D&F Associates

EVALUATION OF AMBIENT BIOAEROSOLS AT:

CRUGMORE FARM COMPOSTING FACILITY
PENPARC
CARDIGAN
CEREDIGION
SA43 1QY

10th OCTOBER 2018

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1. BACKGROUND & SITE DESCRIPTION:

D&F Associates Ltd has been commissioned by MD Recycling Ltd to evaluate bioaerosols at an open windrow composting (OWC) facility situated at Crugmore Farm, Penparc, Ceredigion SA43 1QY. The facility receives green waste from local sources including landscape gardeners and grounds maintenance contractors.

Green waste is processed in a dedicated composting area using an open windrow composting technique. The operational area is surrounded by open farmland to the North, South and West. Wood and demolition/ construction waste recycling areas are situated to the East of the composting area and an anaerobic digestion (AD) plant is located 60m Southeast. Sensitive receptors identified within 250m of the composting facility include the AD plant and a residential dwelling situated 220m North Northwest. Other potential sources of bioaerosols in the vicinity of the site include the AD plant and the other waste recycling processes at Crugmore Farm.

2. SAMPLING POINTS & SAMPLING PROTOCOL:

The Environment Agency Technical Guidance Notes M17 (Monitoring of particulate matter in ambient air around waste facilities, version 2, 2013) and M9 (Environmental monitoring of bioaerosols at regulated facilities, version 2, 2018) offers guidance concerning aerosol emissions from composting sites. In accordance with the site Environmental Permit (EPR/AB3097HG) which refers to the Association for Organic Recycling (AfOR) guidance (A standardised protocol for the monitoring of bioaerosols at open composting facilities, 2009), M17 and the 2009 AfOR Protocol have been used for this assessment as applicable.

The Filter Method given in the 2009 AfOR protocol has been used to evaluate bioaerosol levels and deviations approved by the AfOR Protocol Steering Committee are presented in the Summary Table attached as Appendix 2 (Page 12). Distances have been estimated using the mapping tool provided at www.magic.gov.uk, a geographical information service provided by the Department of Environment, Food and Rural Affairs (DEFRA) and Natural England.

2.1 Samples

Sample locations were chosen in accordance with the guidelines given in the 2009 AfOR Protocol. Sample points are dependant on weather conditions and are chosen with respect to the direction of the wind on the day of monitoring. Sample points may therefore be expected to change for each assessment.

The following sample points were used for the evaluation at Crugmore Farm. Sample locations and relevant wind directions are illustrated on the site diagram attached as Appendix 1 (Page 11).

Sample Point 1: Upwind (50m Southeast of the pad boundary). Grid reference SN 20342 47210 (SP1).

Sample Point 2: Downwind (60m Northwest of the pad in an open field). Grid reference SN 20194 47364 (SP2).

Sample Point 3: Sensitive Receptor (60m Southeast of the pad at the AD plant boundary fence). Grid reference SN 20347 47190 (SP3).

2.2 Sampling, Transport & Storage

Upwind and downwind concurrent sampling was carried out using personal air sampling pumps and IOM Samplers containing sterile 25mm 0.8µm polycarbonate filters. The units were calibrated to operate at 2 L/min using a float rotameter with a linear flowpath of 600-5000 ml/min (SKC 393-0650). Three samples were taken in parallel at each sampling location. The sampling heads were mounted on tripods 1.6 metres high and spaced approximately 3.0-5.0 cm apart in a horizontal forward facing fixed position. The pumps were programmed to run for 30 minutes and the sampling start and stop times were recorded. Exposed filters were aseptically removed from the sampling heads using sterile tweezers and placed into 10ml aliquots of sterile physiological saline. An unexposed filter was aseptically transferred into a 10ml aliquot of sterile saline solution to form a control sample. An electrically controlled coolbox was used to transport the samples at 4ºC to D&F Associates Laboratories where they were placed in a refrigerator and processed the following day.

2.3 Laboratory Enumeration

The samples were shaken and allowed to stand for 10-15 minutes to equilibrate to room temperature. A 10-fold series of dilutions were prepared from the filter suspensions and aliquots were plated onto prepared agar plates containing half strength Nutrient Agar (NA for the enumeration of mesophilic bacteria), Malt Extract Agar (MEA for the enumeration of *Aspergillus fumigatus*) and cooled MacConkey Agar (MAC for the enumeration of Gram negative bacteria). Plates to evaluate mesophilic and Gram negative bacteria were inverted and incubated at 37°C. Plates to evaluate *Aspergillus fumigatus* were inverted and incubated at 45°C.

