



St Anne's College, University of Oxford,  
UK

nicholas.middleton@st-annes.ox.ac.uk

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## HEALTHY DRY CITIES

### Health in dust belt cities and beyond—an essay by Nick Middleton

Desert dust is associated with morbidity and mortality, and distant spread means lessons for mitigating the harms can be found by looking beyond cities in arid regions, writes **Nick Middleton**

Nick Middleton *supernumerary fellow in physical geography*

Every year, usually sometime in December, the residents of cities in west Africa brace themselves for the Harmattan, an annual yellow haze caused by dust blown from the Sahara Desert. It's a time of traffic accidents and flight delays, increased risks of wildfires and medical ailments, from respiratory complaints to skin problems.

The situation is similar across the string of deserts and semi-deserts stretching from the Sahara through the Middle East and central Asia to the Gobi Desert of China and Mongolia (fig 1). The world's greatest dust sources are in this swathe of drylands, dubbed the “dust belt,” but airborne dust also affects dry parts of the Americas, Australia, and southern Africa.<sup>1</sup>

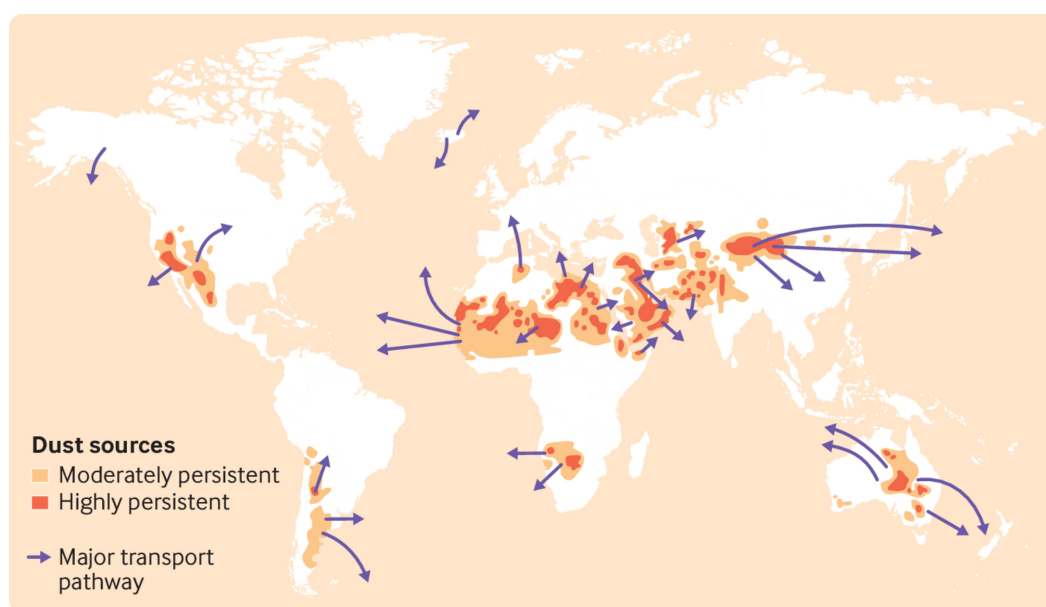


Fig 1 | Major global sources of desert dust and pathways of long distance transport (Modified from Muhs et al, 2014).<sup>21</sup>

Globally, an estimated two billion tonnes of fine particles are raised by winds from the world's dryland soil surfaces each year. Urban areas in drylands are worst affected by these seasonal outbreaks, but fine soil particles are regularly blown over great distances, bringing dust haze to cities well outside areas considered dry. Desert dust is not just a desert problem; it has global ramifications. Dust comprises primarily mineral rock fragments with organic matter, a wide array of microorganisms, plus anthropogenic pollutants from the soil or picked up in transit through the atmosphere.<sup>2</sup>

#### Health impacts

Soil particles entrained by turbulent winds can rapidly create a thick dust cloud. The worst cases involve abrupt and total loss of visibility at ground level, which can cause road traffic accidents, sometimes resulting in multiple vehicle pile-ups.<sup>3</sup> A series of severe dust events in northern India in May 2018 uprooted trees and damaged housing, leaving

more than 125 people dead and many more injured in cities and rural areas of Uttar Pradesh, Rajasthan, Delhi, and Haryana.<sup>4</sup>

