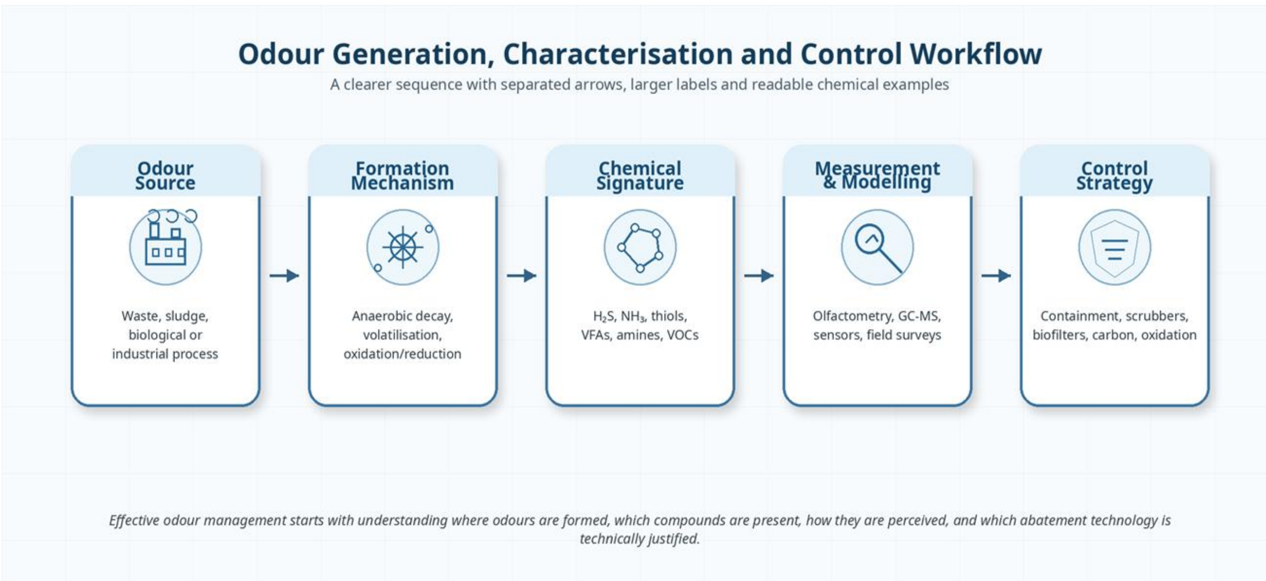
Understanding Industrial Odours

Origin, Chemical Composition, Odour Thresholds, Human Detection, Measurement Techniques, Masking Agents, Regulation and Practical Case Studies



Odour management is not only an air-treatment problem. It is a process-control, containment, sampling, sensory-science and community-impact problem. The same measured concentration can be acceptable or unacceptable depending on frequency, intensity, duration, offensiveness and receptor sensitivity.

Content

1. Executive summary

Odours from municipal solid waste (MSW), composting, anaerobic digestion, wastewater sludge, rendering, food processing and chemical operations are usually caused by complex mixtures of trace gases rather than by one single pollutant. These mixtures often include reduced sulphur compounds, ammonia, amines, volatile fatty acids, aldehydes, ketones, phenols, indoles, terpenes, solvents and other volatile organic compounds (VOCs). Many of these substances are detectable by humans at concentrations in the ppb or even ppt range, well below occupational exposure limits and often below the detection limits of low-cost field sensors.

The practical consequence is important: an installation can be compliant with occupational health limits and still generate severe off-site odour nuisance. Conversely, a low chemical concentration may dominate public complaints if the compound has an extremely low odor threshold, an unpleasant hedonic tone, and occurs under weather conditions that carry the plume toward sensitive receptors.

Effective odour control therefore requires four linked actions: identify the source, understand the chemistry, quantify the odour impact, and verify the abatement performance. The most robust assessments combine dynamic olfactometry, chemical speciation, field inspections, meteorological interpretation, dispersion modelling and operational records such as complaints, maintenance events, process upsets and feedstock changes.

Masking agents and neutralisers may have a role in emergency response, perimeter control or temporary mitigation. However, they should not be considered a substitute for containment, negative-pressure extraction, process optimisation and engineered abatement systems such as scrubbers, biofilters, biotrickling filters, activated carbon or thermal oxidation. Their efficacy must be demonstrated under site-specific conditions and not only by supplier claims.

