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Good Practice and Regulatory Guidance on Composting and Odour Control for Local Authorities

March 2009

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Department for Environment, Food & Rural Affairs
Nobel House
17 Smith Square
London SW1P 3JR

Tel: 202 7238 6000
Website: www.defra.gov.uk

Information about this publication and further copies are available from:

Local Environment Protection
Defra
Nobel House
Area 2A
17 Smith Square
London
SW1P 3JR
Email: noise@defra.gsi.gov.uk

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GOOD PRACTICE AND REGULATORY GUIDANCE ON COMPOSTING AND ODOUR CONTROL FOR LOCAL AUTHORITIES

Report to Defra

Authors: Clare Parker, Nigel Gibson

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AEA Group
Building 551.11
Harwell International Business Centre
Didcot
Oxfordshire
OX11 0QJ

Phone: 0870 190 6478
Fax: 0870 190 6608

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Author	Name	Dr Nigel Gibson
Approved by	Name	Dr Alan Collings
	Signature	
	Date	3rd March 2009

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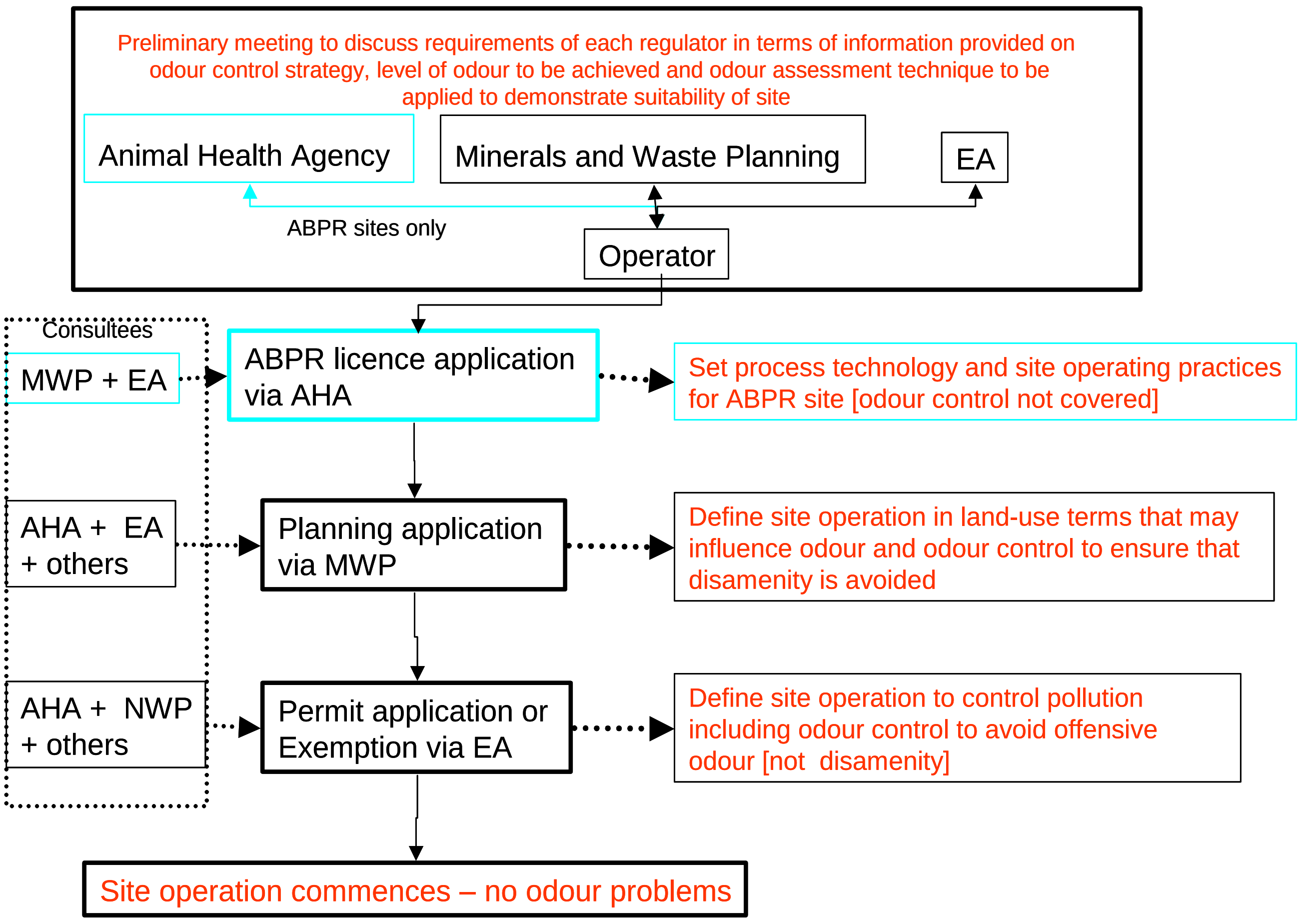
Good Practice and Regulatory Guidance on Composting and Odour Control for Local Authorities - Key Regulatory Regimes for Composting

Navigating through the Regulatory Regimes for Composting (Section 2)



It is far more effective to address odour at the design and planning stage of a new plant than to seek to abate nuisance odours retrospectively

Key Process Control Factors for good composting and Odour Control (See Section 4)

Factor	Optimal Range
C : N Ratio	25 – 30 : 1
Aeration	5 – 15 % in compost mass
Moisture	50 – 70%
Particle size / porosity	Must be adequate to allow air to move freely within compost mass
Temperature	≥ 65°C but excessive temperature must be avoided
pH	6 to 8.6

Minimum Performance - Raw Materials receipt, delivery, and feedstock preparation (See Section 4)

Waste Type	Degree of Containment		Odour Control requirements
	Open	Enclosed#	
Green waste	✓		➢ Raw materials management ➢ Adjust moisture content and C:N ratio ➢ Process as soon as possible
Sewage sludge		✓	
Kitchen waste (ABP)		✓	
Slaughterhouse (ABP)		✓	

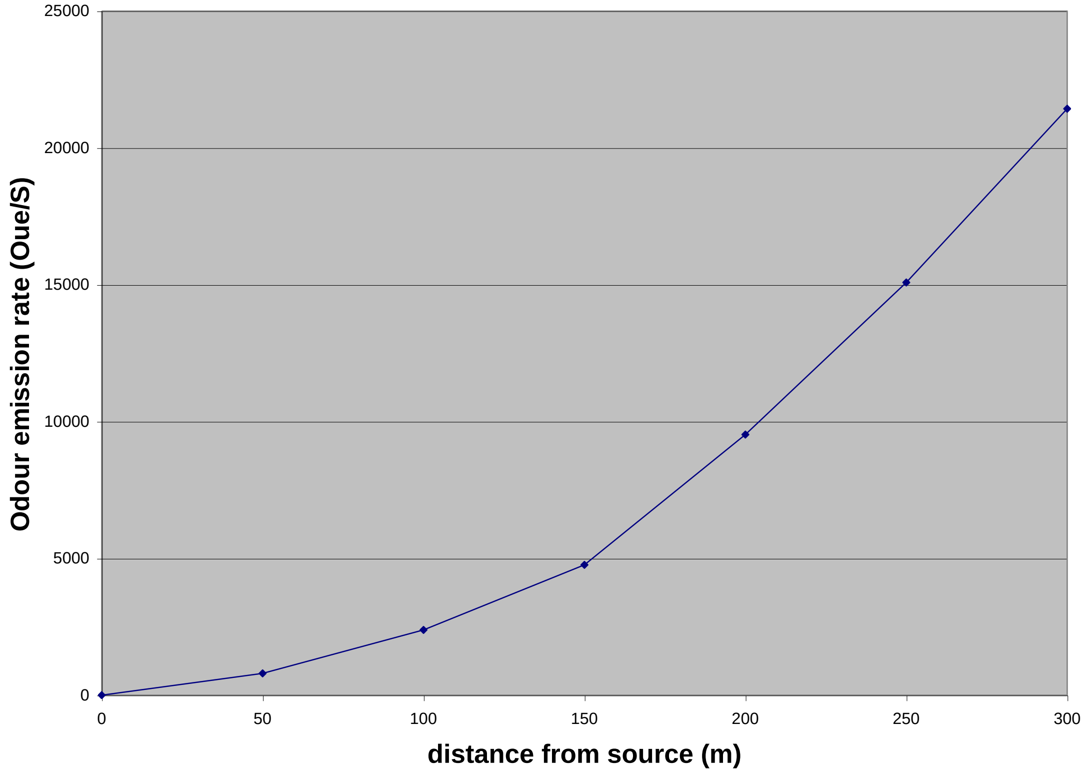
enclosed raw material handling will incorporate an air handling system to maintain building under negative pressure and odour control to treat the extracted air.

Composting Options for different waste types (See Section 4)

Waste Type	Compost Method							Odour Control requirements
	Open windrow	Aerated windrow	Enclosed windrow	Batch or continuous tunnel	Vertical compost units	Rotating drum	Agitated bins	
Green waste	✓	✓	✓	✓	✓	✓	✓	➢ Maintain O_2, moisture, pH conditions within ideal range
Sewage sludge		✓	✓	✓	✓	✓	✓	
Kitchen waste (ABP)			✓	✓	✓	✓	✓	
Slaughterhouse (ABP)			✓	✓	✓	✓	✓	

Siting Compost Plant (See Section 8)

Distance required for dispersion of different ground level odour emissions rates to achieve 3 ou_E/m^3 as a 98th percentile down wind of a source.



Odour Control Options – through design and operation (See Section 8)

Process Stage	Odour Control Option
Raw materials – green waste (external storage)	➢ Good raw material management; and ➢ Good site design and management to avoid anaerobic activity
Raw materials – all other types (internal storage)	➢ Good raw material management; ➢ Good site design and management to avoid anaerobic activity; ➢ Maintain building under negative pressure; and ➢ Treat ventilated air using a suitable odour control system
Feedstock preparation	➢ Maintain aerobic conditions including turning and oxygen monitoring; and ➢ Rapid incorporation into aerobic composting process
Open windrow	➢ Maintain O_2, moisture,temperature pH conditions within ideal range.
Other composting types	➢ Maintain O_2, moisture, temperature, pH conditions within ideal range; and ➢ Treat residual process air using a suitable odour control system
Maturation	➢ Maintain aerobic conditions; ➢ If necessary enclose operation; and ➢ Treat ventilated air using a suitable odour control system
Leachate	➢ Cover store; ➢ Remove solids; ➢ Aerate liquor; ➢ Avoid atomising sprays when wetting compost; and ➢ Location to take account of sensitive receptors.

Odour Control Options – through active odour abatement (See Section 8)

Emission Source	Examples of Control techniques
Ventilated air from raw materials area, and enclosed process or aerated static windrows	➢ Vent to suitable arrestment plant: Biofilters; Scrubbers/biofilters; and Location to take account of sensitive receptors.
Emissions from odour arrestment plant	➢ Final dispersion to minimise adverse impact at sensitive receptors.

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Glossary of Terms

Active composting phase	A loosely defined term often used synonymously to mean the high rate composting phase.
Aerated static pile systems	Un-turned (i.e. static) piles through which air is forced during composting via pipes laid beneath the composting mass. The air may either be blown (positive aeration) or sucked (negative aeration).
Amendment material	Organic material which is used to improve the porosity or balance the C:N ratio within the feedstock. This may include shredded wood waste or oversize compost from screening. This material may be added at any stage of the process; typically it will be incorporated after shredding has taken place as the windrow is being formed.
Aerobic	Occurring in the presence of oxygen. Composting microorganisms (aerobes) require oxygen to break down feedstocks, forming new microbes, creating humic and fulvic acids, and releasing carbon dioxide, water and heat energy as by-products.
Anaerobic	Occurring in the absence of oxygen. Some microorganisms (anaerobes) only function and break down substances in environments without oxygen. In the process, they release by-products such as methane (a potent greenhouse gas) and volatile fatty acids (frequently odorous), which can be problematic in aerobic composting.
Animal by-products (ABP)	These include animal carcases, parts of animal carcases (including blood) or products of animal origin not intended for human consumption, with the exception of animal excretaand catering waste.
Bacteria	A group of microorganisms with a primitive cellular structure, in which the hereditary genetic material is not retained within an internal membrane (nucleus).
Bag tunnel systems	A type of in-vessel composting system that uses high tensile polythene to create a tunnel. Shredded waste is packed into the bag, which gradually unfurls as the loading equipment moves forward. Aeration is supplied by tubing laid inside the tunnel and venting pipes are attached to valves in the tunnel walls.
Batch processing	A processing method for in-vessel composting systems in which a composting mass is loaded, processed and unloaded from the container as a discreet batch without the introduction of new material during the composting process. It differs from continuous processing.
Bed	A term used to describe any active composting floor area utilised for in-vessel composting.(The term ‘bed’ may also refer to the entire mass of biofilter material within an enclosure).
Bioaerosol	Very small biological particles suspended in the air. These particles may be viable spores or cells, or non-viable fragments.
Biofilter	Organic, microbially active substrates (the medium) that filter odorous air through the action of microorganisms that grow on the medium.
Bulk density	The mass per unit volume of a material.
Carbon to nitrogen ratio (C : N)	The ratio of total organic carbon to total nitrogen.
Compost	This has been defined as: Biodegradable waste which has been aerobically processed to form a stable, granular material containing valuable organic matter and plant nutrients which, when applied to land, can improve the soil structure, enrich the nutrient content of soil and enhance its biological activity.
Composting	This can be defined as: The controlled biological decomposition and stabilisation of organic substrates, under conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat. It results in a final product that has been sanitised and stabilised, is high in humic substances and can be beneficially applied to land.
Composting pad	The area where feedstocks are formed into windrows (in open-air turned-windrow systems) and actively composted. On a compact site the pad may comprise blocks or clamps.
Compost storage area	The section of a composting facility where mature compost is kept until sale or use.
Containers	In-vessel composting systems that are generally made out of metal or concrete boxes. Air is often forced through perforated floors into the composting material.
Enclosed halls	A type of in-vessel composting system in which material is composted on the floor of an enclosed building (hall), usually contained in one long bed. The whole composting process tends to occur in the same hall, where machinery is used to turn and move the material through the system.
Feedstock	The general name for any material that is composted.
Forced aeration	A method to provide air (and hence oxygen) to a composting mass, usually via pipes laid beneath the pile. It can be done either with positive pressure, which blows air into the compost, or through negative pressure, which draws air down through the pile by suction.
Fugitive releases	Unintentional emissions from (e.g. windrows, open tunnels)-, points which are not designated or intended as release points.
Green waste	Organic garden waste such as grass clippings, tree prunings, leaves, etc. which can be used as composting feedstocks. Synonymous with ‘garden wastes’, ‘yard trimmings’, ‘botanical wastes’ or ‘garden trimmings’. They can arise from domestic gardens, public areas, private parks or gardens, or landscaping activities.

Hedonic tone	A judgement of the relative pleasantness or unpleasantness of an odour made by assessors on an odour panel. Odours which are more offensive will have a negative hedonic score whilst less offensive odours will tend towards a more positive score. The scores are intended to reflect the average responses of a large number of people. Individual responses may vary greatly.
High rate composting phase	The first stage in the composting process characterised by high rates of biological activity, oxygen demand and of heat generation
Household waste	Waste collected from households at the kerbside, civic amenity sites, other bring or drop-off schemes. It also includes street sweepings, litter, plus bulky and hazardous household waste collections.
Immature compost	Compost that has the potential to harm the germination of seeds or growth of plants. Immature composts usually contain phytotoxic substances, such as acids, and may not be stable and may be liable to reheat and/or generate odours. (See also 'mature compost' and 'stable' compost).
In-vessel composting system	A term adopted to cover a wide range of composting systems in which the material being composted is contained and, usually, enclosed.
Kerbside collection scheme	A collection method where organic wastes (or other recyclables) are regularly collected from commercial and industrial premises and households, normally at the end of curtilage of the property. Compare with 'bring collection schemes'.
Leachate	Water that has percolated through the contents of a composting pile. It can be produced by moisture from composting materials or by rain or other water that has seeped through the pile.
Liquor	A mixture of leachate and run-off. In an open-air turned windrow system, leachate and run-off will flow together, and so cannot be separated.
Maturation or 'curing'	The process whereby phytotoxic compounds in composts formed during the active composting phase are metabolized by microorganisms into compounds that do not harm plants. It is generally characterised by a gradual drop in pH (from alkaline towards neutral), the conversion of ammonium compounds into nitrates, and the re-colonisation of the compost by beneficial soil microorganisms destroyed during the active composting phase.
Maturation area	The area of a composting facility where compost is allowed to mature (or 'cure') until ready for use or sale.
Mature compost	Compost where intermediate breakdown products, many of which are phytotoxic, have been largely consumed so that it does not have a negative effect on seed germination or plant growth (see also stable compost).
Mesophilic	Organisms for which the optimum temperature for growth is within the range of 20 ºC to 45 ºC.
Microorganisms	Microscopic organisms that are capable of living on their own.
Moisture content	The mass of water in a sample, usually expressed as a percentage on a mass for mass basis (wt/wt).
Negative pressure aeration	A method of compost aeration where air is sucked through composting materials from the atmosphere.
Nuisance Odour	An offensive or otherwise problematic odour with the potential to lead to a deleterious impact upon sensitive receptors or an odour capable of generating public complaint.
Odour/odorant	A chemical or mixture which stimulates a human olfactory system so than an odour is perceived. In the context of this guide, odours are generally presumed to be unwanted, unpleasant or malodorous, unless otherwise indicated.
Odour unit	Mixtures of compounds require dynamic olfactometry for assessment of odour level. This involves exposing a selected and controlled panel of observers to precise variations in the concentrations in a controlled sequence, to determine the point at which only half the panel can detect the odour. This point is called the **odour threshold** or **one odour unit**. The number of odour units is the concentration of a sample divided by the odour threshold.
Open-air turned-windrow system	Composting method where windrows are formed outdoors and mechanically turned.
Organic waste	A general, loosely defined term used to describe materials derived from living organisms that can be composted
pH	The measure of acidity/alkalinity (as in soils, composts, solutions, etc.). It is a logarithmic scale. pH 7 is neutral. Not to be confused with total acidity or alkalinity.
Positive pressure aeration	A method of compost aeration where air is blown through composting materials.
Putrescible waste	Solid waste that contains organic matter capable of being decomposed by microorganisms and of such a character and proportion as to cause nuisance odours and to be capable of attracting or providing food for birds or animals.
Reception area	The section of a composting facility where new feedstocks are delivered and stored before being actively composted (e.g. formed into windrows or loaded into an in-vessel system).
Responsible person	Designated person within the workforce who is trained appropriately to carry out on site monitoring.
Rotary composting vessel	A category of in-vessel composting system that consists of an enclosed rotating drum. Feedstock is fed into one end of the drum and exits from the other end in a sanitised condition.
Run-off	Water that has fallen onto a composting pile (for example, rainwater) but has not percolated through it, or that has fallen onto the site surface without touching the pile. Run-off may contain lower concentrations of pollutants than leachate.

Sanitisation	The destruction of pathogenic microorganisms, weed seeds and weed propagules by exposure to high temperatures over an extended period of time. .(For compost to comply with PAS 100 2005, the temperature must remain above 65°C for 7 days)
Sanitised compost	Compost that has been subject to the sanitisation process. (For example a minimum of 60 ºC for 48 hours as required under the Animal by-products regulation 2002).
Screening	The process of separating particles according to their size.
Shredding	The process of breaking up large pieces of feedstock into smaller fragments, so that the structural properties are more conducive for composting.
Source-pathway-receptor	The approach employed in environmental risk assessment techniques. The 'source' is defined by the hazardous properties of the waste types and operations to which it will be subjected. The 'pathway' is the way in which the hazards are transferred into the environment, and the 'receptor' is the target or entities that may be affected by the identified hazards transferred from the source by the identified pathways.
Source separation	The principle of engaging waste producers to keep materials, such as organic wastes, separate from other residual wastes that would otherwise cause contamination.
Stable compost (stabilised compost)	Composts that do not have much oxidisable carbon and therefore have low residual microbial activity, which is characterised by low oxygen uptake rates, and low carbon dioxide and heat evolution rates. (For compost to comply with PAS 100 2005, the rate of respiration must be significantly less than 16 mg CO_2 /g organic matter/day)
Stabilisation	The bio-oxidative process of degrading feedstocks into stable humic substances following the high rate-composting phase.
Stability	The degree of biological decomposition that composting feedstocks have achieved.
'Thatching effect'	This is the condition whereby compost forms a natural barrier to the ingress of additional water to its surface layer. This often occurs after a significant volume of water has already fallen on the surface of the compost and caused a natural barrier or 'thatch'.
Thermophilic	Organisms for which the optimum temperature for growth is within the range of 45º to 80 ºC. The respiration rate of thermophilic bacteria and fungi are much lower than for mesophilic oraganisms.
Tunnel	A category of in-vessel composting system that consists of long enclosed chambers. The material is completely enclosed and usually aerated through floor perforations, although mechanical agitation may also be incorporated.
Turning	The process whereby composting is agitated. The movement of material allows aeration, mixing and to promote decomposition.
Vertical Composting Unit (VCU)	This is a category of in-vessel composting used for the processing of a wide range of biowastes. As the name suggests, the unit comprises of a vertical insulated container which is fed from the top with waste. Feedstock falls with the assistance of gravity to the outlet point at the base of the unit. This unit is modular in design, and may be housed either in the open air or within the confines of a building
Waste	Any substance or object which the holder discards or intends to or is required to discard.
Windrow	A long pile of composting materials, usually shaped as an elongated triangular prism, although the exact shape will vary according to the material and equipment used. The term originates from the farming practice of piling hay in rows so that it will dry out in the wind. An essential feature of a windrow is that it will reach ground level between the individual rows. Failure to maintain this gap will defeat the object of facilitating the flow of air through the pile.
Working plan	A comprehensive document describing how a composting site will be prepared, developed and operated. It should include plans and drawings to appropriate scales, technical descriptions and specifications, documented procedures and recording systems. It should also include or make reference to supporting information, including risk assessments and detailed method statements. The working plan will also need to describe the engineering and/or operational controls (risk management provisions) to prevent or reduce the identified risks.

Abbreviations Used

ABP Animal By Products
AFOR Association For Organic Recycling
EHP Environmental Health Practitioner
EPA Environmental Protection Act
EPR Environmental Permitting Regulation 2007
LA Local Authority
PPS Planning Policy Statement

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PART I - BACKGROUND

1 Introduction and Scope

1.1 Context

The UK faces major challenges in managing waste sustainability. These challenges are important to comply with the UK's commitment to sustainable production and consumption and are also vital in the battle against climate change. All landfilled degradable, organic wastes have a significant greenhouse gas release potential.

