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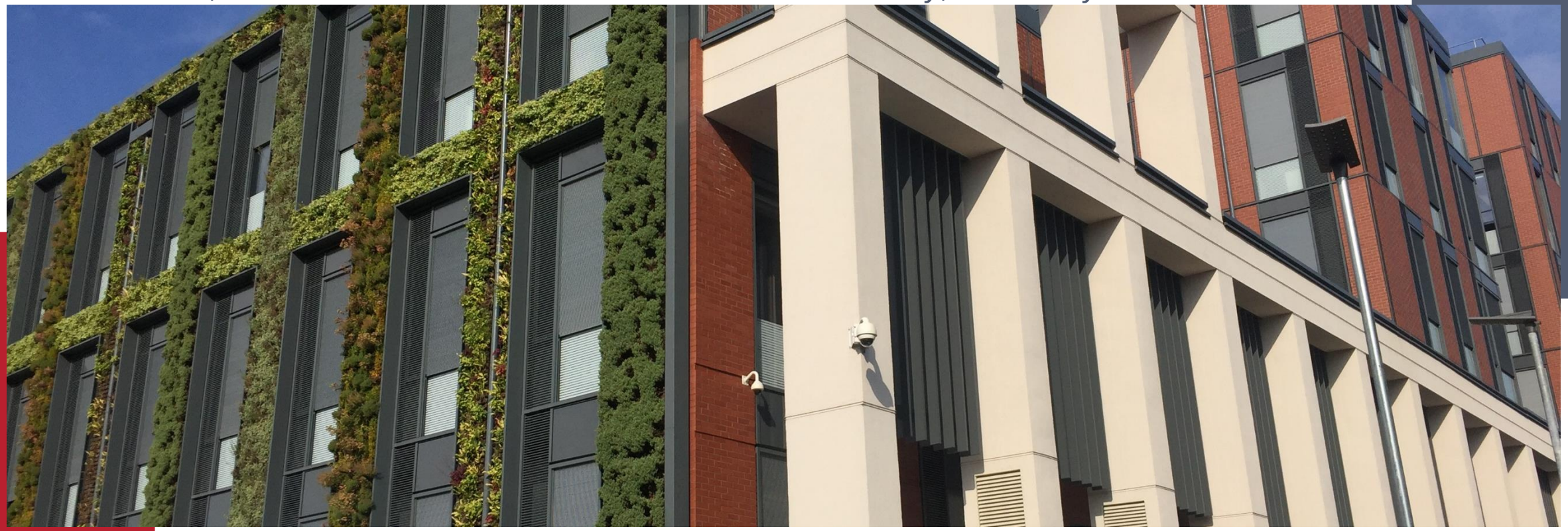
Centre for Environmental Health and Sustainability

Challenges and opportunities for bringing together exposure and health data to identify potential health impacts of bioaerosols

Anna Hansell, Centre for Environmental Health and Sustainability, University of Leicester



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NIHR Health Protection Research Unit (HPRU) in Environmental Exposures and Health Development Award

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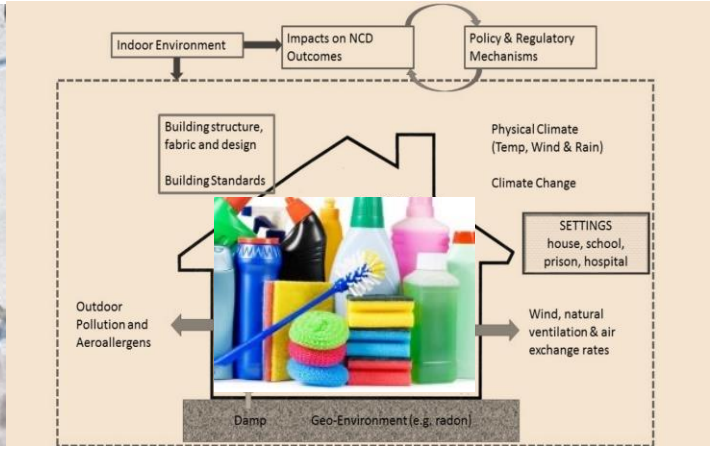

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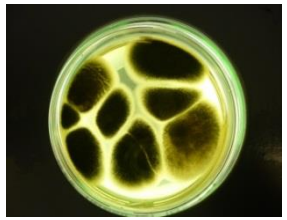
Challenges and opportunities for bringing together exposure and health data to identify potential health impacts of bioaerosols:
Are there health risks from living near large composting facilities?


