An Assessment of the Concentrations of Dust and Bioaerosols and the Expansion of Operations at AWO Recycling

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1.0 INTRODUCTION

This report provides an assessment of the operations of the organic recycling facility at AWO Recycling, Ramsey Heights Nr Huntingdon, Cambs. The intention of this report is to carry out an independent bioaerosol risk assessment of the operations for the purposes of expansion plans from 25,000 tonnes per annum (t.p.a.) to 50,000 t.p.a.

Dr Toni Gladding has carried out this work as an independent consultant as part of a small consultancy known as Priors Environmental. Dr Gladding has previously been involved on a number of projects concerning airborne contaminants that present a risk to health and has extensive experience in the measurement of personal and environmental exposures to dust and bioaerosols in a variety of environments since 1997 and has published several studies on exposure (Gladding *et al* 2003 and Gladding *et al* 2017 for instance).

1.1 Bioaerosols

Bioaerosols are defined as aerosols, aeroallergens, or particulate matter of microbiological, plant or animal origin (Defra 2009). Bioaerosols can interact with living systems through infective, allergenic and/or toxic mechanisms. The biological agents that have been examined in relation to bioaerosol exposures associated with waste handling and treatment processes include pathogenic or non-pathogenic, live (viable) or dead (non-viable) bacteria, fungi, viruses, bacterial endotoxins, mycotoxins, and peptidoglycans. Although other types of biological component may also be present as airborne particles such as algal fragments, protozoa and nematodes, these have not been considered in studies of bioaerosols emitted by the waste industry (Defra 2009).

It is clear from the literature that the potential for particulates to be liberated from organic waste treatment sites does exist (Defra 2009). Airborne dusts and so bioaerosols are likely to be liberated by the handling of the waste materials accepted on site, their storage and movement and by meteorological conditions (presence or absence of precipitation, wind, etc.). Bioaerosols are aerosolised as clumps, aggregates and attached to larger mineral particles in the TSP size range (also noted by Wheeler *et al* 2001). Hence, they generally settle rapidly, i.e. within a minute or two and within 250m of the point of generation. Weather conditions can also affect generation and aerosolisation of bioaerosols. Viability can deteriorate according to temperature, humidity and sunlight. Die off is generally exponential, although non-viable (dead) microorganisms may still be able to cause health effects (allergenic/toxic effects in sufficient concentrations) (Defra 2009). However, the standard protocol for England and Wales (M9 2018) and most data at present utilises numbers of viable microorganisms. These are measured as colony forming units (cfu/m^3), i.e. live colonies that will grow in the laboratory.

It is important to note other activities and environments can affect local concentrations of bioaerosols. In terms of published scientific literature, a range of authors report natural concentrations of bacteria and fungi routinely range from 1000 to 100,000 (10^3 to 10^5) cfu/m^3 air (Cox & Wathes 1995). Defra (2013) also report background concentrations can be exceeded upwind of a composting facility depending on other

local sources (particularly for bacteria). For instance, various farming activities can also be a significant bioaerosol source (Swan *et al* 2003).

The objective of this study is to appraise the potential for significant risks to human health in the at the nearest sensitive receptors which could include footpaths, dwellings or public buildings within the vicinity of the existing treatment facility from the operations on AWO Recycling, and to demonstrate that bioaerosol risks can be maintained at acceptable levels.

2.0 Site Characteristics

The Ramsey site, operated by AWO Ltd., comprises of a stand-alone site, encompassing an area set-aside for composting of 25,000 tonnes p.a. of organic (excluding food) wastes, with plans to expand to 50,000 t.p.a. of the same material. The site outline is seen in Appendix I. Their soil improver products are produced in open windrows over a period of 8 weeks; the organic feedstocks processed include garden waste, fruit and vegetable waste, straw, stable waste, paper and card, or any other organic material not included in the Animal By-Product Regulations and permitted by BSI PAS100. The operational area is about 6 hectares which sits within a farm of about 22 hectares. The site managers estimate that the tonnage of material at any one time would be 6,000 tonnes at peak times in the summer falling to 4,000 tonnes at other times of year. The site is well served with paved and unpaved roads which allow easy access in all directions. It is situated in a rural location, surrounded by relatively flat arable agricultural land with few buildings, hills or other large obstructions. The distances of the nearest sensitive receptors from the site boundary are shown in Table 1:

Table 1: Nearest Sensitive Receptors to the AWO Recycling site

Sensitive Receptor	Distance from Site
Residence	225m to north-west
Footpath(s) nearest	215-250m+ north-west to north-east
Farm Biggin Lane	550m to north-east

The nearest sensitive receptors are a house in the ownership of the operator and a nearby footpath, which are within the 250m guideline suggested by current EA guidance (Environment Agency 2009). All residences without the ownership/control of the operator are without 250m.

3.0 Evaluation

An evaluation of potential issues and of the assumptions made to construct the AWO Recycling site-specific risk assessment examining the general activities on site (in Appendix V) is outlined below. The site has been used extensively as a test site for Environment Agency and Defra research studies the latest data of which is included in Appendix II, which displays data from 8 different sampling days in 2014, 3 in 2016 and 3 in 2017. These data are used to provide a background to the assumptions made regarding concentrations of bioaerosols which may be regularly emitted from this type of operation.

3.1 Description of the process

AWO Recycling has an outside organic recycling composting operation. Materials are derived from various sources, but principally as garden and farm waste from contracts.