Recycling, and the consequential reduction in raw material use, in the UK already saves the equivalent in greenhouse gas emissions of taking 3.5 million cars off the road. This means virgin materials that would otherwise be used in production are conserved and the recycled waste is not disposed of in landfill. Landfill is the worst environmental option for much of the waste produced in this country. The methane produced is a potent greenhouse gas, which is 21 times more potent than carbon dioxide. National targets for future years will increase household recycling and composting from 40% in 2010, to 45% in 2015 and 50% in 2020[1].

The environmental benefits of recycling and composting waste are clear. In order to meet waste recycling targets approximately 3.4 million tonnes of biodegradable source, segregated organic waste is currently composted each year in the UK[2]. Of this total, the majority (nearly 85 %) is municipal waste, with just over half coming from materials deposited at civic amenity sites and just under half from household kerbside collections.

Efforts are underway by authorities to reduce the amount of food waste that is currently sent to landfill. It has been estimated that less than 2% of the 6.7 million tonnes of food waste produced in 2005/06 was captured for recycling[3]. Strategies for dealing with food waste are based on promoting home composting and kerbside collections for treatment in aerobic composting or anaerobic digestion plants.

Local Authorities (LAs) are actively promoting recycling schemes for organic waste due to the considerable cost saving; with landfill tax in 2007/08 at £32/t and set to escalate at £8/year. It is hoped that with recycling widely promoted in the media, the proportion of the public considering home composting as an option will increase and that this will also allow commercial composting facilities to be developed in a responsible and sustainable manner to help meet national recycling targets.

LAs are already well aware of problems associated with composting, including odours, flies, rodents etc.. These issues can be overcome by the following:

- Educating members of the public on how best to undertake home composting. To this end many LAs have posted guidance on their web sites;

- Careful appraisal of planning applications for future development to ensure that siting of, and designed-in odour controls at composting plant are carried out in such a way as to avoid harm to public amenity;

- Working closely with the Environment Agency to ensure that permits for new plant under the Environmental Permitting Regulations are carefully drafted so as to avoid serious odour pollution occurring; and

[1] Defra "Waste Strategy for England 2007"(May 2007)
[2] Association for Organic Recycling "The state of composting in the UK 2005-06" (2008)
[3] WRAP "Sustainable ways of dealing with household food and garden waste in the UK"(2007)

- Where composting plants are already producing a nuisance, the regulating authority and other interested parties should ideally work together to remedy the situation; so avoiding recurrence of the odour pollution problem.

1.2 Who is this guide for?

This guidance document is prepared on behalf of Defra and the Devolved Administration of the Welsh Assembly Government, primarily for Local Authorities. Its purpose is to provide clear guidance on the regulation process. Although this guide is not statutory, it provides information on best practice techniques for the control of composting odours and the proactive and reactive assessment of nuisance odour from composting.

This guidance is for all stakeholders involved with and currently affected by (or may in future be affected by) odour from compost plant including:

- Regulators: who may have regard to the guide when considering planning or permit applications, and when regulating installations which have a permit;

- Operators: who are advised to have regard to it when making applications and in the subsequent operation of their activities; and

- Members of the public: who may be interested to know what standards are envisaged for installations in this sector.

1.3 What is in the guide?

This Guide provides information on the odours emitted from composting plants. The Guide is structured to take the readers through an overview of the problem, the legal framework, the composting industry, the composting process, odours and strategies for odour mitigation.

The Guide is laid out in nine sections and is supported by three appendices:

- Section 1 Introduction and Scope sets out the rationale for this guide;

- Section 2 identifies the regulatory regimes in connection with composting odours: the planning systems and controls in place to protect amenity, and the environmental permitting regulations;

- Section 3 introduces the scale of composting of waste within the UK. The composting processes used in the UK are also discussed;

- Section 4 provides an overview of the composting process;

- Section 5 introduces the reader to odours and the impacts odours can have on your health. The point at which odours become a nuisance is also discussed;

- Section 6 sets out the characteristics and sources of odour emitted from composting plant;

- Section 7 discusses the assessment of odours through a reactive methodology for assessing existing problems and a proactive methodology for avoiding future problems;

- Section 8 identifies strategies for mitigating the odours emitted from composting plants. The general techniques to control fugitive and contained odour emissions are discussed in this chapter. The siting of compost facilities including wind direction, terrain impacts and vegetation are also discussed; and

- The supporting appendices contain the following:

  A. Local Authority Survey: Preliminary Review of Impact of Composting;

  B. Odour Impact Assessment Report Guidelines; and

  C. Guidance on Preparing Odour Management Plans

2 Legal Framework

2.1 Introduction

The control of odour impact from new and existing composting facilities falls under two discrete regulatory regimes:

1. The Town and Country Planning Act 1990 sets out the regulatory framework for land use planning within which local authorities (LAs) will need to operate. Additionally, Planning Policy Statement 23, (PPS23) *Planning and Pollution Control*[4] advises LAs that they should take account of the impacts that a new development will have on the quality of air, including odour; and

2. The Pollution Control regimes under the Environmental Permitting Regulations 2007 sets out a single regulatory regime for the control of the most polluting process industries and waste management operations. PPS23, states that:

   'Pollution control is concerned with preventing pollution through the use of measures to prohibit or limit the release of substances to the environment from different sources to the lowest practicable level [….] The planning system should focus on whether the development itself is an acceptable use of the land, and the impacts of those uses, rather than the control of processes or emissions themselves'. (Paragraph 10).

The two regimes should therefore complement each other and are aimed at preventing and controlling emissions from potentially odorous operations.

Where operations fall outside of these two preventative regulatory frameworks, the LA may address issues arising from nuisance odours through the statutory nuisance provisions of the Environmental Protection Act 1990 (EPA)   LAs dealing with this type of process should consult Defra guidance document "Tackling Nuisance Odour – A Guide for Local Authorities"[5] for additional guidance on statutory nuisance.

Composting plant that receive, handle, use, treat or destroy animal by-products must be approved under the Animal By-Products Regulations (ABPR). This regulation applies to plants dealing with catering waste from premises (including domestic kitchens) handling meat or products of animal origin. In meeting the requirement of this regime an operator will need to demonstrate that the material handling procedures, plant layout and general infrastructure, and composting technology are adequate to carry out the processing of waste in accordance with defined criteria. Satisfactory control of odour is not considered in the ABPR application process. Odour control on these plants must be rigorously assessed within the planning and EPR regimes.

[4] Planning Policy Statement 23: Planning and Pollution Control, Office of the Deputy Prime Minister (ODPM), 2004, and Planning Policy Statement 23: Planning and Pollution Control - Annex 1: Pollution Control, Air and Water Quality, Office of the Deputy Prime Minister, 2004

[5] Defra Tackling Nuisance Odour – a Guide for Local Authorities Consultation Draft November 2008.

2.2 Planning and Amenity

It is far more effective to address odour at the design and planning stage of a new plant than to seek to abate nuisance odours retrospectively

The planning system controls the development and use of land for the public interest and focuses on:

- Whether the development itself is an acceptable use of the land, and
- The impacts of the development on surrounding land users.

Planning controls interface with the issue of odour from composting plants in two ways:

- For New composting plants (and often the improvements/ extensions to existing composting plants) the development requires planning permission; and
- For development in close proximity to existing compost plant; the planning process needs to evaluate the effect of the odour emissions from the compost plant on sensitive development, i.e. “encroachment”.

A County Council’s or a Unitary Authority’s Minerals and Waste Planning team regulates the development and use of land and buildings used for composting operations through the Town and Country Planning Act. On matters relating to odour, the County Council should consult with the LAs Environmental Health Practitioner (EHP), the Envrionment Agency and other interested parties. Through this mechanism the LAs take a leading role in dealing with potential odour issues, and through this role, have a responsibility for the prevention of odour nuisance.

PPS23 provides guidance on the appropriateness of a particular development through the protection of the amenity of members of the public. PPS23 states the following:

> *“Any consideration of the quality of land, air or water and potential impacts arising from development, possibly leading to impacts on health, is capable of being a material planning consideration, in so far as it arises or may arise from or may affect any land use;”* (Paragraph 8)

Specifically in terms of pollution (including odour) that causes nuisance PPS23 states as follows:

> *“It is not intended to secure a high level of amenity but is a basic safeguarding standard intended to deal with excessive emissions. Nuisance does not equate to loss of amenity. Significant loss of amenity will often occur at lower levels of emission than would constitute a statutory nuisance. It is therefore important for planning authorities to consider properly, loss of amenity from emissions in the planning process in its wider context and not just from the narrow perspective of statutory nuisance.”* (Annex 1A, section 1.8).

This can be interpreted to mean that the criterion for assessing ‘loss of amenity’ is a more stringent criterion than would need to be applied to addressing a statutory nuisance problem. It is however, important to understand that in practice this does not necessarily equate either to an absence of odour or even an absence of impact on amenity.

Dealing with a planning application when the submissions only present a general outline of the proposed operation can be difficult, as the information provided by the applicant may be incomplete.

In these circumstances it would be appropriate for the LA to invoke the precautionary principle when assessing a planning application and the information accompanying it. The precautionary principle has been transposed into PPS23 and should be applied where:

- *"There is good reason to believe that harmful effects may occur to humans …….; and*
- *"The level of scientific uncertainty about the consequences or likelihood of the risk is such that best available scientific advice cannot assess the risk with sufficient confidence to inform decision-making."* (Paragraph 6).

The precautionary principle should be applied in circumstances where the following applies:

- The nature and state of the raw materials to be processed are poorly defined;
- The compost process is largely carried out in the open and/or where significant fugitive emissions are foreseen; and
- The control of emissions is solely through process control.

These issues should be addressed in the odour impact assessment that should be submitted as part of the planning application. Appendix B outlines the type of information that should be provided by the Applicant in the format of an odour impact assessment report. The precautionary principle should be taken into account when assigning odour emission rates to a particular situation. An EHP can have a greater degree of confidence in emission data where the following applies:

- The process is fully contained within a building designed to minimise fugitive emission; and
- The process buildings are maintained under negative pressure and the ventilation air is passed to a suitably sized odour abatement plant.

The power to impose conditions on the grant of planning permission is an extremely important element of planning control. In granting a planning permission the LA may see fit to apply planning conditions to ensure adequate control of odour. Drafting appropriate conditions in relation to odour emissions requires an understanding of how effective odour controls can be and of what conditions are likely to be effective in maintaining the amenity of residents living in the vicinity. Planning conditions must "fairly and reasonably relate to the development permitted" and there must be a sufficient connection between the condition and the development permitted. Any vagueness or uncertainty in a condition risks making it void and rendering it unenforceable.

The main planning issue may be perceived to be limited to decisions relating to the suitability of a application site itself for the intended land use being proposed, rather than any direct controls over odour emissions likely to emanate from the site. It might be reasoned that control of emissions would subsequently be controlled by the Environmental Permitting Regulation (EPR) scheme but in practice there should be a coordinated approach between planners and environmental regulators at the planning application stage. Pollution controls need to be considered as an integral part of planning applications, not added as an afterthought.

To avoid duplication of effort the planning and pollution control systems are kept separate, but it must be recognised that their objectives are complementary. Although there is no legal requirement to do so, twin tracking of the applications under both planning and environmental permitting regimes should be encouraged. Twin tracking will ensure that additional information about the process is provided to the LA, which in turn should engender confidence that the pollution control regime will be properly applied and enforced to ensure a true reflection of the planning application. In practice, this will require the operator to submit a full and detailed Odour Impact Assessment report to accompany the planning application where the potential for odour nuisance can be readily anticipated – see Appendix B.

2.3 Environmental Permitting Regulations

Since 6 April 2008, Waste Management Licensing and Pollution Prevention Control regimes have been joined under one regulatory system; the Environmental Permitting Regulations 2007. For regulated waste management operations this has meant a shift in the responsibility for investigating complaints about odour nuisance from the LA to the Environment Agency.

The Pollution Prevention and Control Act (section 6, and paragraph 6 of Schedule 2) amended section 79(10) of the Environmental Protection Act 1990 to the effect that LAs may not institute summary proceedings for an offence under Part III of the 1990 Act in respect of certain statutory nuisances where proceedings could be taken under regulations made under the Pollution Prevention and Control Act 1999. There is an exception available where the Secretary of State may consent to such proceedings being brought by a LA.

EPA 1990, Section 79, (10)

79 (10) A local authority shall not without the consent of the Secretary of State institute summary proceedings under this Part in respect of a nuisance falling within paragraph (b), (d) [(e) [(fb)] or (g)] [and, in relation to Scotland, [paragraph (ga)],] of subsection (1) above if proceedings in respect thereof might be instituted under Part I [of the Alkali &c. Works Regulation Act 1906 or section 5 of the Health and Safety at Work etc. Act 1974.] [or under regulations under section 2 of the Pollution Prevention and Control Act 1999.]

The Environmental Permitting Regulations 2007 are made under the 1999 Act, and therefore section 79(10) applies to the specified statutory nuisances where they arise from a Part A1, Part A(2) or B facility or a waste operation.

This applies therefore not only to odour nuisance but also other statutory nuisances.

Related to this, by virtue of EP regulation 35(c) and Schedule 9, waste regulation must be exercised by regulators for the purposes of implementing Article 4 of the Waste Framework Directive. By virtue of EP Regulation 5(1)(c), a waste operation is only exempt if, among other matters, the method of disposal or recovery are consistent with the need to attain the objectives mentioned in Article 4(1) of the Waste Framework Directive. Those objectives are:

- *“.....waste is recovered or disposed of without endangering human health and without using processes or methods which could harm the environment, and in particular:*
- *“without risk to water, air, soil, plants or animals; or*
- *“without causing nuisance through noise or odours; or*
- *“without adversely affecting the countryside or places of special interest*”

Consequently:

- Where a waste operation permitted by the Environment Agency could cause odour nuisance, the LA should expect the Environment Agency to take responsibility either by instituting proceedings or by varying the permit in order to specify additional relevant conditions and then taking proceedings if those conditions are not complied with[6];

[6] During the transition period between the waste management licence system and the new EPR permiting systems it is envisaged that the condition will be transposed into the new permit. Changes to permit conditions may be introduced if a site has a poor environmental record.

- Where any waste operation which has a registered exemption is giving rise to what a LA considers to be a statutory nuisance due to odours, the authority should inform the local office of the Environment Agency. The Environment Agency will consider whether Article 4 objectives are not being attained and consult the LA in doing so. In the event of Article 4 objectives not being attained, the Environment Agency is obliged to remove the operator's registration.

The very nature of composting operations can be a significant source of odour nuisance. It is essential therefore that there are close working arrangements and co-operation between the LA and the Environment Agency aimed at finding a resolution to any odour issues that arise from these permitted or exempt sites.

The Environment Agency employs a system of exemptions to obviate the need for an environmental permit (formerly a waste management licence) to be issued. Exempt waste operations are not unregulated but are subject to “lighter touch” regulation requiring the operators to comply with certain rules and to avoid harm to health or the environment. The establishment or undertaking of an exemption should ideally provide a working plan demonstrating how the risk management measures will be maintained and monitored throughout the life of the facility. This working plan should state explicitly how any identified residual risks in the risk assessment are to be managed. The Environment Agency will continue to regulate exempted operations to ensure they are following their plan and will also review any exemptions in light of public compliant regarding odour nuisance. In addition, the operation has still to be registered with the regulator. Failure to comply with a working plan should result in the removal of the sites’ exempt status. It should be noted that an exempt site may not always have a working plan or odour management plan in place.

Following an informal consultation on exemptions, the Government concluded that proposals should seek to increase the use of exemptions for as wide a range as possible of low risk operations, whilst restricting the extent of exemptions for higher risk operations. The Government has carried out a consultation to review the exemption process. As part of this process, The Composting Task Force, (a forum of participants from Government and industry and other interested parties) was set up in 2006 to consider exemptions relevant to composting.

It concluded that small scale composting could be carried out at any site without the need for a risk assessment or a high specification of infrastructure. The Task Force felt that the quantity limits and waste types proposed were at a level above which a risk assessment would need to be submitted to the Environment Agency for assessment before registration of the exemption.

Table 2.1 Possible effects of the proposed new exemptions for composting plant[7][8]

Current	Proposed from 2009
Storage and composting of biodegradable waste.	The treatment of relevant waste by aerobic composting and associated prior treatment.
No requirement to renew registration, unless process details change substantially from those previously provided.	3 year registration period.
Max. quantity allowed to be composted 1,000 m^3 [a} at any one time to be composted at place where waste is produced OR where it will be spread. No limits for material in storage but needs to be proportionate to amount composted	Maximum allowed to be treated or stored: ➢ 40 tonnes[b] at any one time, if produced and used on site; ➢ 25 tonnes at any one time if no import/export restriction. Of which: <5 tonnes of paper and cardboard; <10 tonnes of biodegradable kitchen and canteen waste; <10 tonnes of manure Maximum.storage period prior to composting is 1 month Maximum storage period after composting is 1 month
Can be composted in open air windrow without containment and without any impermeable pavement or sealed drainage: ➢ Plant tissue waste; ➢ Waste from forestry; ➢ Waste bark and cork; ➢ Wood (no dangerous substances); and ➢ Waste bark and wood, ➢ Biowaste plant matter.	Waste allowed to be treated under this exemption ➢ Plant tissue waste; ➢ Waste from forestry; ➢ Biowaste plant matter; ➢ Plant tissue waste from inland waters; ➢ Horse manure and farm yard manure; ➢ Paper & cardboard;and ➢ Biodegradable kitchen and canteen waste.
Can be composted in open air windrow without containment but on an impermeable pavement or sealed drainage: ➢ Sludge from washing buildings or yards used for keeping livestock; ➢ Horse manure and farm yard manure; ➢ Shavings, cutting, spoiled timber etc; ➢ Paper & cardboard packaging; ➢ Wooden packaging; ➢ Textile packaging; ➢ Paper & cardboard; ➢ Biodegradable kitchen and canteen waste; ➢ Clothes; ➢ Textiles; and ➢ Wood (no dangerous substances).	

[a] 1,000 m^3 at any one time approximates to between 2,300 to 4,600 t/a of input depending on duration of the process (min of 6 weeks to max of 12 weeks)
[b] 40 tonnes at any one time approximates to between 230 to 460 t/a of input depending on composting process duration (min of 6 weeks to max of 12 weeks).
Note: To the first approximation the density of green waste is 600 kg/m^3. The density of the waste will vary based on moisture content.

The Environment Agency has simplified the EPR permitting for compost plant via a standard permit procedure and the application of associated standard rules. Copies of standard rules can be downloaded from the Environment Agency's web site[9] for open and in-vessel composting for plants <5,000 t/a, <25,000 t/a and <75,000 t/a.

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[7] Comparison of old and new exemptions - http://www.organics-recycling.org.uk/index.php/information/cat_view/86-exemptions-review
[8] the threshold and status of exempt sites, along with any site operating/management requirements are currently under discussion as part of the ongoing review of exempt sites.
[9] http://www.environment-agency.gov.uk/business/1745440/1745496/1906135/1985720/?lang=_e

These rules define the activities that an operator can carry out and specify restrictions on those activities such as emission limits, or the types of waste or raw materials that can be accepted at the facility. It is noted that reference to these standard rules is correct at the time of preparing this report.

There are a number of standard conditions set out by the Environment Agency, dependent upon waste throughput (5,000, 25,000 or 75,000 tonnes per annum), these need to be complied with:

- *The storage, physical treatment, composting and maturation of wastes must be at least 250 metres away from any residential property or workplace;*

- *The activities must also be outside groundwater protection zones 1 (inner) or 2 (outer) and more than 250 metres from any water abstraction point;*

- *The only discharges to controlled waters are surface water from the roofs of buildings and from areas of the site not used for the storage or treatment of wastes; and*

- *The activities are not carried out within 1 kilometre of a European site, Ramsar site or Site of Special Scientific Interest (SSSI).*

The standard rules address odour via the following clauses:

"Emissions from the activities shall be free from odour at levels likely to cause annoyance outside the site, as perceived by an authorised officer of the Agency, unless the operator has used appropriate measures, including those specified in any approved odour management plan, to prevent or where that is not practicable, to minimise, the odour".

Along with:

'The operator shall:

(a) Maintain and implement an odour management plan;

(b) If notified by the Agency that the activities are giving rise to annoyance outside the site due to odour, submit to the Agency for approval within the specified period, a revised odour management plan; and

(c) Implement any approved revised odour management plan from the date of approval, unless otherwise agreed in writing by the Agency."[10]

In developing sets of standard rules the Environment Agency has carried out a one-off national assessment of risk for a common activity. The Environment Agency has gone on to define the risk boundary within which the rules can be used. These are listed above. In the event that a particular compost site fails to comply with the boundary requirement the site must apply for a bespoke permit using the normal Environmental Permitting Regulations application form.

Compost plants fall under the Waste Framework Directive strand of the permitting regime. With respect to odour, the relevant principles should be that:

- All the appropriate preventative measures are taken against pollution; and

- No significant pollution.

Where 'pollution' can be defined as 'the direct or indirect introduction as a result of human activity, of substances …..into the air, water or land which may be harmful to human health or the quality of the

[10] extracted from Standard rules SR2008No16_5kte - composting in open windrows

environment, result in the damage to material property, or impair or interfere with amenities and other legitimate uses of the environment'.

The LA has a clear role in dealing with composting plant through its role as a statutory consultee within the planning and permitting process. This is an opportunity to make sure that any permit delivers what was promised during the planning application stage in terms of the site not causing harm to amenity.

2.4 Summary - Relationship between a Local Authority and the Environment Agency

- Depending on the waste being processed the Animal Health Agency has the responsibility for issuing licenses under the Animal By Product regulation. This licensing process does not consider odour control.
- A Unitary Authority acts as the waste planning, collection and disposal authority, but these functions will be split between the County Council and the District Councils where there is a two tier system.
- Decisions on land-use planning matters are the responsibility of the planning authority not the Environment Agency;
- The Environment Agency has a complementary role in the regulation and enforcement of waste management in support of any planning permission which may have been granted;
- Planning permission and EPR permitting are separate requirements;
- When an EPR permit is sought for the use of land for which planning permission is required, planning approval has to be obtained from the LA before the Environment Agency can grant an EPR permit;
- The LA should remind the applicant to secure a EPR permit or register an exemption with the Environment Agency; and
- The Environment Agency should then inform the LA of the registered exemption.