All plates were counted after 48 hours. NA and MEA plates showing fewer than 100 colonies were returned to their respective incubators. Growth for *Aspergillus fumigatus* was rechecked after 3-days and growth for mesophilic bacteria was rechecked after 5-days.

Microbiological growth media was prepared in accordance with BS EN ISO 11133:2014: Microbiology of food, animal feed and water, preparation, production, storage and performance testing of culture media. Following sterilisation and cooling to 47°C, MEA was treated with Penicillin G Sodium Salt (20 units/ml) and Streptomycin sulphate (40 units/ml), and NA was supplemented with 0.01% w/v cycloheximide (dissolved in <2.0ml acetone). Prepared plates were pre-incubated and quality checked before use.

2.4 Calculation of Results

Exposed filters placed into 10ml aliquots of sterile transport diluent produce microbial suspensions in which the micro-organisms have been diluted by a factor of 10 (*i.e.* 1:10 or 10^{-1}). The number of colonies that develop on microbiological growth media are multiplied by 10 to estimate the number of colony forming units on a filter (*i.e.* cfu/filter). The number of colony forming units in one cubic metre of air (cfu/m^3) is calculated by dividing $1m^3$ (or 1000 litres) by the volume of air sampled as m^3 (or litres) to provide a calculation adjustment factor. The number of micro-organisms enumerated on a filter is multiplied by the adjustment factor to produce results as cfu/m^3 as follows:

$$\text{cfu/m}^3 = \frac{1\text{m}^3}{v\text{m}^3} \times (n \times 10)$$

where,
n = the mean number of cfu quantified in 1.0ml of the filter suspension as received (*i.e.* cfu/ml).
v = the volume of air sampled as m^3.

The minimum level of detection for airborne micro-organisms is determined by the volume of air sampled. Results that are lower than the minimum level of detection are given as <x cfu/m^3 (*i.e.* less than x colony forming units per cubic metre of air where x is the minimum level of detection based on the volume of air sampled).

2.5 Other Considerations

Equipment, consumables and microbiological growth media were assessed in the laboratory for quality assurance before use or release. Results and records of QA and QC checks are maintained as part of Good Laboratory Practice procedures. Industrial Methylated Spirits (IMS) was used to sterilise equipment in the field and 'Control Samples' were collected as part of the assessment to confirm aseptic handling. Procedures are followed to prevent external contamination.

3. METEOROLOGICAL/ WEATHER CONDITIONS:

Wind speed and direction, air temperature and relative humidity were logged at 1-minute intervals using three Kestrel 4500 portable weather stations.

4. SITE ACTIVITIES:

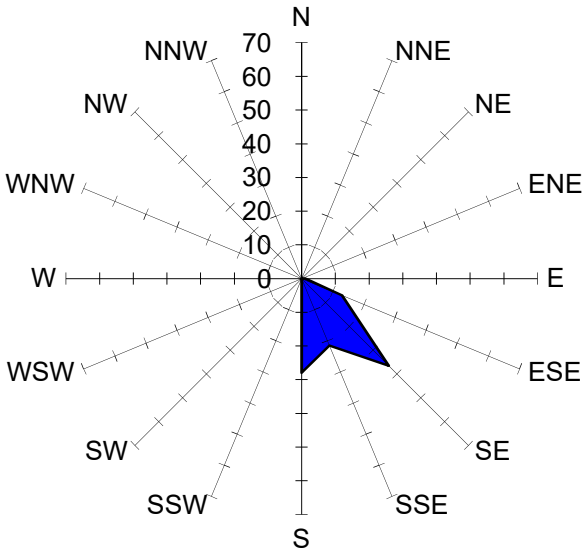
Material movement occurred throughout the assessment. Soil movements adjacent to the South and West of the composting pad also occurred throughout the assessment.

5. RESULTS OF EVALUATION:

5.1 Meteorological Information

Meteorological data recorded at each sample point is summarised in the Meteorological Conditions Table (Page 7). The mean wind direction for the assessment was calculated from 142° (Southeast) with influences recorded from the East, East Southeast, Southeast, South Southeast, and South. (Figure 1, Page 4).

