CHEMICAL ENGINEERING TRANSACTIONS, Volume 15, 2008
Edited by Renato Del Rosso
 ISBN 978-88-95608-09-9

Biofiltration Systems for the Treatment of Waste Gas from Industrial Plants

Mr Ian Phillips
Bord na Móna Environmental Ltd
Main Street, Newbridge, Co. Kildare, Ireland.

Bord na Móna Environmental Ltd have considerable experience in the field of biological air filtration (600 installations). Initially, the majority of installations were on Municipal and Industrial Wastewater applications. This was quickly followed by Municipal Solid Waste, an application Bord na Móna jointly developed with its Italian partners Air Clean srl. Since 2000, Bord na Móna have concentrated their efforts on process development for VOC and industrial applications. New applications include treatment of airstream containing high concentration of H_2S, ammonia, VOC or indeed a combination of all three.

1. Biofiltration Systems For The Treatment Of Waste Gas Streams

Perspective

In response to increased pressures from stringent environmental legislation, and an increased understanding of the impact of pollutants, there is an increasing requirement for sustainable treatment options for various air emissions to the environment. Success in biofiltration will be shown to be closely linked with in-depth analytical process engineering, accurate characterisation of waste gas streams, control of process conditions for optimisation of biological activity, and the physio-chemical properties of the filter media. Biological technologies have been developed to treat a range of applications from relatively straightforward odour emissions from municipal wastewater treatment plants through to difficult complex industrial emissions.

2. The Development Of Mónafil

Background

Biofiltration by definition is the aerobic degradation of pollutants in the presence of a carrier media. The early development work on biofiltration technology concentrated on organic media, such as, peat, compost, wood bark etc. In general terms, organic compounds in air are degraded to carbon dioxide and water, while inorganic compounds, such as, sulphur compounds are oxidised to form oxygenated derivatives.

Bord na Móna identified the UK municipal wastewater market as a target market for biofiltration systems. A research and development programme was set up to establish the optimum operational conditions for the treatment of sulphur compounds (principally H_2S, Mercaptans and Alkyl Sulphides) using peat based biofiltration materials.

The outcome of these results can best be summarised as follows:

(i) Peat/organic media based filtration systems are suitable for municipal applications and can treat H_2S levels typically up to a maximum of 50mg/m^3.
(ii) Two loading regimes were identified as optimum for airstreams with a maximum of 15mg/m^3 H_2S and 50mg/m^3 H_2S.
(iii) The limiting factor for treatment of sulphur compounds in the peat media system was identified as pH. A control system based on the operation of an intermittent irrigation system was developed.
(iv) Various mixes of peat fibre and heather were trialled and optimum media specifications identified.
(v) Optimum operating parameters in terms of gas loading, temperature, pH and operation of irrigation system were identified.
(vi) Requirement for open homogenous media material identified. Peat fibre/heather mixes limited to one metre in depth.

As part of the study, Bord na Móna trialed a new granular peat media. This media is a fractionalised high density peat media. The media has a high "Air Filled Porosity" (85%) and exhibits excellent physical characteristics. The key potential advantage was that it can be installed up to a depth of 3 metres thus reducing footprint by up to two thirds, of particular relevance to industrial sites. This engineered granulated peat media has been granted a patent and is called MÓNAFIL. Bord na Móna undertook extensive work with its Italian partner Airclean to develop the application of treatment of off-gasses from municipal solid waste treatment facilities, including composting plants with this media from the mid 1990's onwards. Over twenty such installations have been successfully installed to date.

3. Development Of Mónashell

Field experience on municipal wastewater applications using peat based biofilter media confirmed the R&D findings that pH was indeed the limiting factor. If the system saw high levels (excess of 50 mg/m^3) of H_2S, it was found that the by-products of H_2S oxidation resulted in lowering in pH of the media. At low pH, while H_2S removal still remains high, odour removal efficiencies tend to deteriorate particularly if Alkyl Sulphides and Mercaptans are present in the air.

