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Consulting Engineers Limited

Beddington Lane Anaerobic Digestion Facility

SUEZ Recycling and Recovery UK Ltd

Bioaerosol Risk Assessment

ENGINEERING CONSULTING

Document approval

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Contents

1 Introduction

1.1 Background

SUEZ Recycling and Recovery UK Ltd (the Client) is applying to the Environment Agency (EA) under The Environmental Permitting (England and Wales) Regulations 2016 (Environmental Permitting Regulations) for an Environmental Permit (EP) to operate an anaerobic digestion (AD) plant with a design capacity of approximately 100,000 tonnes per annum of organic material (the Facility). The operations including the management of organic wastes with the potential to generate bioaerosols. Therefore, it has been requested by the EA that a Bioaerosol Risk Assessment is produced to assess the potential risk posed by bioaerosol emissions from the Facility. The location of the Facility is presented in Figure 1 of Appendix A.

1.2 Objective

The objective of this assessment is to evaluate the likelihood of potential emissions of bioaerosols from the Facility, in conjunction with the consequences to nearby receptors, to determine the overall risk to human health within the vicinity of the Facility.

2 Approach

2.1 Guidelines

There is limited regulatory framework or guidance relating to bioaerosol emissions from facilities managing anaerobic digestion of organic waste. The EA guidance note, dated October 2012, *'Guidance for developments requiring planning permission and environmental permits'* states that bioaerosols from AD plants are not considered to be a serious concern. However, for some facilities it may be necessary to refer to the risk assessment guidance for composting facilities. Whilst this Facility does not operate open air composting and all processes are either enclosed or kept within negative pressure environments, the principles of *Guidance on the evaluation of bioaerosol risk assessments for composting facilities*[1] (the 2009 EA guidance) have been applied in the development of this Bioaerosol Risk Assessment including:

- Hazard identification – what sources of hazard(s) are present and what are their properties.
- Exposure assessment – evaluate the plausibility of the hazard being realised at the receptor, who (or what) is exposed, how long and often.
- Risk estimation – of what relative scale is the probability and extent of possible harm.
- Risk characterisation – how significant is the risk and what are the uncertainties.

2.2 Methodology

The approach detailed in the 2009 EA guidance has been applied to determine the magnitude of risk accounting for the probability of harm and consequence of the hazard.

2.2.1 Probability of harm

The probability of harm examines the likelihood of exposure for an individual. The terminology is taken directly from the 2009 EA guidance. For clarity, the 'probability of harm' in this context is best thought of the likelihood of exposure, as it does not specifically consider the harm that would occur due to that exposure. The following descriptors have been applied:

- High – exposure is probable, direct exposure likely with no/few barriers between source and receptor;
- Medium – exposure is fairly probable, barriers less controllable;
- Low – exposure unlikely, barriers exist to mitigate; or
- Very low – exposure very unlikely, effective and multiple barriers.

The probability of harm is also affected by the proximity of the receptor to the bioaerosol source. For instance a receptor 100m from a source of more likely to be affected than one 250m from the source.

2.2.2 Consequence of hazard

The consequence of the hazard considers the nature of the source, the hazard and the receptor. As such, consideration must be given to the source parameters (e.g. high or low potential for bioaerosol release), the nature of the hazard (bioaerosol release which could lead to adverse health

[1] EA, (2009) Guidance on the evaluation of bioaerosol risk assessments for composition facilities.

effects) and the sensitivity of the receptor. The 2009 EA guidance defines schools and hospitals as being ‘particularly sensitive’. Residential receptors would therefore be considered to be of lower sensitivity than schools and hospitals, and workplaces, where exposure is typically for less time, to be of lower sensitivity still.

The following descriptors for the consequence of the hazard have been applied:

- High – severe consequences, evidence that exposure may result in serious damage;
- Medium – significant consequences, evidence that exposure may result in damage that is not severe and is reversible;
- Low – minor consequences, damage not apparent, reversible adverse changes possible; or
- Very low – negligible consequences, no evidence for adverse changes.

2.2.3 Magnitude of risk

The magnitude of risk can be determined by examining the probability of harm and consequence of the hazard. The matrix presented in Table 1 has been applied to determine the magnitude of risk.