The following operations and activities occur on site:

No.	Activity	Description
1	Organic waste reception (Green Waste)	The main incoming materials are from ongoing contracts. When materials arrive on site, all materials enter via the weighbridge. Once on-site material is deposited in the organic recycling reception area.
2	Shredding	Materials are shredded as soon as practicable and preferably within 72 hours after arrival at the site.
3	Building of windrows	Once material is shredded it is loaded directly into a windrow.
4	Compost Sanitisation and Stabilisation.	The open-air continuous turning process comprises 2 weeks sanitisation and 6-8 weeks stabilisation. This involves mechanical aeration to introduce oxygen into the material.
5	Turning Organic Compost.	Compost is turned using a dedicated turning machine, this operates most days for periods of 1-2 hours.
6	Leachate/Run-off	Leachate from the process gathers in channels which in turn drain into a dedicated collection vessel. Leachate/runoff from the process is both used to help dampen the process when required and is minimised by ensuring the material does not become too moist.
7	Screening	Materials are screened to exclude non-compostable items (e.g. plastics) using a screen and plastics' separator.
8	Site storage	On site until use.
9	Other Activities – principally Spreading Compost to Field	When the material has matured to reach the standard of a soil conditioner it is spread on agricultural fields and/or amenity use.
10	Bagging/bulking of Compost	Preparation for transport of finished product is carried out at the AWO Recycling site.

3.2 The need for a Site-Specific Risk Bioaerosol Assessment (SSBRA)

Within England and Wales, the current Environment Agency (EA) policy requires sites *'within 250 metres of workplaces or dwellings to carry out a Site Specific Bioaerosol Risk Assessment (SSBRA) in support of their application. Before granting a permit, we need to be satisfied that the SSBRA shows that bioaerosols can, and will, be maintained no higher than acceptable levels at the sensitive receptors'.*

The statement clarifies various terms, for example noting that 'composting' can be limited to the actual area within the site where waste storage, processing and handling takes place. 'Acceptable levels' are quoted as 1000 cfu/m^3 bacteria, and 500 cfu/m^3 *Aspergillus fumigatus* (as measured by the M9 (2018) for organic (non-food) open windrow composting.

The EA's position statement also defines receptors and sources of bioaerosol – such as outdoor composting operations likely to result in the '*uncontrolled release of high levels of bioaerosols'* - including '*shredding and turning* of waste *where these operations are not contained or are not subjected to exhaust ventilation and scrubbing/filtering'.*

The EA position statement on bioaerosols is intended to be applied where newly planned outdoor composting activity may take place. However, it is also deemed appropriate if the operations or other material change occurs to an existing site: the proposed expansion of the site is a suitable reason to trigger the requirement for a Site Specific Bioaerosol Risk Assessment to be applied to an existing facility. This assessment is therefore intended to be applied to this change of processing capacity.

Other than capacity, operations have not planned to substantially change from those that were occurring during previous operations. For assessment purposes the scope of 'active composting' is taken to cover from where material is accepted, through processing, until it has achieved the standard to be considered a product (no longer a waste). Hence the scope of the report is the current operation of the site with no substantial procedural changes, the emphasis being on expansion of the current operations.

3.3 Sensitive Receptors

Identification of potential sensitive receptors within 250m is required under current Environment Agency guidance in England and Wales. In the 2010 standard rules and later EA position statement these included:

'This term would therefore apply to dwellings (including any associated gardens) and to workplaces where workers would frequently be present. It does not apply to the operators of composting facilities or their staff while carrying out the composting operation as their health is covered by Health and Safety legislation'.

Hence there are several categories of sensitive receptor (ranked below) that could include:

Table 2: Ranking Sensitive Receptors (taken from EA and previous Defra guidance).

Category of Sensitive Receptor	Sensitivity Ranking
Houses and residents (schools, hospitals etc.);	*High* (individuals living and/or working in the vicinity for prolonged frequent periods)
Trade premises and factories (offices, industrial premises);	*Medium* (individuals working in the vicinity for prolonged frequent periods)
Public footpaths (local environmental areas);	*Medium-Low* (individuals in the area for frequent periods)
Other amenities (minor roads and open public spaces);	*Low* (individuals unlikely to be in the area of direct exposure for prolonged or frequent periods)

Effectively the 250 metres is measured from the 'active composting' area inside the site. Active composting may or may not exclude certain activities such as final maturation or product storage, depending on whether uncontrolled high bioaerosol release activities, such as turning, take place.

At the AWO site the immediate area surrounding the site is flat and open with various farms in the vicinity. The distances of the nearest sensitive receptors from the site boundary are shown in Table 1, with one residence within 250 ranked high (albeit owned by the operator), with the remainder medium-low (roads and footpaths which the public may use). There are no other high sensitivity ranking sensitive receptors within 250m of AWO composting operations.

