buyers' guide

The Composters' Buying Guide to odours and bioaerosols

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What causes odours at a composting site?

Odours from composting facilities are one of the most common causes of complaints about these sites. However, odours are one of the most complex emissions to monitor and quantify because they are frequently the result of a mixture of airborne chemicals. The most common odorous emissions associated with composting are volatile organic compounds (VOCs), a group of organic compounds that volatilise easily at ambient temperatures. VOCs are emitted by the micro-organisms responsible for biodegradation during the composting process.

How are odours detected and measured?

Single chemical compounds or VOCs can be monitored and the concentration quantified using methods such as gas chromatography-mass spectrometry. However, quantifying the odour potential of only one of those chemicals will not provide an accurate assessment of their combined odour potential. In addition, in ambient conditions, the concentrations of these individual compounds are often too low to detect accurately using these methods. Despite this, the human nose will be able to detect an odour at low concentrations, which may result in annoyance. Sensory methods are, therefore, often useful in monitoring where there are several different pollutants combining together to produce an odorous emission, such as at composting facilities.

The most commonly used sensory method is dynamic dilution olfactometry. Here samples are collected directly from the odorous source using the lung principle. This involves creating a vacuum within a sealed drum that contains the sample bag. An inlet pipe is located above the odour source and feeds directly into the sample bag. The vacuum surrounding the sample bag forces the odorous air to be drawn into the sample bag. The sample is then taken to a laboratory, where a trained panel of sniffers analyse the sample at a number of dilutions using s a gas diluter specifically designed for presenting controlled samples of odour to panellists.

Panellists are required to smell air being delivered from a 'horn' and state when they can detect an odour. The number of odour units for a sample is calculated by the number of times the air is diluted before being detectable by only 50 per cent of the panellists. The dilution at which only half the panel can detect the odour is known as the odour detection threshold and equates to one odour unit. The procedure for completing this assessment is defined in an EU standard (CEN EN 13725: 2003). For this reason, this method of determining odour concentrations is now generally adopted in Western Europe and the unit is referred to as an odour unit (ouE). This method currently gives the most useful indicator of smell for the purposes of research and evaluation, but it is very expensive and difficult to undertake.

What are bioaerosols and where do they come from?

Bioaerosols are aerosols of biological origin that are suspended in the air and are often associated particles of dust, soil, plant and water material. They consist of fungi (in particular their reproductive cells), bacteria and associated cellular components. The small size of these cells and their components (usually $<10\mu m$), their aerodynamic shape and there natural design facilitates their dispersal into the air, as they are trying to colonise other areas. Bioaerosols are ubiquitous in the environment, but certain activities at organic waste treatment plants can result in temporarily higher concentrations, for example when screening composted material.

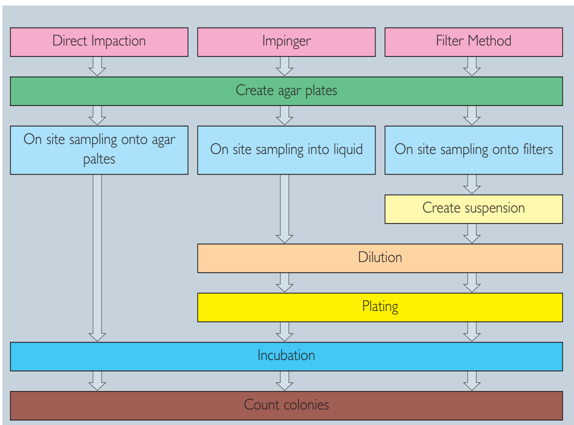
Why is everyone so concerned about bioaerosols?

Bioaerosols can cause health impacts, particularly respiratory problems. This is because they are so small that they can travel deep down into our lungs, where, under the right conditions, they can grow and cause problems. Most healthy people will have a strong immune system that can fight these invaders, but for people with weak immune systems (e.g. TB sufferers or people who have recently received an organ transplant), bioaerosols can make existing problems worse.

