D-NOSES

Distributed Network for Odour Sensing,
Empowerment and Sustainability

End of pipe treatment techniques

Overview of odour abatement technologies

End-of-pipe technologies are those applicable to conveyed odour emission sources.
Very high abatement efficiencies are required for the treatment of odorous emissions as humans are sensitive to very low concentrations of certain odorous substances.

There are a number of parameters to consider for selecting treatment techniques to minimise odour emissions:

- the flow rate of the odorous emissions;
- the concentration of the odorous pollutant(s);
- the physical and chemical properties of the odorous molecules, such as solubility, acidity,basicity, polarity, adsorbability, biodegradability;
- the efficiency of the techniques to abate the targeted odorous pollutants and the variability over time of this abatement efficiency (especially when catalysts are used);
- the generation of secondary pollutants;
- the energy consumption of the techniques;
- the technical limits/restrictions for the use of the techniques (e.g. temperature, maximum pollutants concentration, moisture content);
- the space requirements of the techniques;
- the operation and maintenance requirements of the techniques;
- the costs of the techniques.

Abatement efficiency

Determination of abatement efficiency

The abatement efficiency of the system is determined by monitoring the concentration of odour before and after the adsorption system. When referring to odour removal, abatement efficiencies are determined by taking grab samples at appropriate sampling points at the abatement system inlet and outlet, and subsequently analysing them by olfactometry according to EN 13725:2003.

Typical ranges of abatement efficiencies

In the scientific literature, there are several research and/or review papers reporting abatement efficiencies for different systems. However, it is not always easy to find data about odour abatement efficiency in terms of odour units. The BREF for Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector reports the ranges of abatement efficiencies specifically related to odour removal for the end-of-pipe odour treatment techniques (Table 1).

Technique	Reported odour abatement efficiency (%)	Type
Adsorption	80-99	Physical
Thermal oxidation	98-99.9	
Catalytic oxidation	80-95	
Ionisation	80-98	
Photo/UV oxidation	80-98	
Wet scrubbers	60-85	Chemical
Alkaline oxidative scrubbing	80-90	
Biofiltration	70-99	Biological
Bioscrubbing	70-80	
Biotrickling	70-90	
Moving-bed trickling filter	>90	

Table 1. Odour abatement efficiency ranges reported for different end-of-pipe odour treatment techniques

Another example of comparison of different techniques for the specific treatment of odour emissions from wastewater treatment plants is reported by Estrada et al. (2011) (Table 2).

Technique	**Reported odour abatement efficiency (%)**		
	High Hydrophobicity	Medium Hydrophobicity	Low Hydrophobicity
Biofilter	75	95	99
Activated sludge	50	90	99
Biotrickling filter	50	90	99
Chemical scrubber	50	90	99
Impregnated AC	99.9	98	99
Incineration	99.9	99.9	99.9

Table 2. Odour abatement efficiency ranges for different odour treatment techniques in wastewater treatment plants as a function of the hydrophobicity of the compounds to be abated

Applicability: comparison of different techniques

The information in Table 3 is extrapolated from the BREF for Common Waste Water and Waste Gas Treatment/Management Systems, and from the free-accessible database made available by the Belgian company Vito at https://emis.vito.be/en/luss-0. It compares the applicability of the main odour treatment techniques in function of the flow rate (in Nm^3/h), the temperature, the relative humidity, the discontinuity, and the odour concentration (in ou_E/m^3) of the gas to be treated.

Abatement method	Flow rate (Nm^3/h)	Temperature (°C)	Relative humidity (%)	Discontinuous flow	Odour concentration (ou_E/m^3)
Activated Carbon (Adsorption)	100-100'000	15-80 (opt. <50)	< 70	Y	5'000-100'000
Thermal Oxidation	1000-100'000	900-1200	n.s.	N	1'000-1'000'000
Catalytic oxidation	1000-100'000	300-600	n.s.	N	1'000-1'000'000
Ionisation	20-200'000	20-80	Low	Y	5'000-100'000
Photo oxidation	2'000-60'000 (not critical)	< 60 (opt. 20-40)	< 85	Y	500-10'000
Alkalyne Oxidative Scrubbing	50-500'000	5-80	0-100	Y/N	500-100'000
Biofiltration	100-200'000	15-38	> 95%	N	20'000-200'000
Bioscrubbing	n.s.	15-40 (opt. 30-35)	n.s.	N	> 10'000
Biotrickling	1'000-500'000	15-40 (opt. 30-35)	n.s.	N	> 10'000

n.s. = not specified

Table 3. Comparison of the conditions for the applicability of different odour treatment techniques

Pros and cons of the different odour abatement technologies

Each odour abatement technique has its pros and cons, Table 4 summarises the main advantages and disadvantages, using information from the BREF for Common Waste Water and Waste Gas Treatment/Management Systems, and from the free-accessible database by the Belgian company Vito (https://emis.vito.be/en/luss-0).