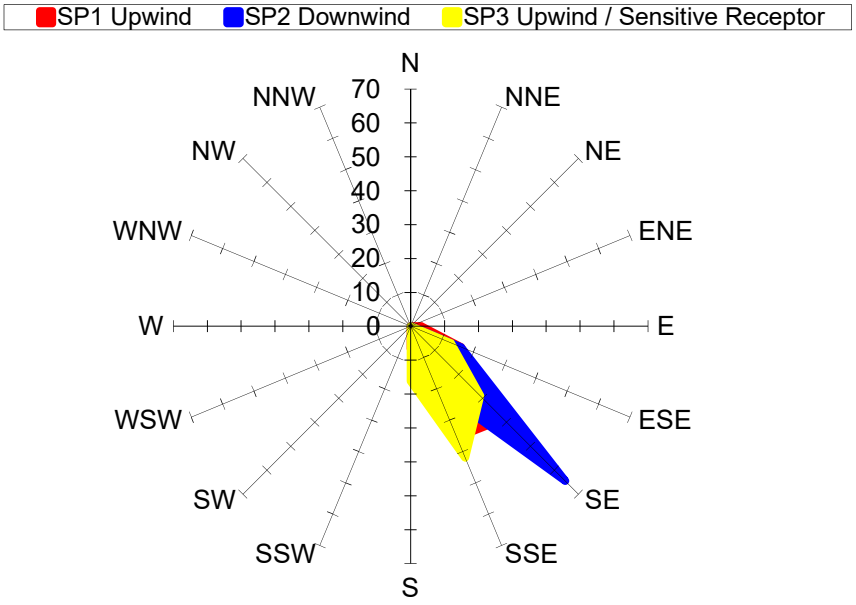
Figure 1: Wind Rose Illustrating Mean Wind Direction from the Southeast.



Note: Units in Percentage Contribution. Wind speed ranged from 0.4-7.3 m/s

Figure 2 illustrates the wind patterns experienced at each sample location during the sampling periods. The mean wind bearings given in the Meteorological Conditions Table have been calculated using the AfOR method described on Page 30 of the Protocol. However, the mean wind bearing at each sample point may not reflect the bearing calculated for the whole of the assessment. It should also be noted that the mean bearing calculated for the assessment may be different than the predominant wind direction. This can be due to the influence of landscape, topography and nearby structures on air movement at the sample location and this should be considered if wind direction patterns at different sampling locations are compared. The calculated mean wind directions are illustrated on the site diagram attached as Appendix 1 (Page 11).

Figure 2: Wind Rose Illustrating Wind Patterns at Sample Locations SP1, SP2 and SP3.



The mean wind direction at SP1 (Upwind) was calculated from 142° (Southeast). Wind influences were recorded from the East, East Southeast, Southeast, South Southeast, and South. Wind speeds were measured within the range 0.8-4.4 m/s with an average wind speed of 2.7 m/s calculated.

The mean wind direction at SP2 (Downwind) was calculated from 134° (Southeast). Wind influences were recorded from the East Southeast, Southeast, South Southeast. Wind speeds were measured within the range 1.5-7.3 m/s with an average wind speed of 4.4 m/s calculated.

The mean wind direction at SP3 (Sensitive Receptor) was calculated from 151° (South Southeast). The wind direction was recorded from the East Southeast, Southeast, South Southeast, and South. Wind speeds were measured within the range 0.4-7.1 m/s with an average wind speed of 3.6 m/s calculated.

5.2 Results for Airborne Micro-organisms:

5.2.1 Current Limits (Based on Open Windrow Composting Systems)

The Environment Agency considers acceptable bioaerosol levels as:

i. Those before the start of the composting process; or
ii. Bioaerosol levels that are no greater than 1,000 cfu/m^3 for total bacteria, 500 cfu/m^3 for the thermophilic fungus *Aspergillus fumigatus* and 300 cfu/m^3 for Gram negative bacteria.

5.2.2 Microbiological Results

The microbiological results obtained for this assessment are given in the Estimated Concentrations of Airborne Micro-organisms Tables (Pages 8-10). The following results discuss the colony forming units per cubic metre of air (cfu/m^3) as calculated average means.

Upwind (SP1)

Sampling was undertaken 50m Southeast of the pad boundary on an area of waste ground. SP1 was upwind of the composting facility and downwind of the AD facility. Mesophilic bacteria were estimated at less than 250 cfu/m^3, *Aspergillus fumigatus* at less than 167 cfu/m^3 and Gram negative bacteria at less than 111 cfu/m^3.