Philippa Douglas, Ioannis Bakolis, Daniela Fecht, Clare Pearson, Maria Leal Sanchez, Rob Kinnersley, Kees de Hoogh, Anna Hansell
Small Area Health Statistics Unit
Imperial College London, UK

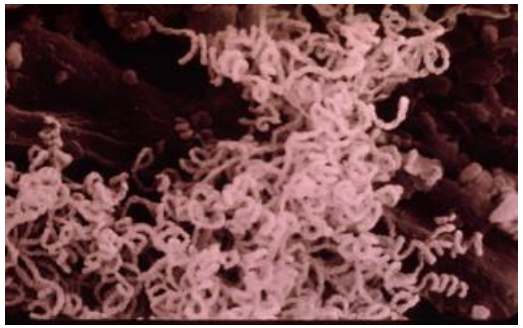
Small Area Health Statistics Unit

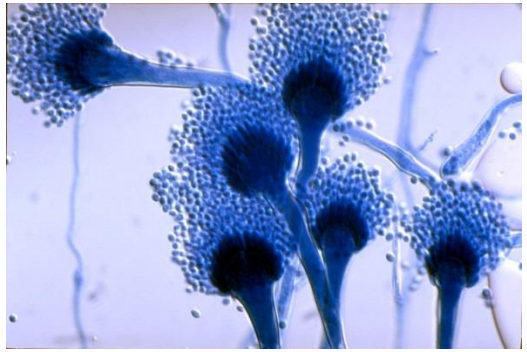
MRC-PHE
Centre for Environment & Health

Public Health England | MRC Medical Research Council | Imperial College London | King's College London

Background

- Composting is increasing in the UK due to the 1999 EU Landfill Directive (1999/31/EC) requiring diversion of waste from landfill
- Composting results in elevated concentrations of biological air pollution (bioaerosols)





- Bioaerosols are aerosolised particles of fungi, bacteria and their cellular constituents
- Bioaerosols can cause ill health but dose-response is unclear

- Research is needed to support policy and regulation of large scale composting sites

Systematic Reviews

Journal of Toxicology and Environmental Health, Part B, 18:43–69, 2015
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DOI: 10.1080/10937404.2015.1009961

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EXPOSURES AND HEALTH OUTCOMES IN RELATION TO BIOAEROSOL EMISSIONS FROM COMPOSTING FACILITIES: A SYSTEMATIC REVIEW OF OCCUPATIONAL AND COMMUNITY STUDIES

Clare Pearson[1], Emma Littlewood[1], Philippa Douglas[1], Sarah Robertson[2], Timothy W. Gant[2], Anna L. Hansell[1,3]

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[3]Public Health and Primary Care, Imperial College Healthcare NHS Trust, London, United Kingdom

The number of composting sites in Europe is rapidly increasing, due to efforts to reduce the fraction of waste destined for landfill, but evidence on possible health impacts is limited. This article systematically reviews studies related to bioaerosol exposures within and near composting facilities and associated health effects in both community and occupational health settings. Six electronic databases and bibliographies from January 1960 to July 2014 were searched for studies reporting on health outcomes and/or bioaerosol emissions related to composting sites. Risk of bias was assessed using a customized score. Five hundred and thirty-six papers were identified and reviewed, and 66 articles met the inclusion criteria (48 exposure studies, 9 health studies, 9 health and exposure studies). Exposure information was limited, with most measurements taken in occupational settings and for limited time periods. Bioaerosol concentrations were highest on-site during agitation activities (turning, shredding, and screening). Six studies detected concentrations of either *Aspergillus fumigatus* or total bacteria above the English Environment Agency's recommended threshold levels beyond 250 m from the site. Occupational studies of compost workers suggested elevated risks of respiratory illnesses with higher bioaerosol exposures. Elevated airway irritation was reported in residents near composting sites, but this may have been affected by reporting bias. The evidence base on health effects of bioaerosol emissions from composting facilities is still limited, although there is sufficient evidence to support a precautionary approach for regulatory purposes. While data to date are suggestive of possible respiratory effects, further study is needed to confirm this and to explore other health outcomes.

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Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

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

Bioaerosol exposure from composting facilities and health outcomes in workers and in the community: A systematic review update

Sarah Robertson[a,b,1], Philippa Douglas[b,c,1,*], Deborah Jarvis[c], Emma Marczylo[a,b]

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ARTICLE INFO

Keywords:
Bioaerosols
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Primary biological airborne particles
Composting
Respiratory health

