

This article first appeared in **tce**, which is published monthly by the Institution of Chemical Engineers  
Editorial: [aduckett@icheme.org](mailto:aduckett@icheme.org); [nigel.stephens@mainlinemedia.co.uk](mailto:nigel.stephens@mainlinemedia.co.uk)  
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# tce

the chemical engineer | issue 845 | november 2011



**Gary Finke** explains why biological scrubbers are so good at treating odours

**W**HILE some odours can be quite pleasant, others can be a downright nuisance. Strong or persistent odours cause nausea, headaches, sleeplessness and other symptoms of stress and therefore can have significant impacts on people's lives. In fact, odour is one of the main causes of complaints to environmental protection authorities within the developed world and is generally classified as a pollutant.

But what causes nuisance odours? While there are many potential culprits, sulphur- and nitrogen-based compounds are responsible for the majority of these due to their very low threshold odour concentration (the concentration at which they become detectable by the human nose, see Figure 1). Odours are typically associated with the degradation of plants and animals, the waste of animals and humans, or industrial processes. Within a sewer system, odours are generally caused by the action of naturally occurring bacteria, which feed on the contents of the sewage under anaerobic conditions.

### old methods

The means by which gaseous odours are removed across industry vary considerably. However, they predominantly consist of containment of the odours through covering unit processes, extracting the underlying gases via fans and treating them to remove the odorous compounds or oxidising them to simpler non-odorous substances.

Treatment facilities have typically involved reacting the odorous gas with oxidising

<i>Crotyl Mercaptan (sulphur based)</i>	0.029 ppb
<i>Hydrogen sulphide (sulphur based)</i>	0.47 ppb
<i>Dimethyl sulphide (sulphur based)</i>	1.0 ppb
<i>Methyl mercaptan (sulphur based)</i>	1.1 ppb
<i>Skatole (nitrogen based)</i>	1.2 ppb
<i>Ammonia (nitrogen based)</i>	37 ppb
<i>Toluene (hydrocarbon)</i>	170 ppb

Note: ppb = parts per billion (vol/vol)

Figure 1: concentration at which sulphur- and nitrogen-based compounds become detectable by the human nose



# Trickle or treat?

chemicals (chlorine, sodium hypochlorite, ozone, hydrogen peroxide, sulphuric acid) in say a wet chemical scrubber; thermal combustion (recuperative, regenerative and catalytic thermal oxidisers, gas flares), physical removal through adsorption onto a media such as activated carbon, and biological oxidation.

It's certainly the case that not one technology suits all situations, but biological treatment has proven effective for a vast number of odorous compounds and is becoming common in many industries due to effectiveness, simplicity and relatively low capital and operating costs. Industries which have successfully applied biological treatment include wastewater treatment, rendering plants, composting operations, slaughter houses, gelatine and glue plants, agricultural, meat, tobacco, cocoa, soy bean and sugar processing industries as well as flavour and fragrance industries.

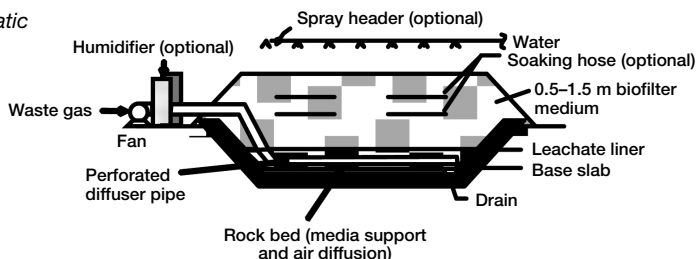
Biological treatment relies on an array

of micro-organisms which live within a thin layer of moisture called a biofilm that surrounds the particles that make up the filter media. The odorous gas is absorbed into the biofilm where it's used by the micro-organisms as an energy source and for cell growth. Using soil bed and compost filters (collectively known as biofilters) can be traced back to the 1950s and 60s in Europe and the US, where they were first used to treat malodours in fairly simple in-ground designs or open concrete wall structures. However, since that time, we have a greater understanding of the main treatment mechanisms and the operating conditions over which effective treatment performance can be achieved. Biofilters now come in many configurations, from vast in-ground or open-vessel filters to fully enclosed high-rate biofilters (see Figures 2 and 3).

While these filters tend to be very efficient, gas residence times (GRTs) can be excessive, ranging from 40 seconds to several minutes,

“biological treatment has proven effective for a vast number of odorous compounds and is becoming common in many industries due to its effectiveness, simplicity and relatively low capital and operating costs”

Figure 2: Schematic of a biofilter



necessitating large media volumes and surface areas. There are a number of design and operating conditions that also need controlling to achieve effective treatment, such as temperature, moisture content and pH buffering capacity within the bed, and the ability to effectively drain away by-products. Treatment efficiencies depend heavily on the population of micro-organisms and are controlled by the food source available within the incoming gas. As such, they may need to be acclimatised for 2-4 weeks or longer, and severely fluctuating sources can produce large outlet spikes. Unfortunately, soil and compost degrade over time as the organic material within the bed is consumed, causing compaction and increased pressure drop. Some odorous compounds such as hydrogen sulphide and ammonia produce acids which further degrade the media. So these systems are generally only suitable for low-strength odours.