Figure 2.1 summarises the regulations associated with the development of a new compost site. The figure highlights the regulatory body that takes the lead role at each stage.

In the event that a composting process gives rise to an alleged nuisance it is recommended that there is adequate communication between stakeholders (EHP, Environment Agency, local residents and site operators). Developing local protocols between all interested parties will be beneficial to all stakeholders as a burden sharing approach will remove uncertainty within the resolution process and avoid any lack of clarity on the delivery and timing of necessary control measures.

These procedures should lay out who is responsible for dealing with different aspects, for example:

- The identity of a local contact in the Environment Agency to whom all complaints regarding odour should be directed to;
- The identity of the Environment Agency officer who has management responsibility for ensuring complaints are assessed and dealt with in a timely manner;
- The identity of the Environment Agency officer who has technical responsibility for dealing with complaints, including liaison with the composting plant and other stakeholders;

- What steps the local Environment Agency office will follow in receipt of a complaint, right up to a decision on whether or not the compost operation breaches the requirement of its site working plan or its permit condition relating to offensive odour beyond the boundary fence; and

- What steps the site operator will follow to ensure the site operation complies with the requirements of its site working plan or its permit conditions relating to offensive odour beyond the boundary fence.

2.5 Good Practice - communications between stakeholders

When a developer/future operator submits a planning application there should be sufficient information accompanying the application to enable determination by the LPA. Pre-application discussions with the local authority should help establish the scope and type of information required and provide the operator with the opportunity to identify and address potential issues of concern with the site early in the planning process.

Where odour issues are likely to arise in relation to a new development, applicants should be encouraged to discuss their proposals with Officers of the local planning authority, Environmental Health Department, Environment Agency and Animal Health Agency (formerly State Veterinary Service). Under certain circumstances it may also be prudent to encourage the future operator to consult local interest groups before submitting an application; this may help establish dialogue with the local community and help avoid future conflict.

Consulting widely from the outset can help avoid time consuming and sometimes costly and avoidable objections to the planning application. Even if objections are received, at least the objectors are better informed about the application itself.

The scale and complexity of the new development and the community's sensitivity to the proposed site will inform the level of engagement required at the pre-application stage. Figure 2.2 presents an example of the pre-application that should take place. Further guidance on communication methods that can be employed are discussed in the Defra guidance document "Tackling Nuisance Odour – A Guide for Local Authorities"[11].

Benefits of early communication between interested parties include:

- reduced time spent by the local authority 'regulating' through the consent or permit determination and ongoing compliance monitoring;

- less of the operator's management time addressing neighbour complaints and local authority liaison;

- avoidance of costly and possibly inappropriate retro-fitting of odour control measures on the site; and

- reduced stress and anxiety experienced by neighbours right from project inception through to operation of the installation.

[11] Defra Tackling Nuisance Odour – a Guide for Local Authorities Consultation Draft November 2008.

Figure 2.1 - Flow chart summarising the relationships between the various regulators

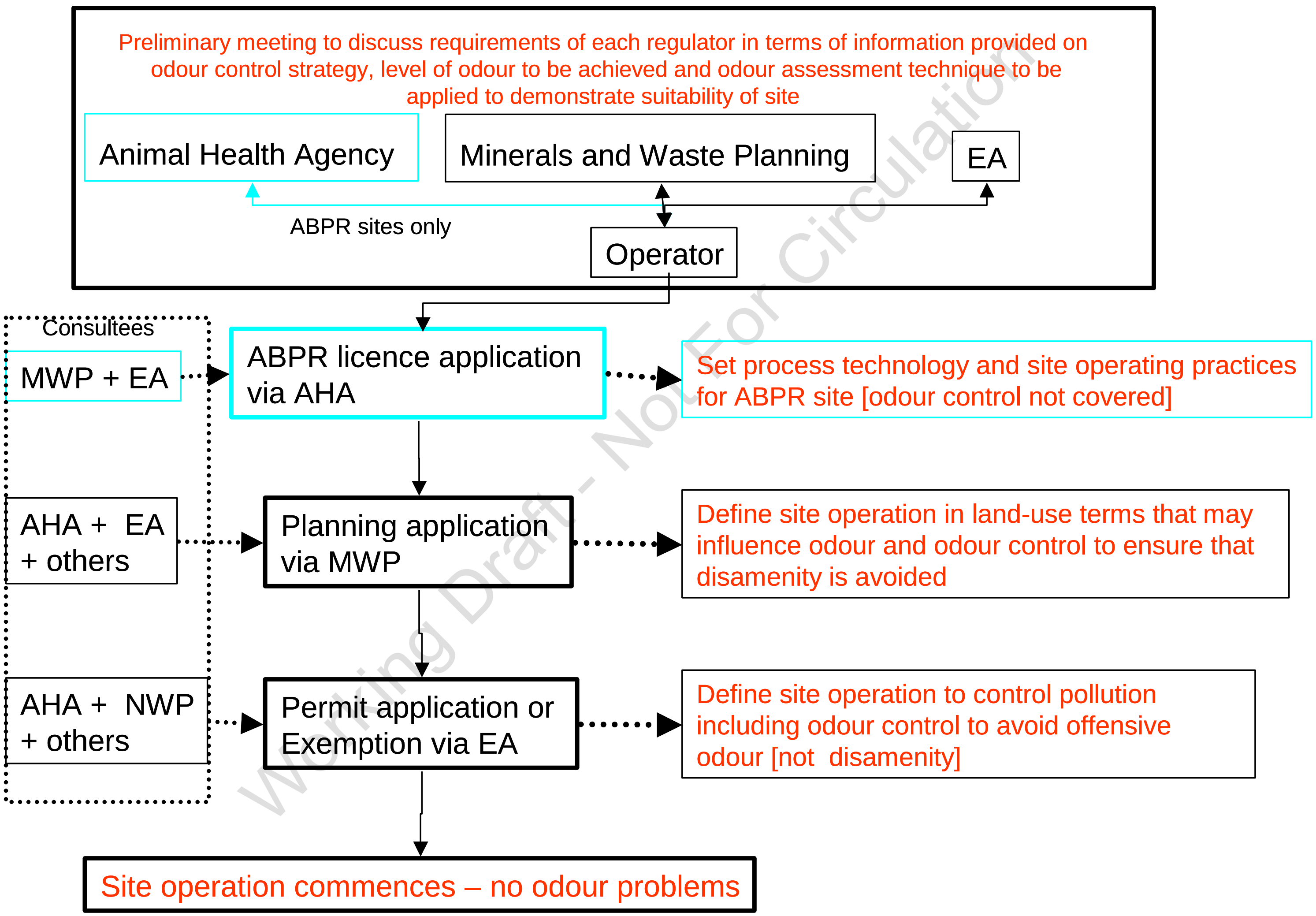
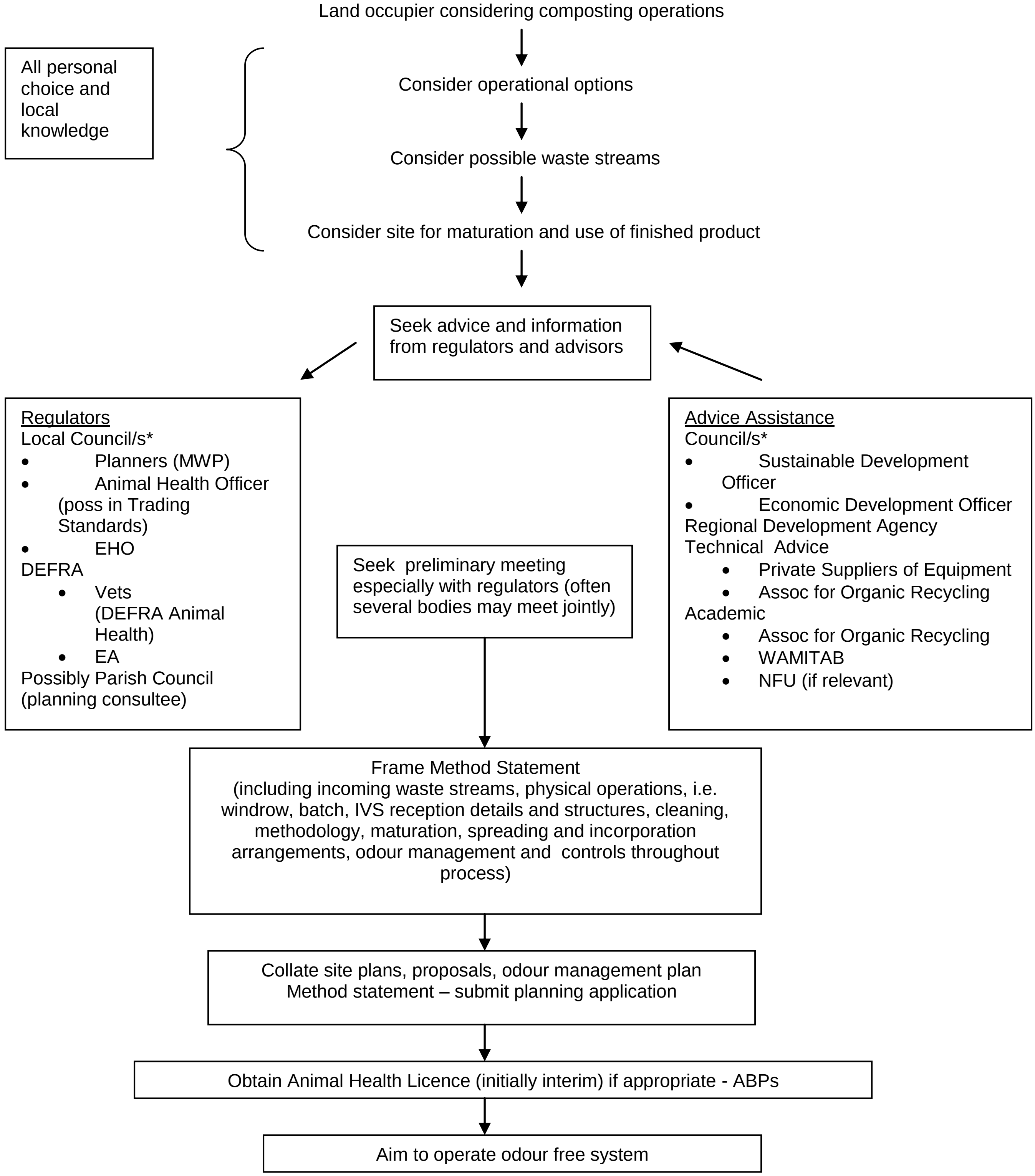


Figure 2.2 Flow chart summarising pre-application communication[12]



*where local council's are 2 tier authorities i.e. County Council and a district Council, the planners and the Animal Health Officers will be with the County Council. Where the Council is a unitary authority all the functions will be under one Council

[12] Example of communication strategy used by East Riding of Yorkshire District Council to facilitate development of new compost facilities.

2.6 Case Study – Interaction between Planning and EPR

The following case study highlighted overleaf demonstrates the consequence of an EPR permit failing to fully reflect the odour control measures detailed in the planning application. A planning application is granted on the basis that it will protect the amenity of receptors living close to a composting site. Situations such as this are foreseen where the LA do not take an active part in the permit process as a consultee. The discrepancy between the two regulatory regimes would be avoided if the planning and EPR application process was twin tracked. The situation may also arise where a compost site is issued an EPR permit containing a standard set of conditions.

Case Study

A planning application for a composting plant was submitted. The proposed plant was designed to deal with 4 tonnes of waste per day through a continuous in-vessel composting unit on a 7-day cycle. The waste to be treated included straw and slaughterhouse waste. Subsequent to this 7-day composting period the compost would be subject to maturation in sealed bunkers for a further 21 days.

During planning, the applicant proposed that an odour control plant would be fitted as follows:

- Air from the reception area and in vessel compost unit would be treated by biofiltration and discharged through a tall stack 3 m above the roof ridge; and
- Air from the sealed maturation bunkers would be treated with a scrubber and biofilter system and discharged through a tall stack 3 m above the roof ridge;

Based on the information provided by the applicant that the odour emission from the site would not exceed 7,000 ou_E/s and that no receptors would be affected by an impact concentration of more than 0.5 – 1.5 ou_E/m^3 as a 98^{th}percentile, the planning authority granted permission on the basis of this information and this level of control.

The site was permitted by the EA, on the basis of a single biofilter to treat all odour emissions.

Shortly after commissioning, odour complaints were received from local residents. An odour survey carried out by the company found that the odour emission from the site exceeded 200,000 ou_E/s and that impact concentration at nearby receptors exceeded 15 ou_E/m^3 as a 98th%ile.

The operator agreed to install abatement equipment consistent with that described in the planning submission. Installing the new equipment reduced the level of nuisance odour at receptor locations.

Part II The Composting Process

3 The Compost Industry

The composting sector comprises a wide scale of activities ranging from large intensive industrial scale composting through to small community projects and home composting. This section provides an overview of the composting activities that are carried out in the UK. The information presented here reflects the position in the year 2005 – 06 and is based on information collected from the Association for Organic Recycling (AFOR; formerly the Compost Association)[13] reflecting the responses of 128 respondents directly involved in composting.

3.1 Scale of Composting

According to the AFOR, their members processed 3.4 million tonnes of source-segregated waste during 2005/06. Composting carried out by non AFOR members would increase this figure.

The survey showed that currently:

- The majority of the compost is processed on dedicated facilities or on farms (see Figure 3.1); and
- The majority of compost is processed either on small scale (<5,000 tpa) or medium scale (10,000 –50,000 tpa) (see Table 3.1).

Many of the smaller composting sites operate under exemptions. The cost of obtaining and complying with the requirements of an EPR permit may lead to a reduction in the number of small composting facilities. The EPR regime will take over from the waste management licence system in 2009.

The majority of compost operations (94%) import all their feedstock. A small number of operations use a feedstock produced on site (2%), whilst a small number of operations (4%) use a feedstock that includes materials imported and materials produced on site.

[13] Compost association "The State of Composting and Biological Waste Treatment in the UK 2005/06"

Figure 3.1: Location where composting is carried out

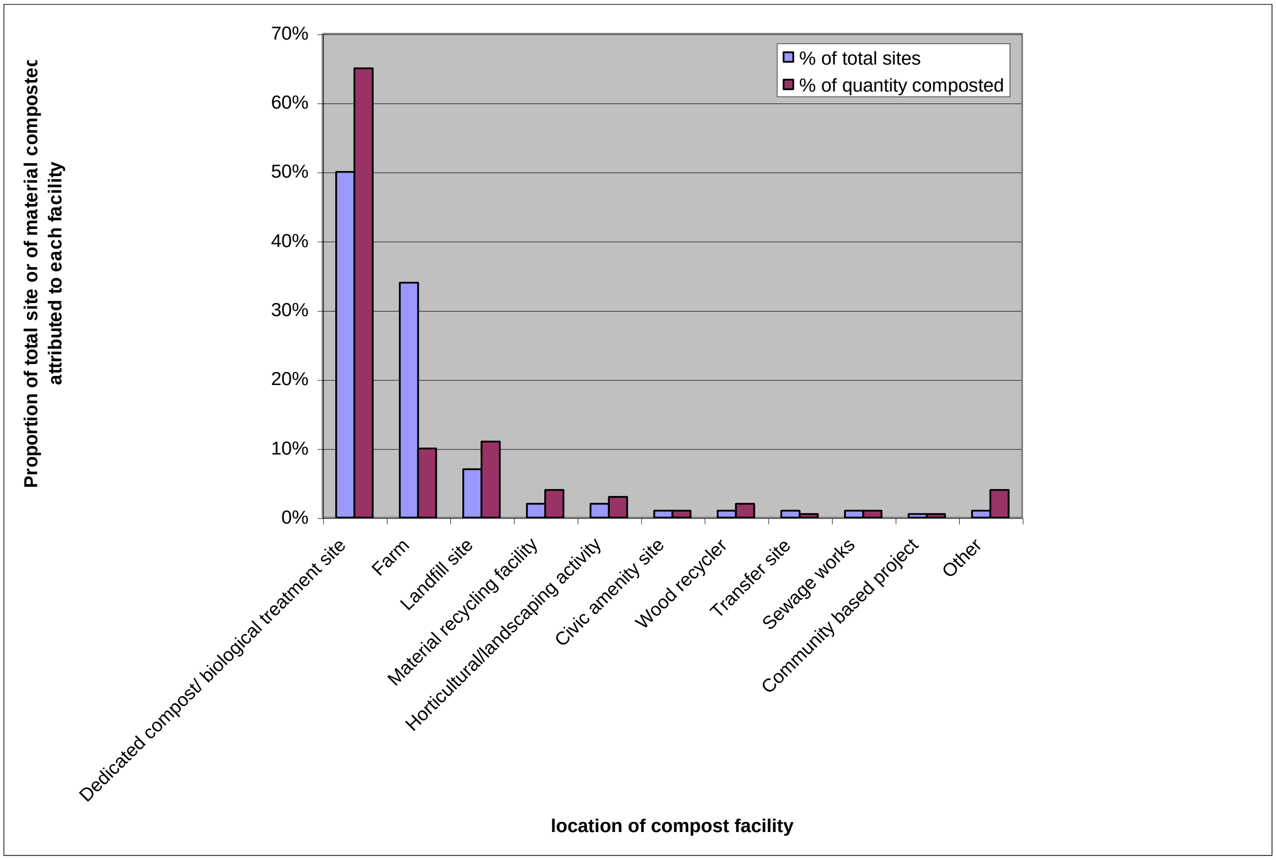


Table 3.1: Scale of composting operation recorded by AFOR members 2005/06

Plant size (tonnes per year)	% of total sites	% of quantity composted
<5,000	41%	5%
5,000 –10,000	17%	11%
10,000 – 50,000	40%	74%
50,000 – 100,000	2%	9%

3.2 Where waste comes from

The type of waste arising and method of waste collection employed is shown in Table 3.2. This illustrates that the majority of waste processed by composting sites is predominantly green waste. It is anticipated that the collection of kitchen waste will increase in the future.

Table 3.2: Types of Wastes Sources Composted by AFOR Members

Waste Category	Relative Proportion
Garden waste from civic amenity/bring sites	43%
Garden waste only from kerbside collection	29%
Garden and kitchen waste from kerbside collection	9%
Kitchen waste only from kerbside collection	<1%
Garden and card waste from kerbside collection	1%
Council parks / gardens waste and green waste from educational institutes	1%
Council-collected food processing by-products and food waste from retailers	<1%
Other municipal waste (includes flytipping, wood etc and unspecified municipal waste)	1%
Landscape/grounds maintenance	4%
Forestry/timber/bark/by-products	3%
Food processing by-products and food waste from retailers	5%
Other non municipal waste (includes tannery waste, site clearance waste, mixed industrial and commercial waste etc)	3%
Unspecified non municipal waste	<1%

3.3 What Composting Processes are used

The majority of composting sites (90%) employ open windrow technology (see section 4.3 for more details) and this technique is used to produce the bulk of the compost (81%) – see Table 3.3. It is anticipated that a rise in food waste will increase the number of contained compost operations.

Table 3.3: Composting Methods Reported by AFOR

Method of Composting	% of Total Site[1]	% of Waste Composted
Open air mechanical turned windrow	90%	81%
Covered mechanical turned windrow	1%	<1%
In-vessel composting	11%	14%
Static pile with aeration	2%	2%
Other	3%	<3%

1 – Some sites may use more than one type of composting

3.4 Impact of odour from composting – LA view

As part of this Defra study a survey of the experience of EHPs dealing with compost odour has been carried out. The results of the survey are presented in Appendix A.

The survey showed that the number and range of complaints varies vastly across districts in England and Wales, with certain sites causing the majority of the problems. The situation however, appears to be improving over time, operators of composting plants are working with regulators and communities to reduce their problems. It is predicted however, that due to the small volume of land available for landfill in the UK and the Governments' present move to encourage people to reduce their waste, the volume of waste diverted to compost it is likely to increase.

With the greater demand on composting facilities, it is important that regulators put in place formal procedures for regulating composting plants and the odours that they generate.

The overall conclusions drawn from the survey are as follows:

1. The size of compost plants must be considered carefully when siting facilities;
2. The quality of raw materials arriving on site should be managed to minimised odour;
3. The compost plant must be fit for purpose to deal with the feedstock;
4. Good site management is necessary to minimise compost odour; and
5. Complaints can extend over distances of 500m and more.

4 Composting Process – A Brief Overview

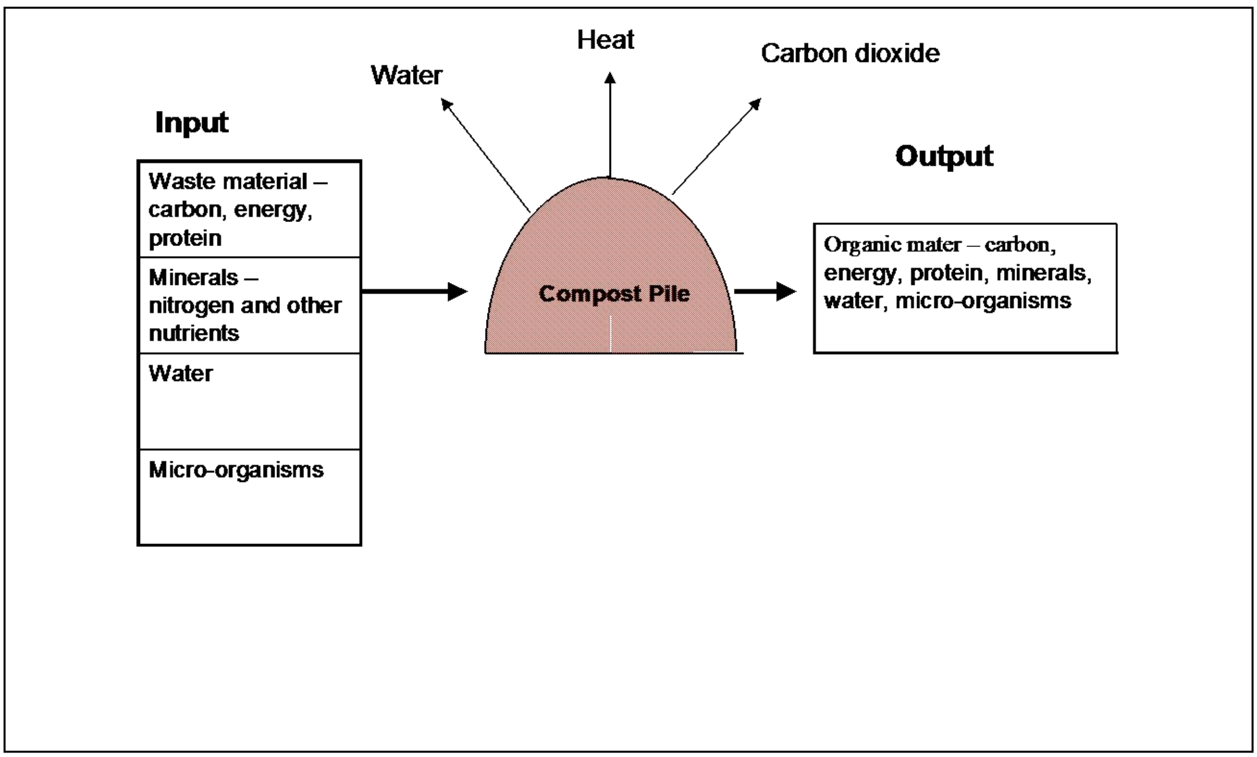
The following section provides LAs with a generic overview of the whole composting process and the ranges of techniques that may be employed. It is not the intention of this guide to identify specific composting techniques for specific sites or feedstocks.