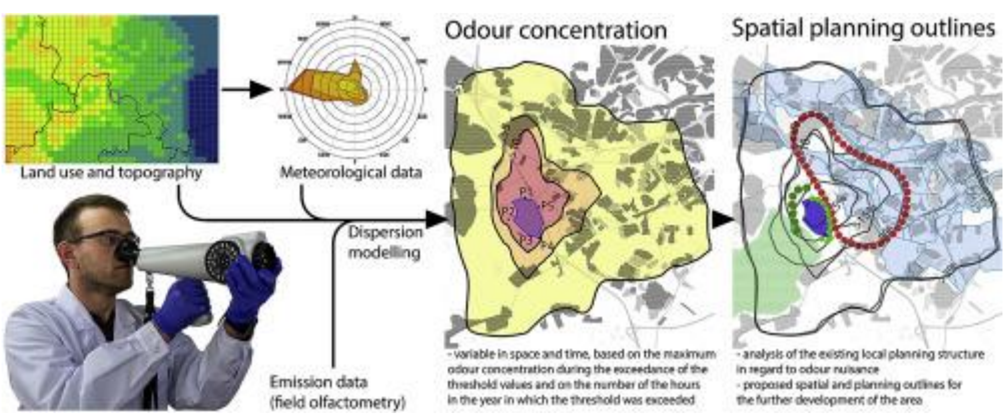


Fig 1 Odor nuisance evaluation

2. Why odors are generated: the technical origin of nuisance

Industrial odors arise when volatile compounds are formed or released faster than they are contained, diluted, oxidised, absorbed, biologically degraded or dispersed. In waste and sludge applications, odour formation is typically driven by biological decomposition, while in chemical and food industries it may also be driven by solvent evaporation, thermal degradation, oxidation of fats, open tanks, fugitive leaks or batch transfers.

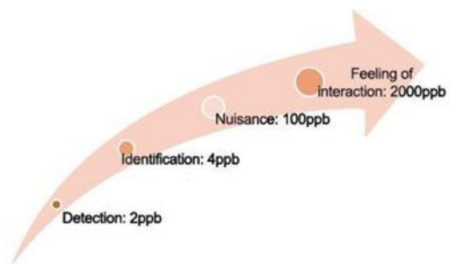


Fig 2 Range of odor concentration and nuisance

2.1 Main formation mechanisms

Mechanism	How the odour is formed	Typical locations
Anaerobic decomposition	Organic matter is degraded in oxygen-deficient zones. Sulphate reduction and protein degradation generate H2S, mercaptans, sulphides, amines and volatile fatty acids.	Waste reception pits, sludge storage, poorly aerated compost piles, leachate tanks, anaerobic pockets in digestate.
Protein and amino acid degradation	Sulphur amino acids generate reduced sulphur compounds; nitrogenous amino acids form ammonia and amines; tryptophan degradation may form indole and skatole.	Sludge, biosolids, rendering, food waste, meat and fish processing.
Volatilisation from liquid surfaces	Compounds transfer from liquid or wet solids to air depending on pH, temperature, Henry constant, turbulence and surface area.	Equalisation tanks, thickeners, centrifuges, dissolved air flotation, digestate tanks.
Thermal oxidation or cooking reactions	Heat can release aldehydes, ketones, fatty acids, amines and sulphur compounds. Thermal treatment may also destroy odour if used as an oxidiser.	Rendering cookers, dryers, sludge dryers, fishmeal plants, frying and food processing.
Solvent and monomer emissions	Low-threshold VOCs are released during storage, transfer, reaction, coating, polymerisation or cleaning.	Chemical plants, resins, plastics, paint, adhesives, acrylates, styrene, amines.
Incomplete biological stabilisation	If compost, digestate or biosolids are not stabilised, microbial activity continues after storage or transport, causing renewed odour.	Compost curing, sludge cake storage, land application, digestate drying.

2.2 Process variables that increase odor risk.

- **Long residence time:** Odour increases when wet biodegradable materials remain in storage, pits, hoppers or conveyors without aeration or extraction.
- **Low oxygen and low redox potential:** Anaerobic zones favour sulphate reduction, fermentation and production of sulphides and volatile fatty acids.
- **Temperature:** Higher temperatures increase volatilisation and biological reaction rates; warm summer conditions often intensify complaints.
- **pH:** Ammonia volatilisation increases at high pH; H_2S volatilisation is favoured under acidic to neutral conditions.
- **Turbulence and surface renewal:** Pumping, mixing, centrifugation and aeration can strip dissolved odourants into the headspace.
- **Feedstock variability:** Food waste, animal by-products, sulphate-rich waste, fat separators and protein-rich streams often cause abrupt changes in odour profile.
- **Poor containment:** Open doors, poorly sealed buildings, uncovered tanks and uncontrolled airflows convert a local source into a community impact.

3. Source-specific odor profiles by industrial activity

Each industrial source has a characteristic odour fingerprint. The table below summarises the most relevant sources mentioned in Fig 3, the dominant formation mechanisms and the compounds typically responsible for nuisance.