The result for Sample 1A (MB) was considered to be an outlier and has not been included in the calculated mean for mesophilic bacteria.

Downwind (SP2)

Sampling was undertaken 60m Northwest of the composting pad in an open field adjacent to the access road. SP2 was downwind of the composting facility, the AD facility and soil movement operations. Mesophilic bacteria were estimated at 3,111 cfu/m^3, *Aspergillus fumigatus* at less than 167 cfu/m^3 and Gram negative bacteria at 889 cfu/m^3.

Sensitive Receptor (SP3)

Sampling was undertaken 60m Southeast of the pad on an area of waste ground at the boundary with the AD plant. SP3 was upwind of the composting facility and downwind of the AD facility. Mesophilic bacteria and *Aspergillus fumigatus* were each estimated at less than 167 cfu/m^3 and Gram negative bacteria at less than 83 cfu/m^3.

The result for Sample 3A (MB) was considered to be an outlier and has not been included in the calculated mean for mesophilic bacteria.

6. CONCLUSIONS & DISCUSSION:

1. Mean results for mesophilic bacteria, *Aspergillus fumigatus* and Gram negative bacteria were below EA guidance levels upwind of the composting facility and at the AD plant, *i.e.* at SP1 and SP3. The AD plant was upwind of the composting facility on the day of the evaluation.
2. Mean results for mesophilic and Gram negative bacteria were above EA guidance levels downwind of composting operations, *i.e.* at SP2. The mean result for *Aspergillus fumigatus* was below the EA guidance level.
3. SP2 was downwind of the AD facility and soil movement operations adjacent to the composting pad. It is not possible to determine if mesophilic and Gram negative bacteria estimated at SP2 were influenced by other potential bioaerosol sources, *i.e.* AD facility emissions and/ or airborne dusts generated by soil movement operations.
4. The mean wind direction for the evaluation was calculated from the Southeast which placed the AD facility upwind of composting operations and at low risk of exposure to composting bioaerosols.

7. SUMMARY:

An evaluation of composting bioaerosols was undertaken at Crugmore Farm Composting Facility on 10th October 2018 using the AfOR filter method.

Aspergillus fumigatus was estimated below the EA guidance level upwind of the composting facility, downwind and at the AD facility.

Mesophilic and Gram negative bacteria were estimated below EA guidance levels upwind of the composting facility and at the AD facility. Mesophilic and Gram negative bacteria were estimated above EA guidance levels downwind of the composting facility. The downwind sampling location was also downwind of soil movement operations adjacent to the composting pad. It cannot be determined if mesophilic and Gram negative bacteria estimated downwind of the composting facility originated from composting operations or were influenced by suspended dusts generated by soil movement operations.

The mean wind direction for the evaluation was calculated from the Southeast which placed the AD facility upwind of composting operations and at low risk of exposure to composting bioaerosols.

METEOROLOGICAL CONDITIONS								
Site:		Crugmore Farm Composting Facility			**Site Operator:**		MD Recycling Ltd	
Sampling Date:		10th October 2018			**Commissioning Laboratory:**		D&F Associates Ltd	
Date processed at Laboratory:		11th October 2018						
Estimated Mass of Materials:		600 Tonnes			**Type of Material Processed:**		Green Waste	
Location	**Sample Reference Number**	**Bearing of samplers from boundary of operational area** **(° from true north)** **Grid Reference**	**Mean wind direction** **(° from true north)**	**Difference in bearing between location of samplers from boundary/ source and mean direction of wind** **(°)**	**Mean wind speed during sampling** **(m/s)**	**Arithmetic mean of air temperature** **(°C)**	**Arithmetic mean of relative humidity** **(%)**	**Prevailing weather conditions**
Upwind	SP1	320-005 SN 20342 47210	142 (SE)	137-178	2.7 (Range 0.8-4.4)	22.2	63.5	Cloud cover = 1/10 Dry and Bright.
Downwind	SP2	115-140 SN 20194 47364	134 (SE)	0	4.4 (Range 1.5-7.3)	21.3	63.8	Cloud cover = 1/10 Dry and Bright.
Sensitive Receptor	SP3	330-010 SN 20347 47190	151 (SSE)	141-179	3.6 (Range 0.4-7.1)	21.8	64.1	Cloud cover = 1/10 Dry and Bright.

