

BIOAEROSOLS IN WASTE AND RECYCLING

This WISH information document is aimed at health and safety improvements in the waste management industry. The Health and Safety Executive provided support to WISH in producing this guidance. This guidance may go further than the minimum you need to do to comply with the law with regard to health and safety

Contents

- 1. What are bioaerosols?**
- 2. Why are bioaerosols a concern?**
- 3. Where do bioaerosols occur in the waste and recycling sector?**
- 4. What does the law say?**
- 5. Assessment and control of bioaerosols**
- 6. References**
 - Disclaimer and WISH**
 - Appendix 1. COSHH risk assessment process**
 - Appendix 2. Research-based exposure guidelines**

1. What are bioaerosols?

Bioaerosols are a complex mixture of bacteria, fungal spores, and other fragments of biological origin that are suspended in air. When organic waste such as domestic, garden and food waste is stored for any period, the microorganisms naturally present will multiply quickly, especially if the waste, or the area where waste is stored, is warm and moist. There is potential for bioaerosols to be generated during handling and processing of organic wastes, particularly when this is energetic.

2. Why are bioaerosols a concern?

Many microorganisms (bacteria, moulds, fungi) that occur naturally can cause ill health. Regular and repeated exposure to high concentrations of bioaerosols may result in the development of respiratory illness including asthma, inflammation, and irritation of the airways, irritation of the eyes and gastro-intestinal disorders. Table 1 below details the generally recorded health conditions reported from exposure (these are not specific to waste and recycling). The health issues associated with bioaerosol exposure have been well known for some time within a range of industries including waste and recycling, and in particular composting. Whilst there is no threshold limit above which health effects are proven to occur, there is likely to be a dose-response relationship, this means that processes that generate the highest exposures are more likely to cause ill health.

Table 1. Summary reported health conditions arising from exposure

Condition	Cause	Common signs and symptoms
Asthma	A sensitisation of the airways. Likely an allergic mechanism but may also aggravate pre-existing asthma due to irritation	Work-related cough, wheeze, and chest tightness
Hypersensitivity pneumonitis	Irritative inflammation of the alveoli (sac-like structures in the lungs). Has also been called Allergic alveolitis: allergic reaction. Includes the condition known as 'Farmer's lung'	Lasts for a long time, breathlessness and cough can shorten life expectancy

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ODTS (Organic Dust Toxic Syndrome)	Also known as Toxic alveolitis: Has been linked to exposure to endotoxin	Similar to the 'flu', fever, fatigue, Difficulty in breathing. Brief illness of flu-like symptoms occurring 6-12 hours after exposure and lasting for about 4 hours
Mucous membrane irritation	Inflammation/ irritation of exposed tissues in the eyes, nose, and throat. (Rhinitis or conjunctivitis could also be present). Can also be an allergic reaction	Watering/prickly eyes, running or stuffy nose, sore throat
Chronic bronchitis and coughs (COPD – Chronic Obstructive Pulmonary Disease)	An inflammation of the respiratory tract caused by long-term exposure to noxious dusts, biological agents, and gases	Coughing. Wheezing on exertion. Long-term illness and breathlessness
Gastro-intestinal disorders	Toxin poisoning, potentially some infective	Nausea, vomiting, diarrhoea. Usually occurs within hours of exposure but some mechanisms may take longer

3. Where do bioaerosols occur in the waste and recycling sector?

Bioaerosols are likely to be released during the handling and processing of waste streams that have an organic content such as residual, domestic, garden and food waste. This can also include dry recyclables if contaminated by food. This advice will, therefore, be relevant to any facility where waste is being moved including, but not limited to activities such as composting, household waste collection, mechanical biological treatment (MBT), material recovery facilities (MRF), energy from waste (EfW) sites, transfer stations and household waste recycling centres/civic amenities (HWRC/CA site). At these facilities, highest exposures have been experienced when workers are undertaking the following tasks:

- Manual sorting or picking through waste
- Maintenance and cleaning activities such as use of compressed air to clean machines, dry brushing of surfaces/floors, high pressure washing of vehicles
- Working in buildings near to waste being moved by heavy plant such as tipping halls
- Working in any area near to movement of waste, such as tipping, conveyor falls, baling or similar energetic movement of materials

4. What does the law say?

Bioaerosols contain biological agents such as bacteria and fungi which may cause infection, allergy, toxicity or otherwise create a hazard to human health. Bioaerosols are therefore classified as a substance hazardous to health under the Control of Substances Hazardous to Health Regulations 2002 (COSHH).