Fig.3 Odor wheel

3.1 Table of origin and typical odorants

Source	Main origin	Typical odourants	Perceived character
MSW reception and transfer stations	Fresh waste decomposition, ruptured bags, leachate, food residues, intermittent doors and vehicle traffic.	VFA, aldehydes, ketones, terpenes, NH_3, H_2S, mercaptans, DMS/DMDS, solvents from household waste.	Sour, rotten, garbage-like, solvent-like, intermittent peaks.
Composting of organic waste	Active aerobic degradation; anaerobic pockets when oxygen, porosity or moisture are poorly controlled; curing phase instability.	NH_3, VFA, terpenes, alcohols, aldehydes, sulphides, geosmin, organic acids.	Ammoniacal, earthy, sour, putrid under anaerobic conditions.
Anaerobic digestion of food waste	Reception hall, pre-treatment, pasteurisation, digestate storage, biogas leaks, condensate and H_2S handling.	H_2S, mercaptans, DMS, NH_3, amines, VFA, siloxanes and VOC traces.	Rotten egg, cabbage-like, fishy, sour, intermittent during unloading.
Municipal WWTP and sewer headworks	Sulfate reduction in sewers, turbulence at inlet works, grit removal, primary tanks and sludge treatment.	H_2S, methyl mercaptan, DMS, DMDS, NH_3, amines, VFA.	Rotten egg, sewage, sulphurous, musty.
Sludge thickening, dewatering and biosolids	Anaerobic degradation of proteins and residual organics; centrifuge aerosolisation; cake storage.	H_2S, mercaptans, amines, VFA, indole, skatole, NH_3.	Faecal, putrid, ammoniacal, rancid.
Rendering, slaughterhouses and animal by-products	Cooking, sterilisation, fat oxidation, protein hydrolysis, wastewater pre-treatment and non-condensable gases.	Amines, NH_3, H_2S, mercaptans, aldehydes, ketones, VFA, trimethylamine.	Meaty, fatty, rancid, fishy, sulphurous.
Food and beverage processing	Fermentation, yeast activity, wastewater equalisation, fat traps, thermal processing.	Ethanol, acetaldehyde, acetic acid, esters, DMS, VFA, aldehydes.	Fermented, sour, yeasty, fruity or rancid.
Chemical, resin, coating and solvent handling	Batch charging, tank vents, fugitive emissions, cleaning, distillation, polymerisation.	Acrylates, styrene, amines, solvents, aldehydes, ketones, sulphur compounds depending on chemistry.	Solvent-like, sharp, sweet, pungent, irritating.
Landfills, leachate and sludge disposal	Anaerobic waste decomposition, landfill gas migration, leachate aeration or storage, uncovered sludge.	H_2S, mercaptans, VOCs, NH_3, VFA, methane-associated trace compounds.	Landfill gas, sulphurous, leachate-like, rotten.

A key point for design is that the same plant may hold several chemically different odour streams. For example, a composting facility may have ammonia-rich air from active composting, sour reduced-sulphur air from anaerobic pockets, terpene-rich air from green waste, and VOC-rich air from waste reception. Treating all streams with a single technology may be technically possible but is not always the best design. Segregating streams by concentration, humidity, temperature and compound class often produces a more reliable and lower-OPEX system.

4. Chemical composition and odor thresholds

Odor threshold is the concentration at which a defined percentage of a panel can detect an odour under specified test conditions. It is not a fixed universal constant: it varies with test method, panel selection, humidity, background air, mixture interactions and individual sensitivity. Detection threshold, recognition threshold and nuisance threshold are different concepts. The detection threshold is the first perception of an odour; recognition threshold is the point where the character is identifiable; nuisance depends on frequency, intensity, duration, offensiveness and context.

4.1 Typical compounds and approximate detection thresholds

The following table uses mainly the Nagata triangle odour bag dataset for pure compounds, complemented with regulatory toxicology sources where useful. Values should be used for screening and prioritisation, not as universal legal limits.

Compound	Formula	Class	Approx. odour threshold	Odour character	Typical sources
Hydrogen sulphide	H2S	Reduced sulphur	0.00041 ppm literature ranges can be higher	Rotten egg	Sewers, sludge, digesters, leachate, anaerobic pockets
Methyl mercaptan / methanethiol	CH4S	Thiols / mercaptans	0.00007 ppm; other references report even lower values	Rotten cabbage, faecal, sulphurous	Sludge, protein degradation, landfills, rendering
Ethyl mercaptan	C2H6S	Thiols / mercaptans	0.0000087 ppm	Skunky, garlic, sulphurous	Natural-gas odorant, chemical processes, protein waste
Dimethyl sulphide	C2H6S	Sulphides	0.003 ppm	Cabbage, marine, sulphurous	Composting, wastewater, food processing
Dimethyl disulphide	C2H6S2	Disulphides	0.0022 ppm	Cabbage, onion, sulphurous	Waste, rendering, composting, WWTP
Ammonia	NH3	Inorganic nitrogen	1.5 ppm ; other studies may use lower/higher values	Ammoniacal, pungent	Composting, sludge drying, protein waste, manure