A large and growing body of research has looked at numerous infections and diseases associated with desert dust. Exposure to dust in the atmosphere can result in conjunctivitis and dermatological disorders, whereas inhalation can cause respiratory illnesses such as silicosis (also known as desert lung syndrome). Many epidemiological studies show associations between exposure to high dust concentrations and increases in mortality and hospital visits and admissions owing to respiratory and cardiovascular diseases such as bronchitis, emphysema, and chronic obstructive pulmonary disease.<sup>5 6</sup> The effect of desert dust outbreaks on asthma incidence has also attracted considerable research, but dust is just one of a host of factors that might influence the development and expression of respiratory allergic diseases such as asthma.<sup>7 8</sup>

In the Sahel region of west Africa, outbreaks of bacterial meningitis are closely associated with the Harmattan season, although the exact nature of the association remains elusive.<sup>9</sup> In dryland parts of the Americas, dusty conditions are associated with an infectious

disease known as valley fever.<sup>10</sup> In this case, a causal link is more clear cut. People contract valley fever by inhaling spores of a soil based fungus (*Coccidioides immitis* or *C posadasii*) that become airborne during dust storms (fig 2).



Fig 2 | Dust storm engulfs Khartoum Credit: Mahmoud Hjj/Anadolu Agency

## Air quality guidelines

Once inhaled, the size of the dust particle is the main determinant of where it comes to rest in the respiratory tract. A distinction is typically made between particles less than 10 microns in diameter (PM<sub>10</sub>), which can enter the lungs, and those with a diameter of less than 2.5 microns (PM<sub>2.5</sub>), which can reach deeper into lung tissue.

Based on evidence, the World Health Organization anticipates no minimum threshold for atmospheric concentration that would mean no adverse health effects,<sup>11</sup> but it still sets standards for acceptable air quality. National governments adopt WHO's limits or set their own similar guidelines.

Nonetheless, these limits are frequently exceeded during dust storms, sometimes by several orders of magnitude. The WHO guideline for the maximum acceptable 24 hour atmospheric concentration is a mean of 50 µg per cubic metre for PM<sub>10</sub>. In Zabol, a city in southeastern Iran that frequently tops global league tables for atmospheric pollution, maximum PM<sub>10</sub> levels during severe dust storms are more than 10 000 µg per cubic metre. Sometimes these storms continue for several days.

## Managing dust sources

Many dust sources are naturally devoid of vegetation, but some environments have become susceptible to wind action through human mismanagement. These situations include agricultural fields left bare after ploughing and harvests, and lake beds desiccated by society's overuse of water. Preventing emissions at source is the most obvious answer to problems presented by dust, and there are numerous tried and tested techniques to prevent wind erosion from agricultural soils.<sup>12</sup> Many of them involve maintaining or restoring some degree of vegetation cover to protect a surface.

Farmers use all sorts of technologies to control wind erosion. These include leaving crop residue in the field after the harvest and erecting windbreaks at right angles to erosive winds. Such barriers might comprise fences made of dead palm fronds, for example, or living plants such as trees or bushes, in which case they are called shelterbelts. Other policy options include set aside schemes designed to allow protective vegetation to grow on former farmland.

Great efforts have been made to promote these techniques to farmers in some parts of the world. In the Canadian Prairie provinces of Alberta, Saskatchewan, and Manitoba, where wind erosion is especially prevalent during recurrent drought periods, numerous initiatives to develop and promote wind erosion prevention were made in the 1980s. A marked reduction in dust in the Canadian

Prairies from 1990 onward has been attributed to the positive effects of these soil conservation campaigns implemented by both government agencies and private non-profit organisations.<sup>13</sup>

Other dust sources are more dependent on sustainable water management. The desert city of Zabol receives dust from a series of shallow, marshy lakes that become dry during times of drought, but also when water is taken from rivers for agriculture and municipal use.<sup>14</sup> The lakes, which straddle the border between Iran and Afghanistan, are a unique series of wetlands in an otherwise extremely arid region. They are fed by rivers that flow from the Hindu Kush mountains, but several of these rivers have been dammed on both sides of the border to provide water to irrigation schemes and for domestic use in the region's towns and cities. The best hope for improving Zabol's air quality lies in an international agreement between the governments of Iran and Afghanistan governing water use in the region.

