Monitoring Landfill Gas

What is Landfill Gas?

Throughout Europe over 100 million tonnes of waste a year is deposited into landfills. We may think we have seen the last of our rubbish when it is taken away each week, but the operators of the landfill sites have to look after it for many years afterwards.

The waste within the landfill will consist of a wide variety of substances, but a large proportion will be biodegradable. This will include animal and vegetable matter, paper and wood.

Component	% Volume
Methane	64
Carbon Dioxide	34
Nitrogen	2.4
Oxygen	0.16
Hydrogen	0.05
Unsaturated Hydrocarbons	0.009
Ethane	0.005
Carbon monoxide	0.001
Halogenated Compounds	0.00002
Hydrogen Sulphide	0.00002

Landfill Gas Composition percent by volume

These substances can be decomposed by micro-organisms within the landfill and this breakdown process produces gas. Landfill gas can be a complex mixture of gases, but a few gases predominate. Initially, carbon dioxide is the main gas, but there can also be significant quantities of hydrogen. Methane is produced during the major part of the decomposition process. Many other gases can be produced in trace amounts and the exact composition of the gas will vary between different landfill sites, different parts of the same site, and over time.

Clearly this gas has to be monitored and controlled. A level of five percent of methane in air is explosive. If uncontrolled it can find it's way into nearby buildings and underground chambers with obvious hazards. Landfill gas can also cause odour problems for those living near to sites. Some of the other constituents of landfill gas can also be dangerous to health if the concentration is allowed to build up.

There is consequently a legal requirement on landfill operators to monitor and control landfill gas on their sites. Indeed the licence for a site may well stipulate that the operator has to control the gas emissions for an indefinite period, even after the site is full and is no longer in active use. Methane can continue to be generated for 15 years or more after a site is closed and capped.

Carbon emissions

More recently, another reason has arisen for wanting to control the methane and carbon dioxide. We have all heard about greenhouse gases, the Kyoto agreement and the need to reduce CO_2 emissions. Methane has a greenhouse effect twenty-one times that of CO_2, and is second only to CO_2 as a contributor to global warming, see *figure 1*[1].

A portable instrument can be used on several sites and has a low capital outlay.

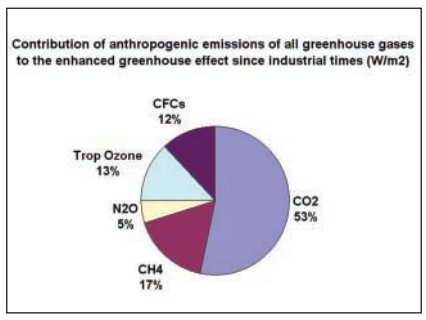

Figure 1

Methane emissions for landfills are the largest single source of methane released into the atmosphere, see *figure 2*[2]. Reduction of methane from landfill sites is therefore a high priority.

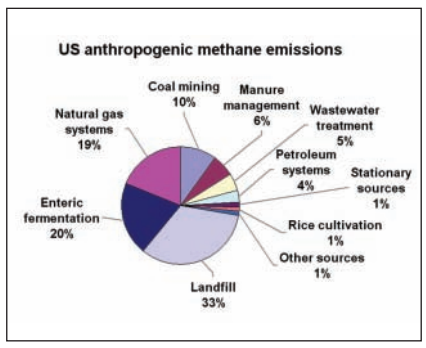

Figure 2

Reductions in methane releases are eligible for carbon credits. Many schemes are being set up in developing countries to collect the methane emissions from landfill sites. The methane can then be used as a fuel in engines to generate electricity, or burned in a flare. The operators of the schemes can then claim carbon credits for the methane saved.

In order to claim the credits the operators have to show exactly how much methane has been saved. This requires them to continuously monitor the concentration and flow of methane to a high accuracy.

The result of this is that there is now a demand for very accurate methane monitoring. The approved methods also require 'continuous' monitoring, so these sites require fixed in place monitoring rather than portable equipment.

Monitoring the gas

How do we monitor landfill gas?

The landfill gas can be monitored either by portable instruments or by fixed installations.

Portable monitoring is the norm for operational sites and for those sites where readings are needed only occasionally. A portable instrument can be used on several sites and has a low capital outlay.

Fixed measurement systems tend to be used on sites where gas extraction is being used to collect the gas for use. These sites may have generators for using the gas to generate electricity. Fixed measurement systems are also normally used where the site is part of a carbon credit scheme where it is necessary to have continuous monitoring and verified data.

A number of techniques can be used to analyse the gas, but almost all on site analysis is carried out by infrared absorption for methane and carbon dioxide, and electrochemical cells for other gases.

Fixed measurement device in automated system

Automated landfill gas extraction monitoring system

Infrared absorption

Infrared absorption is usually the preferred method for measuring methane and carbon dioxide.