3.4 Meteorological conditions in the vicinity of the site

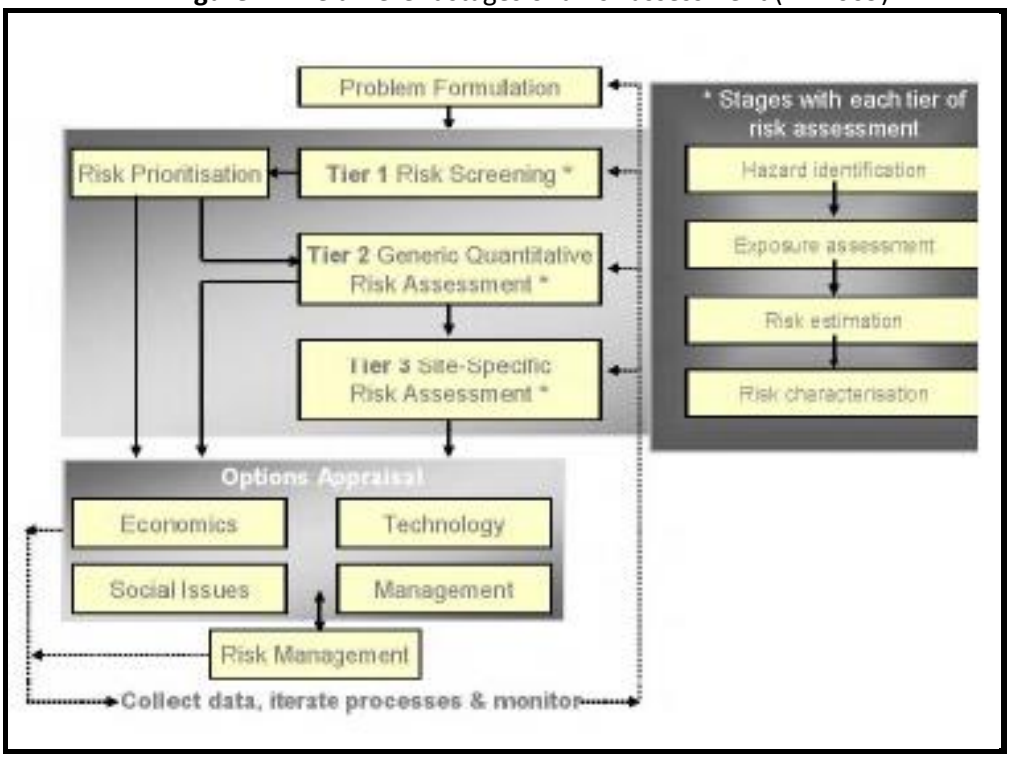
The wind direction for the area is predominantly west/south west (with some variation to North West) for most of the year (windfinder.com, nearest observation station Cambridge Airport approximately 25 miles from site). Appendix I shows the site in context, direction of sensitive receptors and their context in relation to the prevailing wind. Appendix III provides further data on the prevailing winds based on data from Cambridge Airport.

The highest risk sensitive receptor, the residence, is very rarely downwind, with the south-east wind being amongst the rarest occurrence. The nearest medium-low receptor, the pathway, parts of which are within the 250m guideline are also rarely downwind, also relying on a south-east wind.

4.0 Risk Assessment Boundaries

The starting point for every risk assessment is to identify the different aspects, namely the hazards, sources of those hazards, sensitive receptors and the pathways between the source and the receptors.

Figure 1: The different stages of a risk assessment (EA 2009)



Detailed guidance is available elsewhere (EA 2009). The key stages are:

- *Hazard identification*: The situation that could lead to harm. Including what sources of hazard(s) are present and what are their properties/what data is available? Is this substance toxic (or situation hazardous) and how toxic (hazardous) is it?
- *Exposure assessment:* Evaluate the plausibility of the hazard being realised at the receptor - by which mechanisms, allowing an assessment of the probability, magnitude and duration of exposure. Who (or what) is exposed, how long and often?
- *Risk estimation:* Of what relative scale is the probability and extent of possible harm? How big a risk is this? This includes the probability and frequency of a hazard being present, potential pathways and possible harm, e.g. dose-response relationships. (Dose-response relationships in turn depend on duration and concentration of exposure).
- *Risk characterisation:* How significant is the risk and what are the uncertainties? Is this something I need to worry about and if so, how much should I worry? The probability and magnitude of consequences are placed in context and an evaluative judgement is made in response to the data that is available currently.

These criteria will now be applied below.

4.1 Hazard Identification

Section 1.1 outlines the hazard to be evaluated in this case – bioaerosols which may be released from the process that takes place at the AWO Recycling site.

In order to assess the potential risks from bioaerosols, emission sources need to be considered. Table 2 sets out the source-pathway-receptor linkages for exposure of local sensitive receptors to emissions from airborne bioaerosols at the AWO Recycling site:

Table 3: Possible source-pathway-receptors for emissions from the AWO Recycling site

Primary source	Hazard	Transport mechanism	Medium of exposure	Receptor
Material reception Shredding Turning Screening	Chronic or acute illness due to exposure to bioaerosols	Atmospheric dispersion	Aerial deposition	Those within 250m in Table 1
Roadways & vehicles Loading/unloading Material storage	Irritation/ nuisance due to deposition of larger particles	Fugitive emissions	Re-aerosolised material	Likely to be more localised to within 50m of the activity.

Bioaerosols are mostly likely to be released when materials are agitated or processed, current guidance indicates that turning is likely to generate the highest concentrations of bioaerosols (EA 2009). Organic material has the potential to be biologically active at this point, hence it is likely to be the point source likely to generate the most bioaerosols at the site (risk will be discussed in more detail below). Current knowledge indicates these return to background within 200m or so, hence the 250m guideline (Defra 2013).

Fugitive dusts are likely to be liberated by the handling of the materials accepted on site, their storage and movement and by meteorological conditions (presence or absence of precipitation, but particularly wind). Vehicles on site may exacerbate this situation at sites such as the AWO Recycling composting area with hard standing where surfaces can dry out. However, as no sensitive receptors are within 50m of the site fugitive emissions, these are not thought a significant issue at AWO Recycling due to the likelihood of relatively large particles and hence quick deposition.

The nearby farms may constitute other bioaerosol generating activities in the vicinity of the site. These however are all without 250m of the site and hence are not thought to have a direct impact on the site itself, though it should be noted they may increase the general background concentrations within the area.