Table 1: Magnitude of risk matrix

Probability of harm	Consequence			
	Very low	Low	Medium	High
High	Low	Medium	High	High
Medium	Low	Medium	Medium	High
Low	Low	Low	Medium	Medium
Very low	Very low	Low	Low	Medium

3 Problem Definition

3.1 Technology description

The Facility comprises an AD plant with a design capacity of approximately 100,000 tonnes per annum of organic material. Approximately 15.0 Mm^3 of biogas is expected to be generated by the AD plant per annum with 651,000 m^3 used on site and a net production of 14.3 Mm^3 per annum. The biogas would be upgraded for injection into a local gas network. The Facility incorporates a CHP engine (1.2MWe export) which uses the biogas to generate electricity and heat, which is used to support the AD process or be exported from the Facility. The Facility also incorporates a carbon capture plant expected to capture approximately 5.9 Mm^3 of carbon dioxide per annum.

The Facility comprises:

1. A main AD processing building (reception hall, pre-treatment, processing and storage of digestate);
2. Associated tanks, control units, stores, a combined heat and power biogas engine, flare, and carbon capture infrastructure;
3. A two-storey office/welfare building;
4. Staff parking areas;
5. HGV access arrangements at the southeast corner of the site; and
6. Highways upgrade works on Beddington Lane.

A layout of the site is presented in Figure 2 of Appendix A.

3.1.1 Organic waste reception, pre-treatment and storage

Organic waste is delivered to the Facility and deposited into the waste pits within the reception hall, which is held under negative pressure to prevent fugitive emissions from the building. The waste is then fed into a de-packaging plant to remove unwanted packaging and contamination. It is then shredded to increase surface area for the AD process and improve the uniformity of the waste feedstock. The material (27% dry solids content) is diluted using a mix of recovered water from the process, towns water and liquid waste from the food industry before being pumped to the buffer tanks. The buffer tanks act as a temporary storage area for organic waste before being fed into digester tanks.

3.1.2 Anaerobic digester

The digester tanks contain inoculum (microorganisms which facilitate the AD process) which is recovered within the outlet of the digester tank and fed into the digester inlet for reuse. The digester tanks are insulated to reduce heat losses and additional heating requirements are provided by a centrally located heating system within the digester tank. The organic waste within the digester tank is agitated and mixed by horizontal axis paddles to maintain uniformity of the process. A typical retention time for organic waste within the AD process at the Facility is 60 days.

3.1.3 Biogas processing and combustion

A primary step in biogas processing is a cleaning process to remove sulphurous contents which can corrode process equipment and contribute to sulphur oxides emissions during biogas combustion. The biogas is cleaned using a chemical compound such as iron chloride or iron hydroxide. Following cleaning, the biogas is passed to a chiller unit to reduce its temperature and cause entrained water vapour to condense out of the gas before being sent to a carbon filter system to remove any impurities.

Once a cleaned biogas is obtained, it is sent to the onsite gas upgrading unit which separates out the methane from the carbon dioxide and other constituent gases to produce a concentrated biogas often referred to as 'biomethane' or 'compressed natural gas (CNG)'. This gas is then either exported to the wider natural gas grid network or combusted within the CHP engine for electrical generation of 1.2 MWe capacity. A gas flare is included to ensure that during periods of excess biogas production or plant unavailability, biogas production can be managed.

3.1.4 Digestate handling

The digestate is transferred from the digester to a dewatering system comprised of a centrifuge which physically separates moisture contained within the digestate up to 25% dry solids content. Following the drying process, the digestate is pasteurised by heating to 70°C for 1 hour. Following this, the digestate is transferred to an enclosed storage area where it matures until it complies with PAS:110[2] standard for use as an agricultural fertiliser. Air from within the digestate storage area is processed within the odour control unit.

3.2 Sources of bioaerosols from the Facility

There is the potential for bioaerosols to be released from the following sources:

- fugitive emissions from the handling and preparation of incoming waste;
- fugitive emissions from the AD process;
- emissions from the odour control unit; and
- fugitive emissions the handling and storage of digestate prior to transfer off-site.