Most gases absorb radiation in the infrared region. The wavelength of radiation that is absorbed is determined by the natural vibration frequencies of the molecule. These natural frequencies will depend on the bond strengths, molecule size and shape, and mass of the atoms involve. Thus different gas molecules have different natural frequencies and will absorb infrared radiation of different wavelengths. *Figure 3* shows the absorption bands of methane and carbon dioxide.

This property is used in infrared absorption to select a specific gas for analysis. By using infrared radiation of the same wavelength as the absorption band the technique can be made specific to a particular gas - a useful property when analysing one gas within a mixture.

A typical infrared gas cell is shown in the diagram. Infrared radiation from a source is passed through the gas to be analysed. Several infrared detectors are positioned to measure the amount of infrared radiation that has passed through the gas. A filter that is tuned to the wavelength of interest is positioned in

front of the infrared detector. This then makes that particular detector sensitive to the gas of interest. By using several detectors with different filters a number of different gases can be detected at the same time.

The amount of radiation absorbed will be proportional to the path length through the gas and the concentration of the gas. Since the path length is fixed, the concentration of the gas can be calculated.

Infrared absorption can be made robust, accurate, and stable. It also requires little or no routine maintenance and an infrared absorption cell has a lifetime of many years.

Electrochemical cells

Unfortunately not all gas molecules have a good infrared absorption band. For oxygen, carbon monoxide, and hydrogen sulphide, electrochemical cells are used to measure the gases. These are based on chemical reactions and can be designed to give a voltage that is proportional to the concentration of the gas that they are designed to measure.

Electrochemical cells are simple to use. They do however have some problems with 'cross-sensitivity'. That is, they can respond to gases other than the one they were designed to detect, and this can on occasion lead to spurious results. They also have a limited lifetime, typically two years, and must be replaced.

Measurement of Carbon monoxide

Carbon monoxide is usually a trace gas. An increase in the concentration of carbon monoxide can be indicative of a fire in a landfill site which can be a major problem for the operator. Consequently, carbon monoxide measurements are of great importance.

CO is usually measured by an electrochemical cell. These cells are sensitive to gases other than CO. In particular both H_2S and H_2 will give a reading on a CO cell and both of these gases can be present in landfill gas. This can cause spurious CO readings and wasted time and cost in trying to put out a fire that is not there.

An external filter has been developed that will absorb all of the H_2S before it reaches the analyser. These filters are cheap and disposable, and their use will give an immediate improvement in the measurement of CO where H_2S is also present. The hydrogen problem has now been solved by a new technique that can measure the CO in the presence of hydrogen. These two new developments used together should give much improved and more reliable CO measurements and improve the prediction of fires.

Ease of use

Modern landfill gas monitors do much more than just measure gases. It is possible to load them with set measuring protocols and identification tags for the boreholes to be measured. They will record all measurements together with the time and date, and this data can be downloaded into a database for storage.

It is also possible to have automatic processing and reporting of the data with messaging systems warning of out of range values. Concentration plots showing gas concentrations throughout the site can assist in managing sites and balancing gas extraction.

This functionality, together with the ability to measure temperature, pressure and gas flow makes the landfill gas analyser an important tool in the monitoring of a landfill site.