ABSTRACT

Background: Rapid population growth and urbanisation around the world has led to increasing waste generation rates. Composting of organic waste in large-scale facilities is part of a growing trend in the UK, and elsewhere, to better manage and re-use the organic waste. However, composting inevitably generates bioaerosols, which have been associated with human health effects. In 2015, we reported that there was some, albeit limited, qualitative evidence linking bioaerosol emissions from composting facilities to poor respiratory health in nearby residents. However, the limited evidence precluded any quantitative assessment. Since then, the number of operational industrial-scale composting facilities in England has increased by 9% - nearly twice the growth from 2012 to 2014. At the same time, rapid urbanisation has led to expansion of city borders with more people living near large composting facilities and exposed to bioaerosol pollution. It is essential that regulatory authorities have access to the most up to date and accurate information.
Objective: In this update of a systematic review published in 2015, we review and summarise the evidence from more recent studies that have assessed bioaerosol exposures within and near composting facilities and their associated health effects in both community and occupational health settings. Specifically, we wanted to find out if new evidence has emerged since the previous review to strengthen and confirm its conclusions.
Material and methods: Two electronic databases (Medline and Embase) and bibliographies were searched for studies reporting on health outcomes and/or exposure to bioaerosols from composting facilities published between 1 January 2014 and 15 June 2018. Identification of relevant articles and data extraction was undertaken and studies were assessed for risk of bias.
Results: 23 studies met the inclusion criteria (15 exposure studies, 4 health studies, 4 health and exposure studies (one of which used an exposure proxy)). The majority of studies were conducted in occupational settings, and over short time periods. Some progress has been made in the characterisation of bioaerosol emissions from these composting facilities, with the application of molecular-based methods. Whilst the latest health studies do not rely solely on subjective self-reported measures of health status but include more objective health measures, these studies were almost exclusively carried out in compost workers and were characterised by profound methodological limitations. Only one community health study was identified and used a proxy measure of bioaerosol exposure.
Conclusions: Although this review identified an additional 23 studies since the earlier review, the conclusions remain largely unchanged. Given the absence of any consistent evidence on the toxicity of bioaerosols from composting facilities, there is insufficient evidence to provide a quantitative comment on the risk to nearby residents from exposure to compost bioaerosols. To improve risk assessment and to best advise on risk management, it is important to ensure that the research recommendations outlined in this review are addressed.

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Epidemiology (1)

International Journal of Hygiene and Environmental Health 219 (2016) 372–379

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

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

Respiratory hospital admission risk near large composting facilities

Philippa Douglas[a], Ioannis Bakolis[a,b,c], Daniela Fecht[a], Clare Pearson[a], Maria Leal Sanchez[a], Rob Kinnersley[d], Kees de Hoogh[a,e,f], Anna L. Hansell[a,g,*]

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[e] Swiss Tropical and Public Health Institute, Basel, Switzerland
[f] University of Basel, Basel, Switzerland
[g] Public Health and Primary Care, Imperial College Healthcare NHS Trust, United Kingdom

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Keywords:
Bioaerosol
Compost
Respiratory health
Hospitalization
Asthma
Chronic obstructive pulmonary disease (COPD)

ABSTRACT

Background: Large-scale composting can release bioaerosols in elevated quantities, but there are few studies of health effects on nearby communities.
Methods: A cross-sectional ecological small area design was used to examine risk of respiratory hospital admissions within 2500 m of all 148 English large-scale composting facilities in 2008–10. Statistical analyses used a random intercept Poisson regression model at Census Output Area (COA) level (mean population 310). Models were adjusted for age, sex, deprivation and tobacco sales.
Results: Analysing 34,963 respiratory hospital admissions in 4656 COAs within 250–2500 m of a site, there were no significant trends using pre-defined distance bands of >250–750 m, >750–1500 m and >1500–2500m. Using a continuous measure of distance, there was a small non-statistically significant ($p = 0.054$) association with total respiratory admissions corresponding to a 1.5% (95% CI: 0.0–2.9%) decrease in risk if moving from 251 m to 501 m. There were no significant associations for subgroups of respiratory infections, asthma or chronic obstructive pulmonary disease.
Conclusion: This national study does not provide evidence for increased risks of respiratory hospital admissions in those living beyond 250 m of an outdoor composting area perimeter. Further work using better measures of exposure and exploring associations with symptoms and disease prevalence, especially in vulnerable groups, is recommended to support regulatory approaches.