4.1 Process Overview

Composting is the process by which organic waste materials are decomposed in the presence of oxygen, through the action of bacteria and other microorganisms. The microorganisms consume oxygen while feeding on organic matter, which generates heat, carbon dioxide and water vapour (see Figure 4.1). These products are released into the atmosphere. The composting process reduces both the volume and mass of the raw materials while transforming them into a composted organic material.

This general description also applies to the composting part of Mechanical-Biological treatment (MBT) processes, where composting[14] is used to stabilise the putresible fraction and to reduce the moisture content through the action of thermophilic microorganisms.

Figure 4.1: The Composting Process



[14] It should be noted that some MBT processes involve anaerobic digestion rather than composting and whilst there are similarities there are also distinct differences in these processes that may lead to altered odour potential.

The key stages of composting are summarised as follows:

- Waste acceptance process;
- Waste storage;
- Sizing and shredding;
- Composting;
- Compost maturation; and
- Post composting treatments;
    - Screening; and
    - Leachate collection and disposal.

4.2 Organic Waste Materials

Source of Organic Waste

Raw materials processes differ between sites; however, the raw materials are generally green wastes (grass cuttings, plants and weeds, flowers, prunings, hedge clippings, leaves and bark), kitchen wastes (food scraps and vegetable waste) or permitted industrial and animal by-product (ABP) waste.

Organic wastes suitable for composting will be collected from a variety of sources using a range of methods for example:

- Kerbside collection of green waste or a mixture of green waste and cardboard or kitchen waste. Where such schemes are operated, organic waste may be stored in the following way:
    - Mini-bins;
    - Standard non-aerated bins;
    - Aerated bins;
    - Split-bins;
    - Multi-household containers; and
    - Bags or sacks;

  Kerbside collections may be weekly or fortnightly depending on the LA;
- Civic amenity or “bring” sites where green waste is collected in large bulk containers; and
- Non-municipal sources such as commercial canteens or food factories in bulk containers.

Generally organic waste material arriving at the plant will already have started to degrade. The amount of degradation is a function of the time and storage conditions (ambient temperature, moisture etc.) at source and the time and storage conditions during transportation. The more degradation, the more odorous the material is likely to be. It is important therefore that the received material arrives as fresh as possible, as this will result in easier handling and lead to reduced odour emission from the site. This can be a particular problem:

- Where kerbside collections are relatively infrequent e.g. on a fortnightly basis; and
- On Monday mornings or following a Bank Holiday where wastes will have generally been stored for longer periods than usual.

[Note the storage and collection regimes can in themselves lead to nuisance odour levels, especially in urban areas where storage receptacles are located close to properties, and again there is evidence to suggest that nuisance levels of odour can occur during waste collection when large amounts of rotting material are concentrated in the waste collection vehicle].

Waste Organic Materials Receipt and Storage

Waste organic material arriving at the compost facility should undergo a waste acceptance process. This process should verify the conformance of the material with the operating licence and commercial contract, and the general condition of the material via visual and olfactory inspection. Material that complies with site operating procedures will be stored ready for processing (see Photograph 4.1).

Green waste may be stored in the open, while other waste (e.g. kitchen waste and industrial sludges) should be stored within a sealed building. An approved facility under the ABP regulation[15] requires an enclosed reception and processing areas (as shown in Photograph 4.2). The individual storage requirement on a particular site will therefore be dependent on a full, site-specific risk assessment.

Photograph 4.1: Raw Material Delivery Area – Green Waste

[15] Animal By-Product Regulation (EC) No. 1774/2002

Photograph 4.2: Raw Material Delivery – Animal By-Products

Treatment of Rejected Material

Any load that is rejected should either not be unloaded and returned to the supplier or directed to a suitable authorised facility. The reasons for rejecting a load may include:

- Unacceptable level of contamination;
- Unacceptable level of decay and therefore too odorous; and/or
- Unacceptable waste type.

The operators would record what action needed to be taken.

Alternatively, where site infrastructure allows e.g. fully enclosed raw materials reception area maintained under negative pressure with active odour control the site may activate contingency plans to deal with highly odorous raw materials. Such plans would include the immediate incorporation of material into the compost process.

In the event that only a small portion of a load is unacceptable the contaminant material (e.g. glass, metal, non-compostable packaging materials etc.) would be transferred to a quarantine area or container. The amount of material held in the quarantine area would be agreed with the regulator and should not be exceeded. The contaminants should be removed from site to a waste handling facility permitted to receive the contaminants. Typically contaminants would be dispatched within seven days unless the material was rejected on the ground of odour, in which case dispatch should occur on the day of receipt.

Organic Waste Materials Processing for Composting

Certain waste materials contain bulky oversized components, which require shredding. The shredded process aids the blending and mixing of the feedstock and can be accompanied by the addition of water to optimise moisture content. To facilitate the composting process, the particle size must be small enough to maximise the surface area for microbial activity, while being large enough to ensure sufficient porosity to allow aeration. Photographs 5.3 and 5.4 show low and high speed shredders.

The blending of the feedstock involves mixing various waste organic materials which have different properties such as high carbon, nitrogen or moisture content. Careful blending of the feedstock is an important step in managing odour. The feedstock should be mixed to give a specific composition. The preferred performance characteristics are shown in Table 4.1.

Table 4.1: Preferred Performance Characteristics

Characteristic	Preferred Range
Carbon to nitrogen (C:N) ratio	25:1-30:1
Moisture content	50%-60%
pH	6.5-8.5

Failure to maintain the C:N ratio within the target range can have the following consequence:

- Ratios below 25:1 will proceed rapidly and excess nitrogen will readily form ammonia and odorous compounds. In these mixtures, oxygen will be consumed rapidly generating excess heat, both of which may result in anaerobic conditions.

- Ratios above 40:1 tend to compost slowly and the mixture may not achieve thermophilic temperatures.

Photograph 4.3: Raw Materials Shredding – Using a Low Speed Shredder

Photograph 4.4: Raw Materials Shredding – Using a High Speed Shredder

The carbon, nitrogen and moisture content can be measured in the laboratory and the appropriate mixtures calculated. Alternatively, the compositional characteristics of a range of organic waste materials have been published[16] and these provide a means of estimating the feedstock composition.

Table 4.2: Typical C:N Ratios and Moisture Content of Various Organic Waste Materials

Component	C:N range	Average C:N	Moisture content (%)
Grass clippings	9 - 25	17	82
Leaves	40 - 80	54	38
Shrub timmings	Not available	53	15
Hardwood chips	451-819	560	Not available
Softwood chips	212 - 1313	641	Not available
Newspaper	398-852	625	66
Cardboard	Not available	563	8
Vegetable waste	11-13	12	87
Municipal food waste	14-16	15	69
Slaughterhouse waste	3-3.5	3.25	10-78

Waste Materials Processing for Mechanical – Biological treatment (MBT)

The waste material handled by a MBT plant is typically unsorted residual municipal waste. Various pre or post treatment techniques are employed to remove recyclables such as glass, metals and plastics so that the composted fraction is concentrated in biodegradable materials.

[16] http://www.css.cornell.edu/compost/OnFarmHandbook/apa.taba1.html

4.3 Composting

There are two main categories of composting systems:

- Non-reactor systems including heaps, windrows and aerated static piles; and
- Reactor (in-vessel) systems, which include: batch tunnels, vertical solids flow, and horizontal/ inclined solid flows.

Whichever system is employed, the basic fundamentals must be adhered to (see Box 4.1 below).

The type of composting operation used will depend on the organic waste material to be composted.

The industry has a number of regulatory and voluntary drivers; these can influence the design and operation of the composting process. For example:

- A site approved under the ABP regulation must carry out the composting in accordance with a defined set of operating criteria (as shown in Table 4.3), and/ or
- Any site accredited to the BSI PAS 100 standard must carry out the composting to meet defined criteria (see Table 4.4).

Table 4.3: Permitted Treatment Strategies for ABP Wastes

<table>
<tr><th colspan="2">Catering waste meat excluded – i.e. source separated from all meat products</th></tr>
<tr><td>a) Closed reactor
70^{o}C for 1 hour – 6 cm (max particle size) or
60^{o}C for 2 days – 40 cm (max particle size)
and stored for 18 days post treatment</td><td>b) Enclosed windrow
60^{o}C for 8 days – 40 cm (max particle size) with turning every 2 days and stored for 18 days post treatment</td></tr>
<tr><th colspan="2">Catering waste with meat – requires a two barrier process</th></tr>
<tr><td>Barrier 1
Closed reactor
70^{o}C for 1 hour – 6 cm (max particle size) or
60^{o}C for 2 days – 40 cm (max particle size)</td><td>Barrier 1
Enclosed windrow
60^{o}C for 8 days – 40 cm (max particle size) with turning every 2 days</td></tr>
<tr><td colspan="2">Barrier 2
This is a repeat of stage 1 either in a closed reactor or housed windrow or in an open windrow at 60^{o}C for 8 days – 40 cm (max particle size), turned every 2 days</td></tr>
</table>

Table 4.4: Suggested Composting Criteria Suggested for Compliance with PAS 100 and Quality Protocol for Sanitisation

Temperature	Time	Moisture	Mixing/turning
≥ 65^{o}C	7 days	≥ 50 % (wt/wt)	≥ 3 times

Box 4.1: Key Features for Successful Composting

Raw materials influence the ratio of carbon to nitrogen in the initial feedstock and have a major impact upon the composting process. The preferred ratio of carbon to nitrogen in a feedstock mixture falls between 25-30:1. If this ratio is higher, the composting process tends to slow. If the ratio is lower, excessive amounts of ammonia are often released; often with associated odour problems.

Aeration, providing an adequate supply of oxygen, is vital for the composting process. 5%-15% oxygen within the compost mass is normally recommended. Should the raw material or the composting process ever become anaerobic, that is, should the supply of oxygen become insufficient, the process is compromised in a number of ways, and there is a considerable risk of offensive odours being generated.

The provision of adequate aeration depends upon two components: the structure of the composting waste, and the mechanism for the supply of air.

Moisture has an important effect upon the efficiency of the composting process. The optimum moisture content for composting will very much depend upon the water holding capacity of the composting mixture. Typical levels are between 50% and 70%. If the moisture level is too high for a particular mixture, the void spaces may be filled with water and aeration compromised. If the moisture level is too low microorganism activity will slow down. Unacceptable levels of leachate may also be produced with associated odour and water pollution problems. Considerable quantities of nitrogen and other nutrients may be lost as leachate.

Temperature varies throughout the composting process. *Thermophilic* treatment takes place at temperatures over 40^{o}C and is responsible for killing pathogens in the raw material. M*esophilic* treatment takes place at temperatures between 10 to 40^{o}C. Different microorganisms will be active under these conditions.

It is generally accepted that maintaining temperatures between 43^{o}C and 65^{o}C allows for effective composting. When temperatures rise above 65^{o}C the microorganisms suffer the effects of high temperatures and the process slows down. Excessive temperatures can increase the rate of emission of volatile odorants from the compost mass.

Particle size and structure is important in terms of the ability of air to penetrate the composting mass. Also in supplying the maximum amount of surface area on which microorganisms can act. If the average particle size is too great, composting can be slow because the available surface area is proportionally small. If the particle size is too small, composting can again be slow because of the difficulty of supplying sufficient quantities of air.

pH of a composting mixture will depend upon the nature and proportions of the components of the feedstock and will vary throughout the composting process, typically within the limits of 6 and 8.5.

The pH of a composting mixture influences the activity of composting microorganism and will determine the solubility and availability of nutrients utilised by the microorganisms. The pH influences the release of odorants: low pH may result in the emission of acid species (e.g. hydrogen sulphide and mercaptans) if present while high pH may result in the emission of alkaline species (e.g. ammonia and amines)

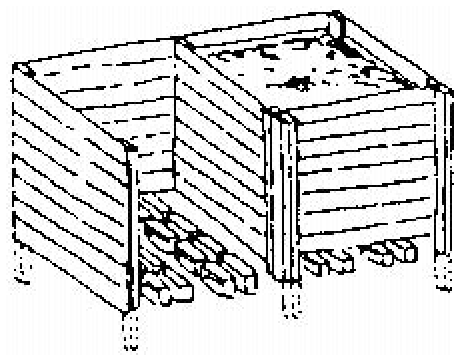
The pH of a composting mixture is not normally actively controlled.

Non-Reactor Process - Heap Composting

This is the simplest form of composting, used by households composting their own green and food waste and by community projects. Composting typically takes 12 weeks during the summer and a little longer during the winter. It is recommended that the heap should be turned every 4 to 6 weeks.

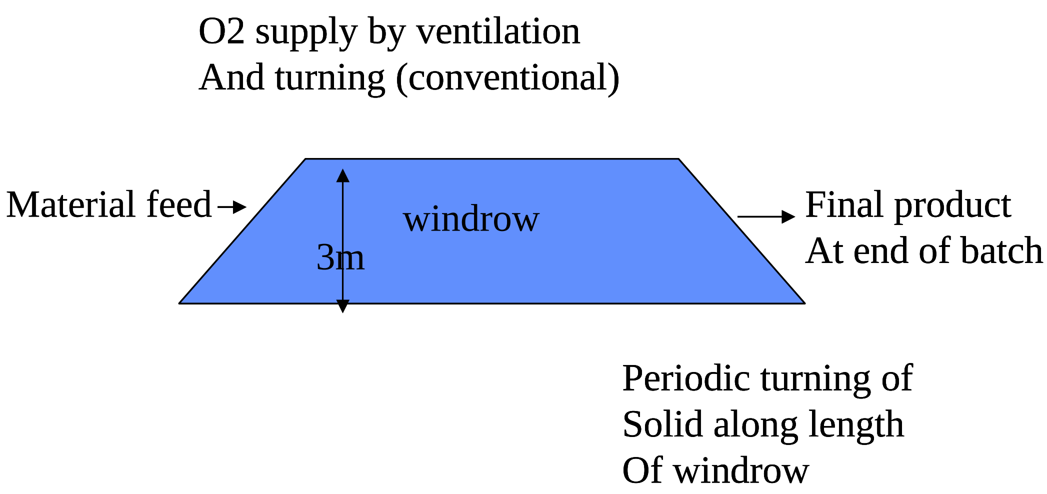
A range of simple composting systems are available for this scale of operation.

“New Zealand Box system”



Non-Reactor Process - Windrow Composting

Suitably shredded feedstock is thoroughly mixed using a front loader or a specialised machine and laid down into rows (windrows). Windrow composting normally takes 12 – 16 weeks depending on the end use of the compost. A period of maturation (3 - 4 weeks), is often carried out after composting *per se* is finished in order to stabilise the compost for particular uses.



Photograph 4.5: Windrow

Photograph 4.6: Windrow being turned by a side turner

These windrows are periodically turned, typically every 2 or 3 days during the first week and then once a week or once a fortnight, by means of a compost turner or a front loader. Temperature or oxygen monitoring can be used to assess when a windrow requires turning. The turning provides a fairly thorough mixing of the feedstock across the sectional profile helping to ensure that all of the material passes through a thermophilic stage and is pasteurised. Water may be added as required to keep the composting material within the optimal moisture range.

Air can be supplied to a windrow by either passive or active means. In the passive process air is supplied by diffusion and natural convection. Natural convection is driven by the chimney effect, with warm air from the centre of a windrow rising out of the top and cool fresh air drawn in at the sides. Passive diffusion can be facilitated by placing a layer of woodchip at the base of the pile. Materials that decompose quickly, such as a mixtures of grass clippings and leaves, must be placed in small windrows (3 metres high by 4 metres wide) or oxygen will be depleted. If the windrow is too large, oxygen will not penetrate to the centre, resulting in an odorous, anaerobic core. Windrows dealing with feedstock containing a high nitrogen content (e.g. grass) will need to be considerably smaller (ca. 1-2 metres high) to ensure adequate aeration, to facilitate more rapid composting. Moisture content and the size of composting particles will also affect the effectiveness of natural convection.

Additional oxygen can be provided by more active, mechanical means, by turning the compost with a front-end loader or a specialised compost turner. Although the oxygen added by turning only lasts a few hours, turning also loosens the piles so that air can flow more easily via natural convection.

Photograph 4.7: Windrow being turned by a straddle turner

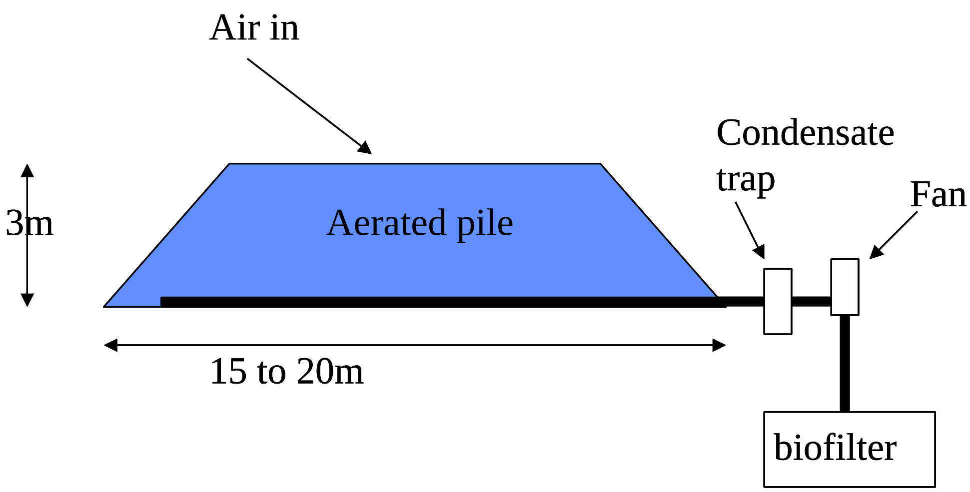
In uncovered windrow systems, there is a considerable risk of odours being released, especially during turning and for some hours after turning. Odour problems can be reduced to some extent by covering the windrows with specialised sheeting or by placing the windrows in a building with an air extraction and treatment system.

Photograph 4.8: Enclosed windrows

Non-Reactor Process - Aerated Static Pile

In this system, organic waste is formed into a windrow-like structure on top of a perforated pipe or channel on a concrete pad. Air is supplied by means of a fan or blower, and is distributed more or less evenly throughout the pile in perforated pipes or channels. Air can be supplied either by blowing air (forced aeration) or sucking air (induced aeration) through the pile. The system aeration can be controlled by a simple feedback mechanism using temperature or oxygen levels as the controlling parameter. An even simpler variation uses a timer to turn the fan on for fixed periods every hour or every day.

The pile is typically covered with a layer of mature compost, about 15 cm - 30 cm thick, to prevent the outer surface of the pile from drying out and to limit any release of odour. This layer can also allow the outside layer of the composting wastes to reach the higher temperatures required for complete composting and pasteurisation.



Photograph 4.9: Aeration Supply to an Aerated Static Pile

Variation to the basic aerated static pile can include the following:

- Covering the pile with an air permeable layer e.g Gor-Tex. The cover retains heat, prevents over-wetting through rain and reduces surface drying. Air can be supplied to composting waste covered in this way by perforated pipes; alternatively by

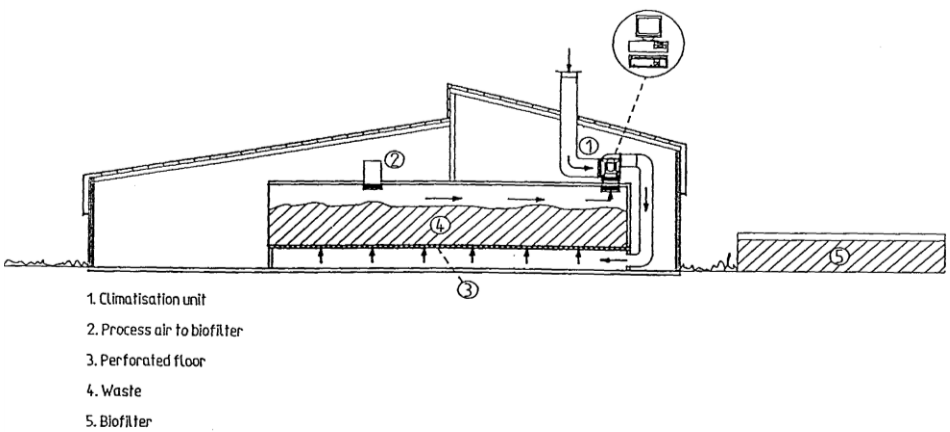
- Placing the pile within a plastic tube with a diameter 1.5 – 2 m and up to 60 m in length. The tube is fitted with a perforated pipe to provide aeration.

Odour emissions from aerated static piles should be substantially lower than from conventional turned windrow systems because there is no need to turn and disturb the compost, Where the aeration is achieved by ‘suction’ there is the opportunity to extract air directly to an odour control system . Potential odour problems can also be further reduced by placing the aerated piles in a building with an air extraction and treatment system.

Reactor (in vessel) Processes Without Flow - Batch Tunnels

This system uses a closed concrete or steel box to contain the composting waste. Dimensions vary from 3 - 5 metres high, 3 - 5 metres wide and up to 25 metres or more in length. The walls and top of the tunnels are normally insulated. The tunnels are filled by front-end loader or conveyor to a depth of about 2 metres, the exact depth depending upon the bulk density and porosity of the mixture. A gap, or headspace, of about 1 metre or less is left between the top of the compost and the roof of the tunnel to aid circulation of air. Once the tunnel is filled the doors are sealed; any air leaving the exhaust port of the tunnel is taken directly by ducting to a wet scrubber and/or biofilter.