The COSHH Regulations aim to minimize the risks to the health of people who may be exposed to hazardous substances at work. The regulations provide a framework of actions designed to control risk. They require employers to assess the risks associated with work activities from exposure to hazardous substances and then to introduce measures to prevent, or if this is not reasonably practicable, adequately control exposure. Adequate control will be achieved by applying **all** the 'principles of good control practice' set out in Schedule 2A of the Regulations and summarised below:

- a. Design and operate processes and activities to minimise emission, release and spread of bioaerosols
- b. Consider all relevant routes of exposure including inhalation and ingestion when thinking about control measures
- c. Choose control measures that are proportionate to the health risk
- d. Choose the most effective and reliable control options which minimise the escape and spread of bioaerosols
- e. Check and review all control measures to ensure their continuing effectiveness
- f. If exposure to bioaerosols cannot be adequately controlled by other means, suitable personal protective equipment (PPE) should be provided in combination with any other control measures
- g. Inform and train all employees about the hazards and risks to health, and the use of control measures required to minimise exposure to bioaerosols
- h. Ensure that the introduction of any control measure does not increase the overall risk to health and safety

Bioaerosols in the waste and recycling sector may contain some microorganisms that are respiratory sensitisers, therefore when applying principle (c) – ‘control exposure by measures that are proportionate to the health risk’, employers should give priority to those controls that contain or minimise the release and spread of bioaerosols into the workplace. Where there is a residual risk of exposure remaining after those controls have been put in place, then PPE including Respiratory Protective Equipment (RPE) must also be worn to provide adequate protection.

Depending on the findings of your risk assessment, health surveillance may also be required. Specific guidance on health surveillance requirements is available at the WISH Forum website (WISH WASTE 30) at <https://www.wishforum.org.uk/waste-30-health-surveillance-for-the-waste-and-recycling-industry-feb-2021/>.

5. Assessment and control of bioaerosols

Risk assessment

All waste site operators should produce site-specific, task specific risk assessments that consider exposure to bioaerosols for staff, contractors, and visitors. The risks to third party visitors such as waste delivery drivers must be assessed by their employer to ensure that suitable controls are in place to protect them from the potential risks from bioaerosols whilst working on operators’ premises. Appendix 1 provides an overview of the risk assessment process and the key steps needed to comply with COSHH.

Monitoring worker exposure to bioaerosols

Personal monitoring of workers’ exposure to bioaerosols may be needed to better understand employee exposure levels, to identify potentially high-risk activities and tasks and to establish high-risk work areas. Additional guidance in the form of an information note is in preparation to provide specific advice in relation to the monitoring requirements for bioaerosols. It is likely that specialist advice will be needed to undertake monitoring and provide competent advice on interpretation of monitoring results and the development of appropriate and suitable control measures.

Interpretation of monitoring results

Currently there are no UK workplace exposure limits (WELs) for bioaerosols or their individual components, although risk-based benchmark levels can be established from published research or occupational exposure standards that exist in other countries. The HSE (Health and Safety Executive) has established the following general workplace bioaerosol exposure 'traffic light' criteria for total bacteria and fungi to assist with the general assessment of bioaerosols in the waste and recycling sector:

Low - below 10^3 cfu/m³ (colony forming units per cubic metre)

Medium - 10^4 – 10^5 cfu/m³

High - greater than 10^6 cfu/m³

For *Aspergillus fumigatus* and actinomycetes, which are known respiratory sensitisers, results greater than 1×10^5 CFU/m³ are considered high and those above 1×10^3 CFU/m³ medium. This banding of results is based on the consensus view of bioaerosol experts and published data from Europe and the USA, although limited data exists on dose-response relationships (source Pearson et al, 2015).

For endotoxin, results over the Dutch proposed health-based limit of 90 EU/m³ are considered high.

Further information on how to interpret results from bioaerosol monitoring is provided in Appendix 2.

