Urban Climate 14 (2015) 457–474

Contents lists available at ScienceDirect

Urban Climate

journal homepage: www.elsevier.com/locate/uclim

# An assessment of the potential for co-exposure to allergenic pollen and air pollution in Copenhagen, Denmark

P.V. Ørby [a,b,*], R.G. Peel [b], C. Skjøth [c], V. Schlünssen [a,e], J.H. Bønløkke [a], T. Ellermann [b], A. Brændholt [d], T. Sigsgaard [a], O. Hertel [b,f]

[a] *Department of Public Health, Aarhus University, Bartholins Allé 2, 8000 Aarhus, Denmark*
[b] *Department of Environmental Science, Aarhus University, P.O. Box 358, Frederiksborgvej 399, 4000 Roskilde, Denmark*
[c] *National Pollen and Aerobiology Research Unit, Charles Darwin Building, University of Worcester, Henwick Grove, Worcester WR2 6AJ, UK*
[d] *Asthma-Allergy Denmark, Universitetsparken 4, 4000 Roskilde, Denmark*
[e] *Department of Occupational Medicine, Danish Ramazzini, Aarhus University Hospital, Denmark*
[f] *Department for Environmental, Social and Spatial Change (ENSPAC), Roskilde University, Universitetsvej 1, DK-4000 Roskilde, Denmark*

ARTICLE INFO

*Article history:*
Received 28 February 2014
Revised 24 October 2014
Accepted 12 December 2014

*Keywords:*
Pollen
Allergy
Air pollution
Co-exposure
Diurnal pattern
Ozone

ABSTRACT

Co-exposure to air pollutants and pollen allergens can aggravate the allergic reaction and reduce the threshold at which susceptible individuals are affected. Here we assessed which air pollutants may be of particular relevance when investigating co-exposure with pollen. We examined the yearly variation and diurnal patterns of pollen and air pollution on days with peak pollen concentrations and non-peak days separately. The analysis was performed for measurements of grass and birch pollen, sulfur dioxide, ozone, nitrogen dioxide and particulate matter. Results indicated that high ozone concentrations coincide both seasonally and diurnally with high pollen concentrations, and that ozone concentrations were higher on peak pollen days, potentially leading to clinically relevant simultaneous co-exposure. For nitrogen dioxide and sulfur dioxide no periods with peaks simultaneously with peaks in pollen

*Abbreviation*: IgE, Immunoglobulin, antibody related to the allergic response; FEV1, Forced expiratory Volume. The maximum volume of air a person can exhale within 1 second.

* Corresponding author at: Department of Environmental Science (ENVS), Aarhus University, P.O. Box 358, Frederiksborgvej 399, 4000 Roskilde, Denmark. Tel.: +45 87158538.

*E-mail addresses:* pv@mil.au.dk (P.V. Ørby), rp@envs.au.dk (R.G. Peel), c.skjoth@worc.ac.uk (C. Skjøth), vs@mil.au.dk (V. Schlünssen), jb@mil.au.dk (J.H. Bønløkke), tel@envs.au.dk (T. Ellermann), ab@astma-allergi.dk (A. Brændholt), ts@mil.au.dk (T. Sigsgaard), oh@envs.au.dk (O. Hertel).

http://dx.doi.org/10.1016/j.uclim.2014.12.002

loads was identified, and concentrations were below potential thresholds for adjuvant effects to the allergic reaction. For particulate matter no simultaneous peaks in diurnal or seasonal concentrations were identified, however concentrations were higher on peak pollen days compared with non-peak days. When considering co-exposure effects from pollen and pollutants, ozone appears to be the most relevant pollutant to further examine for effects of simultaneous co-exposures.



## 1. Introduction

Individuals exposed to allergenic pollen are at risk of developing allergic diseases such as rhinitis, conjunctivitis, asthma or combinations thereof (Cecchi, 2013). This may have a negative impact on quality of life by affecting learning, sleeping, social interactions, and numerous other daily activities, resulting in considerable socio-economic costs (Petersen et al., 2008; Pawankar et al., 2011). Co-exposure to air pollutants and pollen allergens can furthermore elicit or exacerbate a number of conditions in susceptible individuals, including allergic airway diseases (Emberlin, 1998), and potentially lower the exposure thresholds above which health effects are evinced (Molfino et al., 1991).

While the monitoring of air pollutants has developed considerably over recent decades through the introduction of on-line detection and chemistry-transport models (Hertel et al., 2007), a similar development in the monitoring of pollen and other airborne allergens has been less rapid. Whilst real-time online methods are available for key air pollutants (e.g. ozone, NOx, particles), the current core pollen detection method relies on the capture of pollen grains using a low volume air sampler, followed by manual visual detection using a microscope – a labor intensive methodology based on a sampler developed more than 60 years ago (Hirst, 1952). This contrast between air pollution and airborne allergens is also seen in relation to regulation at both national and international level – for example in Europe the air quality directive requires monitoring of a variety of air pollutants but not of pollen, since in this context pollen has not been defined as an air pollutant. For airborne allergenic pollen, the only exposure thresholds commonly applied are related to daily mean concentrations, whilst for air pollutants limit values at multiple time scales from hourly to annual values have been established. The diurnal variation in pollen concentrations can be large and peak values over the day may affect the allergic reaction, making measurements at higher temporal resolution useful in assessment of health effects.

Methods for assessing air allergen content have come to prominence in recent years (Buters et al., 2012), however, pollen grain and allergen measurements are not always well correlated (Rodríguez-Rajo et al., 2011; Galán et al., 2013). To some degree they complement one-another, meaning that future monitoring activities should properly take both of these into account. This however requires changes in the current monitoring program. Future efforts within development of technologies for air pollution monitoring should consider including pollen with a particular focus on allergens. The advantage of focusing on allergens is twofold: firstly it is the allergens that cause the human reaction, the pollen grain is merely the vector by which it is transferred to the exposure target. Secondly, the detection of allergen will automatically take into account the observed alterations of allergens by chemical reactions. This will make co-exposure assessments much more straightforward and provide a direct observation of the causal agent (the allergen) instead of a proxy (the pollen grain). Developments of new cheap and lightweight technologies are crucial for advancing the monitoring of pollen and allergens in relation to human health.

Outdoor concentrations of pollen and air pollution measured at urban background monitoring stations are often used as an estimate for population exposure (Hertel et al., 2013, 2001; Momas et al., 2003; Anderson et al., 1998; Mücke et al., 2014). This is especially the case when health effects related