Site Selection Method

EA have information on sites operating between 08-10 for England and Wales

↓

Wales excluded

↓

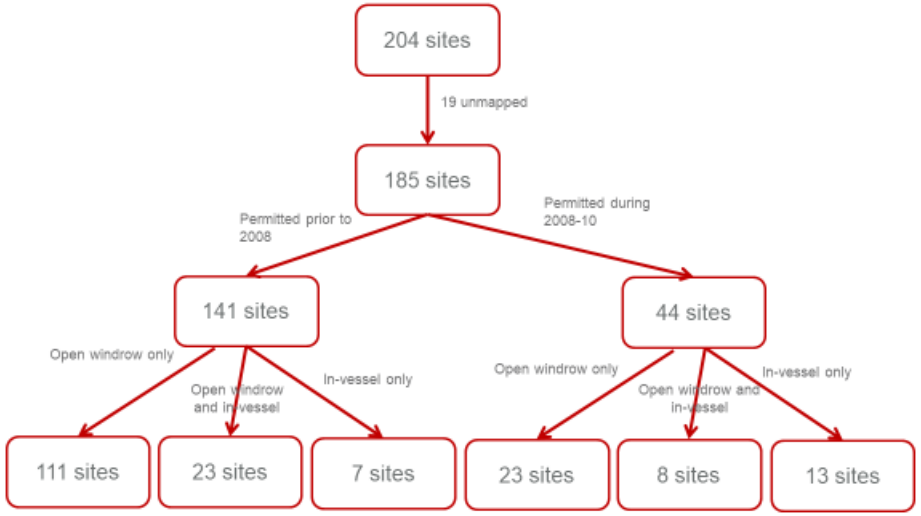
Large scale sites only included (permitted sites only)

↓

Any site with an outdoor composting element included

↓

IV only sites also mapped but may be used as a control case



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Defining distance – not as easy as it sounds!

Site Digitisation and Distance Bands

Site identification in Google Earth

Site digitisation in Google Earth

Shapefile created in ArcGIS

Distance based model for exposure

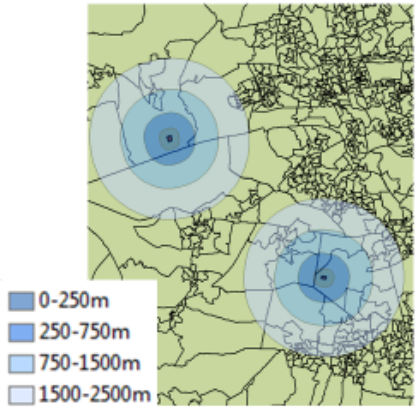
Distance bands at 250, 750, 1500 and 2500m added to each site

Data Extraction

- The number of respiratory hospital admissions for each distance band around each site determined
- The populations for each are can be estimated using postcode and/or census output area [COA] data to provide a denominator

- COA data includes population estimates which are broken down into sex and age
- However some COAs cover multiple distance bands
- The extent of this potential problem was investigated

COA



Results: Respiratory hospital admissions in relation to distance from site

Distance Band (m)	Effect	Unadjusted models (n at COA level = 4654)	Adjusted models (for deprivation and smoking proxy confounders) (n at COA level = 4580)[a]	
250-750m compared with reference area	RR (95% CI) p-value	1.05 (0.99-1.11) 0.08	1.01 (0.95-1.06) 0.68	>1 = higher risk near site
750-1500m compared with reference area	RR (95% CI) p-value	1.02 (1.00-1.05) 0.06	**1.03 (1.01-1.05)** **0.04**	
Reference area 1500-2500m	RR (95% CI)	1.00	1.00	
P for trend		0.01	0.10	
Log-transformed distance	RR (95% CI) p-value	0.97 (0.94-1.00) 0.06	**0.98 (0.96-1.00)** **0.05**	<1 = higher risk near site

a Not all confounders were available for all COAs due to differences in 2001 and 2011 Census geographies

Improve exposure estimates - modelling

Contents lists available at ScienceDirect

Journal of Environmental Management

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

Research article

Sensitivity of predicted bioaerosol exposure from open windrow composting facilities to ADMS dispersion model parameters

P. Douglas [a, b], S.F. Tyrrel [a], R.P. Kinnersley [c], M. Whelan [a, d], P.J. Longhurst [a], K. Walsh [c], S.J.T. Pollard [a], G.H. Drew [a, *]

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[b] Small Area Health Statistics Unit, MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, Imperial College London, W2 1PG, United Kingdom
[c] Environment Agency, Evidence Directorate, Deanery Road, Bristol, BS1 5AH, United Kingdom
[d] Department of Geography, Leicester University, Leicestershire, LE1 7RH, United Kingdom

Parameters relating to the emissions source and pollution deposition properties are the most important in predicting exposure

Contents lists available at ScienceDirect

International Journal of Hygiene and Environmental Health

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

Predicting *Aspergillus fumigatus* exposure from composting facilities using a dispersion model: A conditional calibration and validation

Philippa Douglas [a,b,*], Sean F. Tyrrel [b], Robert P. Kinnersley [c], Michael Whelan [b,d], Philip J. Longhurst [b], Anna L. Hansell [a,e], Kerry Walsh [c], Simon J.T Pollard [b], Gillian H. Drew [b,**]

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[c] Environment Agency, Evidence Directorate, Deanery Road, Bristol, United Kingdom
[d] Leicester University, Department of Geography, Leicestershire LE1 7RH, United Kingdom
[e] [illegible]STrust, Public Health and Primary Care, United Kingdom