3.2.1 Handling and preparation of waste

The AD process provides a controlled environment in which micro-organisms can grow, multiply and break-down organic material. Bioaerosols from AD arise when micro-organisms are released into the air when the encompassing waste material is disturbed.

All waste reception and storage operations are undertaken within buildings which are held under a negative pressure through the extraction of air by forced ventilation. This ensures all air is drawn through the odour control unit to prevent fugitive emissions of odour or bioaerosol from the waste reception building. All external doors are kept closed when not in use as necessary and appropriate and are designed to be fast-acting to minimise opening and closing times. The odour control unit also contains a biofilter. Biofilters were originally designed to remove odour, however some studies have demonstrated their effectiveness at removing bioaerosols, particularly *Aspergillus fumigatus* spores by approximately 90%[3]. Despite this, there is some evidence to suggest that biofilters can become a source of bioaerosol themselves under certain conditions[4]. Whilst this phenomenon is

[2] Waste & Resources Action Programme (WRAP) - BSI PAS 110: Producing Quality Anaerobic Digestate

[3] Cranfield University and Environment Agency, Guidance on the evaluation of bioaerosol risk assessments for composting facilities, 2009

[4] Cranfield University and Environment Agency, Guidance on the evaluation of bioaerosol risk assessments for composting facilities, 2009

not well understood, it is considered within this assessment that the biofilter within the odour control unit is a potential source of bioaerosols.

Any organic feedstock to the AD process is prepared by shredding to reduce its particle size to make it more suitable for the AD process. During the shredding process, the material is approximately 27% dry solids. As such, the potential to release bioaerosols is very low. Furthermore, the waste reception area is enclosed and held under a slight negative pressure with all external doors kept closed, except for short periods during waste delivery.

Once the organic waste is shredded, it is fed into a waste dissolver which liquifies the organic material into an organic slurry. The slurry is pumped to a hydrolysis buffer tank before being pumping into a double sealed membrane bag within one of the three digester tanks. This latter part of the process is an enclosed.

3.2.2 AD process

As the AD process is an enclosed wet process, there is no potential for the direct release of bioaerosols from the AD process as any bioaerosols will remain within the waste until it becomes dry again.

The AD process at the Facility is conducted within double sealed membrane bags, which will rise and fall within the outer digester tank to accommodate for changes in pressure due to the biogas production. Biogas and air in contact with the AD process, which will have the potential for high levels of odour and bioaerosol content, is ducted to the CHP engine to be combusted. In the event of CHP engine unavailability, an emergency gas flare is used to combust gases from the digester tanks to prevent overpressure of the digester tank membranes. As such, the only risk of bioaerosol emissions to atmosphere from 'dirty air' release would be due to failure of two separate gas-offtake safety systems, during which an emergency pressure relief valve activates to prevent the overpressure.

3.2.3 Handling and storage of digestate prior to transfer off-site

Digested material is dewatered and transported to a digestate storage area. The digestate storage area is held at negative pressure as air is extracted from the digestate storage area processed through the odour control unit. Therefore, there is deemed to be no significant risk of fugitive bioaerosols being released to the external atmosphere from the digestate storage area.

Any digestate sludge held in the post digestion sludge holding tanks before being transferred off-site. The digestate cake (dry solids c.25%) has very low potential for bioaerosol release whilst the digestate slurry is transported using sealed tanker trucks. The process uses sealed connections however the tanker air must be vented during the filling process. Therefore, the tanker air is typically vented through the Facility's odour control unit or through its own standalone unit.

3.3 Description of the local area

The areas surrounding the site are of considerably varying land use ranging from open water and grassland areas to built-up industrial and urban fabric. To the west of the Facility is the open grassland and water of Beddington Farmlands wildlife park which extends for c.700m, with residential areas in the Hackbridge area beyond. To the north and east of the Facility is industrial land consisting of commercial distribution and storage premises. To the northwest is Beddington Energy Recovery Facility (ERF), an energy from waste facility of approximately 350,000 tonnes per annum throughput. To the south of the Facility is Beddington Water Treatment Works, a wastewater and sewage treatment facility.