N/A = Not Applicable

ESTIMATED CONCENTRATIONS OF AIRBORNE MICRO-ORGANISMS

Site:	Crugmore Farm Composting Facility	**Site Operator:**	MD Recycling Ltd
Sampling Date:	10th October 2018	**Commissioning Laboratory:**	D&F Associates Ltd
Date processed at Laboratory:	11th October 2018		
Estimated Mass of Materials:	600 Tonnes	**Type of Material Processed:**	Green Waste

Location	Sample Reference Number	Distance From Boundary (Metres)	Sample Volume (Litres)	Microbial Type	Site Activity	Materials Processed	Calculated Concentration of Airborne Micro-organisms (cfu/60 L)	Calculated Concentration of Airborne Micro-organisms (cfu/m^3)	Calculated Mean of Samples (cfu/m^3)	Comments
Upwind **SP1** (14:15:00-14:44:59 hrs)	1A 1B 1C	50	60	MB	Material movement	Green Waste	290* 20 <10	4,833* 333 <167	**<250**	**Mean results for mesophilic bacteria, *Aspergillus fumigatus* and Gram negative bacteria were below EA guidance levels.** Sampling was undertaken 50m Southeast of the pad boundary. SP1 was upwind of the composting facility. The mean wind direction was calculated from 142° (Southeast). **Result considered to be an outlier and has not been included in the calculated mean.*
	1D 1E 1F			AF			<10 <10 <10	<167 <167 <167	**<167**	
	1G 1H 1I			MAC			10 <5 5	167 <83 83	**<111**	

Controls = <10 cfu per filter MB - Mesophilic Bacteria AF - *Aspergillus fumigatus* MAC - Gram Negative Bacteria

N/A - Not Applicable TNTC - Too Numerous To Count UC - Uncountable (smearing)

ESTIMATED CONCENTRATIONS OF AIRBORNE MICRO-ORGANISMS

Site:	Crugmore Farm Composting Facility	**Site Operator:**	MD Recycling Ltd
Sampling Date:	10th October 2018	**Commissioning Laboratory:**	D&F Associates Ltd
Date processed at Laboratory:	11th October 2018		
Estimated Mass of Materials:	600 Tonnes	**Type of Material Processed:**	Green Waste

Location	Sample Reference Number	Distance From Boundary (Metres)	Sample Volume (Litres)	Microbial Type	Site Activity	Materials Processed	Calculated Concentration of Airborne Micro-organisms (cfu/60 L)	Calculated Concentration of Airborne Micro-organisms (cfu/m^3)	Calculated Mean of Samples (cfu/m^3)	Comments
Downwind **SP2** (14:15:00-14:44:59 hrs)	2A 2B 2C	60	60	MB	Material movement	Green Waste	170 150 240	2,833 2,500 4,000	**3,111**	**Mean results for mesophilic and Gram negative bacteria were above EA guidance levels. The mean result for *Aspergillus fumigatus* was below the EA guidance level.** Sampling was undertaken 60m Northwest of the pad boundary in an open field. SP2 was downwind of the composting facility and of soil movements adjacent to the composting pad. The mean wind direction was calculated from 134° (Southeast).
	2D 2E 2F			AF			<10 <10 <10	<167 <167 <167	**<167**	
	2G 2H 2I			MAC			5 120 35	83 2,000 583	**889**	

Controls = <10 cfu per filter MB - Mesophilic Bacteria AF - *Aspergillus fumigatus* MAC - Gram Negative Bacteria

