



Abatement Improvement Plan

ENVAR COMPOSTING –VERSION 1
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1 Introduction

1.1 Current Abatement

The Envar Cambridge facility operates a contained In-Vessel Composting (IVC) system in which process air is extracted from the composting tunnels and associated handling areas and directed to an odour abatement system prior to release to atmosphere.

The current abatement system consists of:

- A leachate-based wet scrubber, utilising process leachate as the scrubbing medium
- A biofilter, providing biological treatment of residual odorous compounds prior to atmospheric discharge

This system has been designed to manage emissions associated with the composting of Category 3 food waste and green waste (CAT3), which represents the current permitted feedstock at the facility.

Operational monitoring and site experience demonstrate that the existing abatement system performs effectively under normal operating conditions associated with composting activities. The combination of wet scrubbing and biological filtration provides effective removal of odorous compounds, and ammonia associated with conventional biowaste composting.

The tunnel ventilation system is designed to maintain controlled extraction from the composting tunnels and associated processing areas. Under normal operation the system is capable of approximately 2.5 to 3.5 air changes per hour within the building depending on operational tunnel parameters.

This ventilation regime ensures:

- Effective capture of process emissions at source
- Maintenance of negative pressure within the building envelope
- Consistent delivery of extracted air to the abatement system

The existing fans and air handling infrastructure are sized to maintain this airflow regime, and this ventilation rate will be maintained as part of the proposed abatement upgrade.

The current abatement system works on the following air flows shown in figure 1 below:

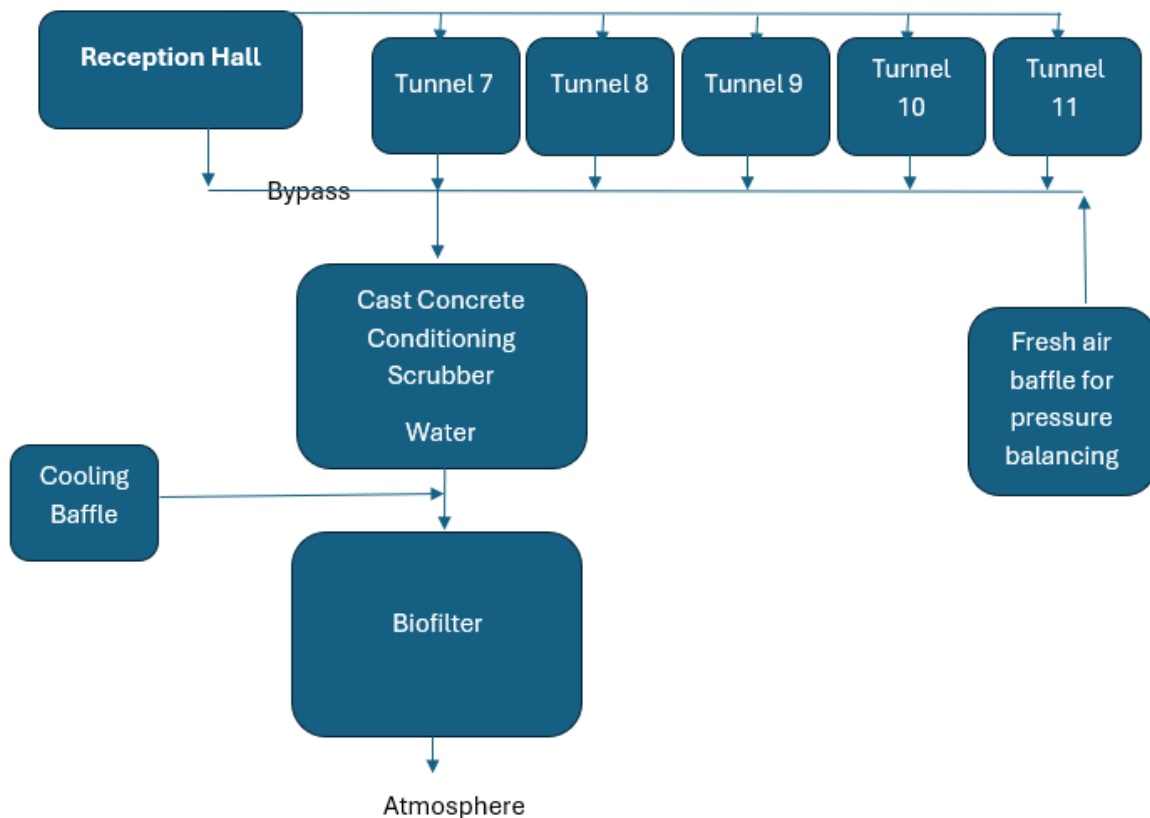


Figure 1 - current air handling

1.2 Sewage Biodrying Trial

As part of the permit variation application to allow the Biodrying of sewage sludge within the IVC tunnels, a controlled operational trial was undertaken using one tunnel.

The objectives of the trial were to:

- Assess the technical feasibility of Biodrying sewage sludge within the existing tunnel infrastructure
- Characterise the emissions generated during the drying process
- Generate operational data to inform the design and specification of the required odour abatement system

The trial was undertaken using the existing ventilation and abatement infrastructure, with monitoring undertaken to evaluate:

- Odour emissions
- Volatile Organic Compounds (VOCs)
- Ammonia concentrations
- General operational performance of the tunnels

The trial confirmed that the tunnels can operate effectively as bio-drying reactors under controlled conditions.

However, the emissions generated during the drying process differ from those typically associated with conventional composting feedstocks, the main difference is in the level of odour and ammonia generated during peak composting



Figure 2 - aerated material biodrying during trial

1.3 Results

Monitoring data obtained during the trial demonstrated that emissions generated during the peak bio-drying phase of sewage sludge resulted in elevated concentrations of certain compounds when compared with emissions typically associated with the composting of Category 3 food and green waste.

In particular:

- Ammonia concentrations were higher during peak periods of activity
- Odour concentrations generated within the tunnels were greater than those typically observed for conventional composting feedstocks
- H₂S was produced close to the limit of detection on one sample. All other samples showed no H₂S.

Results for these will be provided as part of the odour modelling being undertaken.

Despite these increased emission loads, the existing leachate scrubber and biofilter system successfully abated emissions to within the site's current permitted limits.

This demonstrates that the current abatement system retains a degree of treatment capability for emissions associated with the bio-drying process.

However, the business considers that reliance on the existing abatement configuration alone would not represent the most robust long-term solution when processing sewage sludge over the long term and proposes improvements. Envar propose these improvements are designed with the help of odour experts for this type of activity and implemented within a 12-month period post issue and prior to working at full capacity.

Sewage sludge has the potential to generate more complex and higher intensity odour profiles than those associated with typical composting feedstocks. For this reason, Envar Composting Ltd has elected to upgrade the abatement system associated with tunnels G7–G11.

This decision has also been informed by feedback from the Environment Agency during the permit determination process, which indicated that enhanced emission limits are expected to apply to the process, including:

- **Volatile Organic Compounds (VOCs):** 40 mg/m³
- **Odour concentration:** 1,000 ouE/m³
- **Ammonia:** existing emission limits to be maintained

The proposed improvements are intended to ensure that emissions can be consistently controlled within these limits and to provide a robust long-term odour management solution.

Table 1 - results overview

Material / Feedstock Condition	Chemical Measured	Minimum Reading (ppm)	Maximum Reading (ppm)	Average Reading (ppm)
3 Tunnels CAT3 + 1 Tunnel Sewage	Ammonia (NH ₃)	0	120	23.0
3 Tunnels CAT3 + 1 Tunnel Sewage	Hydrogen Sulphide (H ₂ S)	0	0.1	0.004
Cat 3 Compost Feedstock	Ammonia (NH ₃)	25	60	42.5
Sewage Mix (Bio-Drying Trial)	Ammonia (NH ₃)	15	500	207.5
Sewage Mix (Bio-Drying Trial)	Hydrogen Sulphide (H ₂ S)	0	0.2	0.017

2 Improvement Plan

2.1 Proposal

The proposed abatement upgrade will involve the installation of a multi-stage odour treatment system designed specifically to manage emissions associated with sewage sludge bio-drying.