However, although we do know that bioaerosols can cause health problems, we do not have enough data to assess what level of concentration could result in a specific health problem. This is because the different bioaerosols cause different problems and also because different people react very differently to different amounts of bioaerosols.

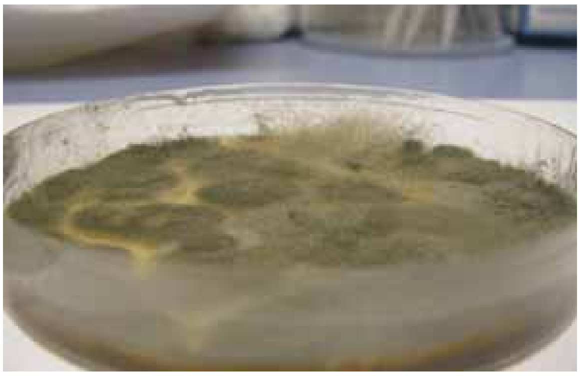
How are bioaerosols monitored?

There are currently three methods of sampling for bioaerosols, namely direct impaction samplers, impingers and the filter method. Each has it advantages and disadvantages, and these are outlined below. The figure below shows the different stages of processing for each of the methods.



Direct impaction samplers are the method suggested in The Composting Association Standard Protocol. With this method, agar plates are loaded directly into the sampler and bioaerosols are collected directly onto the agar plates, which are then incubated upon return to the laboratory. Examples include the Andersen samplers and the Merck MAS100. The Andersen sampler has a flow rate of 28.3 l/min and is able to collect different particle sizes through the use of multiple stages, which have different pore sizes.

The disadvantages of this method are that it cannot be used for non-culture methods, plates can be easily over-loaded, prolonged exposure hardens agar (resulting in particle bounce), the samplers are expensive, and the method is labour intensive in the field. However, it does reduce the post-sampling laboratory procedures.



An overloaded plate of Aspergillus fumigatus, captured at a composting site.

With the liquid impingers, air is transported through a liquid that captures the bioaerosols, with a flow rate of 12.5 l/min. The advantage of this method is that it improves capture of viable organisms, as there is no desiccation and you can, therefore, sample for longer time periods up to 8 hours. It can also be used for both culture and non-culture analysis. Examples of these samplers include the AGI-30 and the BioSampler. The disadvantages of this method are that the liquid can evaporate, resulting in loss of the sample, and as the samplers are made of glass, they are very fragile.

The filter method involves the use of a pump (with a typical flow rate of 2.2 l/min) to draw air through a sampling head and collect bioaerosols onto a filter. The filters are then stored in a buffer solution until you return to the laboratory, where the samples are diluted and then cultured. There are several different types of filters that can be used, such as the nuclepore or polycarbonate. This system can result in loss of viability of the bioaerosols through dehydration, although a new type of filter, which combines the polycarbonate filter with a gelatine layer, is being used very successfully in Germany to counteract this disadvantage. The advantages of this method is that it is a simple system that allows for easy replication and it can be used for both culture and non-culture methods.

Bioaerosols have generated a lot of interest recently and there is a significant amount of research currently underway. There are several new and novel methods for bioaerosol analysis that may become more important in the future. These range from development of the agars used to culture these micro-organisms through to non-culture based methods involving DNA extraction and analysis of the bioaerosol community structure.

Air Spectrum Environmental's new Spectrumist NX mobile odour control package which is ideal for remote or emergency odour situations

Can I estimate the impact of these emissions on the areas around the site?

Atmospheric dispersion modelling is a well established method of calculating the movement of emissions downwind from a source, such as a composting facility, using complex mathematical formulas. The models rely on input data such as local weather conditions, topography, and the size and location of buildings. They also need details about the source of the emission, such as size, location, height and the amount of the pollutant being emitted (the emission rate).

These models have been successfully used for many years to estimate the dispersal of odours around a facility and some research has been undertaken into using them to model bioaerosol emissions. However, there are still some unresolved issues. For example, bioaerosols are so small that they could be considered as a gas, but there is some evidence to suggest that once airborne, the particles may clump together to form large aggregates, which may or may not disperse in the same way as other particles. There is still not enough scientific evidence to allow us to use these models with enough confidence in the results.