N/A - Not Applicable TNTC - Too Numerous To Count UC - Uncountable

ESTIMATED CONCENTRATIONS OF AIRBORNE MICRO-ORGANISMS

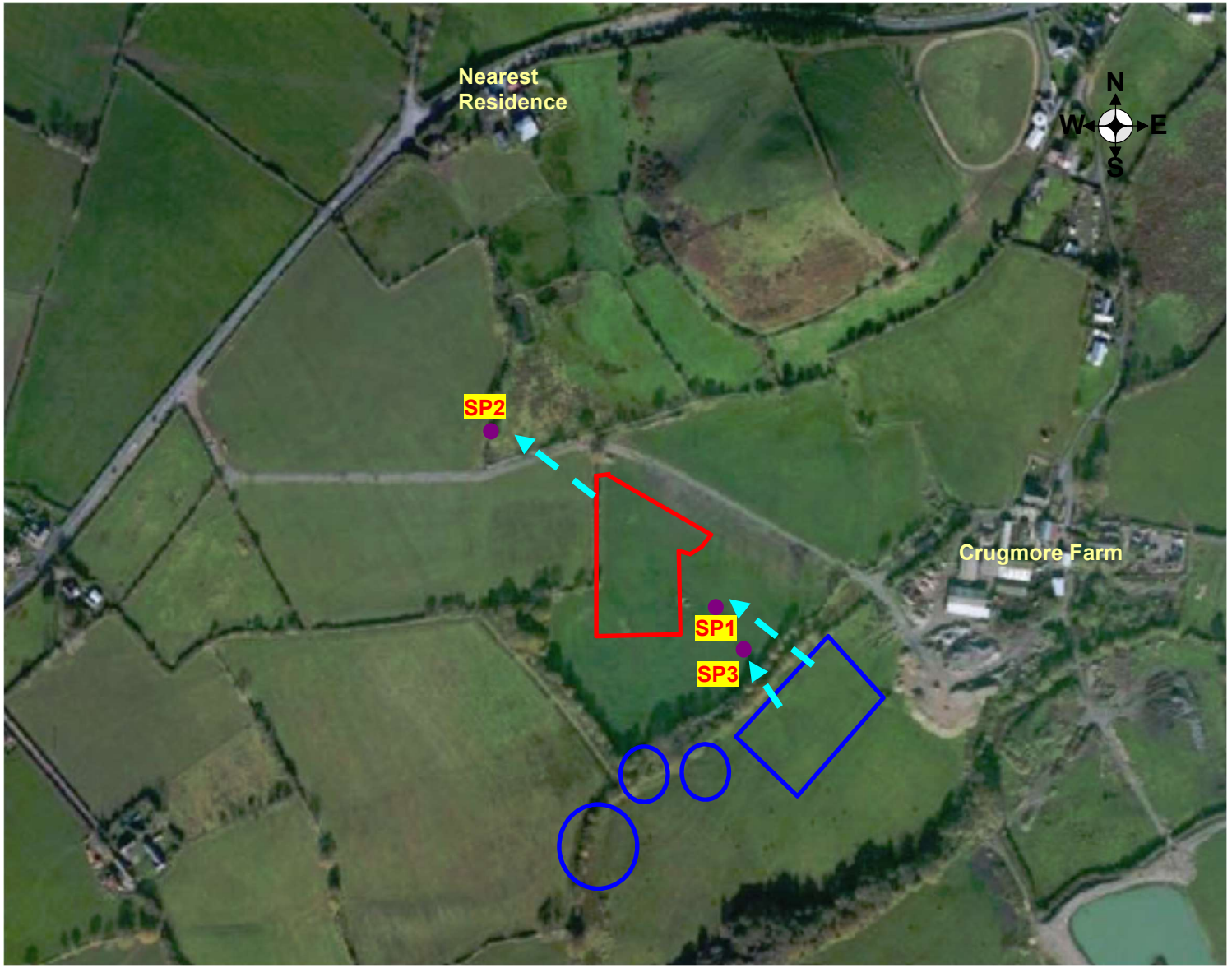
Site:	Crugmore Farm Composting Facility	**Site Operator:**	MD Recycling Ltd
Sampling Date:	10th October 2018	**Commissioning Laboratory:**	D&F Associates Ltd
Date processed at Laboratory:	11th October 2018		
Estimated Mass of Materials:	600 Tonnes	**Type of Material Processed:**	Green Waste

Location	Sample Reference Number	Distance From Boundary (Metres)	Sample Volume (Litres)	Microbial Type	Site Activity	Materials Processed	Calculated Concentration of Airborne Micro-organisms (cfu/60 L)	Calculated Concentration of Airborne Micro-organisms (cfu/m³)	Calculated Mean of Samples (cfu/m³)	Comments
Sensitive Receptor **SP3** (15:04:50-15:34:49 hrs)	3A 3B 3C	60	60	MB	Material Movement	Green Waste	80* 10 <10	1,333* 167 <167	**<167**	**Mean results for mesophilic bacteria, *Aspergillus fumigatus* and Gram negative bacteria were below EA guidance levels.** Sampling was undertaken 60m Northwest of the composting facility at the boundary with the AD plant. SP3 was upwind of operations on the composting pad. The mean wind direction was calculated from 151° (South Southeast). **Result considered to be an outlier and has not been included in the calculated mean.*
	3D 3E 3F			AF			<10 <10 <10	<167 <167 <167	**<167**	
	3G 3H 3I			MAC			<5 <5 <5	<83 <83 <83	**<83**	