3.4 Sensitive receptors

The EA's current policy position on potential health impacts from bioaerosols states a screening distance of 250m between workplace or dwellings and a potential new source[5]. The policy considers fixed or static receptor locations and does not include transient exposure along public footpaths or highways. Therefore, only workplace or dwellings have been considered as sensitive receptors. Furthermore, despite the Facility itself being considered a workplace, as stated with the EA guidance technical note *M9: Environmental monitoring of bioaerosols at regulated facilities*, the health of staff controlling a permitted facility are assessed under the Health and Safety at Work legislation[6]. Based on this screening criterion, four sensitive receptors within 250m of the installation boundary have been identified, as listed in Table 2. A plan showing the location of sensitive receptors is presented in Figure 3 of Appendix A.

Table 2 Sensitive receptors

ID	Receptor Name	Receptor Category	Distance (m) at closest point
R1	1 Therapia Lane	Residential dwelling	c.200m NNE of the installation boundary and >240 m from the storage or handling of organic waste.
R2	Workplace 1	Industrial/Commercial premises	c.10m N of the installation boundary and >120 m from the storage or handling of organic waste.
R3	Workplace 2	Industrial/Commercial premises	c.70m E of the installation boundary and >110 m from the storage or handling of organic waste.
R4	Workplace 3	Industrial/Commercial premises	c.60m SE of the installation boundary and >170 m from the storage or handling of organic waste.

3.5 Wind data

Five years of meteorological data from Gatwick Airport have been used within the assessment to take into account inter-annual fluctuations in weather conditions. Whilst closer meteorological stations are available (namely Kenley and Biggin Hill), these stations are located >100m higher in altitude than the Facility whilst Gatwick is at a similar elevation to the Facility.

[5] Cranfield University and Environment Agency, Guidance on the evaluation of bioaerosol risk assessments for composting facilities, 2009

[6] Environment Agency, M9 Technical Guidance Note (Monitoring) - Environmental monitoring of bioaerosols at regulated facilities, 2018

The period 2018 – 2022 has been used as this is the most recent 5 year period available at the time of this assessment. Wind roses for each year are presented in Figure 4.

An assessment of the location of each sensitive receptor in relation to the Facility has been conducted, including the determination of a range of wind directions which would result in potential bioaerosol exposure from the Facility. The results from this are presented in Table 3.

Table 3 Wind direction

ID	Receptor name	Direction from source	Wind directions with potential to include bioaerosols from Facility (°)
R1	1 Therapia Lane	NNE	180 – 225
R2	Workplace 1	N	315 – 45
R3	Workplace 2	E	45 - 135
R4	Workplace 3	SE	90 - 180

The frequency with which the wind blows within the respective directional ranges for each receptor is presented within Table 4.

Table 4 Likelihood of exposure to bioaerosol

ID	Receptor name	Wind frequency with potential to include bioaerosols from Facility (%)					
		2018	2019	2020	2021	2022	Average
R1	1 Therapia Lane	21.1%	24.1%	26.0%	24.7%	25.0%	24.2%
R2	Workplace 1	15.7%	11.8%	14.5%	18.4%	13.5%	14.8%
R3	Workplace 2	20.4%	21.0%	18.4%	18.5%	21.6%	20.0%
R4	Workplace 3	12.4%	11.7%	9.5%	7.6%	11.9%	10.6%

3.6 Health risks associated with bioaerosols

Bioaerosols, as airborne suspended fungi, bacteria and actinomycetes, pose a range of human health risks with symptoms typically manifesting in the form of:

- inflammation of the respiratory system;
- respiratory illnesses such as 'bronchitis' and 'inhalation fever;
- reduced lung function;
- coughs;
- fevers;
- gastrointestinal illnesses;
- eye irritation; and
- dermatitis/skin conditions.

The fungi species *Aspergillus fumigatus* is of particular concern at waste management facilities due to the severe infection *aspergillosis* which can be fatal in individuals that are immuno-compromised.

Due to bioaerosol particle size typically being <10 µm in diameter, they are not filtered out within the upper respiratory tract and therefore can penetrate the deep lung.

Based on the processes outlined in Section 3.2, the majority of emissions of bioaerosols from the Facility are expected to short term fugitive emissions from the air released from waste management areas or the handling of waste materials. Therefore, the health risk posed by these sources is expected to be acute (short duration) due to the limited likelihood of waste management areas being open to atmosphere for significant periods of time.