4.2 Exposure Assessment

An assessment necessarily requires the consideration of potential routes of exposure of individuals to bioaerosols should they escape from the site. Potential pathways of exposure are:

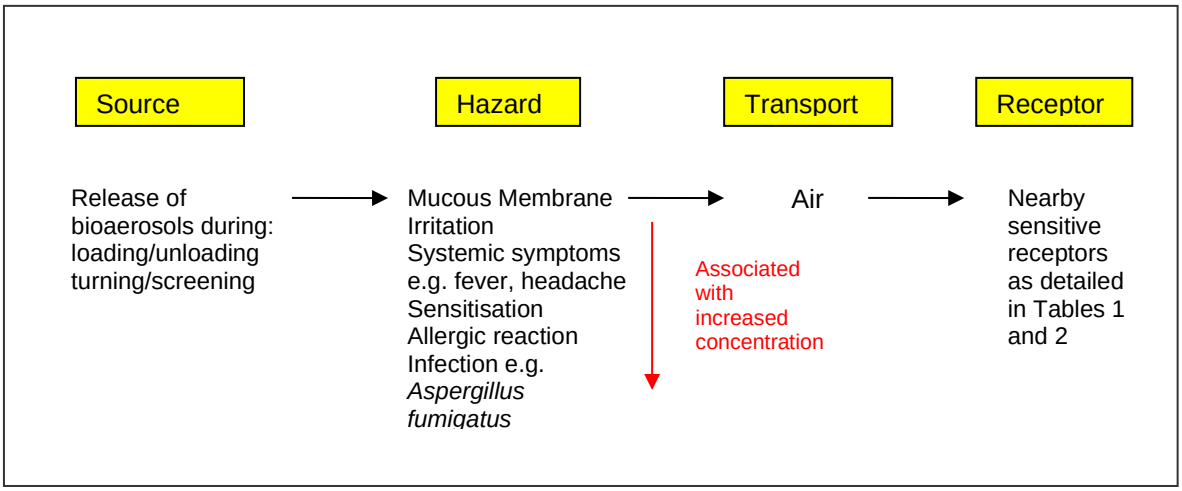
- inhalation – breathing via nose or mouth;
- ingestion – eating or swallowing;
- absorption – through skin or via the eyes (directly or via contaminated surfaces/clothing);
- contact – with the surface of the skin or eyes;

- injection – by high pressure equipment/contaminated sharp objects

Adapted HSE (1990)

It is assumed the most important potential route of any exposure for a sensitive receptor in the vicinity of a site will be airborne inhalation as other routes would involve direct contact with the material (which are more of an occupational issue) (Defra 2009). The conceptual model for the exposure assessment is therefore outlined in Figure 2:

Figure 2: Conceptual model for potential exposure



The conceptual model requires further refinement in terms of the duration of exposure and other issues such as whether effects are likely to be acute (short-term) or chronic (long-term) i.e. the consequences, which will be explored below.

4.3 Consequence and acceptable exposure

Research is limited on what constitutes 'safe' levels of bioaerosols to which an individual can be exposed with respect to biodegradable waste materials, either in terms of occupational or environmental exposures. This general lack of data also means it is very difficult to draw on past studies and provide definitive conclusions. However, it is generally accepted that sufficient data is not available to accurately determine dose-response, and indeed responses may vary between individuals (Defra 2009). The data that is available at this time indicates there is no clear evidence that sub-sets of the population are more sensitive than others, e.g. children or the elderly (Defra 2009), although it is acknowledged there are rare cases of susceptibility. Hence exposure concentrations referred to in this section will assume the population as a whole.

Table 4: Consequence and exposure: colour indicates seriousness

Concentration (cfu/m³)	General Mesophilic Bacteria	*Aspergillus fumigatus*	General Fungi
100			Defra (2009) possible future guidance for 'spores'
300			
500		EA (2009) Guidance[2]	
1000 (10^3)	NOEL (Wheeler *et al* 2001), Defra 2009 EA (2009) Guidance		Defra (2009) general guideline
10000(10^4)	Lavoie *et al* (1991) occupational guide		Lavoie *et al* (1991) occupational guide
100000 (10^5)[1]	Gladding *et al* (2003) occupational effects found		Herr *et al* (2004) effects on sensitive receptors found
1000000 (10^6)			Lacey *et al* (2004) allergic alveolitis

(NOEL: No Observed Effect Level)

[1]Eduard *et al* (2012) recommend 10^5 cfu/m^3 for ''spores for non-pathogenic and non-mycotoxin producing species based on inflammatory respiratory effects'

Key: Green: no effect; Yellow: unknown/low risk; Orange: guideline concentrations; Red: assumed high risk health effects

The latest risk assessment guidance from the Environment Agency (EA 2009 reiterated in M9) indicates concentrations should not exceed 1000 cfu/m^3 for bacteria, and 500 cfu/m^3 for fungi (consisting mainly of *Aspergillus fumigatus*), measured as per the revised standardised protocol (M9 2018) downwind of a site processing green waste. From this it can be seen 500 cfu/m^3 is considered low for general bacteria, but is the guideline exposure standard for *A. fumigatus*, so 'concentrations' must not be generalised but specific to the organisms discussed. These concentrations are thresholds and no reference (EA 2009) is made to the duration, hence it must be assumed these are limits that should not be exceeded.

However, it should be noted that natural concentrations could be regularly expected to exceed this (Defra 2009 acknowledged this), and that farming regularly generates concentrations in excess of this (Swan *et al* 2003), hence this table can serve as a guideline only and background concentrations should always be taken into consideration, which is of relevance to the AWO Recycling site.

4.4 Downwind concentrations

Many studies outlined have investigated occupational exposures to dusts during various types of waste handling. There are few studies that have measured environmental exposures of particulates/dust downwind from open composting facilities, and this area is expanding. AWO Recycling has not previously been required to monitor for bioaerosols hence research data is referred to.