How can I control bioaerosol and odour emissions?

The composting process relies on micro-organisms and increases their biomass [numbers] above ambient levels. But if micro-organisms are removed from the system, the process will not continue. Therefore, a form of control will not only have to reduce the effects of microbial dispersal in the form of bioaerosols, but to also continue the composting process at an efficient level. In order to control bioaerosol and odour emissions, we need to understand the factors involved in emission rates i.e. when are bioaerosols at their highest? And what mechanisms effect their dispersal?

Bioaerosol and odour emissions are increased significantly during periods of activity on site, namely shredding, turning and screening of material, particularly at early stage composting or when the compost has been left to become anaerobic. Movement of composted material in the air, for instance when it is aerated by turning, causes a tumbling effect which in turn increases the release of cells into the air. This process also releases trapped heat and odours from the centre of the compost and surrounding buoyant air is forced upwards. Bioaerosols are then carried upwards into this air-stream.

Bioaerosol and odour emission rates are also affected by meteorological factors (wind speed, wind direction and humidity), windrow alignment (surface area of compost exposed to the prevailing wind) and site topography (careful choice of alignment of site activity according to elevation of site i.e. keeping activity away from areas of high elevation and therefore wind exposure).

To help control bioaerosol emissions, management and monitoring can be combined with knowledge of the factors effecting bioaerosol dispersal. In the same way that odours can be effectively managed using best practice techniques, bioaerosol release can be minimised. The main factors effecting bioaerosol release are wind exposure and site activity. Therefore, site activity should be controlled, minimised or changed (to an activity that may generate 'less' aerosol material i.e. from turning to shredding) on windier days or periods when the wind direction is driving towards a sensitive receptor. Site exposure to wind can also be reduced by adding bunding, banking or tree lines to minimise wind reaching the compost.

Good composting practice to minimise odours

The micro-organisms that decompose the biological material consume oxygen as they break down the particles. Air consists of approximately 21 per cent oxygen. Adequate airflow through the composting material can be achieved by regular turning or mixing of the composting material or use of an engineered aeration system, (e.g. channels with air outlets or perforated pipes underneath). Such management is particularly important during the early phase of composting (sanitisation) when the rate of decomposition is high. Periodic mixing improves the oxygen supply and some systems rely on an engineered means of pumping air through each composting mass.

The structure of the composting material should include sufficient carbon-rich, rigid material to result in an adequate ratio of large to small pore spaces. Nitrogen-rich material such as grass cuttings and food wastes contain more moisture and more readily decomposable forms of carbon than woody plant materials (e.g. straw, garden prunings, wood and bark chips). Overly high nitrogen content such as fish, biosolids or manure can give rise to high ammonia emissions, typically greater than 25 ppm. It is recommended that the Carbon to Nitrogen Ratio (C:N) is between 25:1 and 40:1 in the shredded mix at the start of the composting process.

Control of feedstocks and amendments and composting them as soon as possible will minimise odours from stored materials. Site hygiene is another important aspect of good practice. Ensuring that spills of feedstock or composting material are cleaned up and that liquor pooled on the ground is not left there minimises any malodours from these diffuse sources. Liquor collected in a lagoon or tank can be aerated, which minimises any emission of malodour vapours.

There are other methods to control bioaerosol and odour emissions. Droplet dispersal can be used to bring particles down to ground quickly, thus reducing exposure time to the prevailing wind. These systems can also capture the compounds responsible for odours. In addition, some of these systems can include a masking agent, which produces a perfume to disguise the odours.

Biofiltration has also been used to control emissions from in-vessel and other enclosed composting systems, by simply providing a physical barrier to prevent transfer of particles and odours. This method treats the exhaust air from the plant before it is vented and has become widely accepted for odour control at waste treatment plants (Sanchez-Monerdero, Stentiford and Mondini, 2003), as they have relatively low installation and maintenance costs and are environmentally friendly.