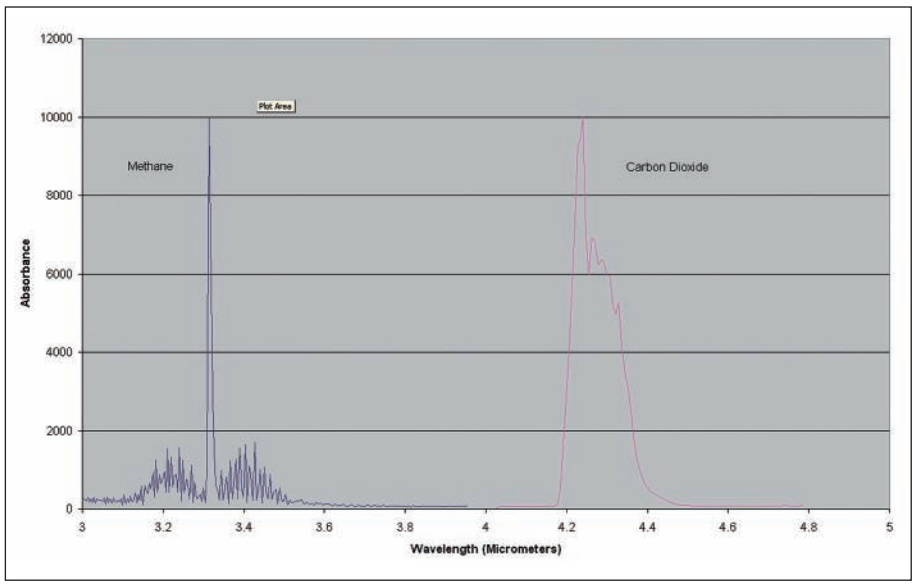

Figure 3, Absorption bands of Carbon Dioxide and Methane

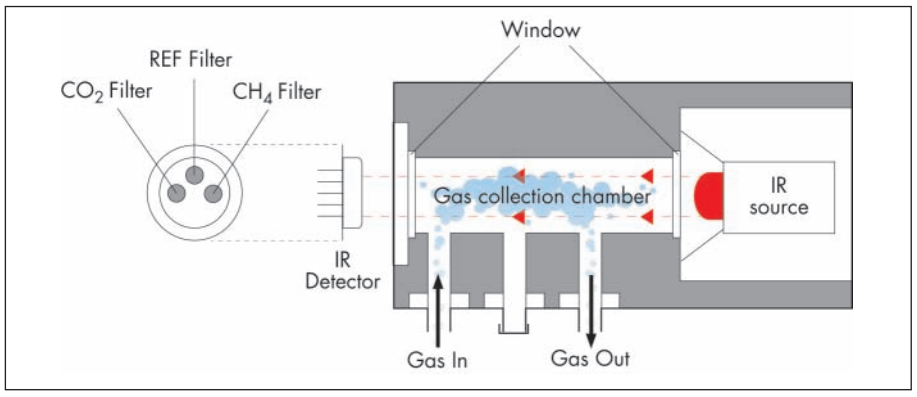

Figure 4, Infrared cell

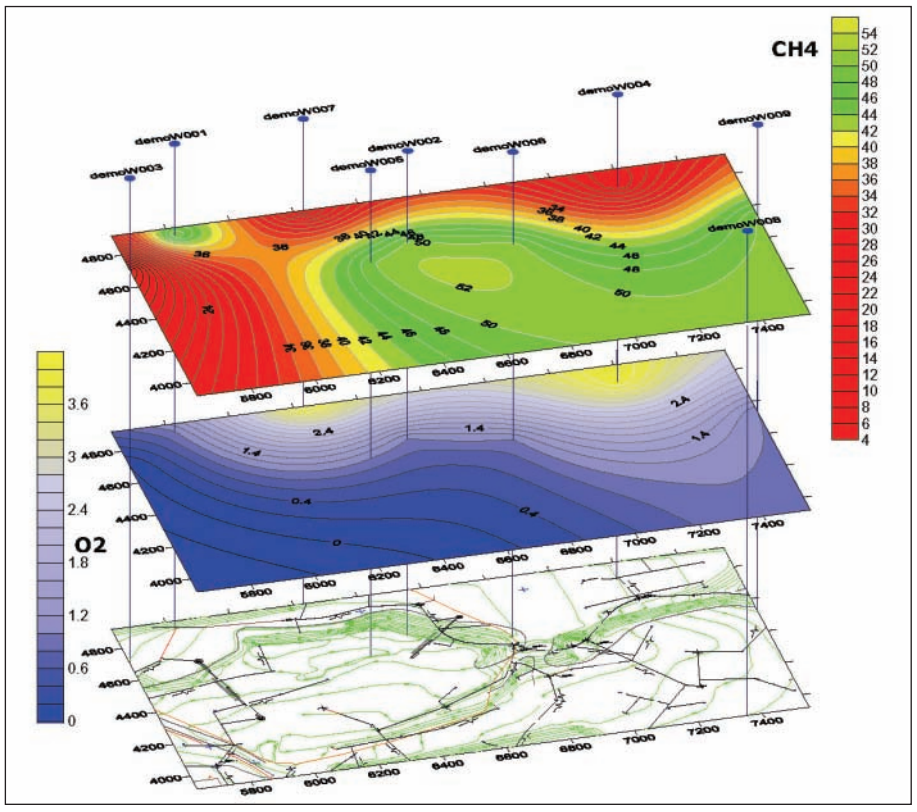

Figure 5 Map of site showing gas concentration contours

Fixed systems

Fixed systems are more complex than portable instruments as they have to work unattended, often in remote locations. Systems have been developed that can automatically monitor the gas and can store the data.

The method of accessing the data is important, as these systems may be remote and difficult to get to. Monitoring systems are available that can automatically download the data to the web so that operators can view the data from anywhere in the world. This allows operators to remotely monitor the amount and quality of the gas produced.

These web-based systems are important when carbon credit projects are involved. Sites may be situated in remote parts of South America or China, while the project administrators may be many thousands of miles away.

Also important for Carbon Credit projects is the accuracy of the readings. While periodic zeroing and re-calibration of portable instruments is sufficient to maintain the required accuracy, fixed systems require a different approach.

Not only is high accuracy required, but the operators have to show to the authorities that that accuracy is being maintained. Fixed systems have been developed that have automatic calibration gas checks to verify the accuracy and automatic calibration if required. Although this adds additional complexity and cost to the system, the additional cost is easily paid back by the carbon credits that can be claimed.

The system can also be set up to produce reports in the exact format required by the authorities.

References:

[1]IPCC (2001) Climate change 2001: The scientific basis

[2]USEPA(2002) Inventory of US greenhouse gas emissions and sinks 1990-2000

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