Control measures

When deciding which control measures to select for a task/activity, waste site operators should apply the hierarchy of control. This places measures in order of their overall effectiveness and sustainability. As bioaerosols are naturally occurring, substitution (for a less hazardous substance) will usually not be possible. Similarly, other than deciding not to process organic wastes, complete elimination of bioaerosols is unlikely.

In most cases more than one measure will be needed to achieve adequate control. Where PPE (personal protective equipment) is selected, this must be in addition to other measures and in accordance with manufacturer and HSE guidance. Table 2 below lists the required hierarchy of control with examples. Note – you should follow this hierarchy in the order given.

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Table 2. Hierarchy of control and examples

Hierarchy of control in order of application	
Control	Examples
Elimination	<p>Not usually practical at waste and recycling sites but in general terms this might be achieved by:</p> <ul style="list-style-type: none"> ■ changing the method of work so that the operation giving rise to the exposure is no longer necessary; or ■ modifying a process to eliminate the production of a hazardous by-product or waste product <p>However, if a specific waste stream is particularly problematic regards bioaerosol exposure and adequate control may not be practically possible, consideration should be given to ceasing to accept the waste stream</p>
Substitution	<p>Not usually practical at waste and recycling sites</p>
Change or modify the work process or workplace to minimise emission, release and spread	<ul style="list-style-type: none"> ■ Reducing drop heights when moving waste using mechanical shovels, grabs or on trommels/conveyors ■ Avoiding unnecessary handling/tipping or double handling/tipping of waste ■ Automated waste sorting/separating machines instead of hand sorting/picking stations ■ Provision of suitably filtered operator control rooms ■ Use of vacuums or damp methods to clean machines and surfaces instead of dry brushing or blasting with compressed air ■ Compressed air should only be used when no other practical alternative is available. In this is the case, the pressure should be reduced to as low possible ■ Use of mains pressure hoses instead of pressure washers to clean whenever possible ■ Use of mechanical shovel loaders and manual scrapers/shovels to clear and clean floors where practicable, instead of manual dry brushing activities

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<p>Apply controls to the process - Engineering controls</p>	<ul style="list-style-type: none"> ■ Extract ventilation of processing areas to increase air changes ■ Local exhaust ventilation (including suitable filtration) to control at emission source ■ Enclosing entrances/exits to tipping chutes etc. with rubber/plastic curtains ■ Enclosing conveyors and hoppers ■ Use of mobile dust suppression cannons to control point sources of bioaerosols as well as static misting and spray systems within the buildings. <p>Note: Other risks need considering e.g., legionella in dust suppression systems and self-heating of wastes</p>
<p>Select ways of working which minimise exposure - Procedural / organisational control</p>	<ul style="list-style-type: none"> ■ Avoiding (where practical) or otherwise minimising stockpiling of waste before processing to reduce growth of microorganisms ■ Restricting access to high-risk areas (zoning – see next section) ■ Arrangements for decontamination for personnel moving from high-risk areas to low-risk areas ■ Provision and use of sufficient welfare and washing facilities ■ Ensuring good personal hygiene practices are maintained ■ Provision and use of vehicles with HEPA filtered cabs ■ Procedures that minimise the transfer of contamination from boots into vehicle cabs ■ Keeping vehicle cab doors/windows closed when tipping waste ■ Ensuring vehicle cab HEPA filters are checked according to an appropriate schedule, cleaned, and replaced as per manufacturers recommended periods or no longer than every 500 hours of vehicle operation ■ Regular planned preventative maintenance schedules for control plant e.g. dust suppression systems to ensure they are effectively working. Note: LEV is also legally required to undergo a thorough, examination and test every 14 months ■ Regular cleaning and disinfection of equipment surfaces and floors to minimise transfer of biological contamination (and potential growth of microorganisms) into vehicle cabs ■ Provision of laundry facilities for coveralls by an external provider or on-site

Personal protective equipment (PPE)	<ul style="list-style-type: none">■ Provision of suitable PPE including gloves, overalls, footwear■ Provision of suitable Respiratory Protective Equipment (RPE) e.g. FFP3 mask, powered respirator with P3 filter. The selection of suitable RPE will also need to consider capability for gases and vapours if required by risk assessment, low oxygen environments and continuous wear time (further guidance in HSG53). Note: Where tight-fitting RPE is worn workers will need to pass a face-fit test (further guidance in INDG479)
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Zoning