In an Environment Agency report Wheeler *et al* (2001) recommend a conservative limit of 250m based on dispersal monitoring during 1999 and 2000 where again it was found background concentrations were reached within 200m. This distance was further

agreed with by Swan *et al* (2003) in a report for the Health and Safety Executive. It should be noted Wheeler also measured concentrations up to 10^7 during active turning operations but dispersal was still at background within 250m. Adas (2005) reported that between 88 and 96% of bioaerosols generated from composting sites were below the guideline of 1000 cfu/m^3 within 125m from windrow sources and all sites could be expected to be at background within 200m. HSE (2010) determined that bioaerosol concentrations of 10^5 to 10^6 cfu/m^3 were found at source during agitation on open windrow sites, but this decreased significantly at 50m to 100m and again that concentrations were at background within 250m in most cases. Defra (2013) also determined concentrations were at background within 250 m for most bacteria and *Aspergillus fumigatus* measurements (as per the AfOR protocol the forerunner of M9). One of the sites in the Defra (2013) study was of similar size to that proposed after expansion at the AWO Recycling site.

In terms of reported concentrations at compost sites, many of the above reports specify that concentrations are elevated during agitation only, and during periods of little to no activity concentrations are similar to background. Indeed, EA (2009) and Defra (2013) state that bioaerosol release is episodic (related to turning, screening and shredding) with turning potentially generating the highest releases.

At the AWO site data is available from 14 different sampling occasions from 2014 to 2017, all via Andersen Sampler and using media compliant with the current M9 site monitoring guidelines (EA 2018). The data are taken at various locations in and around the site, at varying distances and during varying weather conditions (all data collections complied with the requirement of no rain and above 3°C). Upwind samples taken on 19/3/14 and 1/12/16 showed low concentrations of bacteria (500 cfu/m^3 and below) and *Aspergillus fumigatus* (143 cfu/m^3 and below). 2014 data shows a daily average from several repeated samples, 2016 and 2017 data tracks individual activities such as screening or turning. Downwind samples were taken from 25m to 154m. The highest bacteria concentrations were recorded at 25 and 60m from site, at 4.6 x 10^4 cfu/m^3 both during turning. *Aspergillus fumigatus* was highest within 25m at 9.8 x 10^3 cfu/m^3. The data does illustrate the episodic nature of compost site emissions, but generally concentrations are much declined 100m onwards, and the published literature agrees that concentrations are back to background at 200m (Defra 2013 – which incidentally also contains data from this actual site). Where concentrations show a slightly higher average at 154m (9/4/2014) it is noted this sample site is in the vicinity of a much closer access road and hence some fugitive emissions are expected to contribute to this. Later data from 2016 and 2017 show lower concentrations even during activity on site at closer distances.

From the published literature and data derived from the site a risk zoning approach is used:

- Very Low risk: During periods of no activity on site at distances greater than 50m;
- Low risk: At distances greater than 200m concentrations are generally at background during periods of activity;
- Low to Medium risk: Distances of 150m to 200m during periods of activity;

- Medium risk: Distances of 100m to 150m during periods of activity;
- Higher risk: Distances less than 100m during periods of activity;
- Very high risk: Distances less than 50m during periods of activity.

This risk zoning approach (which is effectively a ranking of risk of exposure) is adapted from that used by HSE (2010). It should be further noted that weather conditions may affect this ranking of exposure; during periods of rain it could reasonably be expected that material would be wet, and dust almost completely suppressed, hence the risk of dispersion reduced significantly. It should also be noted the above categories represent a 'worst case scenario' during periods of dry weather and wind speed above 3 mps.

4.5 Risk estimation

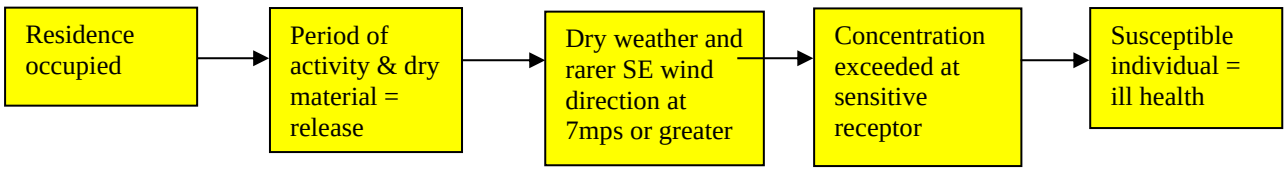
Based on the information on the site (Section 2) and the potential risks (Section 3) a risk assessment profile is constructed and displayed in Appendix IV. The following assumptions are made:

- **Probability of exposure:** relates to the likelihood of the receptor being exposed to the hazard, e.g. how often is the receptor present, wind direction, wind speed, whether it is dry weather and release events (e.g. activity) being the most important elements.
    - **Low:** low occupancy, favourable wind direction, low wind speeds, no release events;
    - **Low-Medium:** as above but with significant release event;
    - **Medium:** occupancy, adverse wind direction, medium wind speed, dry weather, release event;
    - **High:** occupancy, adverse wind direction, increased wind speed, dry weather, release event.

- **Consequence:** the consequences of a hazard being realised may be actual or potential harm. In this case publications mentioned in Section 4. 5 provide a model of likely concentrations vs. distance and this is used. At the present time, realistic modelling of bioaerosol concentrations is not available, as source term data are insufficient and there is a lack of dose-response data. However, it is still possible to estimate the risk following the consequence and probability of exposure.

Probability and consequence are combined to give an overall magnitude of risk. A 'worst case scenario' for AWO Recycling would be:

Figure 3: Worst case scenario



This chain of events is likely to be extremely rare, particularly given the distance and prevalent wind, which is very rarely SE in the area, but in the unlikely event it was to occur it may be mitigated with some planning. It should also be noted any exposure will be transitory on the pathway, e.g. the receptor will be passing through this area hence the categorisation of these as low risk receptors. This will be discussed in Section 5.