Technique	Advantages	Disadvantages
Adsorption	• High efficiency for VOC removal and recovery • Simple and robust technology • High saturation level of the adsorbent • Simple installation • Relatively simple maintenance • Suitable for discontinuous processes	• Particulates in the waste gas stream can cause problems (i.e. clogging) • Not suitable for wet gases (less critical for impregnated activated carbon) • Risk of bed fires • Polymerisation risk for unsaturated hydrocarbons on the activated carbon (exothermal and causes blockages)
Thermal oxidation	• Good and constant performance • Simple principle • Reliable in operation • Recuperative and regenerative oxidation have a high thermal efficiency, with the effect of lowering extra fuel consumption and hence lowering carbon dioxide emission • Process integration of waste heat or steam generation is possible	• Emission of carbon monoxide and nitrogen oxides • Risk of dioxin formation, when chlorinated compounds are incinerated • Additional fuel needed, at least for start-up operations, and VOC concentration below auto-ignition point (not cost-effective with low concentrations and high flow)
Catalytic oxidation	• More compact than thermal oxidisers • Requires lower temperatures (i.e. less energy consumption and less isolation required) and less additional fuel than thermal oxidisers • Little or no NOX produced from atmospheric fixation (about 20–30% of the amount formed by thermal oxidation)	• Higher investment costs than with thermal oxidation • Lower efficiency in VOC destruction than thermal oxidation • System sensitive to changes in the energy content of the waste gas • Risk of dioxin formation, when chlorinated compounds are present in the waste gas

	• CO in the waste gas stream is simultaneously abated by the catalyst • Good, constant and reliable performance is possible • Recuperative and regenerative oxidation have a high thermal efficiency, with the effect of lower extra fuel consumption and lower carbon dioxide emission • Process integration of residual heat or steam generation is possible • Little or no insulation requirements	• All catalysts susceptible to poisoning agents, fouling agents and activity suppressants • Particulates must often be removed first • Spent catalyst that cannot be regenerated may need to be disposed of
Ionisation	• Low energy consumption compared to thermal oxidisers (for gas streams with low pollutant concentrations) • Very compact • Can be placed indoors and outdoors • May be turned on and off at will (almost no start-up time) • Relatively simple operation • Not sensitive to variations in the gas stream • Process takes place at a low temperature	• Electricity consumption • Preliminary testing before installation is recommended to examine whether the technique is suited to a specific emission problem • Only suitable for VOC removal when the system is applied directly to the gas stream • Risk of electromagnetic radiation. This risk is limited when the casing is made of metals
Photo/ UV Oxidation	• Compact and modular system • Close to no start-up time • Can be placed indoors and outdoors • Operation at low temperature • Low energy consumption • Noise-free	• Preliminary testing before installation is recommended to examine whether the technique is suited to a specific emission problem • Not suitable for high concentrations of pollutants (VOC > 500 mg/m3)
Wet scrubbers	• Wide range of uses • Very high abatement efficiency can be achieved • Compact installation thanks to a favourable ratio between capacity and device volume • Simple and robust technology • Simple maintenance • Only few wear-sensitive components	• Water or diluted chemicals are required for the replacement of the purged water and the evaporation losses • Waste water needs treatment • Conditioning agents (e.g. acids, bases, oxidants, softeners) are required for many applications • For roof fitting, support structures are needed

	• Can handle flammable and explosive gases/dusts with little risk • Can also cool hot gas streams (quencher) • Can handle mists • Can be constructed in modules	• Sensitive to corrosion. For outdoor fitting, frost protection is needed (depending on climate) • Packing material sensitive to clogging because of dust or grease • Off-gas may require reheating to avoid visible (steam) plume • Pilot-scale tests are required in order to evaluate the abatement potential of the system • Recirculation of scrubbing liquid may cause an increase in odour emission
Biofiltration	• Low investment and operating costs • Simple construction • In combination with adsorption and absorption, also suitable for barely soluble compounds • High efficiency for biodegradable compounds, e.g. odorous substances • Low amount of waste water (percolate water) and waste material	• Dried-out peat and compost filter beds are difficult to rewet • Relatively bulky design; high surfaces needed • Poisoning and acidification of the biomass must be prevented • Fluctuations in the waste gas stream conditions have a significant impact on performance • Packing is sensitive to dust clogging • Limited control (including pH) • Energy consumption where cooling of the incoming gas is necessary
Bioscrubbing	• High concentrations of easily degradable compounds can be abated owing to high microbial conversion • High concentrations of compounds containing sulphur, chlorine, and/or nitrogen can be abated by controlling the pH • Peak emissions can be controlled better than with a biofilter or biotrickling filter	• Biomass builds up, needs to be disposed of as waste and can result in blockage of the circulating water • Primarily suited for easily soluble compounds, poorly soluble compounds are more difficult to abate • Compounds must be biologically degradable • Fluctuations, e.g. changing concentrations and flow in the gas stream, have a significant impact on performance • Percolate water needs treatment
Biotrickling	• Biological decomposition of components; no VOC residual products	• Fluctuations in intake air stream conditions (type and concentration of pollutants)

	● Suitable for medium concentrations of acidifying compounds which contain sulphur, chlorine and nitrogen ● Suitable for decomposition of acid-forming components ● Small pH corrections are possible ● Low pressure drop ● Average investment and operating costs ● Compact construction and reasonable space requirements ● Low energy consumption and thus limited CO2 emissions ● Little use of additives ● Better reliability than a biofilter	have a significant impact on efficiency ● Poorly soluble compounds are more difficult to abate ● High concentrations of toxic and acidifying substances should be avoided ● The biomass can obstruct the packing ● More complex to construct than a biofilter, and more expensive ● Production of waste water

Table 4. Advantages/ Disadvantages of the different odour treatment techniques