Following HSE research, zoning has been proposed as a practical way to manage workers' exposures to bioaerosols (source Stagg et al, 2010). This is based on anticipated exposures that could occur within the boundaries of a waste facility that could be classified as low/medium/high. For example:

High risk areas – enclosed waste treatment facilities where waste is being agitated, or within 30m of operational areas such as open windrow composting pads where bioaerosol concentrations are known to be high

Medium risk areas – inside a building where there is no activity involving waste handling, or non-operational areas that nevertheless could be contaminated, or in the proximity (i.e., between 30 and 100 metres) of waste being moved in the open air

Lower risk areas – clean areas such as offices, rest rooms, welfare facilities, upwind of waste facilities or greater than 100 metres downwind of where it is being moved in the open air

Note. This is a strategy for control of exposure to workers on site. It is acknowledged that bioaerosol concentrations in the low-risk areas as described above may be slightly higher than background levels away from a bioaerosol source, but at levels unlikely to cause respiratory ill health in a typical working population. Site permits, issued by EA, SEPA, NRW, stipulate a reduction of bioaerosol to background levels by 250 metres from a bioaerosol source as a means to protect sensitive receptors.

Zoning allows the movement of persons between areas (different zones) and their activities in these areas to be managed to facilitate worker protection. Zones can be set based on the classification of risk areas. Classification of areas in terms of risk will help the administration of proportionate risk controls. Examples of how zoning could be applied at a waste and recycling facility include:

- Restricting access (other than essential personnel) to high-risk zones
- Highlight zoning requirements and restrictions on induction sessions for contractors and visitors
- Ensuring vehicle cabs in high-risk zones have adequate and effective cab filtration
- Avoiding exiting vehicle cabs within high-risk zones whenever possible.
- If exiting a vehicle cab within a high-risk zone is essential, then the cab door should not be left open. Time spent outside the cab in the high-risk zone should be minimised and only essential tasks undertaken. The driver should be aware that RPE might be required once outside the cab.
- Windows and doors of vehicles should remain closed at all times in a high-risk zone
- Specify mandatory RPE / PPE requirements and face-fit testing of tight-fitting RPE in high-risk zones. (If RPE is not worn inside vehicle cabs working in high-risk zones then monitoring data must demonstrate employee exposure levels are sufficiently low)
- Specific RPE / PPE and access restrictions for 3rd persons such as sub-contractors, visitors to high-risk zones
- Designating low-risk areas such as offices and canteen 'clean' zones
- Establishing designated areas and procedures for removing dirty overalls and removing or cleaning boots before entering low-risk zones such as offices and welfare areas to reduce cross-contamination

6. References

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Disclaimer and WISH

This information document has been prepared by health and safety practitioners to assist health and safety improvements in the waste management industry. It is endorsed by the WISH (Waste Industry Safety and Health) Forum. This information document is not formal guidance and represents good practice, which typically goes beyond the strict requirements of health and safety law.

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The Waste Industry Safety and Health (WISH) Forum exists to communicate and consult with key stakeholders, including local and national government bodies, equipment manufacturers, trade associations, professional associations and trade unions. The aim of WISH is to identify, devise and promote activities to improve industry health and safety performance.

Appendix 1. COSHH risk assessment process

Step	Process
Identify the hazardous substances	<ul style="list-style-type: none"> ■ Dust, bioaerosols, diesel engine exhaust emissions etc.
Assess the risks associated with exposures	<ul style="list-style-type: none"> ■ Consider exposure scenarios, exposure levels, frequency and duration, potential health effects
Record the assessment	<ul style="list-style-type: none"> ■ Produce written documentation and communicate to all staff
Eliminate or prevent exposure	<ul style="list-style-type: none"> ■ Totally enclose the process ■ Limit the number of people exposed ■ Restrict access and/or reduce so far as is reasonably practicable
Control exposure through a hierarchy of measures	<ul style="list-style-type: none"> ■ Control access e.g. introduce site zoning ■ Introduce engineering controls e.g. partially enclose the system or use machinery with a cab and air filtration ■ Operational controls e.g. the way the facility is operated ■ Personal protective equipment e.g. use of respirators
Inform, instruct, and train employees about	<ul style="list-style-type: none"> ■ The nature of the hazardous substances ■ Safe practices and correct use of engineered control measures ■ The proper use of control measures e.g. PPE
Monitor exposure	<ul style="list-style-type: none"> ■ Where there could be a serious risk to health if control measures fail ■ If you are not sure that concentrations are below levels associated with adverse effect ■ Where you cannot be sure that certain control measures are adequate
Monitor health and employees (health surveillance)	<ul style="list-style-type: none"> ■ Where employees are exposed to a substance known to adversely affect human health or where there is a reasonable likelihood of a specific disease or adverse health effect occurring under the conditions of work and it is possible to detect the disease / adverse health effect