Contents lists available at ScienceDirect

Waste Management

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

Estimating *Aspergillus fumigatus* exposure from outdoor composting activities in England between 2005 and 14

B. Williams [a,*,1], P. Douglas [b,c,d,1], A. Roca Barcelo [b,d], A.L. Hansell [b,d,e,f], E. Hayes [a]

[a] Air Quality Management Resource Centre, University of the West of England, Faculty of Environment and Technology, Coldharbour Lane, Bristol BS16 1QY, UK
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Composting
Modelling
ADMS
Population exposure
Aspergillus fumigatus

ABSTRACT

Bioaerosols, ubiquitous in ambient air, are released in elevated concentrations from composting facilities with open-air processing areas. However, spatial and temporal variability of bioaerosols, particularly in relation to meteorology, is not well understood. Here we model relative concentrations of *Aspergillus fumigatus* at each postcode-weighted centroid within 4 km of 217 composting facilities in England between 2005 and 2014. Facilities were geocoded with the aid of satellite imagery. Data from existing bioaerosol modelling literature were used to build emission profiles in ADMS. Variation in input parameters between each modelled facility was reduced to a minimum. Meteorological data for each composting facility was derived from the nearest SCAIL-Agriculture validated meteorological station. According to our results, modelled exposure risk was driven primarily by wind speed, direction and time-varying emissions factors incorporating seasonal fluctuations in compostable waste. Modelled *A.fumigatus* concentrations decreased rapidly from the facility boundary and plateaued beyond 1.5–2.0 km. Where multiple composting facilities were within 4 km of each other, complex exposure risk patterns were evident. More long-term bioaerosol monitoring near facilities is needed to help improve exposure estimation and therefore assessment of any health risks to local populations.

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Epidemiology (2)

International Journal of Hygiene and Environmental Health 219 (2016) 372–379

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Respiratory hospital admission risk near large composting facilities

Philippa Douglas[a], Ioannis Bakolis[a,b,c], Daniela Fecht[a], Clare Pearson[a], Maria Leal Sanchez[a], Rob Kinnersley[d], Kees de Hoogh[a,e,f], Anna L. Hansell[a,g,*]

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Conclusion: This national study does not provide evidence for increased risks of respiratory hospital admissions in those living beyond 250 m of an outdoor composting area perimeter. Further work using better measures of exposure and exploring associations with symptoms and disease prevalence, especially in vulnerable groups, is recommended to support regulatory approaches.

Environmental Research 183 (2020) 108949

Contents lists available at ScienceDirect

Environmental Research

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

Risk of respiratory hospital admission associated with modelled concentrations of *Aspergillus fumigatus* from composting facilities in England

Aina Roca-Barcelo[a,1], Philippa Douglas[a,b,c,*,1,2], Daniela Fecht[a], Anna Freni Sterrantino[a], Ben Williams[d], Marta Blangiardo[e], John Gulliver[e,f], Enda T. Hayes[d], Anna L. Hansell[a,f,g,**,3]

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[b] Population Health and Occupational Disease, National Heart and Lung Institute, Imperial College London, London, SW3 6LR, UK
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[e] MRC-PHE Centre for Environment and Health, Department of Epidemiology and Biostatistics, School of Public Health, Imperial College London, London, W2 1PG, UK
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ARTICLE INFO

Keywords:
Bioaerosol
Aspergillus fumigatus
Composting facility
Respiratory health
Asthma

ABSTRACT

Bioaerosols have been associated with adverse respiratory-related health effects and are emitted in elevated concentrations from composting facilities. We used modelled *Aspergillus fumigatus* concentrations, a good indicator for bioaerosol emissions, to assess associations with respiratory-related hospital admissions. Mean daily *Aspergillus fumigatus* concentrations were estimated for each composting site for first full year of permit issue from 2005 onwards to 2014 for Census Output Areas (COAs) within 4 km of 76 composting facilities in England, as previously described (Williams et al., 2019). We fitted a hierarchical generalized mixed model to examine the risk of hospital admission with a primary diagnosis of (i) any respiratory condition, (ii) respiratory infections, (iii) asthma, (iv) COPD, (v) diseases due to organic dust, and (vi) Cystic Fibrosis, in relation to quartiles of *Aspergillus fumigatus* concentrations. Models included a random intercept for each COA to account for overdispersion, nested within composting facility, on which a random intercept was fitted to account for clustering of the data, with adjustments for age, sex, ethnicity, deprivation, tobacco sales (smoking proxy) and traffic load (as a proxy for traffic-related air pollution). We included 249,748 respiratory-related and 3163 Cystic Fibrosis hospital admissions in 9606 COAs with a population-weighted centroid within 4 km of the 76 included composting facilities. After adjustment for confounders, no statistically significant effect was observed for any respiratory-related (Relative Risk (RR) = 0.99; 95% Confidence Interval (CI) 0.96–1.01) or for Cystic Fibrosis (RR = 1.01; 95% CI 0.56–1.83) hospital admissions for COAs in the highest quartile of exposure. Similar results were observed across all respiratory disease sub-groups. This study does not provide evidence for increased risks of respiratory-related hospitalisations for those living near composting facilities. However, given the limitations in the dispersion modelling, risks cannot be completely ruled out. Hospital admissions represent severe respiratory episodes, so further study would be needed to investigate whether bioaerosols emitted from composting facilities have impacts on less severe episodes or respiratory symptoms.