Compound	Formula	Class	Approx. odour threshold	Odour character	Typical sources
Trimethylamine	C_3H_9N	Amines	0.000032 ppm	Fishy	Fish processing, rendering, protein hydrolysis, sludge
n-Butyric acid	$C_4H_8O_2$	Volatile fatty acid	0.00019 ppm	Rancid butter, vomit-like	Food waste, anaerobic zones, sludge cake
n-Valeric acid	$C_5H_{10}O_2$	Volatile fatty acid	0.000037 ppm	Sweaty, rancid	Compost, sludge, fat residues
Isovaleric acid	$C_5H_{10}O_2$	Volatile fatty acid	0.000078 ppm	Sweaty, cheese-like	Protein degradation, sludge, food waste
Indole	C_8H_7N	Nitrogen heterocycle	0.0003 ppm	Faecal at high concentration, floral at low concentration	Sewage, sludge, animal waste
Skatole	C_9H_9N	Nitrogen heterocycle	0.0000056 ppm	Faecal	Sewage sludge, manure, animal by-products
Acetaldehyde	C_2H_4O	Aldehyde	0.0015 ppm	Sharp, fruity, pungent	Fermentation, food and beverage, oxidation
Styrene	C_8H_8	Aromatic VOC	0.035 ppm	Sweet, solvent-like	Resins, plastics, chemical industry
n-Butyl acrylate	$C_7H_{12}O_2$	Acrylate ester	0.00055 ppm	Pungent, acrylic, fruity irritating	Coatings, adhesives, polymerisation
p-Cresol	C_7H_8O	Phenolic	0.000054 ppm	Medicinal, tar, faecal	Sludge, animal waste, phenolic wastewaters

4.2 Odour activity value (OAV)

A useful concept for screening is the odor activity value:

$$\textbf{OAV = measured concentration / odour threshold concentration}$$

A compound with an OAV much greater than 1 can contribute strongly to perceived odour even if its concentration is very low. In complex mixtures, however, OAVs do not simply add linearly. Compounds can mask, suppress or enhance each other. For this reason, chemical analysis should be combined with olfactometry when community impact or permit compliance is at stake.

5. Why the human nose detects extremely low concentrations

The human nose is a biological detector with high sensitivity for many volatile compounds. Olfactory receptor neurons in the olfactory epithelium express receptor proteins that respond to different odorants and different concentration ranges. Odour perception is encoded combinatorially: one compound may activate several receptors, and one receptor may respond to multiple compounds. This is why small chemical differences can produce very different odour characters, and why the perceived smell of a compound can change with concentration.

- **Specialised receptor neurons:** Different olfactory neurons have different thresholds and tuning curves, so some neurons respond at extremely low concentrations while others are activated only at higher concentrations.
- **Combinatorial coding:** Odour quality is not determined by a single sensor; the brain interprets patterns of activity across many receptors and glomeruli.
- **Signal amplification:** Binding odorants to receptors triggers intracellular signaling cascades, allowing small chemical stimuli to generate a neural response.
- **Evolutionary relevance:** Many low-threshold odours are associated with decay, food spoilage, smoke, sulphur chemistry or biological risk. Human sensitivity to some classes is therefore extremely high.
- **Mixture effects:** Industrial odours are mixtures. A compound below its individual threshold may still modify the perceived character of the mixture, and another compound may suppress or enhance it.
- **Adaptation and fatigue:** Sustained exposure can reduce perception. H2S is particularly dangerous because high concentrations can cause olfactory fatigue, so smell is not a reliable safety indicator.

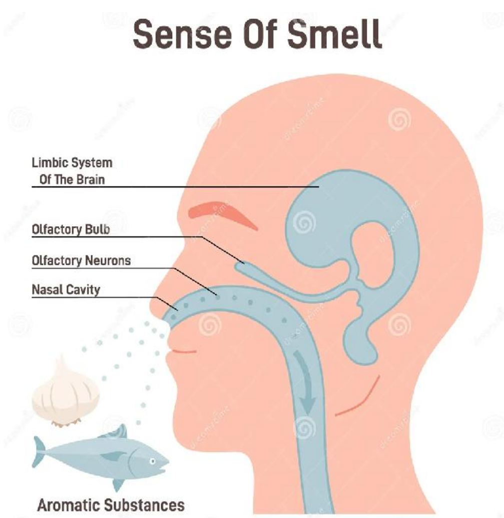


Fig 4 Sense of smell in human

6.Measurement techniques: sensory, chemical, field and continuous monitoring

Odor cannot be fully characterised by one method. The method must be selected according to the question: source emission rate, receptor impact, compound identification, process control, legal compliance or complaint investigation.