The upgraded system will treat process air extracted from tunnels G7–G11 and the proposal is currently (subject to change) consisting of the following treatment stages:

1. Fresh water scrubber (conversion of the existing leachate scrubber)
2. Acid scrubber
3. Dehumidification stage
4. Activated carbon polishing filter
5. Point source stack emission

This multi-stage treatment approach provides progressive removal of contaminants through complementary treatment technologies.

2.1.1 Fresh Water Scrubber

The existing leachate scrubber will be converted to operate as a freshwater scrubber.

This stage will:

- Remove water soluble gases and particulates
- Provide initial reduction of VOC loading
- Reduce temperature and particulate burden entering downstream equipment

Using fresh water rather than process leachate reduces operational complexity and prevents recirculation of contaminants within the system. This step is physically in existence, easy to convert and uses free resource available on site. It reduces compounds required to be treated before the air stream is further treated by expensive (both in terms of environmental and monetary cost) treatment stages. This is designed to reduce the resource use and the subsequent impact on the environment and the OPEX associated with running the abatement systems.

2.1.2 Acid Scrubber

Following the freshwater scrubber, the air stream will pass through an acid scrubber.

This stage is primarily designed to remove ammonia, which can be present in emissions associated with sewage sludge processing.

The acid scrubber operates by converting gaseous ammonia into soluble ammonium salts through controlled acid dosing.

2.1.3 Dehumidification Stage

Prior to carbon filtration, the air stream will pass through a dehumidification stage.

This stage reduces moisture content in the air stream to ensure that the activated carbon operates at optimal efficiency.

2.1.4 Activated Carbon Polishing Unit

The final treatment stage will consist of an activated carbon polishing filter, designed to remove residual VOCs and trace odorous compounds that remain after the wet scrubbing stages.

This stage provides a high-efficiency final treatment barrier prior to atmospheric release.

2.1.5 Emission Point

Following treatment, the cleaned air stream will be discharged via a point source emission designed to provide appropriate atmospheric dispersion and monitoring ability.

The precise location has been identified indicatively within site plans but will be finalised during the detailed engineering design phase.

The upgraded abatement system will be designed to treat the full airflow extracted from tunnels G7–G11, whilst maintaining the existing building ventilation regime of approximately 2.5–3.5 air changes per hour.

Fans and air handling infrastructure will therefore be designed to:

- Maintain the required extraction rate from the tunnels and processing areas
- Ensure consistent airflow through each stage of the abatement system
- Deliver treated air to the emission stack while maintaining the required emission standards

It should also be noted that the smaller tunnel group G3–G6 will continue to operate under the existing abatement configuration consisting of:

- A leachate scrubber, and
- A biofilter

These tunnels will continue to process Category 3 food and green waste feedstocks, for which the current abatement system has demonstrated effective performance. The movement of air from the bio drying sections of the building to the IVC part shall be prevented by segregation of the buildings