5.0 CONCLUSIONS

Research is still on-going into the impact of bioaerosols as a result of composting. However, lack of standards in this area should not necessarily preclude a precautionary approach. The assessment has illustrated that the risk of bioaerosol exposure from the AWO Recycling site is low, mainly due to the fact there are few sensitive receptors within the 250m zone, but also due to prevailing winds and the transitory nature of some sensitive receptors. However, there are options to further mitigate release to sensitive receptors which are considered in 5.1.

5.1 Mitigation options (Recommendations)

In terms of dust and so bioaerosol release, movement of the maturation piles and similar external activities have a higher potential to generate significant concentrations of dust beyond background concentrations. A full list of activities and potential mitigation measures are listed in Appendix V. Overall, however, various themes emerge on how to mitigate bioaerosols by a variety of means, for example:

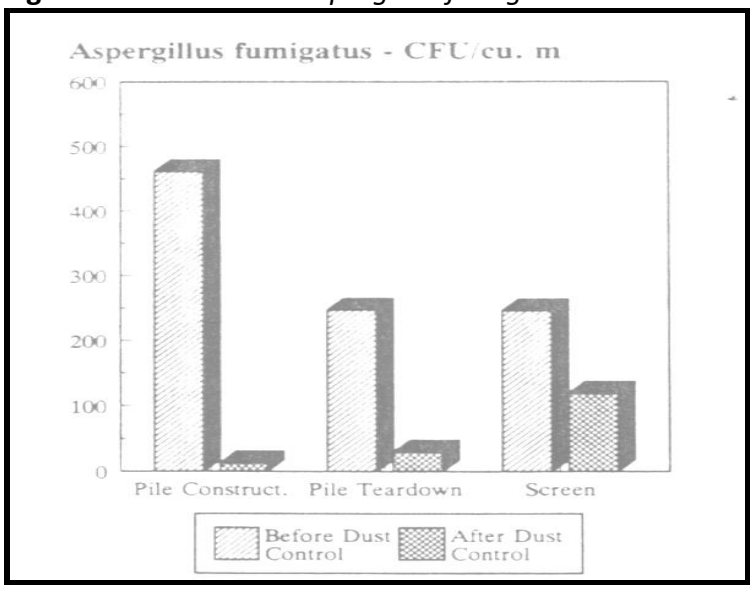
- The site should be maintained in as clean a condition as possible e.g. boundary fencing and/or bunding/trees etc.;
- Daily visual observations should take place and include activities such as litter checks, fugitive releases and conditions potentially affecting bioaerosol release should be daily recorded in the site logbook;
- Activities and conditions associated with high releases of bioaerosols could be controlled:
    - by carrying out high impact activities when the wind is blowing away from the nearest sensitive receptor or when wind speeds are below 3 metres per second (mps) (>10 kilometres per hour or kph) which is classed as a 'light breeze' on the Beaufort scale (ranked at 2),
    - by monitoring the moisture content of the compost regularly (as per odour requirements) to reduce generation of finer dusts which travel the furthest;
    - by damping down of material (Epstein *et al* 2001) (discussed further below) and other dust suppression measures, e.g. watering of roadways;
- By physical barriers, e.g. the trees surrounding the site, and the use of bunds. Planting of further vegetation in and around the bunding may also assist as windbreaks and reduce distribution of dust.

(Adapted from EA 2009 and others)

Epstein *et al* (2001) recommend that it is important to maintain the compost at a moisture content of around 60%-70% to prevent emissions. This study found that by controlling moisture levels and by using dust control this significantly reduced the

release of *Aspergillus fumigatus* from a composting facility during the construction of windrows, turning and screening processes.

Figure 4: Reduction of *Aspergillus fumigatus* downwind



Hence if the material is dampened down prior to these activities the release of bioaerosols is significantly reduced. Wheeler *et al* (2001) also recommended that compost be kept moist to reduce production of bioaerosols. Damping down of material often leads to continued cohesion of particles even upon drying which can reduce the distance dust will be transported (Watson *et al* 2000).

It is for this reason that dust suppression is always recommended on these sites with nearby sensitive receptors as in this case. Hence it is recommended monitoring of moisture content is carried out for the AWO Recycling site to reduce both point source and fugitive emissions.

The site may also consider research by Epstein (2001) who found that the effective management of dust significantly reduced the release of *Aspergillus fumigatus* from a composting facility and consider wetting the material prior to turning to reduce concentrations of bioaerosols.

Monitoring and logging of the wind direction already takes place and the site may wish to consider restrictions of turning or moving large amounts of material during a SE or possibly a south wind with wind speeds of over 7 mps (~25 kph). Watson *et al* (2000) comment that PM_{10} levels in an urban setting increased at speeds of 4 to 5 mps upwards, but most noticeably at speeds greater than 7 mps (25 kph), which is when particles are liberated from land storage. This represents a reasonably windy day and particles may travel much further as a result.

The site could also consider more physical barriers, particularly tree planting on the parameter which would act as both a windbreak and capture.

It is felt if these mitigation options are followed then the risk of the worst-case scenario outlined in figure 3 would be reduced further. However, obviously the situation should be monitored for against wind direction over time.

5.2 Future bioaerosol sampling

Considering the proximity of nearby sensitive receptors, monitoring as per the M9 guidelines may be required to ascertain the increase in tonnage and any impact on potential emissions. However, wind direction is an important variable, as are any issues. In the first instance, monitoring with active damping of roads and recorded compost moisture levels can be recommended if any issues develop. However, frequency may need to be reviewed if substantially different materials (for instance food waste) were planned for the site.