The use of shells in a biotrickling process was identified as offering the following potential advantages:

(i) In-built buffering capability due to the chemical make-up of shells (calcium carbonate)
(ii) High air-filled porosity. (AFP)
(iii) Ability to sustain high irrigation rates and capacity to retain large quantities of water.
(iv) Shape and size of packing is in the correct range for good mass transfer.

(v) Calcium Carbonates are known to be a good media for supporting biological activities.
Media has a high affinity for sulphur compounds.

(vi) Shell media, a natural by-product of shell-fish processing, offer the nutrients required to sustain biological activity.

Laboratory and field trials were carried out on shell-based systems. Early trial results indicated excellent results, so much so that it was decided to develop the process as a stand alone technology. Patents were applied for and the technology was launched in 1995. Since then, over 500 installations have been installed worldwide for airstreams with levels up to 500ppm H_2S.

4. Development Of Mónashell Enhanced Filtration Technology For Voc Treatment

As a result of European VOC directives and legislation, a significant requirement was identified for low cost treatment of low to medium, and medium to high levels of air-borne VOC from industrial processes (chemical / pharmaceutical), paint booths, printers and industrial coatings.

From application experience, it was known that the main limiting factors when treating VOC are as follows:

(i) Limited solubility of many organic compounds leading to poor capture and treatment.

(ii) Excessive biomass production leading to plugging of filter media with excessive back pressure and reduced airflow.

In 1997 a VOC research project was initiated. From the outset it was decided to adopt a bi-directional approach to the development of a biological technology for treatment of VOC levels as follows:

- Explore the potential of Bord na Móna's existing technologies for use on VOC application.
- Enhancement of existing process by combining existing Bord na Móna processes with other technologies to enhance treatment and effect the following:

  - Increase mass transfer of contaminants to the aqueous phase
  - Treat high concentration regimes
  - Control excess biomass over growth.

At the outset it was demonstrated that MÓNASHELL was capable of removing 15-20g of carbon per hour per cubic metre filter media. This value is consistent with other biological systems.
Two dynamics were explored to enhance solubility and capture as follows:

1. Recirculation of Air

A dynamic had been developed on a high H_2S application whereby treated air was recirculated to the inlet of the filter.

2. Electromagnetic Stimulation

As part of a study to enhance solubility the use of electro-magnetic stimulation of the water was also examined. While carrying out this work it was noticed that use of electromagnetic stimulation enhanced system performance and prevented excess biomass formation.

Supplementary nutrients are not added in the process. The system effects metabolism of solvents with only minimal synthesis of biomass.

The first commercial installation on high level VOCs was commissioned at B.P.I. Ardeer, a printing application in Scotland in February 2002. This system is monitored remotely and has been operating successfully achieving specified outlet levels.

5. Conclusion

The experience which Bord na Móna has gained over the years has proved that biological technologies can be successfully applied to difficult applications with remarkably predictable performance.

Biological systems need to be engineered such that all critical parameters can be monitored and controlled. Biofiltration is successfully emerging from the shadows as a reliable, low cost option for a broad range of air treatment applications. It is now becoming apparent that biological treatment will play a far more significant role in achieving environmental control on air emissions.

Conclusion with respect to MÓNAFIL

- Media successfully installed up to 3 metres deep.
- Media life span in excess of five years.
- Media can be regraded and re-used at the end of its life.
- No evidence of media breakdown, proven process performance on installation over prolonged time period in excess of five years.

Conclusion with respect to MÓNASHELL

- Ability to treat high and variable contaminant levels (up to 1000 ppm H_2S).
- Inbuilt PH control with no additional chemicals.
- Media consumed in reaction. Predications of media life calculation (based on stoichiometric calculations confirmed).
- Typical efficiency in excess of 99%.
- Excellent performance on a broad range of odour components (VOC and nitrogen based compounds).
- Process proven as effective odour control technology on stand along basis.

Conclusion with respect to MONASHELL EBF

- Recirculation of air increases removal efficiency from 30 to 80% at the same net contact time on low solubility persistent VOC's.
- Eliminates capacity increased from 20g/m^3f/h to 60g/m^3f/h.
- Electromagnetic stimulator reduces accumulation of biomass on media preventing build up of pressure.