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Review the assessment	<ul style="list-style-type: none">■ Where deterioration in control effectiveness is identified from the results of exposure monitoring, health surveillance, or the examination and testing of engineering controls■ Following reports or complaints from supervisors, employees, maintenance staff, or safety representatives etc. about defects in control measures■ If any significant changes in work practices are made■ After evidence of ill health that might indicate deleterious effects of working conditions
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Appendix 2. Research-based exposure guidelines

Note. This table is provided to assist operators in making risk-based decisions on the potential health risks associated with bioaerosol exposures and are **NOT** to be interpreted in any way as workplace exposure limits (WELs) or pass/fail criteria. Operators are advised to build this general guidance framework, which is based on current research literature, into risk-based decisions at their facilities when they have sufficient understanding and information regarding workers exposure concentrations. It is likely that bioaerosol concentrations in work areas and workers personal exposure will vary considerably and this table is designed to inform the development of proportionate risk controls when sufficient exposure data estimates exist. A suitable sampling methodology should also be employed (further guidance to be provided by WISH).

Concentration (cfu/m ³)	General Mesophilic Bacteria	<i>Aspergillus fumigatus</i>	General Fungi	Action Level
100			Defra (2009) possible guidance for 'spores'	1
300				
500		EA (2009) Guidance ¹	Consider species	2
1000 (10 ³)	1 x 10 ³ cfu/m ³ NOEL (Wheeler <i>et al</i> 2001) & Defra (2009); EA (2009) Guidance; 5 x 10 ³ cfu/m ³ Sigsgaard (1990)	Allergen (HSE2013) and pathogen at concentrations above background	Defra (2009) general guideline; Lavoie <i>et al</i> (2006) 'at general background'	
10000 (10 ⁴)	Lavoie and Guertin (2001) 1 x 10 ⁴ cfu/m ³ ; Lavoie <i>et al</i> (2006) occupational guide		5 x 10 ⁴ (Dutkiewitz 1997) ; Lavoie <i>et al</i> (1991) occupational guide	3
100000 (10 ⁵)	Gladding <i>et al</i> (2003) occupational effects found; Eduard (2012) suggested guideline		Herr <i>et al</i> (2004) effects on sensitive receptors found; Eduard (2012) and Walser <i>et al</i> (2015) suggested guideline; Defra (2009) suggested NOEL 2 x 10 ⁵ cfu/m ³	
1000000 (10 ⁶)			Lacey <i>et al</i> (1994) allergic alveolitis; Swan <i>et al</i> (2003)	4

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Action Level:

- 1 **Green**: Typical background no further action required
- 2 **Yellow**: Keep under review and assess again if further information becomes available
- 3 **Orange**: Suggested action to reduce bioaerosols, reduce exposure and provide RPE as a last resort
- 4 **Red**: Health outcomes strongly indicated immediate action required, mandatory RPE area

Note. It is recommended that bioaerosol assessments should consider the assessment of Endotoxin (cell components of gram-negative bacteria) as these are known to cause respiratory inflammation and they also provide an indication of total biological load. Assessments that focus solely on viable or 'live' organisms can underestimate workers exposure to bioaerosols.

An Occupational Exposure Standard for Endotoxins has been proposed by the Dutch Expert Committee on Occupational Standards (DECOS) at a level of 90 EU/m³ (Endotoxin units per cubic metre) as a 'No Observed Effect Level'. It is recommended that this level is used as a guideline in interpreting any monitoring undertaken for endotoxins. Note: This health-based standard is for long term occupational exposure and based on 8-hour time weighted average (TWA) exposure to reflect whole shift exposure.