5.3 Final conclusions

Various studies have shown different dispersal distances and have used differing reference values for estimating effects on health to local populations. The results in this report indicate that the AWO Recycling site can generate concentrations which could be higher than EA guidelines within 200m, but that only medium and medium-low sensitive receptors are within the 250m guideline. As a result, monitoring may be required, depending on the occupancy of the nearby residence.

In conclusion, with the management measures in place, the development of the site surrounding the AWO Recycling composting operation should present a low risk to the resulting sensitive receptors.

6.0 REFERENCES

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7.0 APPENDICES

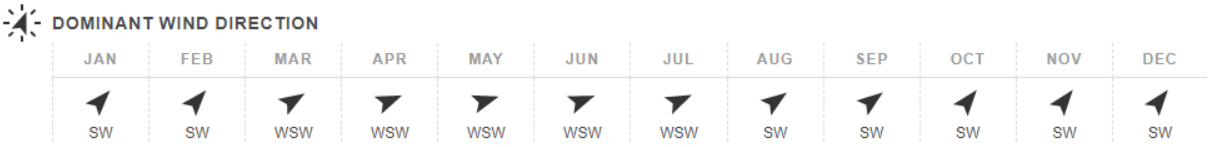
Appendix I: Outline and Location of AWO Recycling Site

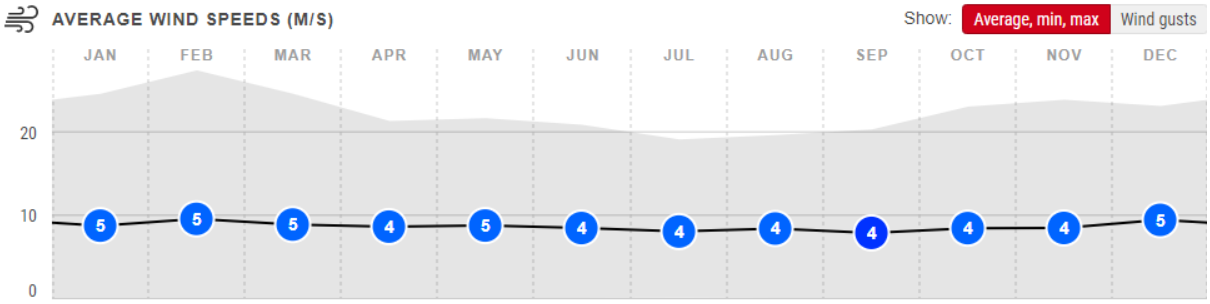
Appendix II: AWO Data

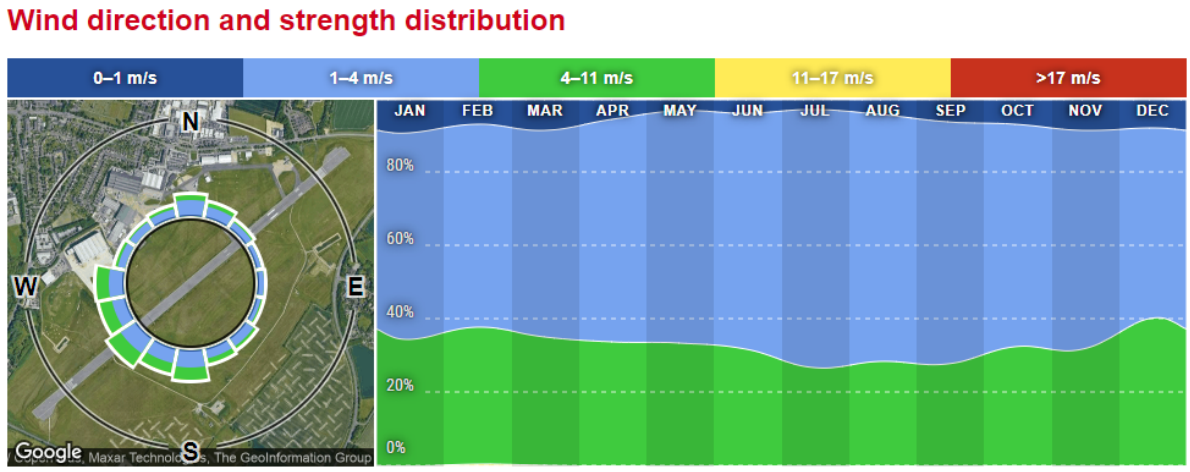
Date	Notes	Total Particles (ug/m3)	PM10 (ug/m3)	Total Bacteria (CFU/m3)	Aspergillus Fumigatus (CFU/m3)	Average Windspeed (m/s)	Average Temperature (°C)
12/03/2014	103m downwind buildings S	84	55	4585	823	1.2	14.5
19/03/2014	62m upwind road NW site	62	51	202	14	3.4	13.1
01/04/2014	150m downwind access road S	47	29	495	127	0.9	17.3
09/04/2014	150m downwind access road S	51	35	5208	537	2.5	16.9
01/07/2014	154m downwind field W	30	18	983	197	0.9	23.3
27/08/2014	154m downwind field W	133	66	6270	354	1.8	26.9
02/09/2014	100m downwind access road SW	85	53	1985	213	0.5	23.4
01/10/2014	80m downwind access road NE	205	100	5327	979	2.2	16.1
25/10/2016	25m Downwind S. Screening	255.2	197.8	4382	5371	0.4	11.8
25/10/2016	25m Downwind S. Screening	124.0	83.8	1360	442	1.1	12.8
25/10/2016	25m Downwind S. Screening	132.2	90.6	686	689	0.9	13.2
25/11/2016	25m Downwind S. Compost turning	117.9	88.9	1689	159	2.2	8.0
25/11/2016	25m Downwind S. Minimal site activity	74.3	57.8	ND	177	2.9	9.9
25/11/2016	25m Downwind S. Compost turning	55.5	42.9	362	177	3.5	9.9
25/11/2016	25m Downwind S. No site activity	52.3	41.4	251	88	3.3	9.6
01/12/2016	60m Upwind E. No site activity	104.2	84.5	512	143	1.0	7.0
01/12/2016	60m Downwind E. Compost turning	58.9	44.0	46431	4519	1.8	9.2
01/12/2016	60m Downwind E. Compost turning	70.2	48.8	3880	1212	1.5	8.3
25/07/2017	25m Downwind S. Compost turning	88.3	42.7	4970	9286	1.4	17.6
25/07/2017	25m Downwind S. Compost turning	31.6	14.6	724	145	1.0	19.4
25/07/2017	25m Downwind S. Compost turning	196.7	104.0	46431	9286	1.1	20.7
10/08/2017	25m Downwind S. Compost turning	52.5	32.1	608	571	2.0	17.7
10/08/2017	25m Downwind S. Compost turning	50.7	32.8	608	9286	1.8	18.4
10/08/2017	25m Downwind S. Compost turning	41.6	24.0	4004	9286	1.8	20.2
16/08/2017	50m Downwind E. Delivery of compost material and turning	105.1	59.8	2081	629	2.4	20.0
16/08/2017	50m Downwind E. Compost turning	51.2	28.2	1148	804	2.9	22.0
16/08/2017	50m Downwind E. No site activity	43.5	21.8	1360	382	3.0	23.3