The floor of the tunnel is made from concrete or steel, perforated with holes about 1 cm in diameter, or constructed from concrete slats with spaces between. Air is blown by a fan through the floor structure, through the composting waste and recirculated to the fan through ducting. Temperature is controlled by allowing fresh air to enter from outside the tunnel through a motorised variable flap. The ratio of fresh to recirculated air determines minimum oxygen levels within the compost and also controls the temperature within the compost. Ideally the entire composting mass should be around the same temperature at any time. The whole system can be computer controlled allowing full monitoring, recording and analysis of data.



An alternative design is the open bays system. In this type of batch system, the composting waste is held between concrete walls usually about 3 metres high, 3 – 5 metres apart and up to 25 metres long. The floor of the bay is perforated and connected to a fan to supply forced air. There is no roof to the bay and there are no end walls or a wall only at one end. The bay is filled to a depth of about 2 metres. Air is then forced through the composting waste without recirculation. Temperature and oxygen probes can be inserted into the compost and linked to a computer to control the process. Air supply may be continuous or pulsed. The composting waste may be removed from the bay mixed and re-filled during the process.

Photograph 4.10: Example of Fixed Roof Tunnel

Photograph 4.11: A and B – Example of Sliding Roof Tunnel System

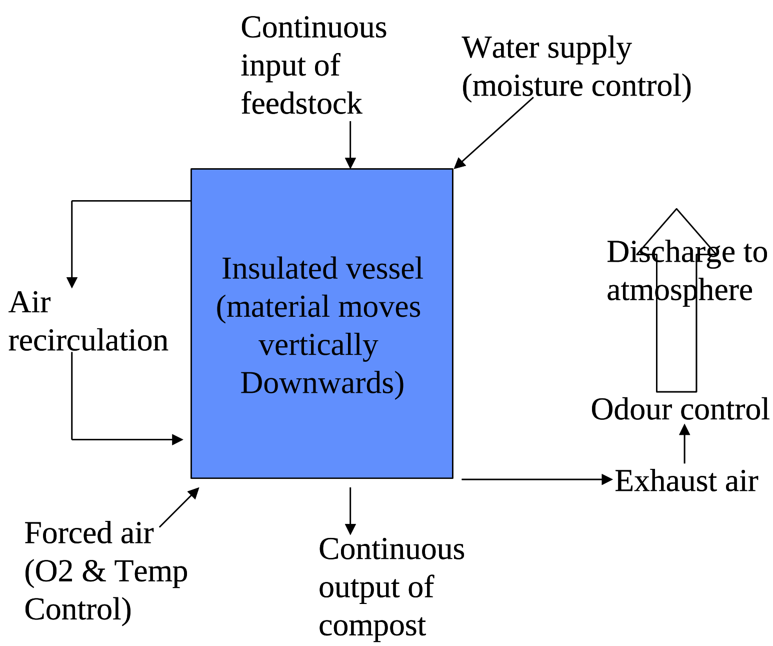
Photograph 4.12: A and B – Example of Opening Roof Tunnel System

Photograph 4.13: Batch Container System

Photograph 4.14: Open Aerated Bays

Reactor (in vessel) Processes With Flow

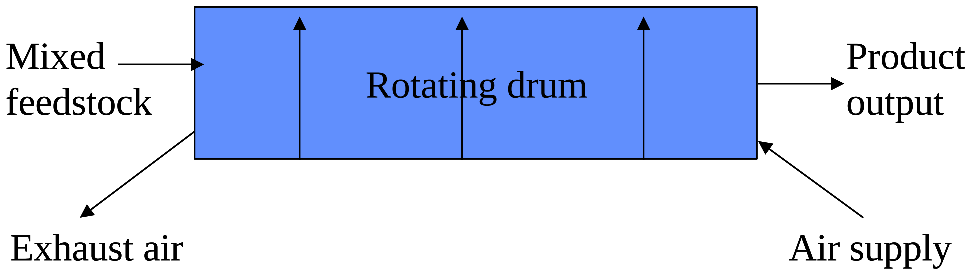
Vertical Solids Flow: where solid materials flow vertically through a container or reactor. These systems can be automated. They also normally require a smaller area of land to process a fixed volume of waste.



Photograph 4.15: Vertical Compost Vessel

Horizontal and Inclined Solids Flow Systems fall into three categories:

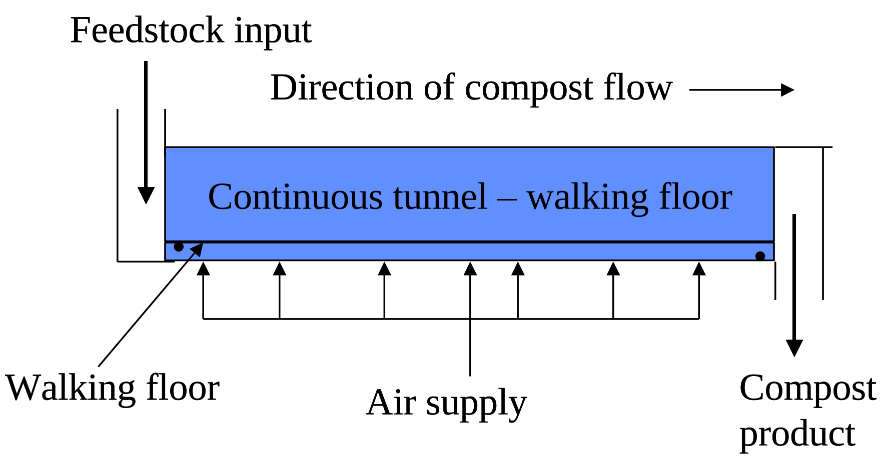
Rotary Drum system in which the feedstock enters from one side of a large rotating drum and the compost exits from the other. Residence time is 3 - 14 days but considerable post-treatment composting may need to be carried out.



Photograph 4.16: Rotating Drum Compost Vessel

Agitated Bin systems are available in both circular and rectangular forms. In both cases, agitation and forced aeration are applied. Reactors are normally uncovered at the top and housed in a building for protection against adverse weather. Most are operated on a one feed per day cycle. Processing time is 7 - 21 days with post-treatment maturation required.

Continuous Tunnel system is essentially a plug flow tubular reactor or rectangular container which composts a continuous supply of organic waste. The volume of each reactor can vary from 10 to 500 cubic metres. The smaller systems are typically constructed from steel, while the larger ones are made from reinforced concrete.



In all in-vessel composting systems, the aeration air can be contained and treated via a suitable odour control system.

4.4 Compost Maturation

Maturing happens at mesophilic temperatures and the moisture evaporation, heat generation and oxygen consumption are all much lower than at the active composting stage. A long maturation period can provide a comfort zone to cover any potential shortfalls from the composting methodology used, reducing the chance of an immature composted organic product being produced.

Maturing continues the aerobic decomposition of large particles, resistant compounds and organic acids which shifts the pH towards neutral and decreases the C:N ratio. Soil microorganisms will colonise the windrow or pile creating disease suppressing qualities. Nitrate-nitrogen may also be formed. As maturation continues during the aerobic decomposition process, aeration is still a requirement (by turning or fans) or anaerobic conditions and subsequent odours may result.

As a general guide for windrow composting, the maturation period begins when the windrow no longer re-heats after turning. For forced aeration, maturation begins after the pile temperature shows a steady decrease and approaches mesophilic levels (40^{o}C). Maturation may be complete when the temperature falls to ambient without the composted materials becoming too dry or anaerobic.

4.5 Compost Post Treatment

Following completion of the composting process, the compost may be screened typically using a trommel or star screen. Screening may occur either straight from the windrows or after maturation. Screening is used to remove oversized particles which will therefore lead to a decreased volume of compost produced. The extent to which the volume decreases will depend upon the nature of the feedstock, the efficiency of the shredder and the screen size of the screening equipment.

Typically screening will remove 20% - 40% of the finished compost (by volume). This oversized material can then be reintroduced into the feedstock, used or sold as coarse mulch, or otherwise removed from the site.

Photograph 4.17: Compost Screening

4.6 Compost Leachate

All composting processes involve the production of leachate. This is often high in dissolved nitrogenous and sulphurous material and can be a major source of odour production. In systems where this leachate is allowed to accumulate in significant quantities, often stored in non-aerated tanks or pits, the subsequent movement of this water can release significant quantities of odours. If the water is allowed to become anaerobic and sprayed on the feedstock it can be a major source of odours.

Leachate can be collected separately via a leachate collection system, which should be distinct from the surface water drainage system. If necessary the leachate should be stored in tanks or lagoons as an interim measure. Odour control measures may need to be applied to leachate storage and the management of leachate storage can be improved by:

- Screening the leachate prior to storage to remove solids. This reduces the oxygen demand and the tendency to go anaerobic during storage;

- Mixing within the storage tank to prevent the build up of solids at the base of the tank or lagoon. This prevents anaerobic zones being established; and

- Actively aerating the tank or lagoon so as to provide additional oxygen thus preventing anaerobic conditions being established.

Leachate that cannot be used in the process can be disposed of by:

- Discharging to foul sewer (consent permit required); and

- Disposal off site via road tanker.

4.7 Case Study – Example of Site Operation Utilising Tunnel Technology

Reception and Sorting
Upon receipt, input materials are unloaded within the enclosed raw material reception area. Material is tipped in one of two areas (one for ABP material and one for green waste) prior to shredding. Vehicles delivering ABP material have their wheels washed prior to leaving the site. Any visible contaminants such as glass, soils, plastic and other non-compostable items are removed prior to shredding. Such contaminants are managed as non-hazardous waste, stored indoors and sent off-site for disposal with the appropriate documentation. Shredding is carried out using a slow speed shredder.

The carbon and nitrogen content of the waste streams received have been determined using laboratory tests. Based on this information the compost feedstock mixture is prepared on the basis of approximately 2 parts shredded green waste mixed with 1 part ABP material. Depending on the nature of the feedstock received on site the moisture level may need to be adjusted.

The reception and sorting building is kept under negative pressure with the extracted air used as input air for the compost tunnels.

Composting
Following mixing the material is loaded in to the Phase 1 composting tunnels. These tunnels are accessed directly from the raw material reception area. Active composting is carried out for 1 week, following which the compost is removed from the Phase 1 tunnels and transferred to the Phase 2 tunnels for a sanitisation in accordance with the ABP requirement at 60^{o}C for two continuous days.

The aerobic composting conditions are controlled by managing the oxygen and moisture using probes in the tunnels. Negative pressure is maintained by forced aeration and extraction using air fans. Exit air is captured and either recycled back into the tunnel or exhausted to a biofilter.

Green waste which is not mixed with APB does not undergo the sanitisation stage. Phase 1 green waste not mixed with APB is moved directly to the maturation pad.

Maturation
Compost is removed from the tunnels and placed in concrete walled bunkers for maturation and stabilisation. Maturation lasts approximately 5 weeks. The maturation bunkers are aerated by negative aeration through channels cast into the concrete base.

Leachate
The channels in the maturation bunkers also collect liquid run-off. This leachate is stored in lined lagoons, which are covered. Leachate is used to wet the compost feedstock prior to filling the Phase 1 tunnel, but not for moisture adjustment of sanitised, mature compost. Surface water is collected and stored in separate facilities, it may be used for wetting the compost or may be discharged via a soak away once it has passed through an oil interceptor.

Finishing and storage
Following composting and maturation, the material is screened using a trommel screen. The finished product is stored temporarily to await export from the site.

Odour control
Odorous air extracted from various process areas is treated via two woodchip biofilters (one dealing with the air from the reception area and composting tunnels and one dealing with air from the maturation bunkers). The residual odour from the biofilter serving the reception area/composting tunnels is further treated by carbon filtration prior to discharge to atmosphere through a 10 m stack. The use of carbon filtration as a polishing step only works if the air is not moisture laden.

Part II – Assessment of Nuisance Odour from Compost Plant

5 What is Odour ?

5.1 Odour – General

Odour effects from composting are not caused by one single pollutant or chemical species, but rather compost odour is a 'cocktail' of chemical species emitted from the process. The nature of the ‘cocktail’ may change throughout the composting process.

The nose is an extremely sensitive receptor of odour - it can respond to small variations in concentration over periods of a few seconds and at concentrations of fractions of a part per billion.

In simplest terms, mechanism by which an emission of odorous chemicals leads to complaint of odour nuisance is as follows:

Emissions of Odorous Chemicals ➔ Odour Exposure ➔ Odour Stress ➔ Annoyance

There are many issues that influence the perception of an odour including variations as follows:

- The generation of odour due to the raw materials and various other periodic operations in the process;
- The dispersion of odour due to local meteorological conditions; and
- The sensitivity of the receptor.

The causal effect of odour on a receptor is a complex one. The response of an individual when exposed to an odour is subjective and depends on:

- How strong is it? - The strength of an odour is described in terms of odour strength;
- What does it smell like? - The odour type is described in terms of its offensiveness or hedonic tone (pleasantness/unpleasantness);
- How frequent and over what duration/when does it occur?; and
- In what context? Does the odour interfere with the enjoyment of the amenity of a neighbourhood.

The following characteristics further complicate the assessment of odour:

- An odour can arise from a single substance or from a combination of substances;
- In combination with other substances, the characteristic odour of a single substance can be modified so as to be unrecognisable;

- Odour from a combination of substances changes as the mixture becomes diluted and the concentration of each component falls below its odour threshold; and

- Odours that are pleasant or acceptable to one person can be offensive to another.

5.2 Odour and Health[17]

In most odour situations, including those involving compost odour, the odorant concentration that receptors may be exposed to will generally be a small fraction of Environmental Assessment Levels[18]. Therefore using this recognised assessment approach, it is accepted that exposure to odour is unlikely to cause 'harm to health'. In the event that a receptor is exposed to chemical species at high proportions of the Environmental Assessment Levels then the regulator should impose the necessary conditions to control their emission.

The relationship between nuisance odour and health is only partially understood. An individual's response to an odour is related to odour levels, as well as psychological and social factors. The response of one individual to an odour may however, be very different to another's response to that same odour. Some odours are associated with positive effects and others with negative impacts on an individual's health and well-being. An individual's own experience may have an important role in determining whether he/she reacts positively or negatively to an odour.

Notwithstanding the earlier comments, environmental exposure to malodorous substances is, nonetheless, associated with a wide range of health issues including complaints of the eye and nose, throat irritation, headache, diarrhoea, hoarseness, sore throat, coughs, chest tightness, nasal congestion, palpitations, shortness of breath, stress, drowsiness, and mood alterations[19]. Odours can also potentially impact on an individual's mood and memory. *These symptoms arise at odour concentrations well below those associated with toxic effects.*

There are at least three mechanisms by which ambient odours may produce health symptoms:

- Exposure to odours at levels causing irritation or other toxicological effects. This irritation causes the health symptoms, rather than the odour itself. A broad range of odourous volatile organic compounds including trees, flowers and foods can produce sensory irritation;

- Health symptoms associated with exposure to odours at non-irritant levels can arise from innate or learned aversions to that odour; and

- Co-pollutants (such as endotoxin) that are part of the odour mixture, rather than the actual source of the odour can cause irritation.

The importance of odour as a cause for ill health is not widely considered important in environmental regulations possibly due to the relatively minor nature of the symptoms. There are also difficulties with measuring and managing exposure levels. Although a number of the symptoms such as, headaches and nausea may be minor in nature they can have a significant impact on individuals' quality of life. There has been recent, growing evidence that an area's characteristics are more important determinants of health than individual socio-economic status. Odour nuisance is likely to have a negative impact on the perceived environmental quality that may contribute to some loss of well-being.

[17] A Searl, S Hankin and N Gibson "The Health Impacts of Odour Task 1- Assessment of Health Effects of Odourants" (2008) report prepared by AEA for SEPA (product code R60084PUR)
[18] Environment Agency. Integrated Pollution Prevention and Control (IPPC): Environmental Assessment and Appraisal of BAT. Horizontal Guidance H1.(2003)
[19] Schiffman SS and Williams CM. Science of odour as a potential health issue. J Environ Qual. 2005 Jan-Feb;34(1):129-38.

The following are précis of published studies directly concerned with the effect of composting:

- In a study of microbial volatiles (MVOC) emitted during composting[20], it was reported that compost-derived and microbial volatile organic compounds (MVOC) were found at distances of up to 800 m from the composting facilities. Terpenes like alpha-pinene, camphene and camphor were the dominant compounds and coincided with typical compost odour;

- The terpenes in combination with certain MVOC may play an important role in the perception of compost odour. Although exposure concentrations were not of toxicological relevance, the authors highlighted the potential for sensory irritation and psychohygienic effects due to odour annoyance; and

- A study[21] was carried out of the prevalence of somatic [physical rather than psychological] symptoms in three study/population samples living in the vicinity (150 m to 1,500 m) of composting plants. The percentages of the study population reporting somatic symptoms were higher in sample populations living near composting sites compared to the corresponding control samples. The frequency of reporting of general somatic symptoms was influenced by the perceived environment near the three composting sites. The highest complaint record was in the study sample/ population living close to a site exposed to bioaerosols and odour annoyance. In this group, breathlessness was reported more than twice as often as in the other two sample populations. There was, however, little evidence of a relationship between environmental odours or medically relevant bioaerosol concentrations and the type of reported somatic symptoms with the exception of nausea which was associated with annoying residential odours. The only group that reported a significant number of complaints (as a bodily total per individual) was that exposed to medically relevant concentrations of residential outdoor bio-aerosols. This group also reported high rates of breathlessness.

5.3 When does odour become a nuisance?

Candidate odours for consideration as nuisances include those which cause obvious and active changes in receptor behaviour, such as avoiding use of the garden, closing windows, making complaints, and keeping “odour diaries”. However, the determination of a nuisance has also to take account of the frequency and duration of odour episodes or events, as well as the characteristics of the odour and the numbers of people affected.

The opinion and judgement of the regulator are usually the most important factors in deciding if, or when, an odour constitutes a nuisance. The opinions and evidence of the regulator will also constitute important evidence before magistrates in any court proceedings involving nuisance, so it is crucial that regulators are appropriately objective, competent and thorough in their investigations of alleged nuisance odour.

In assessing the odour in a particular area a regulator might well look at the proportion of the population who complain. He/ she could be justifiably less influenced by a small number of complaints from a large or high density residential area where one would expect a high level of reports or complaints to be made.

The characteristics of the odour are very important. At one extreme, almost all receptors could be expected to find a strong odour arising from the composting of green waste under anaerobic condition, or the handling and composting of ABP waste, to be both objectionable and offensive, even with fairly regular exposure for short periods. The concentrations at which these odours become a nuisance could be relatively low if they are persistent and frequent. However, short term exposure to these offensive odours on an irregular basis would be less likely to be considered a justified nuisance. Such an event should however trigger the operator of the site to review their odour management plan (see Appendix C) to ensure that adequate management and operational controls were in place and in use.

[20] Müller T, Thissen R, Braun S, Dott W and Fischer G. VOC and composting facilities. Part 2: (M)VOC dispersal in the environment. Environ Sci Pollut Res Int. 2004;11(3):152-7.
[21] Herr CE, zur Nieden A, Bödeker RH, Gieler U and Eikmann TF. Ranking and frequency of somatic symptoms in residents near composting sites with odour annoyance. Int J Hyg Environ Health. 2003 Jan;206(1):61-4.

Other odours, such as those arising from composting carried out under aerobic conditions, may become objectionable, if not offensive, to almost all sectors of an exposed population by virtue of its persistence and intensity, particularly where the receptor population lives in close proximity to a compost site having inadequate odour control measures in place.

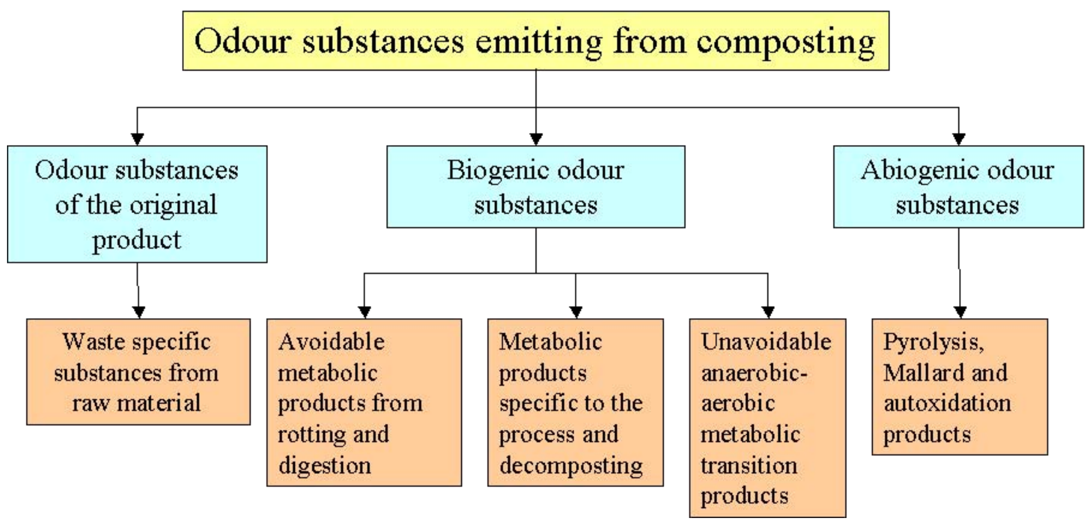
The odour impact of these examples could be assessed in a more structured way using the FIDOL factors approach described in Section 7.

6 Characteristics of Odour from Composting

6.1 Composting Odour

The nature of the odour emitted from the composting process will depend on the type of material being processed and the stage within the composting cycle. Due to the necessary reliance on microorganisms to degrade the organic waste, there will always be some odour emitted at each stage of the process. The key to good composting is to manage the process to avoid excessive odour emissions.

Figure 6.1: Pathways for Generation Odour in the Composting Process



Organic Waste Material

The nature of the odour from the composting process is partially governed by the organic waste material used on the composting site. Material will have started to decay once it was generated, for example once the grass is cut, the food discarded or waste is produced from an industrial process. The extent of that decay will depend on the storage period, temperature and any other factors that can promote anaerobic conditions to prevail.

Delivery, Storage and Preliminary Processing of Organic Waste Material

Once material is delivered to the composting facility, odours associated with the original waste material will predominate. During this initial storage, handling and preliminary processing period, odour is mainly generated in the mesophillic microbial activity. The odours arising from the material are not only dependent on its organic components but importantly because the waste has already started the decomposition process by the time the material is received.