Biofilters are constructed out of a mass of porous and wet organic material, which is naturally populated with microbial biomass to degrade odours. The process works by fan-forced air passing through the biofilter where the absorption of pollutants by the liquid layer in the filter occurs, which in turn allows pollutants to become available to the micro-organisms for biodegradation. The efficiency of bioaerosol removal using these techniques, however, can be very variable and it is an area that could benefit from further research.

What about risk assessments and regulatory requirements?

The Environment Agency requires a site specific risk assessment for new composting facilities (or where changes are made to existing facilities) where a sensitive receptor is within 250m of the boundary of the facility. Sensitive receptors include homes or work places, such as offices or even pubs. The risk assessment should consider the sources of the emission, the receptors (those that may be affected by the emission), and the pathways (or linkages) between the source and the receptor.

Odour sampling on site

The simplest method is to construct a conceptual model, which is a diagram representing each of the sources, pathways and receptors. Risk assessments should be site-specific and the process of undertaking the risk assessment should be clearly stated, including any limitations of the study. For most composting facilities, it will be necessary to undertake bioaerosol monitoring at the site being assessed to accurately examine the risks associated with that site.

Table 1. Odour consultancy and abatement technology suppliers

Company	Contact Name	Contact Number	Email	Website
Air Spectrum Environmental Limited	Haley Shurmer	01905 362100	haley.shurmer@specenv.com	www.airspectrum.com
Covered Systems Ltd	Steve Bailey	0845 2903610	steve.bailey@greenviewgroup.co.uk	www.coveredsystems.co.uk
Enviros Consulting Ltd	Dr Mark Broomfield	01743 284812; 07800 624027	mark.broomfield@enviros.com	www.enviros.com
Entec UK Ltd	Ken Rigby	01606 354850	rigbk@entecuk.co.uk	www.entecuk.com
GICOM	Luc Klunder	0031 321 332682	lkl@gicom.nl	www.gicom.nl
GOC Technologies Ltd	David Moyce	01580 831223	sales@goctechnologies.co.uk	www.goctech.com
Melcourt Industries Ltd	Mr A R Chalmers	01666 502711	mail@melcourt.co.uk	www.melcourt.co.uk
Milbury Systems Ltd	Brian Mees	01275 857799	sales@milbury.com	www.milbury.com
Odournet UK Ltd	Paul Ottley	01225 868869	pottley@odournet.com	www.odournet.com
SLR Consulting Ltd	Matthew Stoaling Richmond Kingsbury	01225 309400 0115 964 7280	mstoaling@slrconsulting.co.uk rkingsbury@slrconsulting.co.uk	www.slrconsulting.co,uk
The Composting Company Ltd	Mark Drury	01440 708277	mark@thecomposting.co.uk	www.thecomposting.co.uk
Veldeman	Kurt Vanleysen	0032 474 996083	kurt.vanleysen@veldemangroup.be	www.veldemangroup.com

Notes

1 using activated carbon, zeolite, or alumina. **2** biofilters (made of soil, woodbank, composted material or other filtration media). **3** spray and packed towers, plate absorbers. **4** e.g. condensation, plasma technology catalytic iron filters, ozone and ultraviolet