a better way

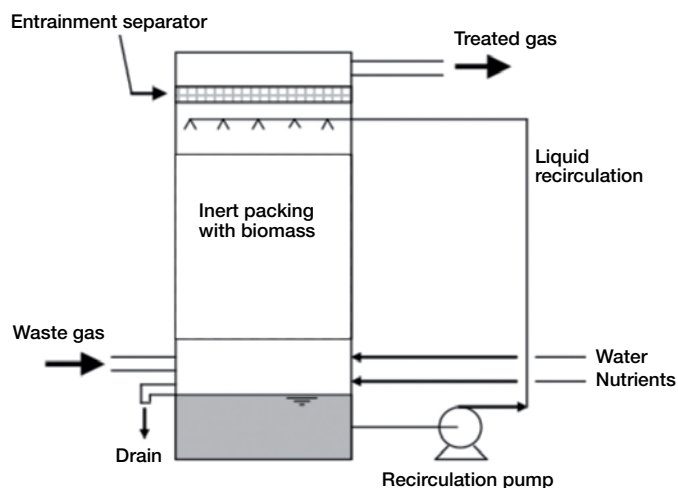
Biotrickling filters (otherwise known as bioscrubbers, see Figure 4) comprise a vessel similar to a wet chemical scrubber but with micro-organisms living on an inert non-biodegradable packing. The recirculating fluid is trickled (continuously or intermittently) over a packing media. A small dosing system

provides trace nutrients for the resident bacteria to thrive and function effectively. It's easy to control the pH and remove reaction by-products, so that any acids formed as a result of the process do not create the same problems as in biofilters. It's also not necessary to humidify the air stream or install filters to remove particulates, as is usually the case with biofilters.

Biotrickling filters have been around since the 1970s where they were operated at neutral pH conditions and at GRTs of around 30-60 seconds. However, performance was variable and overall reliability generally poor. Over the last ten years, however, developments in their design and operation have led to a dramatic increase in performance and reliability. New media have increased the surface area to volume ratio, making room for more bacteria. The bacteria are now specifically tailored to the main odorous constituents that have to be removed, and the operating pH has been adjusted accordingly. For example, in the case of hydrogen sulphide removal, the bacterial strain *Thiobacillus thiooxidans* (see Figure 5), operating at pH 2, is more than 99% efficient. These autotrophic bacteria use carbon dioxide from the air and hydrogen sulphide as their energy source, resulting in the formation of a weak acid and salts.

These changes have reduced GRTs to 6-10

Figure 4: Schematic and photo of a biotrickling filter



The Odour Unit Pty Ltd



Figure 3: Example of an open biofilter

seconds whilst maintaining high removal efficiencies for specific compounds, as well as odour (measured in terms of dilution units). Further trials have shown that biotrickling filters maintain their high removal efficiency at GRTs as low as 2 seconds.

Where several compounds have to be removed, it's now common to operate each vessel with two or more media sections, each operating with a different bacterial population and at different pH levels. For example, the bottom bed may be operated at pH conditions specific to the bacteria required to treat the dominant odorous chemical, whereas the top bed is operated at a neutral pH to remove trace odorous compounds using another bacterial population.

Another recent development is use of highly adsorptive media in combination with specific bacteria in either single or multi-stage media systems. These systems allow for even higher removal efficiencies and lower outlet concentrations. One of the benefits of such a system is the ability to handle peak loads. High removal of odorous compounds continues even when the inlet load is too great for the quantity of micro-organisms present. Once the inlet load peaks have passed, the adsorbed compounds can be removed through bacterial action, and the adsorptive media regenerated.

### problem solving

There are a number of drawbacks associated with biological treatment: plants have to operate in whatever temperature range best suits the bacteria they use; the bacteria have to be acclimatised before they reach peak efficiency; widely-varying inlet concentrations

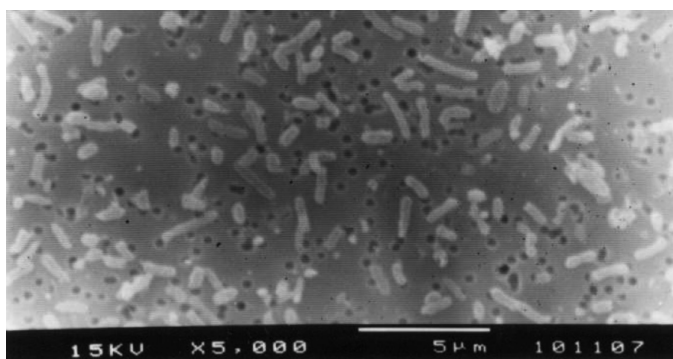


Figure 5: Thiobacillus thiooxidans

can affect overall removal efficiencies; and residual odours limit what outlet concentrations can be achieved. So, secondary treatment with compounds such as activated carbon may be used when very low outlet odour concentrations are required.

In the case of biotrickling filters, it's important to properly characterise the inlet gas stream to maximise treatment and avoid subsequent secondary treatment steps.

With regards to temperature and in the case of mesophilic bacteria, which the majority of biological treatment systems use, it may be necessary to heat or cool the gas stream (and even the vessels and other process equipment). Both cryophilic and thermophilic bacteria certainly exist to treat odorous compounds; however, more research is needed to find the most appropriate bacterial strains for treating very hot or cold gases such as the hot odorous gases from steel mill lime calcination plants or paper mills.

For each of the other challenges, using adsorptive media biotrickling filters will help to address these limitations.

### time to thrive

Advances in the design of biotrickling filters have addressed a number of drawbacks so that biological treatment as a whole is now suitable for the removal of odours in most industries. Within the wastewater treatment field, biotrickling filters have effectively replaced wet chemical scrubbers as the preferred treatment system because they are cheaper, don't require hazardous chemicals, have fewer safety risks and are more sustainable. This trend is expected to continue in other industries. **tce**

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