Method	Principle	Best use	Main limitations
Dynamic olfactometry	A sampled odorous gas is diluted with neutral air and presented to a trained panel to determine odour concentration in ouE/m3.	European source testing, emission rate calculation, abatement efficiency, dispersion modelling input.	Requires correct sampling, short holding times, accredited laboratory and representative operation. It gives total odour, not chemical composition.
Field inspection: grid method	Qualified assessors record odour presence/absence in a defined assessment area over representative periods.	Assessment of ambient odour exposure and community impact.	Time-consuming; not designed to identify all chemicals or quantify source emission rate.
Field inspection: plume method	Assessors map the extent of a recognizable plume under specific meteorological conditions.	Locating plume boundaries, verifying off-site impact and supporting complaint investigation.	Weather-dependent snapshot; requires trained panel and clear source signature.
GC-MS / EPA TO-15 / sorbent tubes	Chemical speciation of VOCs and selected odourants using canisters or adsorbent tubes.	Identifying solvents, aldehydes, aromatic compounds, acrylates and VOC fingerprints.	May miss very reactive or highly polar sulphur compounds unless sampling and analytical method are tailored.
Sulphur-specific analysis	Methods such as GC with sulphur detectors or specific analysers for H2S, mercaptans and sulphides.	WWTP, biogas, landfills, sludge, rendering.	Low detection limits and sample stability are critical.
Colorimetric tubes and portable electrochemical sensors	Rapid screening for H2S, NH3 and some VOCs.	Operator safety, hot-spot identification, maintenance and process checks.	Often insufficient for odour thresholds; cross-sensitivity, humidity and detection limits must be understood.
Electronic noses / IOMS	Sensor arrays trained against known odour patterns and site-specific references.	Continuous trend monitoring, alarms and source classification.	Not a replacement for olfactometry unless validated. Requires calibration, humidity compensation and periodic retraining.

Method	Principle	Best use	Main limitations
Dispersion modelling	Uses emission rates, stack parameters, building effects and meteorology to estimate receptor concentrations or odour percentiles.	Permit applications, design verification, complaint risk assessment.	Output quality depends on representative emission data and local meteorology.

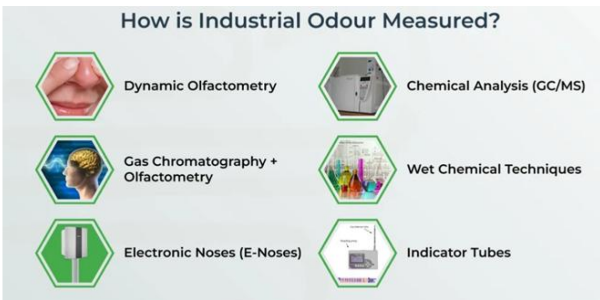


Fig 5 odor measuring techniques

Fig 6 Dynamic olfactometry test.

6.1 Good sampling practice

- Sample under representative and worst credible operating conditions: unloading, mixing, centrifuge start-up, sludge cake discharge, compost turning, tank filling, elevated temperature and adverse wind direction.
- Separate point sources, active area sources and passive area sources. Biofilters, open tanks, windows and ventilation stacks require different emission-rate methods.
- Record process state, feedstock, temperature, humidity, pressure, airflow, doors, bypasses, maintenance and meteorology at the time of sampling.
- Avoid long storage times in sample bags; reactive sulphur compounds and polar compounds can be lost or transformed.
- Use dilution sampling for high-concentration, humid or corrosive streams to protect the sample and the olfactometry panel.
- For low-threshold compounds, specify detection limits below the relevant odour threshold when possible; otherwise, a non-detect result may not mean no odor impact.

7. Masking agents and odor neutralizers: types, efficacy and limitations

Masking agents, counteractants and neutralisers are widely marketed for waste and wastewater applications. They can be useful tools, but they are often misunderstood. A product that changes perceived odour at the point of application does not necessarily reduce odour emission rate, off-site impact or regulatory risk.

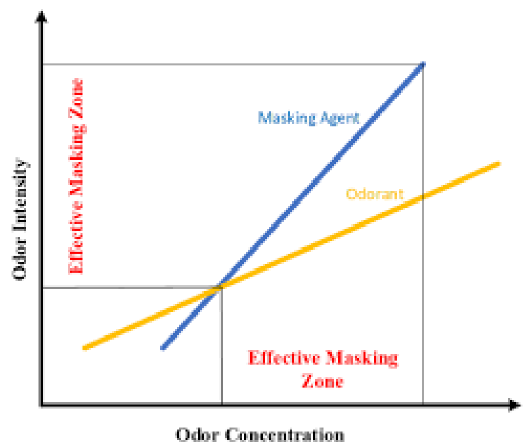


Fig 7 Evaluation of masking effectivity vs odorant

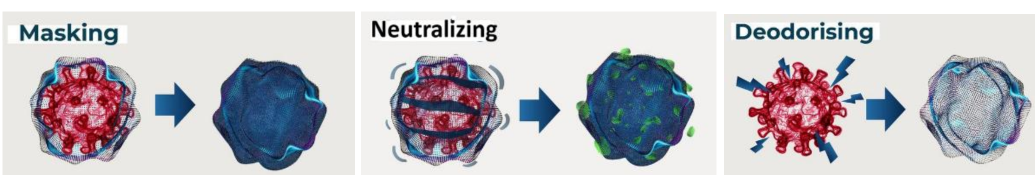


Fig 8 Differences between Masking, Neutralizing and deodorizing agents

-**Odor Masking (Covers):** Uses a stronger, pleasant scent to cover up a bad odor, which remains present underneath. It is a short-term fix, such as scented candles or aerosol spray.

-**Odor Neutralizing (Eliminates):** Uses active ingredients to chemically react with and destroy odor molecules, removing the smell. It addresses the root cause for long-term results.