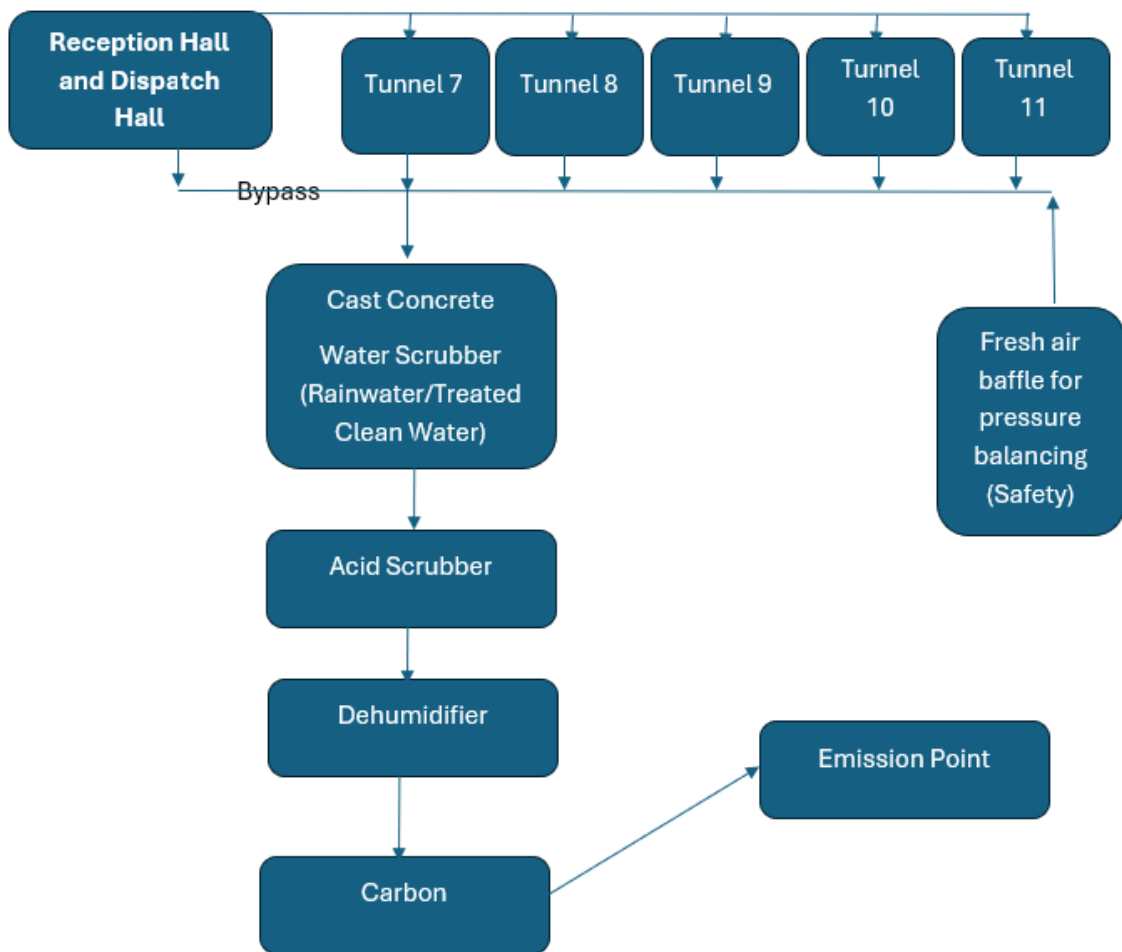


Figure 3 - proposal at current

2.2 Consultancy

To support the development of the abatement upgrade, Envar Composting Ltd has engaged a specialist consultancy with experience in the design and implementation of odour control and air treatment systems within the waste and wastewater sectors.

The specialist has extensive experience in:

- Odour abatement system design
- Scrubber technologies
- Carbon filtration systems
- Waste sector air treatment applications

Their involvement ensures that the abatement system will be designed in accordance with industry best practice and will be capable of achieving the emission limits specified by the Environment Agency.

2.3 Design Details & Proposed Submission

At this stage, the abatement system design is at the conceptual engineering stage.

Detailed engineering design will be undertaken in collaboration with the appointed specialist consultant to ensure that the system is correctly specified for the expected airflows and contaminant loads.

An updated waste gas characterisation inventory is currently being established. In a small study, gas samples will be taken for GCMS analysis to characterise the profile of VOCs emitted at various stages during the heating of sewage sludge using a scientific oven. The analytical results will be evaluated against the range of VOC profiles documented in the existing literature on sewage sludge, a summary of which is provided in Table 1, Appendix A.