Further related areas of study under review at present are:

- Performance comparison of different shell based media.
- Development of Multi-Pass system Vs recirculation (reduced power requirements).
- Buffering of emission from non continuous processes.
- Optimum operating and control requirements for control of pressure drop through system.

MÓNA Case Studies

Table 1. MÓNAFIL Case Study

Location	**Animal by-product Rendering**
Application	Factory ventilation air, non-condensable process gases
Pre-treatment of non-condensable gases	Cyclones for removal of particulates packed tower acid scrubber
Biofilter volume	250 m^3
Total gas flow rate	25,000 m^3/hr
Inlet odour concentration (after pre-treatment)	10,000 – 50,000 ou/m^3
Performance	Mean odour removal efficiency across filter bed
Date	
December 1992	98.7%
May 1993	98.5%
April 1993	99.5%

* Determined by Force Choice Dynamic Olfactometer

Table 2. MÓNAFIL Case Study

Location	**Milan**
Application	Treatment of emission from Municipal waste composting
Date of installation	1996
Biofilter size	2 x 1500 m^3
Total gas flow rate	300,000 m^3/hr
Typical emission	Ethanol, Limonene, Acetone, Methyethyl, Ketone, Toluene, Benzene, Xylene
Inlet VOC	100-300 mg/m^3
Inlet odour concentration	10-12,000 OU/m^3
Outlet odour concentration	<200 OU/ m^3
Outlet VOC	<50 mg/ m^3

Table 3. MÓNAFIL Case Study

Location	Rome
Application	Treatment of emission from Municipal waste composting
Date of installation	2001
Biofilter size	1500 m^3
Total gas flow rate	150,000 m^3/hr
Typical emission	Ethanol, Limonene, Acetone, Methyethyl, Ketoe, Toluene, Benzene, Xylene
Inlet Odour (average)	50,000 OU/m^3
Inlet VOC	100-150 mg/ m^3
Outlet odour concentration	<200 OU/ m^3
Outlet VOC	<10 mg/ m^3

Table 4. MÓNASHELL Case Study

Location	Sewage Treatment Plant, Ireland
Application	Treatment of emissions from picket fence thickener
Date of installation	April 1998
Biofilter size	3 m^3
Total gas flow rate	160 m^3/hr
Inlet odour concentration	12,722 ou/m^3
Outlet odour concentration	294 ou/m^3
Odour removal efficiency	98%*

* Determined by Force Choice Dynamic Olfactometer

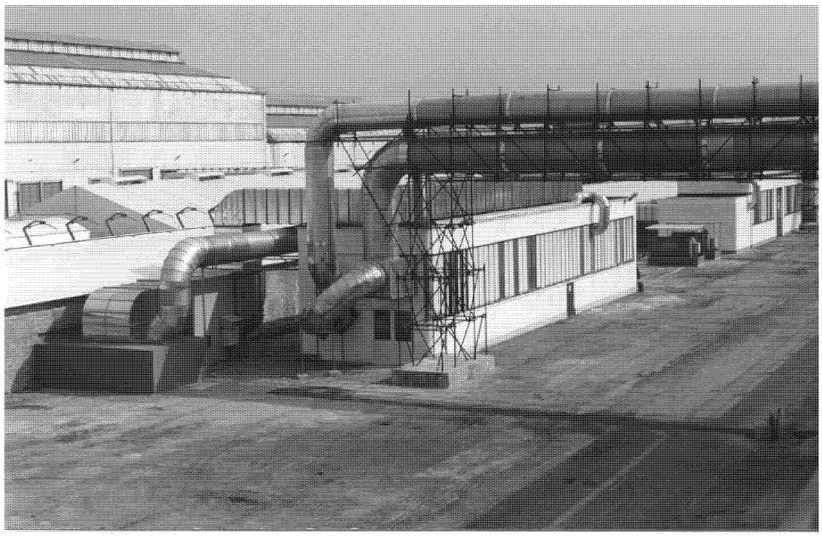
Table 5. MÓNASHELL Case Study

Location	Industrial Plant, Ireland
Application	Treatment of emissions from anaerobic digestor of effluent
Date of installation	January 1998
Biofilter size	24 m^3
Total gas flow rate	200 m^3/hr
Inlet odour concentration	434,531 ou/m^3
Outlet odour concentration	508 ou/m^3
Odour removal efficiency	99%*
Inlet H_2S concentration	1,600 ppm