Risk of hospital admission 2005-14 (Roca-Barceló 2020)

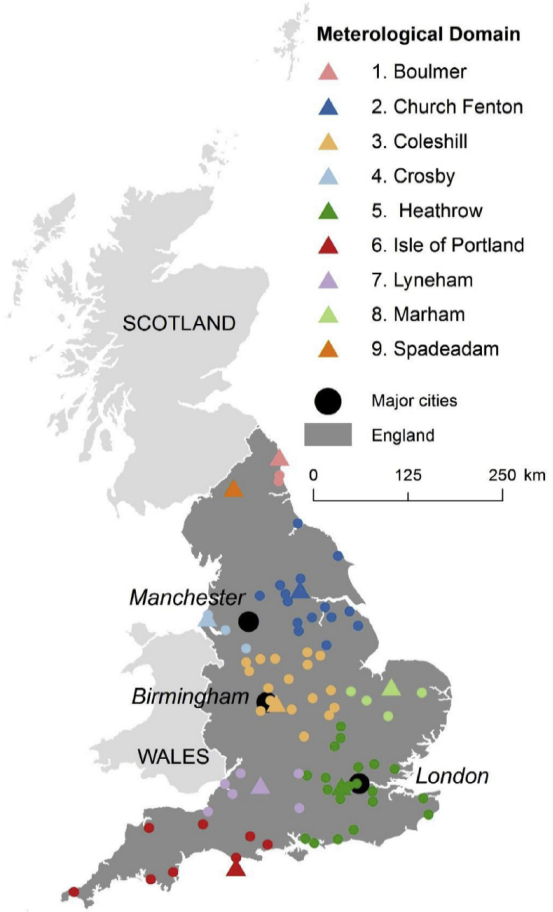


Fig. 1. Locations of the permitted open windrow composting facilities included in the study (coloured circles) and meteorological stations assigned to each composting facility (coloured triangles). Major cities are indicated (black circles).

- 76 sites
- Exposure: wind direction, overlaps important
- ~ 250,000 hospital admissions including 3,163 for cystic fibrosis within 4km of sites
- Multi-level modelling with random intercepts (clustering by COA and by composting facility)
- No associations for any respiratory condition

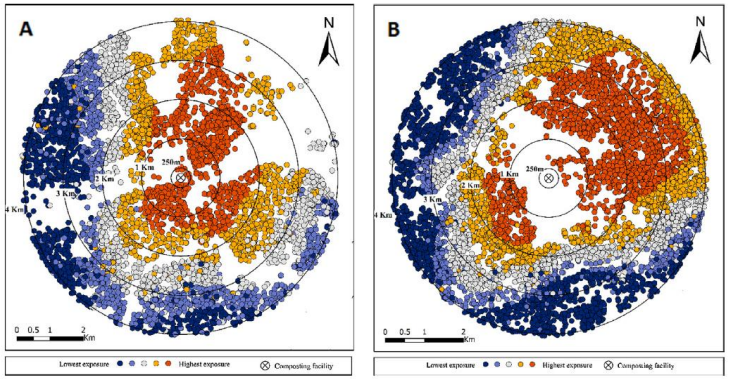


Fig. 5. Mean average modelled concentrations for the entire study period (presented as quintiles) at postcodes for two composting facilities for (A) a composting facility located in an urban area and (B) a composting facility located in a rural area. The black concentric circles represent distance bands at 250 m, 1000 m, 2000 m, 3000 m and 4000 m from the composting facility.

