diseases are children, the elderly, and people with pre-existing heart and lung diseases [1].

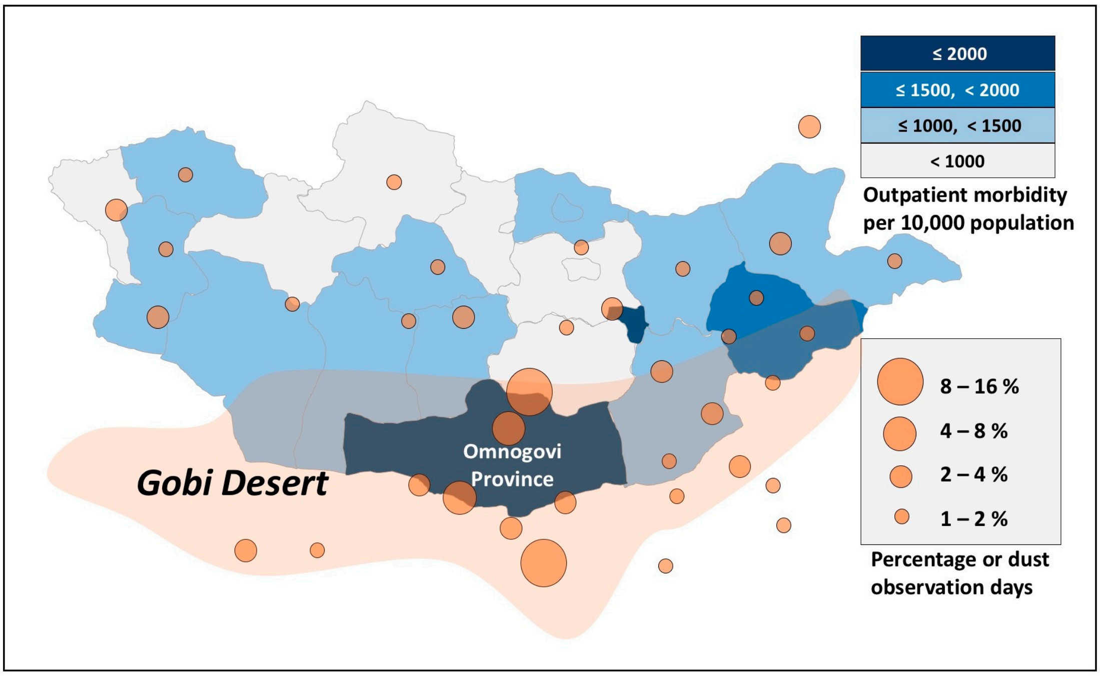

Figure 2. Morbidity associated with diseases of the respiratory system in each province of Mongolia (2011) and observations of dust event (1988–2004). Dust days were based on Code Table 4677 of the World Meteorological Organization (WMO) and dust outbreak frequency was defined as the percentage of the number of dust outbreaks to the total number of observations. The elements of surface meteorological data were the 3-hourly present weather and the surface wind speed at a height of 10 m in East Asia from March 1988 to May 2004 from WMO (see detail in Reference [3]). This dust outbreak map is a modified version of Figure 3 in Reference [3].

3. Impacts of Asian Dust on Health in Downwind Regions

Using trajectory analysis, confirmed by satellite observation data, we have clarified that Asian dust events transport both soil-derived and anthropogenic metals [8]. Additionally, based on aerosol sampling in both Mongolia and Japan, it has been established that "bioaerosols" (i.e., airborne microorganisms) carried by dust events include fungi and bacteria [9,10]. Therefore, it is necessary to consider not only the physical impacts of dust but also the physiological-biochemical responses when we evaluate the health effects of Asian dust events.

In downwind regions of Asian dust events such as Japan, South Korea, and Taiwan, recent epidemiological studies have shown that such events have coincided with increases in daily hospital admissions and clinical visits for allergic diseases such as asthma, allergic rhinitis, and conjunctivitis [1,11]. Children have been found to be particularly vulnerable. Globally, exposure to dust particles transported by desert storms is associated with increased hospital admissions for childhood asthma [12]. Worsening asthma symptoms caused by Asian dust might be attributed to the combination of particulate matter from soil and anthropogenic pollutants [13]. In relation to cardiovascular diseases, it has been suggested that Asian dust is a potential trigger of acute myocardial infarction [14].

As we have previously reported, it has been highlighted that Asian dust can induce symptoms such as itchy eyes and skin, nasal congestion, and sore throats in otherwise healthy subjects [15].

We evaluated the association between daily symptoms and dust events in 54 healthy subjects. In this study, scored symptoms were significantly higher on Asian dust days than on non-Asian dust days, and the skin symptom scores were correlated positively with the levels of suspended particulate matter [15].

4. Allergic Reactions and Asian Dust in Downwind Regions

The association between skin symptoms and Asian dust events has been reported previously [16]. Analysis of Asian dust particles in Japan has shown the presence of ammonium ions, sulfate ions, nitrate ions, and heavy metal compounds that are considered not to originate from soil. During transport, Asian dust particles are thought to adsorb atmospheric pollutants caused by anthropogenic activities. To compare skin symptoms on an Asian dust day with metal allergic reactions, we performed patch testing, which is a useful method for the estimation of contact dermatitis. In this previous study [16], we performed tests on nine subjects with skin symptoms and 11 subjects without skin symptoms on an Asian dust day. It was found that 89% of subjects with skin symptoms reacted to nickel samples. Conversely, 82% of subjects without skin symptoms had no reaction to nickel samples [16]. Nickel is a common cause of contact allergies, and it has been found that skin symptoms on Asian dust days are significantly associated with the levels of atmospheric nickel in corrected total suspended particulates [17]. Skin symptoms during Asian dust events might reflect allergic reactions to Asian dust particle-bound metals.

Recent studies have shown that microbes such as bacteria and fungi can migrate vast distances during Asian dust events by attaching themselves to dust particles. In Korea, springtime air contains a large variety of fungi and potentially high levels of fungal allergens including *Penicillium* [18]. In Japan, the possibility of bacterial attachment to aeolian dust particles has been identified [19]. We have previously published a relationship between serum immunoglobulin E (IgE) levels and subjective symptoms on Asian dust days with 25 healthy subjects [19]. Significant association was found between IgE levels of microbial allergens and nasal symptom scores. Asian dust events might trigger some kind of hypersensitivity to fungal allergens [19].

5. Conclusions

Although the effects of Asian dust on human health differ between the emission and downwind regions, they are closely connected to each other by human activities leading to desertification. Moreover, industrial development makes the issue more complicated. An implication for public policy in East Asia is that to protect public health, anthropogenic sources of particulate pollution must be controlled more rigorously in areas highly impacted by Asian dust events.

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