-**Deodorizing (Odor Modifiers):** Similar to neutralizing, this involves pairing, encapsulation, or reacting to make malodorous molecules imperceptible

7.1 Table for products and mechanism identification

Product type	Mechanism	Where it may help	Limitations
Fragrance masking agents	Perfumes, essential oils, terpenes or aromatic mixtures added to overpower or change the perceived odour.	Short-term mitigation near waste reception, perimeter misting, temporary operations.	May create a new nuisance; does not destroy the original pollutant; can increase VOC load.
Counteractants / odour modifiers	Proprietary blends intended to reduce perceived intensity by sensory interaction or receptor-level effects.	Specific malodour profiles where pilot testing confirms reduced discomfort.	Performance is site-specific and difficult to extrapolate.
Neutralising agents	Products claimed to react with or bind odorants, often atomised as fine mist or injected into ductwork.	Local treatment of low-to-moderate odour plumes where contact time is available.	Requires contact, mixing and residence time; supplier claims should be verified by olfactometry and chemical analysis.
Oxidising additives	H_2O_2, potassium permanganate, chlorine compounds or ozone applied to liquid streams or sometimes to foul air.	H_2S and reduced sulphur control in wet streams, emergency control, sludge conditioning.	Can inhibit biological treatment, create by-products, consume chemicals on non-odorous substances and increase OPEX.
Bio-enzymatic additives	Microbial or enzymatic products applied to waste, sludge or surfaces to reduce formation of odourants.	Selected storage, fat trap or waste-handling situations.	Evidence varies; requires time, suitable pH/temperature and substrate contact.
Adsorptive powders or surface treatments	Activated carbon, mineral adsorbents or absorbent covers applied to surfaces.	Small area sources, emergency treatment, residual odour from cake or compost.	Handling, dust, spent media and limited capacity must be managed.

7.2 How to evaluate efficacy.

Define the objective: reduced complaints, lower odour concentration, reduced H_2S, improved working conditions, lower plume frequency or temporary emergency control.
Measure before and after using the same sampling locations, same process conditions and same meteorological interpretation. Use dynamic olfactometry for total odor, chemical analysis for target compounds and field observations for receptor impact.
Evaluate whether the product introduces a new odour, visible aerosol, slippery surfaces, corrosion, VOC emissions or worker-exposure concern. Compare cost per treated cubic metre or per tonne of waste against engineered alternatives such as source containment, biofiltration, wet scrubbing, activated carbon or process optimisation.

Practical conclusion: masking and neutralising products are auxiliary measures. They may be valuable during start-up, maintenance, upsets or open operations, but they are rarely accepted as the primary long-term BAT solution for a serious odour source near sensitive receptors.

8. European and US regulatory framework

Odor regulation is fragmented. Some authorities define numerical criteria in odour units or dilution-to-threshold; others rely on nuisance provisions, permit conditions, BAT requirements, complaint investigation and site-specific odour management plans. Engineers should therefore design for both measurable performance and community acceptability.

Region / instrument	Relevant references	Practical implications
European Union	Industrial Emissions Directive (IED) and sector BAT conclusions; for waste treatment, Commission Implementing Decision (EU) 2018/1147 is central.	BAT 10 requires periodic monitoring of odour emissions where odour nuisance is expected or substantiated; methods include EN 13725 for odour concentration and EN 16841-1/-2 for exposure. BAT 12 requires an odour management plan with actions, monitoring, complaint response and source-reduction programme.
European measurement standards	EN 13725:2022; EN 16841-1:2016 grid method; EN 16841-2:2016 plume method.	EN 13725 is the main standard for dynamic olfactometry and odour emission rate from stationary sources. EN 16841 assesses ambient odour exposure through field inspection.
United States	No single federal ambient odour limit equivalent to EU dynamic olfactometry practice. Regulation is often state, regional or local and frequently nuisance based.	ASTM E679 describes forced-choice ascending concentration threshold determination. Some authorities use dilution-to-threshold (D/T), field investigation, complaint history, state H2S rules or chemical-specific screening levels.
Texas example	TCEQ odor-based Effects Screening Levels and Air Monitoring Comparison Values.	TCEQ states that the goal of odor-based values is to prevent nuisance conditions, not merely to prevent detection; complaint evaluation uses frequency, intensity, duration and offensiveness (FIDO).
California / local air districts	Complaint investigations, inspector training, odour wheels and corroboration are commonly used tools.	Guidance emphasises wind direction, source identification, complaint logs, trained vocabulary and systematic field investigation.

9. Practical case studies

The following case studies combine published examples with representative engineering configurations typically encountered in odour-control projects. They are written as practical implementation models rather than as vendor-specific endorsements.

Case Study 1 - Food-waste anaerobic digestion plant near sensitive receptors

Context: A food-waste anaerobic digestion facility receives highly degradable material and operates close to residential receptors. Odour peaks occur during unloading, pre-treatment, tank ventilation and digestate handling.