The air exhausted from the odour control unit is expected to potentially emit bioaerosol from bacterial/fungal accumulation within the biofilter. Whilst the odour control unit operates continuously to process air from waste management areas, it is anticipated that appropriate cleaning/replacement procedures to the biofilter during maintenance outages would aid in mitigating this health risk.

3.7 Other sources of bioaerosols

A desktop study has identified one significant source of bioaerosols within 250 m of the Installation boundary.

Beddington Water Treatment Works is a sewage and wastewater treatment works (WWTW) c.35m south of the Facility installation boundary. WWTWs are understood to be potential sources of bioaerosol through aeration of wastewater containing bacteria in addition to handling of sludge materials. However, evidence is unclear about bioaerosol emission rates from WWTWs due to the variation in processes between facilities. In the case of Beddington Water Treatment Works, it is expected that the settling tanks/clarifiers (primary treatment processes) and aeration tanks (secondary treatment processes) would potentially generate the most bioaerosols. These two areas are located a minimum of c.140m and c.130m from the Facility installation boundary respectively. Meanwhile, the nearest sensitive receptor is 'R4', located c.150m to the NE of these areas. Therefore, whilst we expect a level of chronic (long term) baseline contribution of bioaerosols from Beddington Water Treatment Works due to the continuous nature of WWTW processes, it is not possible to quantify the potential dosage of bioaerosol emissions without specific monitoring results.

4 Risk Assessment

In line with the assessment methodology set out in Section 2.2, the magnitude of risk has been determined based on the probability of harm and consequence of the hazard. As explained within Section 3.1, the sources of bioaerosols are from:

- The handling and preparation of waste;
- The AD process; and
- The handling and storage of digestate prior to transfer off-site.

4.1 Probability of harm

The design of the Facility incorporates multiple barriers to prevent fugitive emission of bioaerosols to atmosphere. Additionally, all waste handling process is conducted within enclosed buildings from which air is sent to an odour control unit which filters bioaerosols through both a carbon filter and biofilter before release to atmosphere. However, the biofilter may be a source of bioaerosols from the Facility albeit these would be released from a stack with a height of 18.3 m to aid dispersion. Additionally, the biofilter is expected to be cleaned or replaced as required during maintenance activities.

Based on the effective measures in place for the control of fugitive releases of bioaerosol, the maximum probability of wind blowing emissions from the biofilter to a receptor being 24.2%, and a minimum distance from a bioaerosol source to a receptor of 110m, the probability of harm is deemed to be "*low*" at all R1-R3 as exposure is unlikely and barriers exist to mitigate the risk and *"very low"* at R4 due to the higher distance of ~170m and lower frequency of wind blowing towards this receptor (~10%).

4.2 Consequence of hazard

As discussed in Section 3.6, the potential health effects of bioaerosols can be severe, particularly in individuals that are immuno-compromised or with existing respiratory or gastrointestinal issues. As such, the consequence of the hazard is highly dependent on the sensitivity of receptors and the nature of the source.

All of the receptors identified within this assessment are either residential dwellings (R1) or workplaces (R2, R3, R4). No particularly sensitive receptors (schools, hospitals, care homes) have been identified within the 250 m screening distance, in line with the 2009 EA guidance.

The sources of bioaerosol emissions from the Facility are the biofilter and potential fugitive emissions from storage and handling areas. As there are control measures to prevent fugitive emissions, and the biofilter is a controlled point source, the potential quantity of bioaerosol emissions from these sources is expected to be low; particularly when compared to open composting which the 2009 EA Guidance is based upon. As no particularly sensitive receptors have been identified within the screening distance, it is considered that the likely consequence of the hazard is 'low' at all receptors.

4.3 Magnitude of risk

Table 5 provides a summary of the risk assessment and justification for the overall magnitude of risk. As shown, for all receptors the overall risk from bioaerosols is considered to be low.