Composting – Starting Phase

During the starting phase of composting the feedstock will contain organic substances that will degrade more easily. These are mainly decomposed by mesophilic microorganisms in fresh feedstock in the presence of adequate oxygen. Through this microbial activity, oxygen is consumed rapidly. In a windrow situation, the diffusion of oxygen from the atmosphere is not enough to reach deeper areas so more and more anaerobic degradation processes arise. The aeration of the material through frequent turning or by forced aeration during decomposition improves the oxygen input. The aerating process however, causes volatile substances to be released leading to elevated odour emissions.

The types of odorous substances emitted from the starting phase based on a fresh feedstock will include the following:

- Aldehydes;
- Alcohols;
- Carboxylic acids;
- Esters;
- Ketones;
- Sulphides; and
- Terpenes.

Composting – Thermophillic Phase

Once biological activity begins to increase, there is an increase in the temperature of the compost mass. The temperature rise causes a change in the composition of the microbial flora from predominantly mesophillic microorganisms to heat-loving (thermophillic) and heat tolerant (thermotolerant) microbial species. Additionally, the high temperature level releases more heavily volatile biogenic odour components. As the available oxygen becomes depleted during this phase there is an increase in anaerobic processing. The aerobic-anaerobic metabolic transition, together with the metabolic products of rotting and fermentation, produce increasing odour emissions. The rotting and fermentation metabolic products, which can be avoided, arise predominantly from the method of treatment of the raw materials prior to the active composting process commencing. Odours released to this point in the process are driven off by turning or aeration of the windrow.

During the thermophillic phase, as the proportion of easily degradable substances in feedstock decreases during the decomposition period there is a consequential decrease in the formation of biogenic odour components. However, abiogenic odour substances, i.e. those not derived from microbial action are simultaneously generated and are released via a purely chemical pathway, for example through pyrolisis or products of auto-oxidation. The formation of compounds increases with increasing temperatures. The odours generated at this time tend to have an unpleasant 'sweet-spicy' tone.

The types of odorous substances emitted from the thermophillic phase will include the following:

- Ketones;
- Organic sulphides;
- Terpene, and
- Ammonia and amines.

Photograph 6.1: Emission During Windrow Turning

Composting – Mesophillic Phase (maturation)

As the thermophillic phase reaches its conclusion more of the medium and heavily degradable components of the feedstock are degraded. This transition changes the properties of the decomposed material and is followed by a decreasing microbiological activity and temperature decline. Once again, mesophillic microorganisms prevail and the compost becomes stabilised. The reduced rate of degradation causes the oxygen consumption to be reduced and hence it becomes easier to maintain an aerobic environment with a consequent reduction in odour emissions.

The types of odorous substances emitted from the mesophillic phase will include:

- Organic sulphides;
- Terpene; and
- Ammonia.

6.2 Odour Emissions from Composting

Odour Sources

The primary releases of odours can be greatly reduced by ensuring that the composting process does not become anaerobic. Where significant emissions are released in the initial composting phase, emissions may need to be contained. The potential release points are as follows:

- Raw material reception, storage and handling;
- Accelerated decomposition of the raw materials often due to storage of wet material prior to delivery to site;
- From the application of leachate onto the feedstock;
- From the storage, handling and transport of the feedstock during the composting operation, particularly during, and after, mechanical turning and mixing operations;
- From the composting process particularly if the material becomes anaerobic;
- From the storage and disposal of any waste materials;
- From the collection, storage and re-use of liquid effluent (leachate);
- From the collection, treatment and discharge of waste and effluent from the odour arrestment plant; and
- From the odour arrestment plant discharge (this may be a stack or vent or may be a biofilter with an area source at ground level).

Where the odour arrestment plant includes a scrubber, emissions of materials which are added to the scrubber for improved performance (such as acids, hypochlorite, sodium hydroxide etc.) may be released with the plume if the scrubber and mist eliminator are not properly managed.

Magnitude of Emissions

A number of studies have been carried out to investigate how odour emissions vary throughout the composting process. For the purposes of this report the most useful data sets rely on odour sampling and olfactometry analysis[22]. This can be used to estimate the odour emissions from various parts of the composting process.

Magnitude of emissions depends on the following:

- The state and type of raw materials used on site and how they are delivered and stored;
- The process e.g. the control of moisture, temperature and oxygen content; and
- The scale of the operation, e.g. the surface area of the composting process, the quantity and quality of (intermediate) products.

[22] Ideally such assessment should be carried out using BS EN 13725:2003. 'Air quality – Determination of odour concentration by dynamic olfactometry'. This technique determines the dilution to threshold value based on the observation of a screened panel of assessors. This dilution to threshold value, expressed as in ou_E/m^3, gives the odour concentration in terms of the number of dilutions that are required before 50% of the screened population can and cannot detect the odour. For the purpose of estimating the odour emission from surfaces sources it is best practice to use a Lindvall Hood sampling technique, this will provide odour emissions in terms of odour units per square metre per second ($ou_E/m^2/s$).

A number of odour emission estimates have been made on composting sites. To illustrate how emission rates can vary from different stages of the compost process on a particular site and how emissions can vary from site to site depending on the type of material and compost process carried out, a number of different data sets are presented here. The examples presented are not intended to be an exhaustive list of emission rates but are presented to show the rough range of emission rates that may occur on a particular site. This information may be of use when reviewing input data in an odour impact assessment study.

The following data sets demonstrate the wide range of odour emission rates released from different composting methods at differing stages of the composting process. Odour is released from all stages of the process; however, those activities which involve the greatest level of disturbance of the material generally lead to the greatest odour emissions. The data sets also demonstrate the need for extreme care when assigning odour emission rates when carrying out an odour impact assessment especially where site specific odour measurements cannot be made.

Site 1 Windrow Composting[23]

This site used the outdoor windrow method of composting. Feedstock arriving on site was shredded out of doors and formed into windrows which were turned until composting was complete. The feedstocks varied, but included green waste, fruit waste and vegetable waste. Composted material was moved to maturation heaps and screened prior to removal from site.

Example Site 1: Odour Emission Data from Windrow Composting of Mixed Waste

Odour Source	Odour Emission Rate $ou_E/m^2/s$
Undisturbed, fresh shredded green waste	220 – 267
Undisturbed green waste mixed with straw	40 – 65
Undisturbed windrow – during week 1	74 – 102
Undisturbed windrow – during week 2	26 – 32
Disturbed compost off final windrow	1081 – 1574

[23] South West Industrial Crops Ltd “Bioaerosol Monitoring and Dispersion from Composting Sites” (2005)

Site 2 – Vertical Flow 'in-vessel' Composting[20]

This site used a vertical flow composting technology. The main feedstock was green waste, although some pet food waste was also processed. The reception area was a bunker with a metal frame and plastic canopy. Feedstock was shredded out of doors and the shredded material filled into the composting unit. The product was screened and stored under cover prior to removal from site.

Example Site 2: Odour Emission Data from In-Vessel Composting of Green Waste

Odour Source	Odour Emission Rate $ou_E/m^2/s$
Undisturbed, fresh shredded green waste	26 – 42
Fresh compost out of vessel	18 – 30
Previous batch of compost in stockpile	19 – 99
Older material in stockpile	15 – 28

Additional tests were carried out on the discharge from the compost vessel during the composting of a feedstock containing pet food residue. Odour concentrations were found to range from 1,172,819 ou_E/m^3 to 1,644,807ou_E/m^3. Subjective assessment of the odour showed the following:

- Undiluted sample – predominantly ammonia;
- Sample diluted 10 fold - predominantly compost; and
- Sample diluted 100 fold- rotting/ rotting animal, earthy, decay, cooking.

Site 3 – Clamp Composting[20]

This site used a 'clamp' composting technology, consisting of a series of enclosed, aerated, computer-controlled units. The reception area, shredding and screening were initially out of doors, but an indoor reception area was built during the course of the project. Shredded feedstock (mainly kerbside collected green waste and kitchen waste) was filled into the composting units. Material was then removed from the units and windrow composted. The compost was then screened and removed from site.

Example Site 3: Odour Emission Data from Tunnel Composting of Green Waste

Odour Source	Odour Emission Rate $ou_E/m^2/s$
Fresh compost, from tunnels$_1$	13 – 30
Mature, coarse, unscreened$_2$	10 – 13
Matured, freshly screened$_2$	16 – 19
Matured, screened on stockpile$_2$	1.7 – 3.3

[20] South West Industrial Crops Ltd "Bioaerosol Monitoring and Dispersion from Composting Sites" (2005)
[20] South West Industrial Crops Ltd "Bioaerosol Monitoring and Dispersion from Composting Sites" (2005)

Site 4: Tunnel Composting

This site used 'tunnel' composting technology, consisting of a series of enclosed, aerated, computer-controlled units. Green and other wastes are stored in a large temporary tarpaulin enclosure. Shredding takes place outside. Some mixed feedstock storage is provided inside a small converted agricultural building. Material was then removed from the units and transferred to maturation piles. The compost was then screened and removed from site.

Emissions from the composting process was treated by biofiltration.

Example Site 4 – Odour Emission Data from Tunnel Composting of Green Waste

Source	Odour concentration (ou_E/m^3)	Odour emission rate (ou_E/s) or ($ou_E/s/m^2$)
Biofilter	2200 - 2800	12,500* ou_E/s
Green waste stock pile	3,100 – 5,400	210 $ou_E/s/m^2$
Green waste shredded stockpile	9,200 – 11,000	440 $ou_E/s/m^2$
Product stock pile	950 – 1200	35 $ou_E/s/m^2$
Product screen	100 – 1300	7000 ou_E/s
Green waste shredder	18,000 – 250,000	220,000 ou_E/s

* based design flow rate

Example 5: Data set for a mechanical biological treatment plant[24]

This MBT plant processes 65,000 tonnes of household waste per year. Following shredding the waste undergoes a de-watering process to remove about 30% by weight. The extraction flow rate on the plant is approximately 82,000 m^3/h at maximum production to ensure minimal fugitive loss.

The odour control system illustrated is based on a woodchip biofilter sized to provide a 45 second residence time at peak flow. Typical odour concentrations leaving the MBT process range from 9,000 to 12,000 ou_E/m^3. Compliance tests carried out at a number of sites have demonstrated that residual odour concentration leaving the biofilter range from 133 to 300 ou_E/m^3.

MBT Process Hall

Biofilter Serving MBT plant

[24] Personal communication Alberto Maggi, Sistema Ecodeco

Example 6: Data set presented in the Netherlands Emission Guidelines for Air[25]

Data set derived in the course of an industry wide investigation into odour related problems at facilities for producing compost from household organic waste.

Part of Process	Odour Emission Factor	Units
Dumping	15×10^5	ou_E/tonne
Storage	138	$ou_E/s/m^2$
Pre-processing	15×10^5	ou_E/tonne
Composting composting in halls composting in open cells with evacuation aeration composting in tunnels composting in containers	 416 30 194 18	ou_E/tonne/s
Post-processing 1(of crude compost)	270	ou_E/tonne/s
Maturing	33	$ou_E/s/m^2$
Post-processing 2 (of finished compost)	270	ou_E/tonne /s
Storage of compost	Nil	n/a

[25] http://www.infomil.nl "Netherlands Emission Guidelines for Air" (section 3.3)

7 Assessment of Odour

7.1 Introduction

There are no "simple" instruments which can be used to objectively measure odours in the field. However, regulators should try to evaluate actual and potential odour impacts and 'nuisance odours' in an impartial and objective way that will be fair and reasonable to both process operators and odour sensitive receptors. The following guidance sets out some methods that can be used to improve the objectivity of odour assessments. The focus of this section is primarily on proactive assessment for use in planning/permitting applications. A brief summary of techniques that can be used for the reactive assessment of existing 'nuisance odours' is provided[26].

The most useful tools available to an EHP assessing the possible impact of a new, potentially odorous process at the planning application stage will be quantitative dispersion modelling techniques and the FIDOL table.

Typically, the most useful tools for regulators in assessing nuisance odours from existing plant, will be on-site "sniff" test type assessments (ideally by two or more officers) at the complainants'/ receptors' locations; diary sheets and complaint records, ideally with some wind/weather record analysis for corroboration.

7.2 FIDOL

The FIDOL factors are **F**requency, **I**ntensity (and therefore concentration), **D**uration, relative **O**ffensiveness (hedonic tone/character) and **L**ocation, along with any aggravating characteristics.

Although an odour does not have to be offensive in order for it to be detrimental to local amenity (in planning terms) or a nuisance odour , there are similarities between the criteria. Table 7.1 outlines the "FIDOL" factors that are useful in determining potential odour impact or "offensiveness", and some of the important factors that should be taken into account when assessing potential harm to amenity or nuisance odour levels.

[26] A comprehensive overview of monitoring and assessment tools is provided in Defra Tackling Nuisance Odour – a Guide for Local Authorities Consultation Draft November 2008.

Table 7.1: Relating Odour Impact (or Offensiveness) to 'Disamenity' in Planning Terms and to Nuisance Odour

The `FIDOL` Factors etermining offensiveness	Factors determining disamenity or Nuisance	Comments
FREQUENCY (How often an individual is exposed to odour)	Frequency (How often an individual is exposed to odour)	Even an odour with quite a pleasant hedonic score can contribute to disamenity or can be perceived as a nuisance if exposure is frequent. At low concentrations a rapidly fluctuating odour is more noticeable than a steady background odour,i.e. this is an aggravating factor.
INTENSITY (The perceived strength of the odour, proportional to concentration)	Level of odour	Factors are equivalent, however avoiding disamenity requires a lower threshold than for a nuisance assessment #.
DURATION (The length of a particular odour event or episode. Duration of exposure to the odour)	Duration	Factors are equivalent.
OFFENSIVENESS (relative)/character (Offensiveness is a mixture of odour character and hedonic tone at a given odour concentration/intensity)	Type of odour	Some odours are universally considered offensive, such as decaying animal matter. Other odours may be offensive only to those who suffer unwanted exposure in the residential intimacy e.g. coffee roasting odour.
LOCATION (The type of land use and nature of human activities in the vicinity of an odour source. Tolerance and expectation of the receptor.)	The characteristics of the neighbourhood where the odour occurs The sensitivity of the receptor	Factors are essentially equivalent. Nuisance uses the concept of the response of the average, reasonable person, disamenity should take into account expectation of all receptors.

Note: relationship between nuisance and disamenity is considered in PPS23 at (Annex 1A, section 1.8).

7.3 Proactive Odour Assessment

Planning applications for new composting plant or for plant undergoing significant redevelopment have the potential to cause off-site odour impact and should be supported by an evaluation of the expected odour impact and proposals for odour mitigation measures, where necessary. The degree of detail provided in such assessments should be proportionate to the risk of odour impact, taking account of factors including the proximity of receptors, the scale of the proposed activity and the nature of the composting process.

It is now common and accepted practice for planning applications for such composting plant to be supported by detailed odour impact assessments. These assessments are typically based on computer models which predict odour dispersion from the proposed development, based on local weather records and estimated or predicted odour emissions from the proposed development.

The outputs from dispersion modelling are usually presented as odour contours or “isopleths” on a base map of the area, and this allows potential odour impact to be predicted at odour sensitive receptor locations such as residential developments in the area and for this impact to be compared with 98th percentile impact benchmarks. Typical benchmark values have been published by the Environment Agency[27]. For composting, the following benchmarks are considered appropriate:

- 3 ou_E/m^3 as a 98th percentile – provides a starting point for assessing the impact from most compost plant; and
- 1.5 ou_E/m^3 as a 98th percentile – provides a starting point for assessing the impact from compost plant dealing with slaughterhouse waste (or similarly offensive material);
- The benchmark criterion can be reduced to take account of the following:
    - The population density around the site. This reflect the potential that sensitive receptors are more likely to be present in larger receptor populations; and/or
    - Any history of justifiable compost odour complaints. This is specific to an application to redevelop an existing site; and
    - Reductions will typically be of 0.5 ou_E/m^3 per applicable criterion.

Dispersion models can also be used to estimate what level of odour mitigation is required to control odour impact, or to determine the maximum permissible odour emissions from a site to avoid off-site impact or loss of amenity. These predictions, and the mitigation measures which can be prescribed as a result of objective measurement, can play a key role in preventing many years’ experience of nuisance odours downwind of the site.

An example of an odour impact assessment report is presented in Appendix B.

7.4 Reactive Odour Assessment

There are a number of monitoring methods that can be used by a regulator to address and tackle odour issues from an existing site, these are summarised in Table 7.2. A full description and guidance on their application has been prepared by Defra[28].

Reactive odour assessment techniques may be used in the following circumstances:

- By an operator as a means of characterising the odour emissions from operations carried out on site and assessing the odour impact on local receptors. This type of information can be used as follows:
    - To demonstrate compliance of the site operation with that illustrated within any odour impact assessment study carried out as part of the planning application process. The planning permission may include a requirement to carry out this type of assessment during plant commissioning; and
    - To improve the quality of data held within an odour management plan (see Appendix C). Source specific odour measurements made on a particular site should supercede predicted odour emission data which may have been used in impact assessment studies during planning. In certain circumstances if the odour emission and odour impact are significantly different from the original/previous data within the odour management plan, additional control measures may be required.

[27] Environment Agency (2002) Draft IPPC guidance on odour (H4 – Horizontal Guidance Note for Odour)
[28] Defra Tackling Nuisance Odour – a Guide for Local Authorities Consultation Draft November 2008.

- By a regulator as a means of:
  - Allowing other odour sources to be eliminated from the investigation;
  - Assessing whether odour complaints are justified;
  - Determining whether the odour emissions from the site breach an acceptability standard. This acceptability standard will depend on the regime, for example – for breaching planning conditions the standard would reflect causing harm to amenity (disamenity); for causing statutory nuisance the test would be that of material interference with the enjoyment of land; for causing offensive odour at the site boundary as perceived by the Environment Agency inspector; and
  - Determining the principal cause(s) of odour emissions from a site.

Table 7.2: Reactive Odour Assessment Techniques

Reactive Odour Assessment Techniques	Comment
Source emission characterisation combined with computer dispersion modelling.	Usually used as a predictive tool to assess the impact of proposed plant. But also successfully used to identify causes of off-site odour impact or to rank relative efficacies of odour abatement strategies. Requires the input of source emission data (in odour units) that may not be easily available to regulators. Allows comparison with numerical odour benchmarks. Source emissions can be characterised using measurement at source EN 13725:2003.
Source characterisation using surrogate chemical species.	A range of unpleasant odour types can be emitted from composting. Using simple colorimetric analytical techniques (e.g. for hydrogen sulphide, mercaptan, and amines) can indicate whether the emission from a site contains highly offensive components.
Field odour assessment using “sniff test”.	This is likely to be the main tool used by regulators to assess odour impact. Sniff Tests are designed for assessing the odour impact by recording some or all of the FIDOL factors.
Measurement of odour exposure, expressed as frequency of ‘odour hours’.	Direct measurement of the frequency of ‘odour hours’ on a grid of receptor points, using trained observers. This technique is cumbersome, due of the long period required for observations (6 months minimum).
Complaints monitoring – the level of complaints from surrounding sensitive receptors.	Monitoring the frequency, timing and total number of odour complaints about a particular compost plant or operation can provide an indication that there is a potential nuisance issue. Records about the time of day when complaints occur can help identify specific causes of alleged nuisance. Plus, records of complaints can be used to provide evidence of an offensive odour or nuisance in legal proceedings in the event of a plant operator appealing against either a notice, or defending a prosecution for a breach of a notice.
Odour diaries, etc.	Odour diaries can assist complainants in providing details of their perception of the suspected nuisance odours and any effects that the odour has on their behaviour. Details are recorded using a standard diary record sheet on a daily or weekly basis and particularly whenever an odour episode occurs. Simple local wind or weather records can also help identify or confirm the source of alleged nuisance odours.
Ambient air quality monitoring at the receptors.	This is very difficult to carry out in a way that enables valid conclusions to be drawn. In fact in the vast majority of situations it will be impractical because gas concentration instruments and analysis techniques are generally much less sensitive than the human nose. Note that dynamic olfactometry cannot be used for ambient monitoring.

Part IV: Control of Odours from Compost Plant

8 Strategy for Odour Mitigation

Unlike a mechanical process, the breakdown of organic materials is very difficult to stop once started. When the necessary components for a particular biological process are not present to a sufficient degree, the microbial population will shift to favour microorganisms capable of making best use of the prevailing conditions. For example, when adequate oxygen is available, aerobic microorganisms will dominate the population, but a lack of oxygen will cause organisms that do not require oxygen (facultative anaerobes) to take over as the dominant group. These different microorganisms use alternate processes to degrade organic material.

To minimise offensive odour emissions, the following odour control techniques should be applied:

- Good housekeeping and raw material handling practices;
- Careful selection and inspection of raw materials;
- Timely incorporation of fresh feedstock into the composting process;
- Control and minimisation of odours from residual materials and waste during the composting process;
- Maintaining aeration of leachate;
- Avoiding anaerobic conditions; and
- Containment of strong odour sources and treatment by odour control equipment.

Table 8.1: Overview of Control Techniques

Release Source	Examples of Control Techniques
Loading and unloading processes	Control of quality of raw materials - Rejecting unfit materials (e.g. too wet, too odorous) Covered vehicles and containers.
Raw materials, leachate and waste storage	Location to take account of sensitive receptors. Raw material quality. Avoid any anaerobic activity. Aeration of leachate.
Feedstock preparation	Maintain aerobic conditions including turning and oxygen monitoring. Rapid incorporation in to aerobic composting process
Composting process	Ideally locate within buildings, tunnels, bunkers or vessels where feasible or economic Adequate aeration and oxygen control. Avoid excess temperature and moisture Ventilate to odour control equipment. Aeration of static piles to avoid high emissions associated with turning windrows outside
Ventilated air from raw materials area, and enclosed process or aerated static windrows	Vent to suitable arrestment plant: ➢ Biofilters; ➢ Scrubbers; and ➢ Location to take account of sensitive receptors.
Emissions from odour arrestment plant	Final dispersion to minimise adverse impact at sensitive receptors

The main elements of the odour control strategy presented here are split into two sections. Firstly, general control techniques that should be applied to all composting sites, especially those sites using open windrow technology. Secondly, more specific techniques which should be applied to enclosed operations.

To minimise the risk of nuisance odour from proposed sensitive development, irrespective of the type of raw material handled, all raw material handling and phase/barrier 1 composting activities should be enclosed.

8.1 Siting of Compost Facilities

This section is particularly relevant to the siting of a new compost facility, however the factors discussed here may exacerbate nuisance odour situations around existing plant if not sited correctly.