Sulphur-containing VOCs are consistently identified in the literature (Appendix A) as the dominant drivers of odour from sewage sludge, and they form the main priority for control strategies. The most frequently cited high-impact odorants include hydrogen sulphide, methyl mercaptan, dimethyl disulfide, dimethyl sulphide, ammonia, and carbon disulfide. Alongside these odorants, several compounds are highlighted for their potential health relevance, particularly benzene, toluene, chlorobenzene, and dichloromethane.

The detailed design phase will include:

- Final system sizing
- Airflow calculations
- Scrubber design parameters
- Carbon filtration capacity
- Emission point height and dispersion considerations
- Monitoring and sampling point design

Once the detailed design has been completed, the relevant technical information will be submitted to the Environment Agency where required as part of the permit variation implementation process.

2.4 BAT Justification for the Selected Abatement Technology

The proposed abatement configuration has been selected based on industry experience, operational trial data and consultation with specialist odour abatement consultants.

The combination of wet scrubbing followed by carbon polishing is widely recognised as Best Available Technique (BAT) for the treatment of odorous emissions generated from sewage sludge processing and wastewater treatment operations.

The selected system provides several advantages:

- Effective removal of ammonia and water-soluble compounds through wet scrubbing
- Progressive removal of odorous compounds across multiple treatment stages
- High efficiency removal of residual VOCs through activated carbon filtration
- Reliable and robust performance under variable emission conditions

Alternative abatement technologies such as thermal oxidation, plasma treatment or regenerative carbon systems were considered unnecessary given the emission profile

associated with the proposed process and the airflow volumes involved however further design and review shall consider the final system.

These technologies typically involve significantly higher energy consumption and operational complexity and are generally applied in situations involving very high VOC concentrations or industrial solvent emissions.

The selected multi-stage wet scrubbing and carbon filtration approach therefore represents a proportionate and effective BAT solution, capable of achieving the required emission limits while maintaining operational efficiency and minimising environmental impact.

This proposal is subject to design review and written to explain the operator's intentions rather than final design which will be submitted at a later date.

3 Implementation Timeline

The abatement system upgrade will be delivered through a staged programme of design, procurement, installation and commissioning. The anticipated implementation period for the project is approximately 12 months from the commencement of detailed engineering design.

This timeframe reflects the need to undertake appropriate engineering design, procure specialist equipment, integrate the system with the existing infrastructure and ensure that the upgraded abatement plant is fully commissioned and operating effectively.

The indicative programme is outlined below

3.1 Stage 1 – Detailed Engineering Design

During this phase the appointed consultant and engineering partners will undertake detailed design of the proposed abatement system.

Key activities will include:

- Finalisation of airflow and ventilation calculations
- Detailed design of the freshwater scrubber conversion
- Specification and sizing of the acid scrubber system
- Design of the dehumidification stage
- Specification and sizing of the activated carbon polishing units
- Preliminary design and dispersion considerations
- Preparation of engineering drawings and process flow diagrams

Outputs from this phase will include detailed design documents which may be submitted to the Environment Agency where required.

3.2 Stage 2 – Procurement of Equipment

Following completion of the engineering design phase, procurement of the required equipment will take place.

This stage will include procurement of:

- scrubber components and vessels
- carbon filtration units and media
- dehumidification equipment
- fans and ducting modifications where required
- monitoring and control systems; and
- engagement with GiCOM to tie into existing SCADA

Lead times for specialist odour abatement equipment can be several months, and this period allows for manufacture and delivery of the required components.

3.3 Stage 3 – Installation and Integration

Once the required equipment has been delivered to site, installation works will commence.

This phase will include installation of:

- the freshwater scrubber conversion system
- the acid scrubber
- dehumidification equipment
- the activated carbon polishing unit
- the emission stack and associated ducting; and
- Integration with the existing air handling infrastructure

Installation works will be undertaken in a manner that minimises disruption to ongoing site operations where practicable.