The economic incentive to reach an agreement has been assessed on the Iranian side of the border. In the Zabol region, dust storms cost an estimated \$25m (£19m; €21m) a year in physical damage and loss of productive work hours.<sup>15</sup> Such economic assessments are few and far between. A rare valuation of dust related medical costs, in the US state of Arizona in 2007, showed that 1735 hospital visits for valley fever resulted in \$86m in hospital charges alone.<sup>16</sup>

## Impact mitigation

Preventing dust emissions at source is not always possible. Harmattan dust, for example, emanates from natural sources in the Sahara Desert, which are too large and remote to stabilize feasibly. In situations like this, a range of monitoring, forecasting, and early warning measures can be implemented to mitigate the numerous effects of dust in the urban environment.

In northeast Asia, governments and their meteorological services cooperate to produce forecasts of transboundary dust events based on an ensemble of computer climate models from China, Japan, and South Korea. South Korea is outside the Asian drylands, but the season of yellow haze created by dust from China and Mongolia is common enough to have a Korean name: hwang sa.

The South Korean approach to managing the risks associated with hwang sa offers lessons for responses elsewhere. In the capital, Seoul, the metropolitan government issues dust forecasts in weather reports, on the internet, and through emergency broadcasts. It also has a guide on its website advising on what to do before, during, and after a hwang sa event.<sup>17</sup> Alerts are issued when a mean hourly PM<sub>10</sub> concentration of greater than 800 µg per cubic metre is expected to last more than two hours. The threshold concentration is noteworthy given that Seoul is over 1000 km from the nearest dust source.

During an alert, people are advised to close windows and stay indoors and to avoid secondhand pollution by thoroughly washing hands before processing food and cooking. If people must go outside, they are advised to wear protective glasses, a mask, and long sleeved clothes. Schools are told to cancel classes if necessary and to prohibit outdoor activities for kindergarten and elementary school students. Outdoor sports events and other open air activities should be stopped or postponed. When the yellow dust has dissipated, everything should be cleaned, and some facilities need to be disinfected.

Alerts of desert dust events are a simple way of reducing harmful health effects if they lead to behavioural changes that lower exposure. Studies of the large "red dawn" dust storm in Australia in 2009, the worst in terms of reduced visibility to have passed

through the city of Sydney since the 1940s, found the incidence of adverse health outcomes in Sydney was reduced by public health messages and their widespread media coverage.<sup>18</sup>

## A pressing matter

Dust storms do not typically result in the substantial destruction of infrastructure and loss of life associated with other natural hazards such as floods or earthquakes. But the cumulative effects on society can be substantial, not least because dust events occur more frequently than most other hazards. The disruption they bring to economic and social activity, including their diverse health effects, is an area of growing concern, albeit that dust events are also important for ecosystem functioning.<sup>19</sup> The effects of climate change only heighten these concerns. Member states of the UN General Assembly have adopted resolutions on combating sand and dust storms each year since 2015 because they realise that these atmospheric phenomena present a severe obstacle to achieving the sustainable development goals.<sup>20</sup>

Nevertheless, many gaps remain in our understanding of the relation between desert dust and the wellbeing of urban residents. In west Africa, a critical knowledge gap lies in the precise nature of the association between meningitis outbreaks and the dry, dusty atmospheric conditions of the Harmattan. In more general terms, evaluating the detailed health effects of dust as an individual component relative to numerous other risk factors is another gap. Filling these gaps can only improve the ways in which we deal with desert dust in the city.

### Biography

Nick Middleton has worked with several United Nations bodies on issues around sand and dust storms. One of his current workstreams is with the Asian and Pacific Centre for the Development of Disaster Information Management, a regional institution of the UN that is developing a sand and dust storms risk assessment and a regional plan of action to combat sand and dust storms.

### Recommendations for policy makers

- Protect ecosystems, promote agricultural practices that reduce soil erosion, and manage water resources judiciously in places with anthropogenic origins of this global environmental health problem
- Conduct assessments of dust risk and vulnerability as part of the Sendai Framework for Disaster Risk Reduction
- Implement dust monitoring, forecasting, and public health early warning measures to reduce dust exposure and harmful impacts

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