Wind Direction

Local meteorological conditions (wind speed and direction) will influence dispersion between a compost site and local receptors. However an odour event will only occur if certain conditions prevail. For example

- If the wind direction is away from a receptor, the odour will not impact on the receptor;
- if the wind speed is high the odour will be diluted below the olfactory threshold before it reaches a receptor down wind of the site; and
- if the wind speed is low and unstable atmospheric conditions prevail then the odour will be diluted below the olfactory threshold before it reaches a receptor down wind of the site.

It is not possible to define the generic meteorological conditions that contribute to a nuisance event, as each site will have different characteristics.

In general it is recommended that compost plant should not be located close to and directly upwind in the prevailing wind direction of residential receptors. In the UK, the predominant wind direction is usually south westerly, but typically prevailing winds only have maximum frequency of 15%-25% from any one point of the compass.

When seeking planning permission for new or proposed sites, a wind rose should be provided as part of the odour impact assessment to provide accurate data on historical wind patterns.

It is recommended that a high visibility wind sock is installed to provide instantaneous information on wind direction available to all operatives on a site. The use of a meteorological station is also recommended to provide objective data that can be stored.

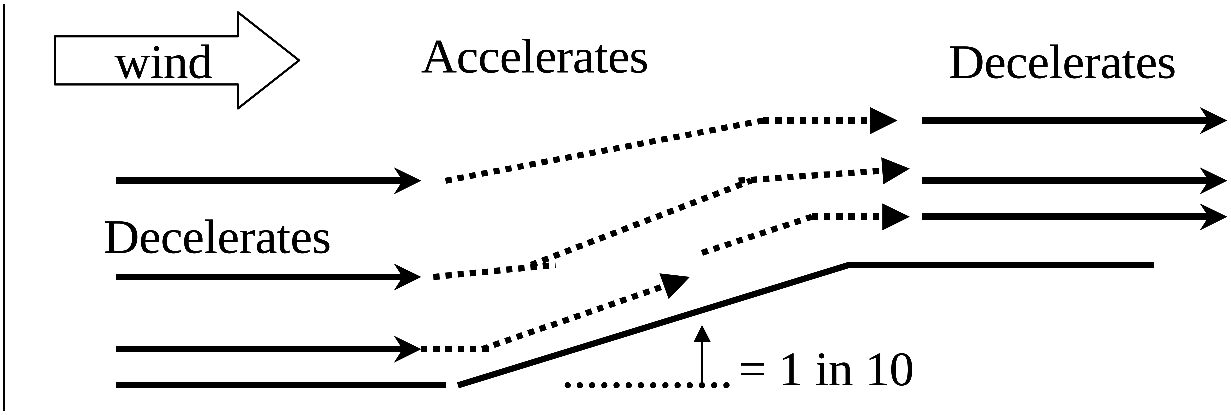
Photograph 8.1: Example of a high visibility wind sock

Terrain Effects

Topographical features, such as hills and ridges, valleys and escarpments or slopes, can have significant influence on local wind speed and wind directions. For instance large river and estuary “valleys” can cause wind funnelling with effects on wind directions and speeds, and hence will influence local dispersion of odour. The effect of terrain can be one of the considerations when siting compost plant. The suitability of a particular site may therefore depend on the location of sensitive receptors in an prevailing direction of a terrain feature.

A shallow slope, with an incline of less than about 1 in 10, will cause approaching wind speed to reduce at the foot of the slope, will increase to a maximum value near the crest of the slope, before decelerating to a constant value downwind of the slope (Figure 8.1). Where the slope is shallow there should be negligible effect on odour dispersion.

Figure 8.1: Flow Up a Shallow Slope



For steeper slopes, an upward air flow produces separation of the air-flow upwind of the base of the slope and upwind of the crest, resulting in a reverse flow of air in each location, or as it is more commonly known, a vortex. Because the air-flow in a vortex is circulating, it provides an upward force which will tend to cause odorous compounds to become entrained in the air mass (Figure 8.2). Flow down the slope creates a vortex only at the base and not at the crest (Figure 8.3). Siting a compost plant where dispersion could be influenced by such effects may be inappropriate unless highly effective odour control is in place.

Figure 8.2: Flow up a Steep Escarpment

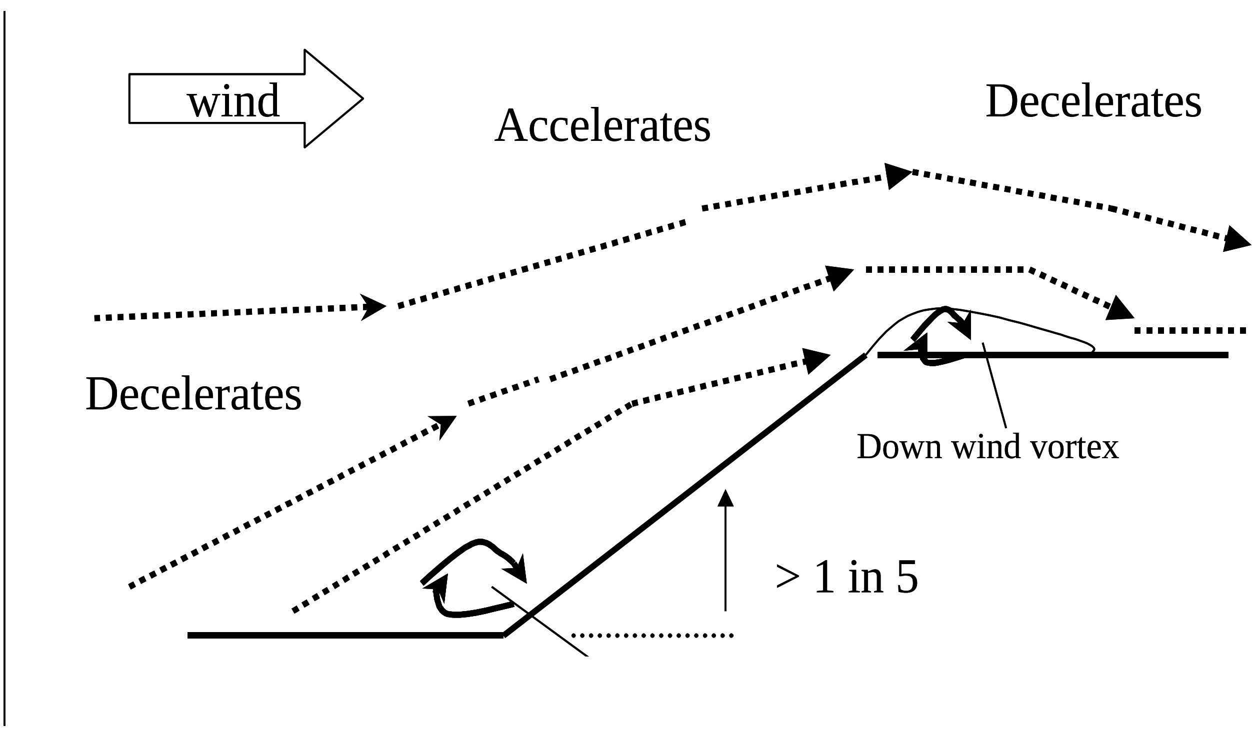
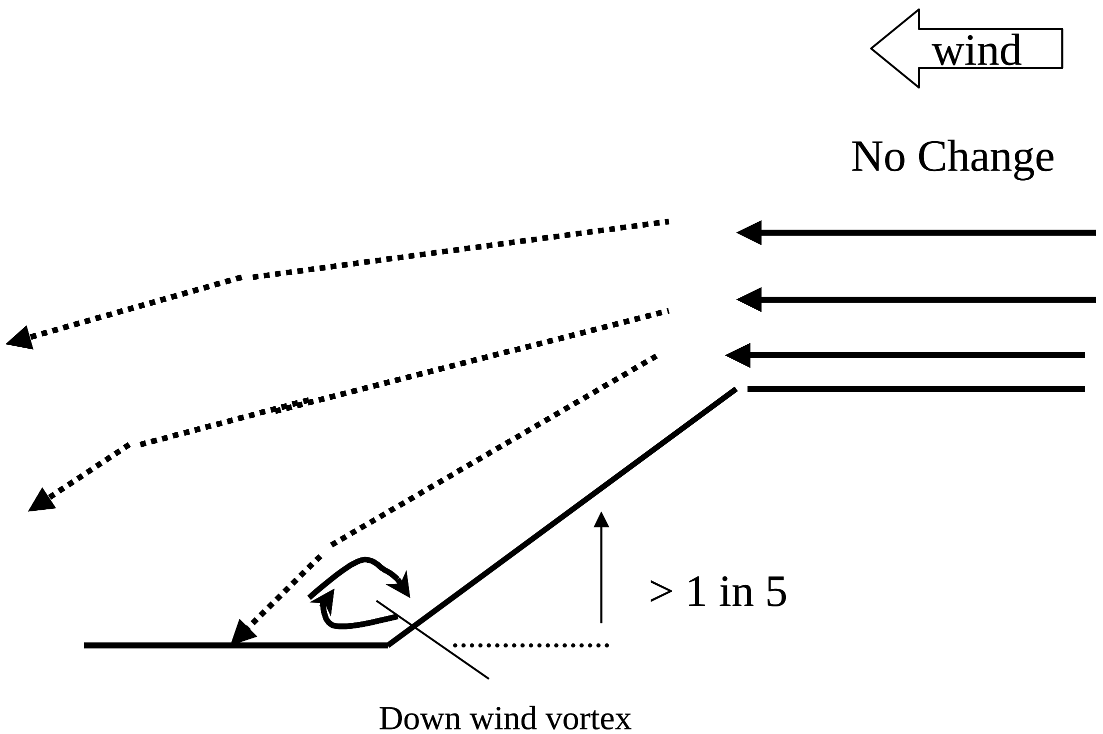


Figure 8.3: Flow Down a Steep Escarpment



Vegetation

Providing a natural or artificial barrier between facilities and locations where members of the public have access or reside can help reduce the localised odour impact of a compost operation. Planting several fast growing trees or shrubs, constructing a soil bund or a high windbreak fence between the site and sensitive receptors can be beneficial. Apart from beneficially reducing visual intrusion, such natural and artificial barriers may enhance turbulent mixing and hence improve dispersion and reduce the impact of odour emissions on local residents.

Set Back Distances

The provision of a sufficient buffer zone or set back distance between a compost plant and the nearest sensitive receptor is desirable. A sufficient set back distance provides emissions from the site with a zone in which residual odour from the site can dilute and disperse before reaching a receptor.

The Environment Agency has applied a distance function as a cut off for sites seeking to obtain permits using Standard Rule (set at 250 m). This distance is applied irrespective of the throughput of the compost plant. This is guidance may be primarily concerned with bioaerosols, but is good practice from the point of view of odour impact control too.

The Dutch Government[29] has issued guidance on the set back distances of facilities producing compost from green waste using three different methods:

- **Method A**: Intensive method with frequent turning. At the beginning of the process the heaps are turned approximately once every three days. The frequency of turning is reduced while the process progresses. This can be controlled by process parameters. The heaps are turned approximately ten times over a period of three months;

[29] "Netherlands Emission Guidelines for Air" (section 3.3)

- **Method B**: Conventional method. After building up the heaps, they are turned at regular intervals using shovels and cranes. The heaps are turned approx. seven times over a period of six months; and

- **Method C**: Intensive method with forced aeration. The process should be done in such a way that full aerobic processing is achieved. Now and then turning the heaps will be necessary to maintain aerobic conditions in the complete heaps.

Table 8.2: Set-back distances for different composting techniques discharging at ground level[30]

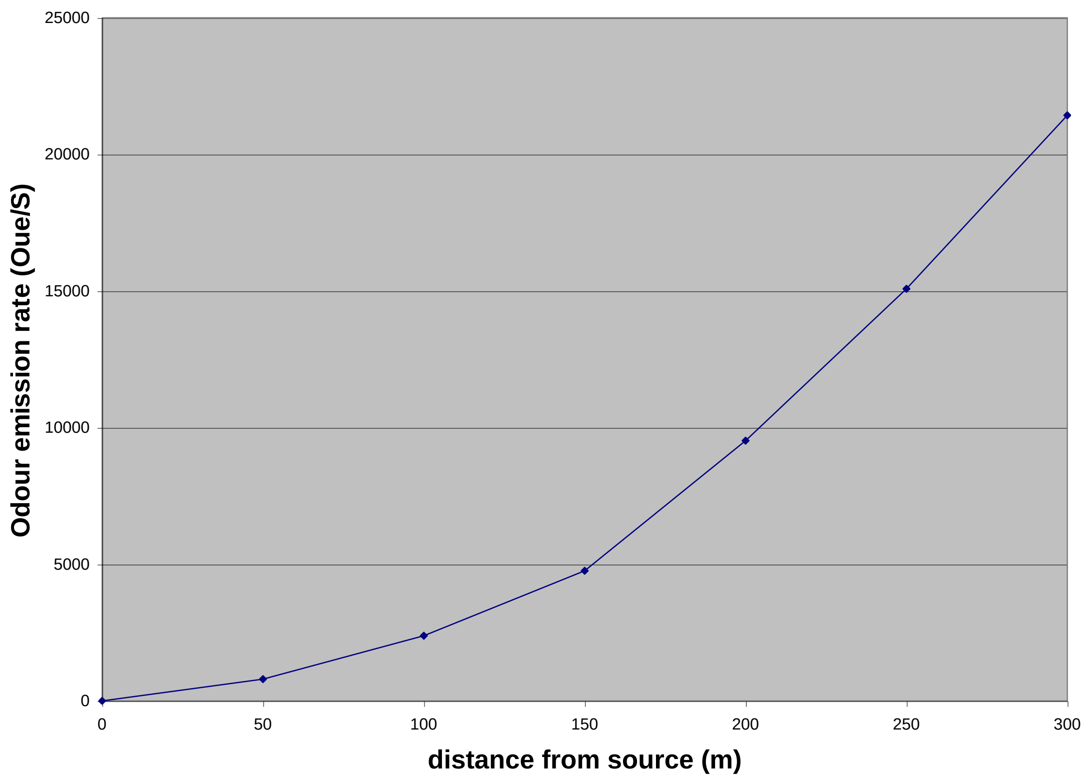
Production rate (tonnes*/year)	Method A Distance (m)	Method B Distance (m)	Method C Distance (m)
0-5,000	100-200	225-300	100
5001 – 10,000	200-400	300-450	100
10,001 – 15,000	400 – 600	450-600	100
15,001 – 20,000	600 – 750	600-700	100
>20,000	>750	>700	200

* tonnes of material to be composted

An alternative approach is shown in Figure 8.3. This shows the correlation between odour emission rate (ou_E/s) discharged at ground level and the distance at which the 3 ou_E/m^3 as a 98^{th} percentile is predicted to occur. This provides a rule of thumb guide as to the safe distance between the emission source and the closest sensitive receptor. In the situation where a site is within the suggested distance a greater level of odour control should be used on site. In the situation where the compost process is enclosed, treated by a suitable odour control plant and discharged via a tall stack the correlation shown in Figure 8.3 will not apply because of the improved discharge characteristics.

[30] http://www.infomil.nl "Netherlands Emission Guidelines for Air"

Figure 8.3: Distance required for dispersion of different ground level odour emissions rates to achieve 3 ou_E/m^3 as a 98th percentile down wind of a source.



8.2 General Techniques to Control Fugitive Odour Emissions

The operator must maintain and control the quality of incoming raw materials to reduce potential odour release during delivery and storage. Unacceptable materials should be rejected. Potentially odorous raw material storage quantities should be minimised and introduced into the composting process as soon as possible. Where this is not possible raw material storage and processing should be carried out within an enclosed building. Where raw materials are stored outside it is good practice to incorporate material in to composting windrows on the day of delivery or in any case within 24 hours of delivery to site.

A proactive management strategy in the form of a Raw Material Delivery Plan should be employed by the operator to demonstrate that the risk of offensive odour from raw materials is minimised. A Raw Material Delivery Plan should identify:

- What materials will be delivered to site;
- The maximum and minimum volumes that will be delivered;
- How the volumes are likely to change throughout the year, especially in the spring and autumn;
- When they will be delivered;

- What is the delivery schedule over bank holidays;
- Which materials or material sources are most likely to be odorous; and
- What rejection criteria should be applied to deal with unacceptably malodorous wastes.

To minimise odour emissions at the delivery stage:

- The design and use of delivery vehicles and containers to prevent spillage and subsequent odour emission;
- Rejection of all potentially malodorous raw materials delivered to the site or material with a sufficiently high moisture content as to be likely to give rise to odour during storage prior to use;
- All potentially malodorous solid raw materials should be stored so as to prevent them becoming so wet as to lead to offensive odour emissions - for example, by sheeting the material or by the provision of covered storage areas. The size of stockpiles should be kept to a minimum and all potentially malodorous raw materials should be incorporated into a composting process as soon as possible after delivery; and
- The location of material storage should take account of sensitive receptors.

The operator must ensure that all surfaces and equipment liable to come into contact with raw materials or waste and all wall and floor surfaces of areas where such materials are handled should be impervious, capable of being readily cleansed and they should be kept clean:

- All floors of processing and storage areas should be of impervious construction and laid to fall to the effluent collection system. Trapped drainage inlets should be provided where necessary, with sedimentation tanks and interceptors to prevent the transmission of material likely to impair the free flow of any receiving effluent system.
- Buildings should be constructed of suitable materials (for example brick or concrete walls and sealed metal sheet roofing), the integrity of the buildings should be regularly inspected and maintained to prevent the uncontrolled escape of air from the processing area.

The composting operation should be carried out in such a way as to ensure that organic decomposition proceeds aerobically. This will involve optimising the penetration/distribution of air into the composting material at all times-for example, by ensuring that:

- Sufficient woody material is used;
- The substrate does not become too wet;
- The size of individual piles of feedstock is optimised;
- The substrate does not become too hot. To avoid excess heat generation core temperature should be monitored and feedstock turned or the aeration rate increased to maintain optimal temperature composting;
- The feedstock is turned regularly to prevent as far as possible the development of malodorous anaerobic breakdown conditions;
- The incorporation of leachate onto the feedstock is achieved by methods which reduce aerosol production and overspray. Only aerobically treated or low odour potential leachate should be used in sensitive locations. Liquid spray heads which are used to irrigate the substrate with leachate should not employ high pressures or small orifices that might lead to the atomisation of the liquid sprayed;

- All liquid should be applied in droplet form. Methods of application which do not involve open sprays are preferred (for example the use of spray bars integrated within turning and blending machines or injection nozzles). If spray bars are used, the spray nozzles should be set close to the compost surface;

- The process incorporates oxygen either by mechanical turning of windrows or by forced aeration of the process either in a building, tunnel or vessel provided with extract ventilation discharging to an odour arrestment plant. The method of forced aeration will be dictated by the design of the composting equipment. The level of oxygen within the feedstock should ideally be continuously monitored and recorded where practicable. In the case of turned windrow systems monitoring of oxygen should be carried out periodically, typically this will include not less than 2 spot readings of the core oxygen concentration down each windrow in any 24 hour period. Based on the measured oxygen concentration the aeration process should be managed to ensure that oxygen level does not fall too low; and

- The point at which raw materials which promote rapid composting are introduced to the process should be considered carefully. Raw materials which promote rapid composting (e.g. grass, certain farm yard manures, animal waste) may lead to the generation of offensive odours. In circumstances where mixing and wetting operations are not carried out within a building, consideration should be given to mixing these raw materials at the final stage immediately before placing the feedstock into the windrow, tunnel or vessel.

The operator must ensure that equally effective control of the composting material is also applied to the maturation phase as there is still potential for anaerobic conditions to be created. Leachate should not be used to maintain moisture levels in stablised, mature compost.

The process will usually recycle all effluent for use in the process to maintain moisture within the feedstock.

- All potentially malodorous liquids, such as leachate arising from composting operations, should be stored in tanks or lagoons, designed and situated to minimise the impact of any odour which is generated. All pipework and channelling which carries such leachate from the process to storage and vice versa should be totally enclosed and maintained. Ideally all such pipework and channeling should be fully flushable *in situ*;

- All malodorous waste materials, such as sludge arising from the cleaning of leachate storage tanks or lagoons, should be held in enclosed storage pending removal from site, or preferably drawn straight into road tankers ready for removal from site. Fixed draw-off points should be provided in liquid storage facilities to facilitate the drawing off of accumulated sludge without the need to open the storage container;

- Storage tanks or lagoons which contain leachate arising from the decomposition of the substrate should be fully and effectively aerated to prevent malodorous anaerobic conditions developing in the liquid;

- Where possible submersible pumps should be used to minimise the potential for odour escape; and

- Yard surfaces should be impervious, laid to drain and be free from surface imperfections to ensure free flow of effluent and rainwater and avoid the collection and possible stagnation of liquids.

Good housekeeping should be employed at all times. The adoption of good cleaning and working practices must be routine and will reduce process odour emissions. A proper cleaning programme should be documented and instituted. This should cover all structures, equipment and internal surfaces and containers and hoppers used for raw material processing and collection and waste storage. The cleaning of all drainage areas and collecting tanks, yards and roads should be undertaken regularly and at least once a week.

A senior manager who recognises the importance of controlling the odours produced by compost manufacturing should be designated to be specifically responsible for all aspects of liaison with the regulator and where applicable with members of the general public.

8.3 General Techniques to Control Contained Odour Emissions

Emissions from the composting comprise odours of a cocktail of chemicals but particularly ammonia, amines, mercapatans and terpenes. The main principles for preventing odour emissions are maintaining the process under aerobic conditions using good design, operation and process management. There will be circumstances, for instance where highly putrescible wastes are composted where the operation cannot be controlled to guarantee that emission of malodour will not occur. In these situations it is necessary to contain the process operations and use abatement systems to ensure that the emissions do not result in nuisance odour beyond the process boundary or at sensitive receptors. Containment is achieved by ensuring that all operations are carried out within a building provided with sufficient extract ventilation to prevent fugitive emissions.

Raw materials delivery and unloading should be carried out within a building provided with ventilation to maintain an adequate negative pressure within the preparation areas to eliminate the possibility of odours escaping to the atmosphere without treatment. On plant where ABP materials are processed airlocks should be provided at the vehicle entrance and no transfer or unloading of raw materials should take place within the airlock. All doors used by vehicles should be of the rapid opening and closing type.