3.4 Stage 4 – Commissioning and Performance Verification

Following installation, the abatement system will undergo commissioning and performance verification.

This stage will include:

- System commissioning and operational testing
- Adjustment and optimisation of airflow and treatment parameters
- Verification of system performance under operational conditions
- Confirmation that the system can achieve the required emission limits

Where required, monitoring and testing shall be undertaken to verify performance of the abatement system.

3.5 Completion

At the conclusion of the commissioning phase, the upgraded abatement system will be fully operational and capable of treating emissions from the sewage sludge bio-drying process.

The improvement programme therefore represents a proactive enhancement to the site's odour management infrastructure, ensuring that emissions associated with the new process can be effectively controlled in accordance with regulatory requirements and best available techniques.

Appendix A

Table 1: A review of UK/ EU evidence on sewage-sludge and sludge-composting compounds

Compound	Type	Role in sewage-sludge / composting odour (UK/EU evidence)	Key UK/EU evidence context	References
Ammonia (NH ₃)	Volatile inorganic (N)	Major contributor to sludge odour; associated with sludge handling, storage and land-spreading.	Highlighted as a principal malodour gas from WWTPs and sludge management in EU/UK guidance and reviews.	SEEG CoP 2005, Scottish Govt 2021; Czarnota et al 2023; Gębicki et al. 2023; UK EA odour guidance 2025
Hydrogen sulphide (H ₂ S)	Volatile inorganic (S)	Primary “rotten egg” odorant; very low threshold; often used operationally as an odour surrogate.	Consistently identified as key WWTP/sludge odorant in UK/European guidance and technical reviews.	SEEG CoP 2005, Scottish Govt 2021; Czarnota et al 2023; Gębicki et al. 2023; UK EA odour guidance 2025
Methyl mercaptan (methanethiol, CH ₃ SH)	Reduced sulphur VOC	Extremely odorous; characteristic sewage / cabbage / garlic note; important under anaerobic or low-redox conditions.	Reported as a principal malodour VOC in sludge and WWTP emissions in European studies; grouped with H ₂ S/DMDS.	González et al. 2019; Scottish Govt 2021; Czarnota et al 2023; Gębicki et al. 2023
Dimethyl sulphide (DMS, C ₂ H ₆ S)	Reduced sulphur VOC	Strong contributor to sludge and sludge-compost odour; emitted during anaerobic degradation.	Identified among the dominant sulphur VOCs from sludge and composting in EU work.	González et al. 2019; Scottish Govt 2021; Czarnota et al 2023; Gębicki et al. 2023

Dimethyl disulphide (DMDS, C ₂ H ₆ S ₂)	Reduced sulphur VOC	Very odorous; tracks anaerobic activity and process stage; important in sludge-compost odour fields.	Reported as a key odour VOC in EU sludge-compost studies; often grouped with DMS as principal sulphur odorants.	Zhu et al 2016; González et al. 2019; Scottish Govt 2021; Haider et al. 2022; Gębicki et al. 2023
Dimethyl trisulphide (DMTS)	Reduced sulphur VOC	Extremely low odour threshold; “cabbage / decayed vegetable” note; can dominate perceived odour even at low concentrations.	Found as a major sulphur odorant in EU sludge / manure / compost odour work.	González et al. 2019; Senanu et al (2021); Czarnota et al 2023; Gębicki et al. 2023
Carbon disulphide (CS ₂)	Sulphur-containing inorganic/organic	Odorous and toxic; contributes to sulphurous character in some sludge odour plumes.	Detected in sludge/compost odour studies; often considered more for health than for primary odour impact.	Zhu et al 2016; Czarnota et al 2023; Gębicki et al. 2023
Volatile fatty acids (VFAs: acetic, propionic, butyric, isobutyric, valeric, isovaleric acids)	Short-chain organic acids	Critical odorants for sludge and compost; “rancid / vomit / sweat / manure” notes; often co-dominate with sulphur compounds at compost plants.	EU sludge-compost studies identify VFAs plus sulphur VOCs and indolic compounds as main odour drivers.	González et al. 2019; Senanu et al (2021); Czarnota et al 2023; Gębicki et al. 2023
Trimethylamine and other low amines	Volatile amines	Strong fishy / septic odours; important especially in undigested and thickened sludge, screenings, and some compost feedstocks.	Reported at high levels in anaerobically stabilised sludge and WWTP odour studies in Europe.	González et al. 2019; Czarnota et al 2023; Gębicki et al. 2023