Appendix III: Meteorological Data

Statistics taken from nearby weather station located At Cambridge Airport, data based on observations taken between *09/2009 - 07/2020* daily from 7am to 7pm local time.







Source: Windfinder.com

Appendix IV: Risk Table

	Data and Information					Judgement		Action/control measure	
Receptor (Table 1)	**Source (Table 2)**	**Harm**	**Pathway**	**Probability of exposure**	**Consequences**	**Magnitude of risk**	**Justification for magnitude**	**Risk management**	**Residual risk**
Residents at nearest house	Release from bioaerosols from turning, screening, shredding	Harm to human health - respiratory irritation and potential lung injury	Inhalation	Low	Medium: potential lung injury	Low	Wind direction would need to be SE at over 7 mps	Monitoring of wind direction, monitoring of moisture content of piles, dust suppression	Low
Walkers and cyclists on nearby path	Release from bioaerosols from turning, screening, shredding	Harm to human health - respiratory irritation and potential lung injury	Inhalation	Low	Medium: potential lung injury	Low	Wind direction rarely blows towards the path at over 7mps	Monitoring of wind direction, monitoring of moisture content of piles, dust suppression	Low
Drivers and public on surrounding roads	Release from bioaerosols from turning, screening, shredding	Harm to human health - respiratory irritation and potential lung injury	Inhalation	Low	Medium: potential lung injury	Low	Wind direction over 7mps required, exposure transitory however due to speed travelled	Monitoring of wind direction, monitoring of moisture content of piles, dust suppression	Low
Public on surrounding roads	Fugitive dusts from roadway	Upper respiratory irritations	Inhalation, possibly ingestion	Low	Low: mucous membrane irritations	Low	Only an issue after periods of dry weather, wind speeds over 7mps not within 250m	Dust suppression on the entrance roadway	Low

*Risk ratings based on those from EA (2009) pg17

Appendix V: Evaluation of activities on site

Area/Activities	Bioaerosol sources	Management Measure
1. Green Waste Reception & Shredding Area	Incoming waste: green waste, older/decaying waste, waste which is potentially dry and dusty.	**Emissions**: Consider spraying material and roadways with clean water to dampen the worst of the dust. **Feedstock management:** Moisture monitoring wetting if appropriate or addition of amendment materials to wet waste. Ensure best mix of waste prior to shredding to ensure dust is controlled.
2. Green Compost pad	Maturing compost material, pockets of drier material.	**Emissions:** Moisture (addition on a little and often basis), moisture monitoring – squeeze test. Aeration, mechanical aeration: turning in batches on a regular basis. Wetting hard surfaces. Continuous monitoring to determine potential problems and implement contingencies e.g. increased watering rate to increase moisture levels. Only disturbing material during periods of favourable wind (direction and speed).
3. Turning green compost	Composting material, pockets of drier material.	**Emissions**: As described in 2 to prevent establishment of dry conditions in the pile. Use of site misting systems and chemicals during turning, in line with control on operation due to wind directions and conditions. Wetting of roadways. **Continuous monitoring and review**: Monitoring weather conditions, wind, temperature, precipitation patterns and odour in line with location of sensitive receptors. Use of abatement equipment if appropriate. Review of conditions and restriction of activities if necessary.
4. Leachate and run-off from green compost pile	Biologically laden leachate run-off from process, saturated pile due to excess moisture, improper mixing, and ponding at base of pile or on hard standing.	**Emissions**: Leachate reduced by regular turning to promote effective mixing. No liquid waste input to green pile. Continuous moisture monitoring. No spraying of leachate or disturbance if wind over 7mps blowing towards nearest sensitive receptors. **Housekeeping**: Daily site maintenance checklist to ensure drainage channels clear and free-flowing, screen clear, etc. Responsibility for reporting daily housekeeping issues assigned to single site operative. Housekeeping audit programme on-going. Cleaning to be initiated for clearing any spillages or surface ponding.
5. Other activities: spreading compost & bagging/bulking compost products	Disturbed compost at bagging/bulking stage which is potentially odorous, unstable or immature compost on turf fields	**Emissions**: At this stage the material should be biologically stable. **Continuous monitoring and review**: Monitoring weather conditions, wind, temperature, precipitation patterns and odour in line with location of sensitive receptors. Review and restriction of activities if necessary.