Chemistry: H_2S, methyl mercaptan, DMS, VFA, ammonia and amines. Feedstock variability changes the odour profile from sour to sulphurous or fishy.

Measurement: Ventilation airflow, dynamic olfactometry at source, H_2S/NH_3 screening, field observations during unloading and meteorological review.

Solution: Full enclosure of waste reception and process rooms under negative pressure, extraction of odorous air, pre-conditioning/quencher to remove dust and control humidity, followed by a full-scale biofilter. A published Bicester food-waste AD example reports 60,000 m^3/h treated through six biofilter modules with coconut-fibre media and a horizontal quencher upstream.

Lesson: For biological waste, capture and ventilation design are as important as the abatement unit. Biofilters work best when temperature, humidity, dust loading and empty-bed residence time are controlled.

Case Study 2 - WWTP headworks and sludge dewatering

Context: A municipal WWTP receives septage and long-retention sewer flows. Complaints occur during warm weather and centrifuge operation.

Chemistry: H_2S dominates acute rotten-egg perception. Mercaptans and dimethyl sulphides provide persistent sewage odour. Sludge cake storage adds amines, volatile fatty acids, indole and skatole.

Measurement: H_2S logging at headworks and dewatering room, dynamic olfactometry at extraction ducts, chemical sampling for reduced sulphur compounds, airflow balancing tests.

Solution: Cover headworks and sludge tanks, maintain negative pressure, separate high-H_2S streams to caustic/oxidising scrubber, treat residual mixed air in biofilter or activated carbon. A published WWTP case example reports odour abatement of at least 98% and H_2S abatement of at least 99% using a washing tower and biofilter.

Lesson: The best results come from segregating high-concentration sulphur streams from large-volume low-concentration ventilation air.

Case Study 3 - MSW reception and composting hall

Context: A mechanical-biological treatment or composting facility handles organic fractions of MSW. Odours are intermittent, strongest during waste reception, shredding and turning.

Chemistry: VFA and aldehydes from fresh waste, ammonia from aerobic degradation, terpenes from green waste, and sulphur compounds from anaerobic pockets or leachate.

Measurement: Odour mapping inside the hall, airflow smoke tests, olfactometry at stack/biofilter outlet, NH_3/H_2S screening, pile oxygen and moisture monitoring.

Solution: Minimise residence time of incoming waste, rapid processing, enclosed tipping hall, fast-closing doors, leachate drainage, forced aeration, optimised C:N ratio, moisture 50-60% during treatment, and treatment of extracted air by acid scrubber plus biofilter where ammonia load is high.

Lesson: The first odour-control technology is process control. If compost piles become anaerobic, no end-of-pipe unit can compensate indefinitely for poor oxygen, moisture and structure.

Case Study 4 - Rendering / animal by-product plant

Context: Rendering plants generate high-intensity, low-volume process odours from cookers and non-condensable gases, plus large-volume building ventilation from raw material handling.

Chemistry: Trimethylamine, ammonia, H2S, mercaptans, aldehydes, ketones and volatile fatty acids. Fish or poultry residues increase amines and sulphur compounds.

Measurement: Source segregation by process stream, GC-MS and sulphur analysis for high-strength vents, olfactometry at biofilter or oxidiser outlet, condensate odour checks.

Solution: Condense hot vapours, treat non-condensable high-strength gases in thermal oxidation or suitable scrubber/oxidation system, and treat lower-strength building air in biofilters. Published rendering studies describe biofilters used for non-condensable and composite rendering odours and note favourable economics versus afterburning for suitable streams.

Lesson: Do not mix hot, concentrated process vents with large ventilation flows unless the selected treatment technology is designed for the combined temperature, humidity, concentration and flow.

Case Study 5 - Sludge cake storage before land application

Context: Dewatered sludge cake is stored for several days before transport. Neighbour complaints occur after weekend storage and during truck loading.

Chemistry: Amines, volatile fatty acids, H2S, mercaptans, indole and skatole; odour increases when cake remains biologically active and wet.

Measurement: Odour sampling of cake headspace, sludge age and temperature, residual volatile solids, sulphide content, field notes during loading and transport.

Solution: Reduce storage time, improve sludge stabilisation upstream, cover storage bay, extract air to biofilter or carbon, keep floors clean, avoid anaerobic leachate accumulation, and use temporary oxidant or counteractant only as an auxiliary measure.

Lesson: A low-cost chemical spray cannot replace stabilisation, housekeeping and covered extraction if sludge remains biologically unstable.

Case Study 6 - Chemical plant emitting acrylates or amines.

Context: A batch chemical plant has intermittent complaints during tank filling, batch charging and cleaning. Occupational VOC measurements are low, but neighbours detect a sharp odour.

Chemistry: Low-threshold acrylates, amines, aldehydes or solvent impurities. Some acrylates have odour thresholds in the sub-ppb range and may be detected far below workplace limits.

Measurement: Event-based sampling during transfers, GC-MS or target compound method with low detection limits, PID trend data for timing, olfactometry if the mixture is complex, and wind-correlated complaint analysis.