Epidemiology (3) – future work

- **What's the research question?**
- Look at sensitive groups
  - Cystic fibrosis patients. e.g. PhD studentship at Imperial looking at environmental factors in people living with CF. Includes analysis of living near registered composting sites (RCS)
  - Known asthmatics/allergic rhinitis sufferers
- Look at those with higher exposure
  - Occupational health studies
- Use existing health datasets available for retrospective/prospective studies
  - UKRI estimate 2.2 million (3.5%) of UK population are in a cohort study
- Biomarker studies
- Improve exposure estimates

Exposure estimation – the Achilles heel of environmental epidemiology

	$PM_{2.5}$	Pollens	Fungi
Personal monitoring	Special studies	Special studies – nasal filters most successful	?
Ambient daily monitoring [distance valid for]	Defra AURN from 2009, up to 150 sites [needs modelling]	Met Office network, 14 sites usually, 6 in 2020 [41km: Pashley, 2009]	1 (Leicester!) [30-40km]
Modelled ambient – coarse scale	Defra background annual averages at $1km^2$	Worcester models for Met Office	No
Modelled ambient – fine scale/to address	Special studies	No	No
Indoors – monitor/model	Special studies [indoor sources e.g. cooking, wood burning, candles, ETS]	No [outdoor sources]	No [indoor and outdoor sources]

Pollen types counted and their allergenicity

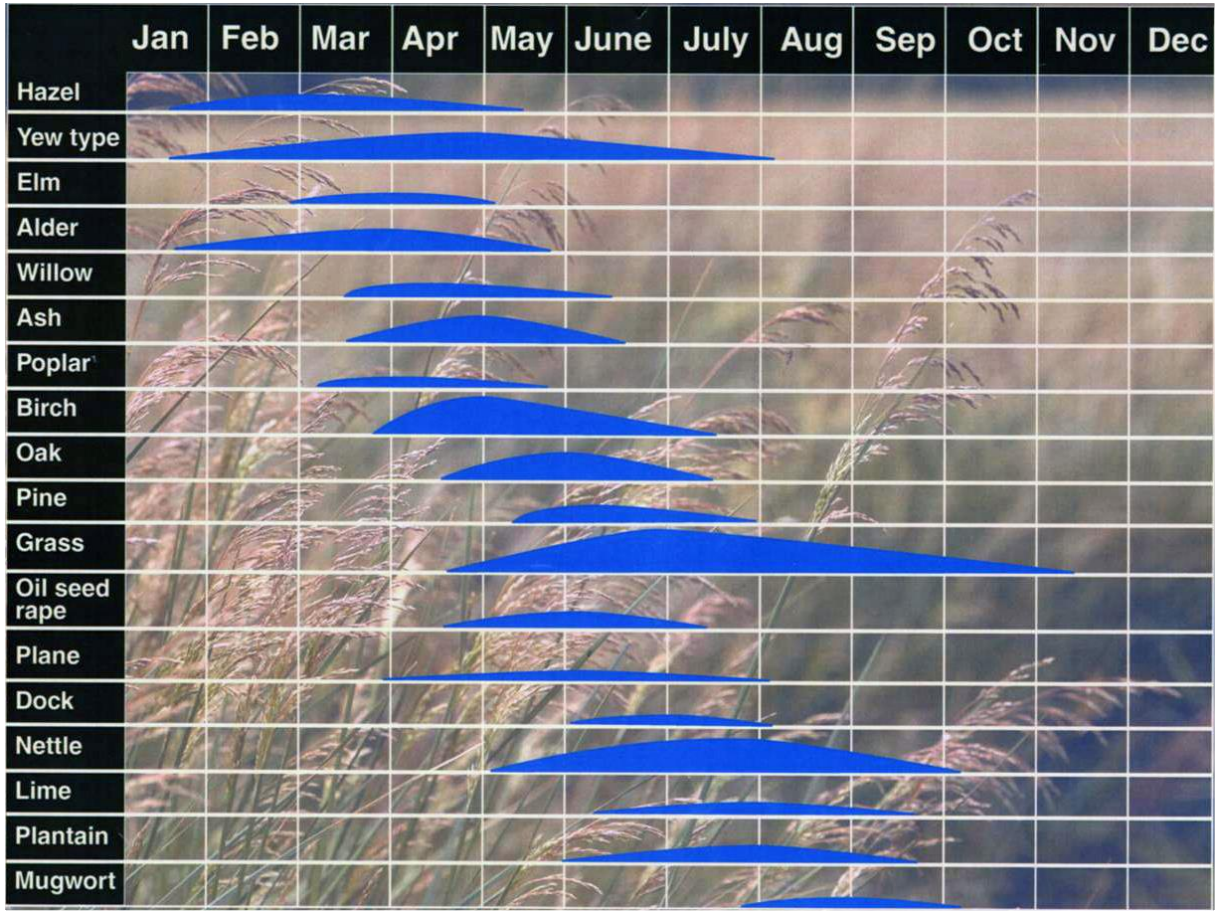
High	Moderate to High	Moderate	Low to moderate	Low	None or very low
Birch	Ash	Oak	Beech	Elm	Nettle-type*
Grass	Alder		Elder #	Pine-type	Lime #
Mugwort	Dock		Goosefoot	Plantain	
Ragweed	Hazel		Hornbeam	Poplar	
	Plane		Horse Chestnut #	Willow	
	Yew-type		Sweet Chestnut #	Winter Jasmine #	
			Rape-type #		