Controls = <10 cfu per filter MB - Mesophilic Bacteria AF - *Aspergillus fumigatus* MAC - Gram Negative Bacteria

N/A - Not Applicable TNTC - Too Numerous To Count UC - Uncountable

Appendix 1: Illustration of Sample Points Evaluated at Crugmore Farm Composting Facility on 10th October 2018



Indicates Mean Wind Direction at Sample Point **Indicates Sample Point** **Compost Pad** **AD plant Buildings**

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Appendix 2: Summary of Approved Deviations from the 2009 AFOR Protocol - Filter Method

Deviation/Amendment	Reason for the Deviation/Amendment
5.5. Quality assurance.	All equipment, consumables and microbiological growth media was checked for sterility in the laboratory before use or release. Results and records of QC checks are maintained. Equipment may be swabbed in the field using IMS and additional field controls are collected to assess aseptic handling. Procedures are followed to prevent external contamination. **Impact on the results:** None
6.1. The malt extract medium culturing *Aspergillus fumigatus* should be incubated at 40ºC.	M9 recommends incubating malt extract medium at 45ºC and *Aspergillus fumigatus* was incubated at this temperature. **Impact on the results:** None. *Aspergillus fumigatus* is a thermo-tolerant fungus and incubation at 45ºC can improve its recovery.
6.2. Filters stored in separate resealable bags.	Individual filter membranes were batch sterilised (autoclaved) in stainless cassettes. The batch was checked for sterility before loading the cassettes into individual samplers in the laboratory (5.5) Impact on the results: None.
6.2. Transportation of loaded filters to the laboratory.	Exposed filters were aseptically removed from the filter holder using sterile tweezers on site. The filters were placed into 10ml aliquots of sterile buffered saline water containing Tween 80 to prevent osmosis. Two unexposed filters were also aseptically placed in 10ml aliquots of sterile buffered saline water on site to i) demonstrate aseptic handling, and ii) to create blank controls. **Impact on the results:** Micro-organism quality and recovery is safeguarded during the storage and transportation of exposed filters as long as the filter is not exposed to other contamination sources. Good aseptic handling is critical.
6.2. Initial suspension of the impacted filter into 5ml of sterilised physiological saline solution.	The sterilised physiological saline solution is chemically the same as the buffered saline water used by D&F but the D&F solution is buffered to pH 7.5. The impacted filters were placed into 10mls of solution instead of 5mls. The resulting suspension was plated out directly and this allowed the minimum limit of detection to be reduced from 417 cfu/m^3 (AFOR) to 167 cfu/m^3 (in 60L of air). **Impact on the results:** Improved detection level and reduced calculation errors due to the multiplication factor that is applied.
6.2. Filters shaken at 35ºC to 40ºC for 15-minutes.	The filter suspensions were allowed to stand at room temperature for 10-15 minutes to allow them to equilibrate. This was to reduce the effects of thermal shock on the microbes following transportation at 4ºC. The samples were shaken but they were not heat-treated at 35-40ºC prior to plating out. The total number of viable bacteria in the mesophilic temperature zone (20-45ºC) including the recovery of stressed micro-organisms were therefore assessed following standard incubation at 37ºC. **Impact on the results:** Heating the sample above 37ºC will adversely affect the recovery of micro-organisms that are grown at 37ºC.
6.2. 0.1ml of each respective step is plated on to culture medium with a pipette and spread out by circular movements.	0.5ml of each dilution (including the original suspension) was plated onto culture media and the bacterial suspension was gently spread across the surface of the medium using a sterile L-shaped spreader. This is a traditional microbiological technique used for the cultivation of micro-organisms. The inoculated plates were left for a few minutes to dry prior to incubation. **Impact on the results:** Taking 0.5ml instead of 0.1ml allows the minimum level of detection to be reduced. This is significantly important for *Aspergillus fumigatus* which has a recommended guidance level of 500 cfu/m^3.
11.1. Data calculation for filters.	The results were calculated as described in section 2.5 of this report.
Additional: Enumeration of Gram negative bacteria	In addition to mesophilic bacteria and *Aspergillus fumigatus*, Gram negative bacteria were assessed.