Solution: Closed transfer, vapour balancing, nitrogen blanketing with controlled vent treatment, activated carbon for low-humidity VOC streams or thermal/catalytic oxidation for high-load streams; avoid relying solely on perfume masking.

Lesson: For chemical odours, the threshold value may be lower than the analytical method detection limit. Analytical method selection must be driven by odour chemistry, not only by occupational exposure requirements.

10. Engineering conclusions

Start with source control: reduce residence time, avoid anaerobic conditions, keep materials enclosed, drain leachate, maintain cleaning discipline and prevent fugitive airflows.
Separate odour streams by chemistry and concentration. High-H2S, high-NH3, solvent-rich, hot humid and biologically treatable streams often need different treatment trains.
Use sensory measurement and chemical analysis together. Olfactometry quantifies total odour; GC-MS and sulphur/amine methods explain why the odour exists and how to treat it.
Design for operating reality, not only nominal flow. Peak unloading, summer temperature, feedstock variability, maintenance bypasses and door openings are often responsible for complaints.
Treat masking agents as secondary measures. They can reduce perceived impact temporarily but should be verified and should not be used to hide an uncontrolled emission source.
Link engineering design to the regulatory language of the site: odour management plan, EN 13725/EN 16841 monitoring, nuisance criteria, FIDO-style complaint investigation and dispersion modelling percentiles.
Verify performance after installation. Commissioning should include airflow balance, pressure checks, olfactometry, chemical speciation, outlet monitoring and a complaint-response protocol.

12. References

1. European Commission, Commission Implementing Decision (EU) 2018/1147 of 10 August 2018 establishing BAT conclusions for waste treatment under Directive 2010/75/EU.
2. CEN, EN 13725:2022, Stationary source emissions / Air quality - Determination of odour concentration by dynamic olfactometry and odour emission rate from stationary sources.
3. CEN, EN 16841-1:2016, Ambient air - Determination of odour in ambient air by using field inspection - Part 1: Grid method.
4. CEN, EN 16841-2:2016, Ambient air - Determination of odour in ambient air by using field inspection - Part 2: Plume method.
5. ASTM International, ASTM E679-19, Standard Practice for Determination of Odor and Taste Thresholds by a Forced-Choice Ascending Concentration Series Method of Limits.
6. Y. Nagata, Measurement of Odor Threshold by Triangle Odor Bag Method, Japan Ministry of the Environment / Odor Measurement Review.
7. Olfactory Research and Engineering Association, Odor Threshold Values of Odorous Chemicals by Triangle Odor Bag Method.
8. US EPA, Biosolids and Residuals Management Fact Sheet: Odor Control in Biosolids Management, EPA 832-F-00-067, September 2000.
9. World Bank Group / IFC, Environmental, Health, and Safety Guidelines for Waste Management Facilities, 2007.
10. US EPA, Compendium Method TO-15: Determination of VOCs in Air Collected in Specially Prepared Canisters and Analysed by GC/MS.

11. National Research Council / NCBI Bookshelf, Acute Exposure Guideline Levels for Hydrogen Sulfide and Methyl Mercaptan.
12. TCEQ, Approaches to Derive Odor-Based Values, Toxicology Division position paper.
13. California Air Resources Board, White Paper: Odor Complaints, Health Impacts and Monitoring Methods, 2019.
14. ATSDR, Environmental Odors - Odor Control.
15. Olores.org, Odor Control at a Waste-To-Energy Anaerobic Digestion Plant by a Full Scale Biofilter.
16. Meat & Livestock Australia, Biofiltration for Rendering Odours, final report.
17. BMB Technologies & Services, Case Study: Wastewater Treatment Plants, Odor Abatement / H2S Abatement.
18. Purves et al., Neuroscience, 2nd edition, Odorant Receptors and Olfactory Coding, NCBI Bookshelf.
19. C. Bax et al., How Can Odors Be Measured? An Overview of Methods and Their Applications, Atmosphere, 2020.
20. Bruchet et al., Commercial products used as masking or neutralizing agents against odour emissions from solid waste activities: pilot and full-scale study, Water Science and Technology, 2009.

Glossary

Term	Meaning
Detection threshold	Lowest concentration at which an odour is detected under specified conditions.
Recognition threshold	Concentration at which the odour character can be identified.
Odour unit (ouE/m3)	Unit used in European dynamic olfactometry; 1 ouE/m3 corresponds to the detection threshold under the standard method.
D/T	Dilution-to-threshold, commonly used in US odour practice; conceptually similar to how many dilutions are required to reach threshold.
Hedonic tone	Pleasantness or unpleasantness of an odour. Two odours with similar concentration can have different nuisance potential.
FIDO	Frequency, intensity, duration and offensiveness; common structure for nuisance assessment.
OAV	Odour activity value: measured concentration divided by odour threshold.
IOMS / electronic nose	Instrumental odour monitoring system using sensor arrays and pattern recognition.