Indole	Nitrogenous aromatic	Fecal/manure-like odour; significant contributor in faecal sludge, biosolids and some composting systems.	Identified as a key odorant from sludge and faecal matrices in EU odour control studies.	González et al. 2019; Senanu et al (2021); Haider et al. 2022; Czarnota et al 2023; Gębicki et al. 2023
Skatole (3-methylindole)	Nitrogenous aromatic	Extremely strong fecal odour; important in sludge odour and as secondary organic aerosol (SOA) precursor during landspreading periods.	European chamber work on undigested sludge shows high skatole emissions and strong odour/SOA relevance.	González et al. 2019; Haider et al. 2022; Czarnota et al 2023; Gębicki et al. 2023
Other nitrogenous VOCs (e.g. thiazoles, heterocyclic N-S compounds)	N/S-containing VOCs	Add “burnt / rubber / faecal” tones; can be prominent in undigested sludge odour spectra.	Reported as notable contributors in European PTR-MS sludge studies.	González et al. 2019; Haider et al. 2022; Czarnota et al 2023
Terpenes (e.g. limonene, isoprene, other monoterpenes)	Biogenic / consumer-product VOCs	Citrus / pine / resinous odours; often abundant by mass but secondary for nuisance; may be prominent where green waste or fragranced products are present.	Found in EU sludge and composting facilities; significant mass fraction but limited odour dominance.	Kotowska & Isidorov 2012; González et al. 2019; Czarnota et al 2023; Gębicki et al. 2023
Aromatics (BTEX: benzene, toluene, ethylbenzene, xylenes; plus styrene, trimethylbenzenes)	Aromatic hydrocarbons	Common in sludge/WWTP VOC profiles; more important for toxicity and regulatory air-quality considerations than for odour per se.	Frequently detected at WWTPs and sludge plants; treated as air-quality pollutants rather than main odorants.	Kotowska & Isidorov 2012; González et al. 2019; Haider et al. 2022; Gębicki et al. 2023; Czarnota et al 2023; UK EA odour guidance 2025

Oxygenated VOCs (OVOCs: acetone, 2-butanone, aldehydes, alcohols)	Oxygenated VOCs	Often dominate total VOC mass, especially from drier sludge; some have noticeable solvent/fruity odours but usually secondary to sulphur/VFAs.	EU sludge VOC studies show OVOCs as dominant mass fraction, with moderate odour relevance.	González et al. 2019; Haider et al. 2022; Czarnota et al 2023; Gębicki et al. 2023
Light alkanes and alkenes (C ₃ –C ₁₂)	Hydrocarbons	Common in sludge VOC profiles; contribute to overall VOC load and reactivity; limited direct odour impact compared with sulphur/VFAs/amines.	Detected in EU sludge and compost VOC work; typically minor in odour assessments.	Kotowska & Isidorov 2012; González et al. 2019; Haider et al. 2022; Czarnota et al 2023; Gębicki et al. 2023
Halogenated VOCs (dichloromethane, chloroform, carbon tetrachloride, chlorobenzene, etc.)	Halogenated organics	Generally low odour significance but important as hazardous and regulated air pollutants.	Reported in sludge/landfill VOC studies; considered mainly as toxic pollutants in EU context.	Kotowska & Isidorov 2012; Zhu et al 2016; Scottish Govt 2021 (risk-assessment report); Czarnota et al 2023; Gębicki et al. 2023

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