Table 2. Bioaerosol Monitoring & Testing

Company	Contact Name	Contact Number	Email	Website	Service/Technology
Crestwood Environmental	Sid Lambert	01902 824037	info@crestwoodenvironmental.co.uk	www.crestwoodenvironmental.co.uk	Bioaerosol Monitoring, full in house monitoring and analytical team operating Nationwide, call us for a quote today
Entec UK Ltd	Ken Rigby	01606 354850	rigbk@entecuk.co.uk	entecuk.com	Entec provides a full range of consultancy services including odour monitoring, air quality assessment and bio-aerosol risk assessment.
Enviros Consulting Ltd	Dr Mark Broomfield	01743 284812; 07800 624027	mark.broomfield@enviros.com	www.enviros.com	Preliminary monitoring surveys, detailed dispersion modelling and evaluation of bioaerosols in support of risk assessment studies
SLR Consulting Limited	Richmond Kingsbury	0115 964 7280	rkingsbury@slrconsulting.co.uk	www.slrconsulting.com	Bioaerosol Risk Assessment: UK's leading waste services provider; 30 BRAs completed; BRA advisor to operators, regulators, government & technical bodies.
University of Wales Institute Cardiff (UWIC), Centre for Health, Safety and Environment (CHSE)	Peter Sykes/ Rhys Sherman	+44 (0)29 2041 6802	psykes@uwic.ac.uk rsherman@uwic.ac.uk	www.chse.uwic.ac.uk	Bioaerosol Assessments, Risk Assessment, Personal / Environmental Dust Moniting, Allergy / Sensitisation testing (IgG/IgE), Lung function testing and Occupational / environmental noise surveys

It should be noted that there is growing focus on the emissions from organic waste treatment. The Environment Agency has recently published several position statements outlining their position on the sustainable management of biowastes. In the statement entitled *Composting – maximising the benefits and minimising the environmental impacts*, the Agency has stated:

"We are concerned about the unacceptable impacts caused by composting sites if they are poorly managed and operated. In particular, they can:

- give rise to nuisance odours
- produce immature compost (which is likely to be malodorous), contaminated or otherwise poor quality compost
- catch fire
- expose people nearby to high concentrations of potentially harmful bioaerosols.

Outlining the measures already in place, the statement indicates that current risk assessments are often not up to standard:

"We already require licence/permit applicants and those wishing to register exemptions to provide us with a site specific bioaerosol risk assessment where the proposed composting facility will be within 250 metres of dwellings or workplaces. These risk assessments need to demonstrate that bioaerosols from the proposed facility will not pose an unacceptable risk to human health. In practice we have found that many are of poor quality or are not sufficiently comprehensive."

It then goes on to outline some solutions, including:

"We want Environmental Permit and exemption registration applicants (for composting sites within 250 metres of dwellings or workplaces) to produce site specific bioaerosol risk assessments that are fit for purpose. We will be rigorous in rejecting them if they are not. We are improving and streamlining the way we deal with bioaerosol risk assessments and are producing guidance on them for applicants, which should be available later this year."

The full position statement can be found at: http://www.environment-agency.gov.uk/aboutus/512398/289428/2010701/

Service		Odour abatement technology			
Odour monitoring and evaluation	Consultancy on odour control/ abatement technology	Adsorbtion 1	Biological treatment 2	Absorption (scrubbing) 3	Other (please specify) 4
x	x	x		x	Misting systems
x			x		Aeration system
x	x		x		
x	x				
		x	x	x	GICOM Scrubbers: acid scrubbing, stack placement, straw filter
			x		compost additives; topical odour control
			x		
					Low cost aeration for liquor
x	x				
x	x				
x	x				Innoculant added during composting
					sealed fabric structure

Information and References

CEN, 2003. CEN EN 13725: 2003. Air quality – Determination of odour concentration by dynamic olfactometry. Committee Europeen de Normalisation, Brussels, http://www.cenorm.be

The Composting Association (1999). Standardised protocol for the sampling and enumeration of airborne micro-organisms at composting facilities. The Composting Association: Wellingborough, UK, http://www.compost.org.uk

DETR, Environment Agency, Institute for Environment and Health (2000). Guidelines for environmental risk assessment and management – revised departmental guidance. The Stationery Office: London, UK, http://www.tso.co.uk

Environment Agency (2001). Position Statement on composting and health effects. Environment Agency, Bristol, http://www.environment-agency.gov.uk.

IEMA Best Practice Series 7 (2006) Risk management for the environmental practitioner, http://www.iema.org.uk

M. A. Sanchez-Monedero, E. I. Stentiford and C Mondini (2003). Biofiltration at composting facilities: Effectiveness for bioaerosol control. Environ. Sci. Technol. 37, 4299-4303.