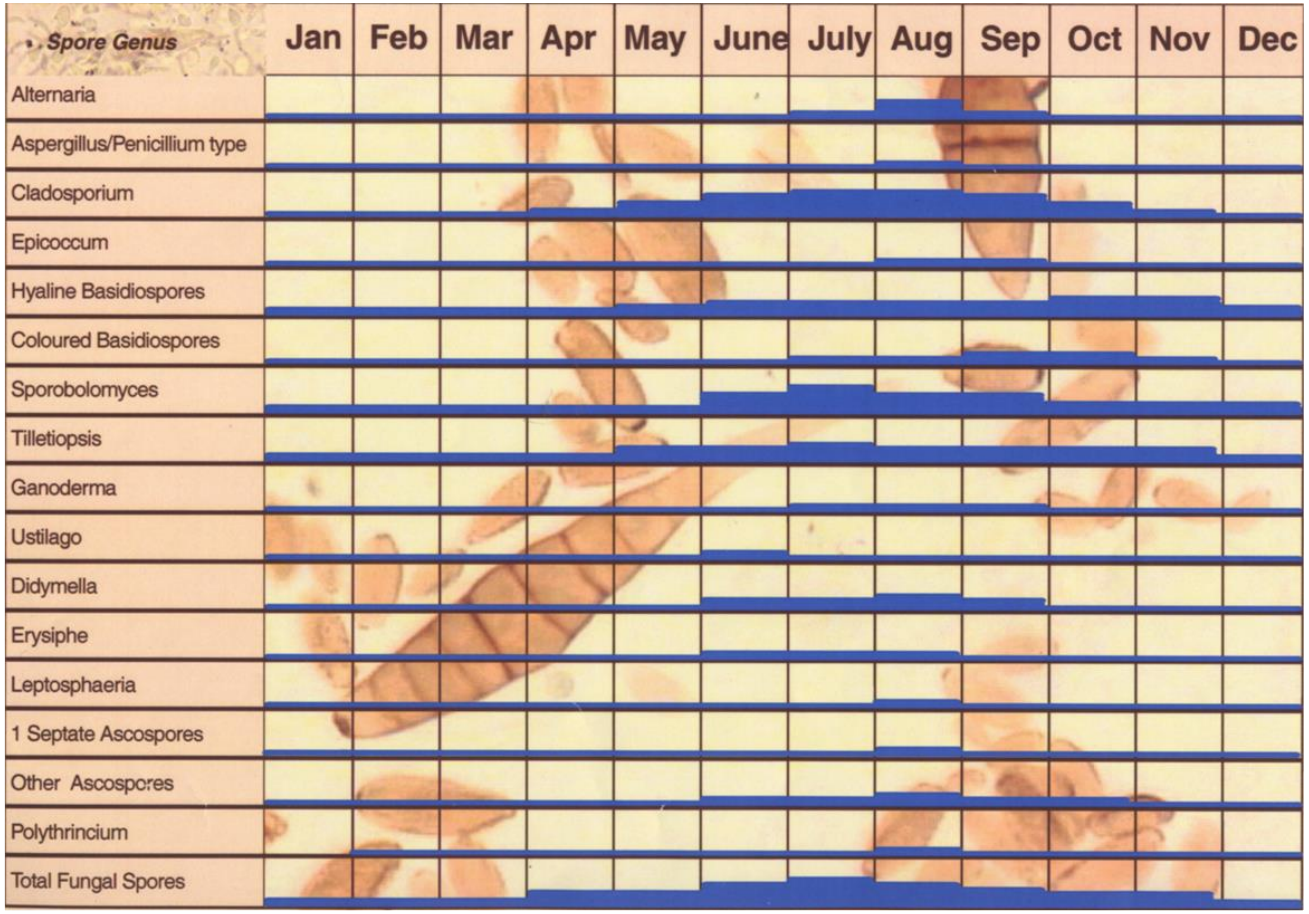
Insect pollinated

* Includes pellitory of the wall (high)

12 pollen-types counted by UK pollen network

Aeroallergen calendars





http://www.maara.org

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Thank you

Occupational and Environmental Epidemiology Society

The 14th UK & Ireland Occupational and Environmental Epidemiology Society annual meeting will be held on afternoons of 3&4 June 2021 hosted by UoL

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Call for abstracts on new occupational and environmental epidemiological research relevant to the UK & Ireland setting, deadline March 22nd

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