Table 5: Bioaerosol risk assessment

Receptor	Sources	Harm	Pathway	Probability of harm	Consequence	Magnitude of risk	Justification	Risk management	Overall risk
R1	Anaerobic digestion process, reception, handling, and preparation of incoming waste. Potential emissions from biofilter. Potential for fugitive emissions of bioaerosol through handling of waste material.	Human health: Respiratory illnesses, reduced lung function, gastro-intestinal disorders and allergic reactions.	Direct air transport followed by inhalation or ingestion	Low	Low	Low	Receptor c.240m from all identified potential bioaerosol emission sources. Receptor down-wind for less than an average of c.24% of the year.	All reception, handling, and preparation of waste to occur within an enclosed area; Waste reception areas held under negative pressure with all air exhausted through filters within odour control unit.	Low (not significant)
R2	Anaerobic digestion process, reception, handling, and preparation of incoming waste. Potential emissions from biofilter. Potential for fugitive emissions of bioaerosol through handling of waste material.	Human health: Respiratory illnesses, reduced lung function, gastro-intestinal disorders and allergic reactions.	Direct air transport followed by inhalation or ingestion	Low	Low	Low	Receptors c.120m from all identified potential bioaerosol emission sources. Receptor down-wind for less than an average of c.15% of the year.	All reception, handling, and preparation of waste to occur within an enclosed area; Waste reception areas held under negative pressure with all air exhausted through filters within odour control unit.	Low (not significant
R3	Anaerobic digestion process, reception, handling, and preparation of incoming waste. Potential emissions from biofilter. Potential for fugitive emissions of bioaerosol through handling of waste material.	Human health: Respiratory illnesses, reduced lung function, gastro-intestinal disorders and allergic reactions.	Direct air transport followed by inhalation or ingestion	Low	Low	Low	Receptors c.110m from all identified potential bioaerosol emission sources. Receptor down-wind for less than an average of c.20% of the year.	All reception, handling, and preparation of waste to occur within an enclosed area; Waste reception areas held under negative pressure with all air exhausted through filters within odour control unit.	Low (not significant
R4	Anaerobic digestion process, reception, handling, and preparation of incoming waste. Potential emissions from biofilter. Potential for fugitive emissions of bioaerosol through handling of waste material.	Human health: Respiratory illnesses, reduced lung function, gastro-intestinal disorders and allergic reactions.	Direct air transport followed by inhalation or ingestion	Very Low	Low	Low	Receptor c.170m from all identified potential bioaerosol emission sources. Receptor down-wind for less than an average of c.10% of the year.	All reception, handling, and preparation of waste to occur within an enclosed area; Waste reception areas held under negative pressure with all air exhausted through filters within odour control unit.	Low (not significant

4.4 Uncertainties

All uncertainties identified within the assessment are summarised below:

1. Bioaerosol behaviour in atmosphere (dispersion and particle dynamics) and resulting dose-response relationships.
2. Quantification of bioaerosol concentration and emission durations for activities at the Facility from:
   a. Fugitive emissions resulting from handling and preparation of organic waste prior to the AD process;
   b. Emissions from the AD process;
   c. Emissions from the biofilter within the odour control unit; and
   d. Fugitive emission from the handling and storage of digestate prior to transfer off-site.
3. Quantification of the bioaerosol emissions from the Beddington Water Treatment Works and the baseline bioaerosol conditions at the Facility and at receptors.

4.5 Summary

In line with the assessment methodology detailed in the EA's Guidance on the evaluation of bioaerosol risk assessments for composting facilities[7], this bioaerosol risk assessment evaluates the likelihood of potential emissions of bioaerosols from the Facility, in conjunction with the consequences to nearby receptors, to determine the overall risk to human health within the vicinity of the Facility. This is achieved through identification of potential bioaerosol hazards, the plausibility of hazards being realised at receptors, the probability of the risks to human health and the significance of those risks. As such, the magnitude of risk identified across the four receptors identified within screening distances is deemed to be 'low'. Whilst exposure is possible at locations other than these specific identified receptors, the probability of harm and magnitude of risk will not be substantially different; therefore, the overall magnitude of risk is deemed to be 'low'.

[7] Cranfield University and Environment Agency, Guidance on the evaluation of bioaerosol risk assessments for composting facilities, 2009

Appendices

A Figures

Figure 1: Site Location

Figure 2: Site Layout

Figure 3: Sensitive Receptors

Figure 4: Meteorological Data (Wind Roses)

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