* Determined by Force Choice Dynamic Olfactometer

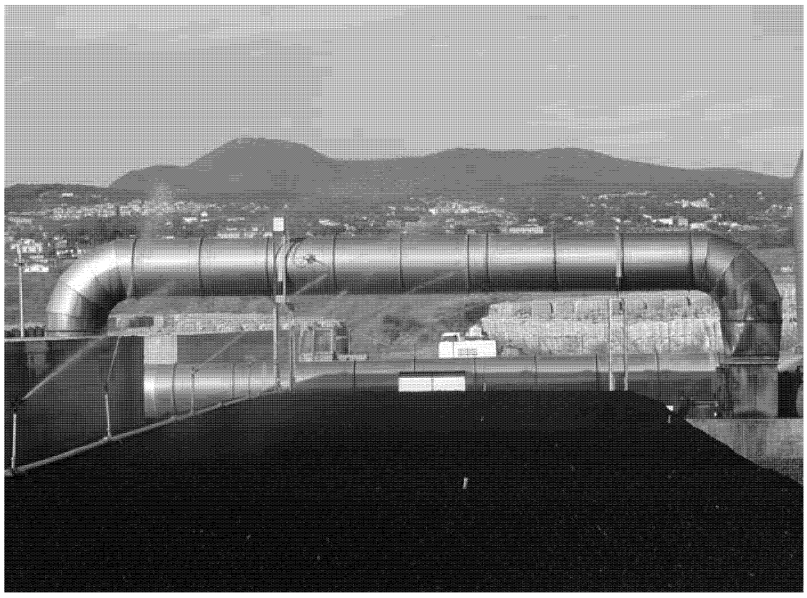
Table 6. MÓNASHELL Enhanced Biofilter Case Study

Location	Printing Plant, Scotland
Application	Treatment of emissions from 8-colour printer
Date of installation	2001
Biofilter size	2 x 46 m^3
Total gas flow rate	11,500 m^3/hr
Typical Emissions	500-1200 mgC/m^3
Components	Isopropyl Alohol, MEK, Ethyl Acetate, Butyl Acetate, Ethanol
Removal Efficiencies	to <150 mg C/m^3



Milan: 275,000 tonnes/annum unsorted Municipal Waste

MÓNASHELL Enhanced Biofilter -First Commercial Application at B.P.I, Adeer, Scotland



Rome: Refuse Plant treats 175,000 tonnes/annum

6. Ackknowledgements

Dott Paolo Caruson
Dott Cesare Carati
Dott Imelda Egan
Ing Jim Fitzgerald

7. References

- VDI 3477 Biological Waste Gas Purification
- Warren Spring Laboratories Odour Control a Concise Guide 1980.
- Elridge, A F and Blitz S Cost Benefits of Biological Odour Control Industrial Waste Management, June 1992 18 - 20.
- Peat Filtration as an Odour Control Technology for Sulphur Based Odours CIWEM Conference *B M Brennan, M Donlan, E Bolton April 1994.*
- Odour Control in Wastewater Treatment Facilities *Robert Maloney, Dr Paolo Caruson, Waste Management February 2000.*
- Odour Control in Wastewater Treatment Processes *Dr Imelda Shanahan April 1993 The Institute of Water Offices Journal.*
- Use of Peat Biofilters for the Removal of Organic Solvent Odour Marc Beerli (1) and Alan Rotman (2).
- Controlling VOC's and Odour *January Pollution Engineering July 1999.*
- Biofiltration: An Innovative Air Pollution Control Technology for VOC Emissions *M Winer – Air and Waste Management Association August 1991.*
- Biological Methods for odour control in solid waste treatment plant, 11th November 2004, Dr Paolo Caruson.
- Biofiltration Systems for Treatment of Waste Gas from Municipal and Industrial Waste Water Treatment Plants – I Phillips 26/27 October 1999. Biodépol, Rennes, France.