Ideally, the feedstock preparation should be carried out within a building provided with ventilation to maintain an adequate negative pressure within the preparation areas to eliminate the possibility of odours escaping to the atmosphere without treatment. The preparation areas should be provided with forced aeration of feed stockpile to prevent anaerobic conditions being established before the compost mass is formed. Depending on the design of the site, the air extracted from this area may be used as aeration air for the composting process.

- The process operations may either be carried out using standard windrow methods or using aerated windrows, tunnels or vessels. In the case of windrows methods forced aeration should still be employed to provide better control of composting conditions and to eliminate the need for, or to at least reduce the frequency of, mechanical turning which potentially causes short-term peaks of odour emissions that can lead to complaints.

- The ventilation system design and extract point distribution should ensure that negative pressure is maintained in all processing areas of composting buildings. It may be more effective to use increased extract ventilation rates in areas of the building where operations generate higher intensity odours. The use of tunnels with fast acting doors or in-vessels systems can be operated with variable extraction rates that are matched to process operations and associated odour generation. Judicious use of such control systems will reduce the amount of extracted air for arrestment.

- The necessary ventilation rate will depend upon many factors, including the following:

    - Environmental conditions (higher ventilation rates are required in hot weather);
    - Raw material quality and throughput;
    - Composting activity;
    - Production rate;

    - Process operations (higher ventilation rates are required during movement and turning of materials);

    - Building design and ventilation plant distribution; and

- The ventilation equipment should be vented to suitable odour arrestment plant.

Odour arrestment plant may be required to avoid nuisance odour emissions, especially where sensitive receptors reside close to the plant or where particularly odorous waste materials are handled. Biofiltration is the most commonly used active odour abatement method in composting. Biofilters have some performance limitations with highly variable odour streams, they require relatively large floor areas and they must be actively maintained to ensure effective operation. Due to these limitations there may be circumstances where wet chemical scrubbing is appropriate as a supplement or alternative to biofiltration in the removal of compost odours. Applications where the use of chemical scrubbing may be considered would include:

- Composting processes that generate exceptionally high levels of ammonia where pre-treatment using chemical scrubbing assists the performance of the biofilter; and/or

- Composting processes that generate high levels of reduced sulphur and nitrogen contain compounds (e.g. composting of poultry feathers).

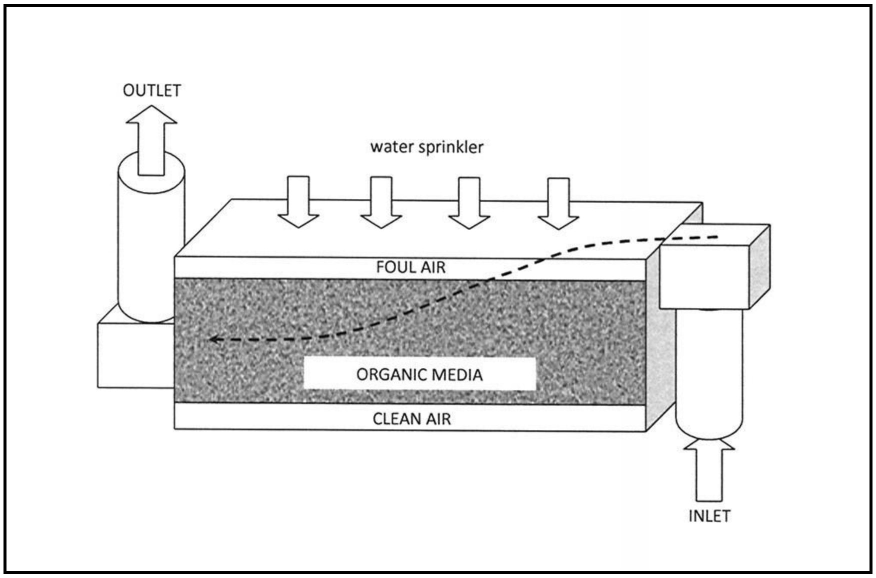
Other techniques may be used to treat odour emissions, e.g. using ozone technology and/or activated carbon filtration. Due to the lack of practical experience, the design and operation of “new” technologies, such as ozone, the use of such systems should be considered very carefully.

In circumstances where a high degree of control must be guaranteed to prevent nuisance odour, then an activated carbon filter may be installed after the primary odour control plant to ‘polish’ the odour prior to release. The using a carbon filter as a polishing step will only be effective if the air to be treated is <u>not</u> moisture laden.

The use of odour masking agents and counteractants as the sole means of odour control should be discouraged as these do not abate emission and may exacerbate a situation.

Biofiltration

Biofilters consist of an open or closed container that is divided by a support structure (e.g a mesh or a grid) into an air distribution chamber or plenum under the grid /mesh and filter media bed. Air is forced though the media bed, after being equally distributed over its surface. The flow can be upward or downward. The filter bed contains a stable porous solid carrier as medium, which supports a moist and biologically active film or layer. This bacterial film/layer biologically degrades odorants by metabolic oxidation. An effective irrigation system for moisture control is a vital part of the biofilter system to ensure the filter bed does not dry out. Pre-humidification of the air to be treated is often advocated as an alternative to irrigation but it is not always effective, especially with high temperature air streams. There is therefore usually also a requirement for irrigation too. Some excess liquor drainage is desirable to remove oxidised contaminants.



Biofilter medium can include: oversized compost, peat and heather, shredded pallet wood or roots, coconut fibre, bark, shredded tyres, calcified seaweed, lave rock or sea shells. The medium must provide a large surface area for absorption and to host microorganisms, however the medium must be of sufficient size and have sufficient mechanical strength to avoid compaction and unacceptably high pressure drops.

The residence time describes the length of time odorous air should reside within the filter medium to achieve effective absorption. The residence time is affected by factors such as media particle size, but it is calculated on an empty bed basis and should normally be set at no less than 45 seconds where there are likely to be low solubility compounds, such as terpenes, in the odour stream.

Adequate moisture is required to ensure that odorous chemicals can be absorbed on to the surfaces of the media and associated biological films. Once absorbed the chemical can be utilised by the microorganisms present. Adequate moisture may be provided by pre-humidification using a simple spray tower using and/or by irrigation of the surface of the filter.

Temperature influences both the absorption process and the types of microorganisms available to utilise the odorous chemicals. Temperatures between 25 ^{o}C - 35^{o}C are ideal. Air off sealed tunnel systems can be substantially above these targets. The temperature of the incoming air can in some circumstances be partly reduced by humidification or by dilution with lower temperature air from other areas of the composting installation e.g raw material storage and processing).

Back pressure is a measure of the restriction to air movement through the filter bed. The pressure should be monitored regularly and will increase towards the end of the working life of the filter bed. Rapid drops in pressures can indicate the formation of cracks or fissures within the bed or partial failure of the ventilation system.

Certain compounds such as ammonia are toxic to microorganisms, when passing through the biofilter in significant quantities they can adversely affect the viability of the microbial population, resulting in failure of the odour control system. In such a situation, reseeding of the biofilter may be necessary. Such compounds also alter the pH within the biofilter medium which may adversely affect the absorption process. Pretreatment using a wet scrubber, or higher rates of irrigation to flush out alkaline contaminants, can help prevent these problems.

A well designed biofilter can reduce the odour concentration from a composting process to concentrations as low as 200 – 500 ou_E/m^3, depending on the inlet odour loading.

The discharge from an enclosed biofilter can be discharged via a stack to improve dispersion and therefore increasing the overall odour mitigation effect.

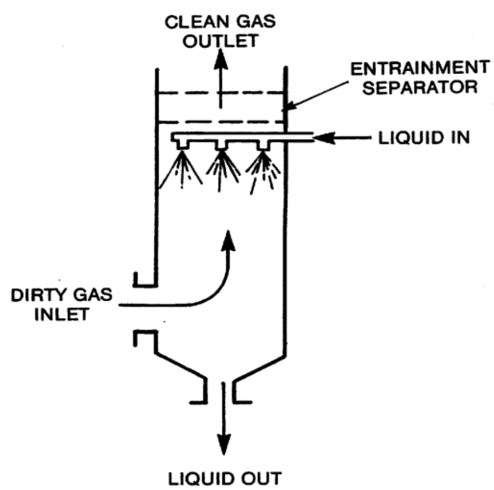
Wet Scrubbing

In a wet scrubber, foul air is intimately mixed with a scrubbing liquid. Typically the airflow is countercurrent (upwards) to the flow of the scrubbing liquor down through the scrubber but crosscurrent is an option. Most systems are based on towers packed with random plastic media. Unpacked scrubbers rely on fine droplets (mist scrubbers) and usually require demisting, but they are generally much less effective than packed towers. Scrubbers are essentially a chemical processing system and thorough chemical engineering design is required for successful application.

Wet scrubbing relies on mass transfer of (odorous) compounds from the gas phase to the liquid phase. Once in solution the scrubbing liquid, with dissolved odorants, can be discarded. Usually chemical scrubbing is applied, where chemicals are added to the scrubbing liquid that react to transform odorous substances into ionized forms or to decompose them to less odorous compounds by oxidation. Alkaline or acid scrubbers rely on formation of salts. Oxidizing scrubbers (e.g. sodium hypochlorite) will oxidize dissolved pollutants. Catalysts can be used to make the chemical reactions in the scrubbing liquid more effective and reduce the requirement for chemicals.

Scrubber systems can be used as a preconditioning step before a biofilter. This is generally required where high concentration of ammonia are generated by the compost process.

Example of simple spray tower configuration



Wet scrubbers:

- Can be designed to treat large gas flows and will take up a relatively small area;
- Work well for most soluble odorants but are less effective for low-soluble organic odorants. Their application in composting may be limited to pretreating odour streams prior to biofiltration;

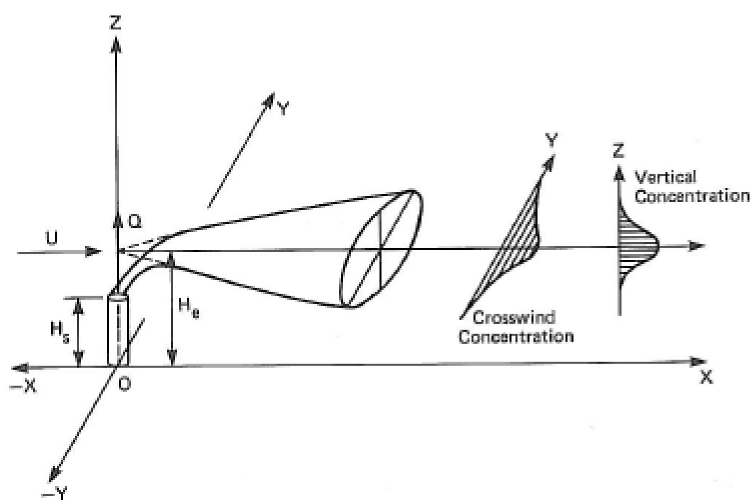
- Require careful control of pH and dosing chemicals;
- Can be controlled relatively quickly to respond to fluctuating inlet odour concentrations;
- Require careful selection of scrubber medium as odorous by-products can be formed e.g. chloroamines due to the reaction of hypochlorite with amines;
- May have residual emissions of ‘chemical odour’;
- Can re-release odorous compounds from re-circulating liquids;
- Produce a residual liquor which will require to be disposed of in an appropriate manner; and
- Droplet carry over must be avoided by using mist eliminators or a low efflux velocity (less than 9m/s).

Wet scrubbers as a sole means of odour abatement are likely to be less effective than long residence time biofilters in treating compost odour streams which have a significant odour contribution from low solubility compounds such as terpenes

Stack Dispersion

Treated air from an odour abatement plant can be discharged to atmosphere via a stack to improve the dilution and dispersion and hence to minimize ground level concentrations.

Stacks should be designed to take into account local meteorological conditions, local topography, the influence of potential building downwash and other local emissions. These various factors should be taken into account when using air dispersion modelling techniques to design and evaluate stack systems.



The dispersion from a stack can be impaired by low exit velocity or deflection of the discharge. Ideally efflux velocities should be a minimum of 15 m/s to optimise plume rise.

9 Further Reading

AFOR (2005) “The composting industry code of practice”

AFOR (2007) An industry guide for the prevention and control of odours at biowaste processing facilities

Compost Association (AFOR) “Introduction to PAS 100:2005: Summary of the BSI specification for composted materials”

Cornell Waste Management Institute (July 2007)“Compost Facilities: Off-Site Air Emissions and Health”

Defra BSE Division (2004) “Guidance on the treatment in approved composting or biogas plants of animal by-products and catering waste”

Defra (2008) “DESIGNING WASTE FACILITIES a guide to modern design in waste”

Department of Environment and Conservation (NSW) (2003) “Environmental Guidelines: Composting and Related Organic Processing Facilities”

Environment Agency (October 2002). IPPC “Horizontal Guidance for Odour (IPPC H4) Part 1 - Regulation and Permitting. Working draft for consultation.”

Environment Agency (October 2002). “IPPC Horizontal Guidance for Odour (IPPC H4) Part 2 - Odour Assessment and Control. Working draft for consultation.”

Environment Agency Guidance for Registering an Exempt Activity: Storing and Composting of Biodegradable Waste – Paragraph 12 (Form WMX12)

Environment Agency (2002) Processes and Plant for Waste Composting and other Aerobic Treatment R&D Technical Report P1-311/TR Prepared by David Border Composting Consultancy

Environment Agency (2001) “Technical Guidance on Composting Operation”

Environment & Heritage Service of Northern Ireland (2005) “Waste Management and Contaminated Land:-Composting Guidance”

Ontario Ministry of Environment “Composting processing technologies” prepared by The Composting Council of Canada.

Organic Recycling Ltd (2001) “A state of the art review into composting commercial and the non-green waste fraction of municipal solid waste.”

US Environmental Protection Agency (1994) “Composting Yard Trimmings and Municipal Solid Waste”

Defra Tackling Nuisance Odour – a Guide for Local Authorities Consultation Draft November 2008.

Appendix A:

Local Authority Survey: Preliminary Review of Impact of Composting

Approach

To understand the main issues and the scale of the composting odour problem from the perspective of LAs, a survey of Environmental Health Practitioners (EHP) was carried out. This survey questionnaire was sent by email to EHPs in the England and Wales that have a composting plant in their district. The objectives of this survey were to obtain information on:

- The scale of public complaints received by LAs;
- The types of raw materials composted and the odours emitted;
- The composting processes in use;
- The likely cause of nuisance odour emissions; and
- The strategies used by LAs to address nuisances.

Results of the Survey

EHPs from across England and Wales responded to our survey and it is clear from the responses that the scale of the problem and the procedures adopted vary greatly between districts.

All the data presented in this section is derived from the responses to the survey. Limitations of surveys of this type – respondents tend to be EHPs who have problems. It is therefore not possible to draw general conclusions about the industry as a whole.

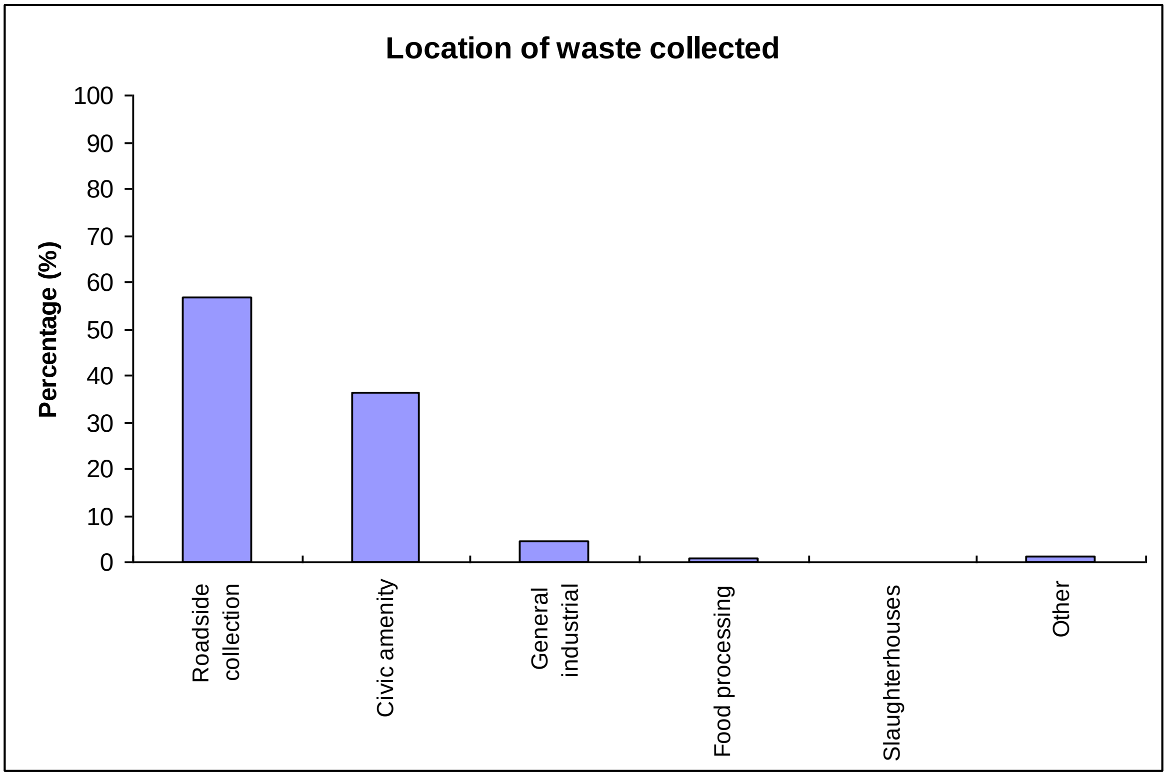
Extent of Composting

The survey showed that:

- The largest number of composting plants in a district was seven, although the majority of respondents' districts had between one and three composting plants within them;
- The scale of composting within districts ranged, in the responses, from 664 tonnes per annum to approximately 60,000 tonnes per annum;
- Of the biodegradable waste composted 80% was green waste, whilst the majority of the remainder was identified as food waste; and
- There is a large number of sources of biodegradable waste, although at present the majority of this composted waste is collected through roadside collections and civic amenity sites (see figure A.1).

One EHP noted that waste from roadside collection could be over 10 days old when collected, and that such waste will already have partially degraded and so be emitting odours in uncontrolled conditions, possibly anaerobic conditions, before it reaches the composting plant. The EHP also noted that roadside collection of 'old' material can lead to localised nuisance odour either from the waste stored in the recycling bin while awaiting collection, or from the waste vehicle during collection. It was the EHP's experience that nuisance odour could be minimised by collecting waste with a frequency of less than 10 days and by using a starch based lining material within the recycling bin to avoid the accumulation of moisture and putrescible debris.

Figure A.1: Raw Sources of Biodegradable, Organic Waste identified by LAs in response to the survey



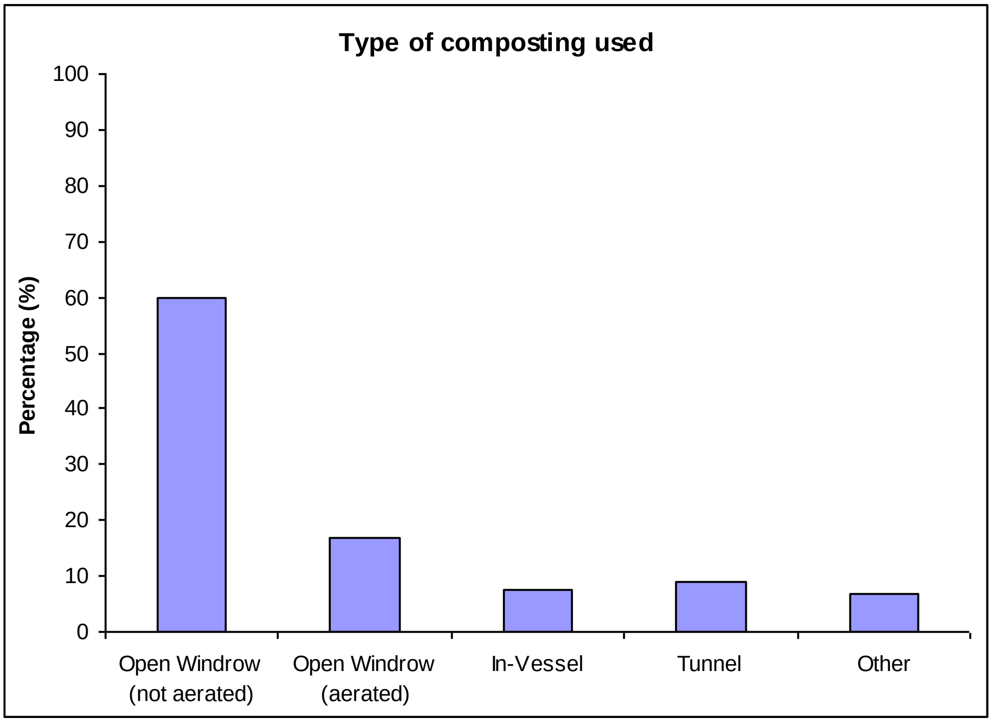
The Composting Process

There are a number of processes and methods of converting the biodegradable organic material into compost, which can lead to a wide variety of associated problems. EHPs in the survey identified a large number of processes and problems as the sources of complaints received. These processes / problems included:

- Shredding;
- Screening;
- Turning Windrows;
- Anaerobic conditions;
- Non-aerated open windows;
- Maturation pads, either within the boundary of the composting facility or land owned by a third party (e.g. nearby farm land); and
- Maturity of the material (i.e. active composting passing prematurely to the maturation phase).

The majority of storage facilities reported in the survey were open air (85%) rather than in-building (15%) facilities. Since odour emissions from open air facilities are more difficult to control, it is expected that contained systems will be recommended and so predominate in the future. There are a wide range of composting plant types in use across the country although the majority of composting plants still use either aerated or non aerated Open Windrow, (see Figure A.2). The proportion of sites using aerated windrows identified in this survey is probably higher than across the industry sector as a whole.

Figure A.2: Composting Plant Types in use identified by LAs in response to the survey



The majority of composting sites used open (86%) rather than enclosed (14%) maturation, of which around half the sites aerated the material. Using open maturation rather than enclosed has been noted as a cause of complaints from members of the public. One EHP noted that a number of complaints were received about an open composting plant; however, once the maturation stage was enclosed the number of complaints fell.

Scale of Complaints

The number of complaints received by the LAs varied greatly from a couple to more than 300 complaints per annum, although the vast majority of districts received a much lower volume of complaints than the identified maximum (see Table A.1).

The volume of complaints within a LA district appears to be dictated by:

- The size of the compost operations;
- The nature of the compost operations;
- The design and management of the composting plant; and
- Proximity of complainants to compost plant.

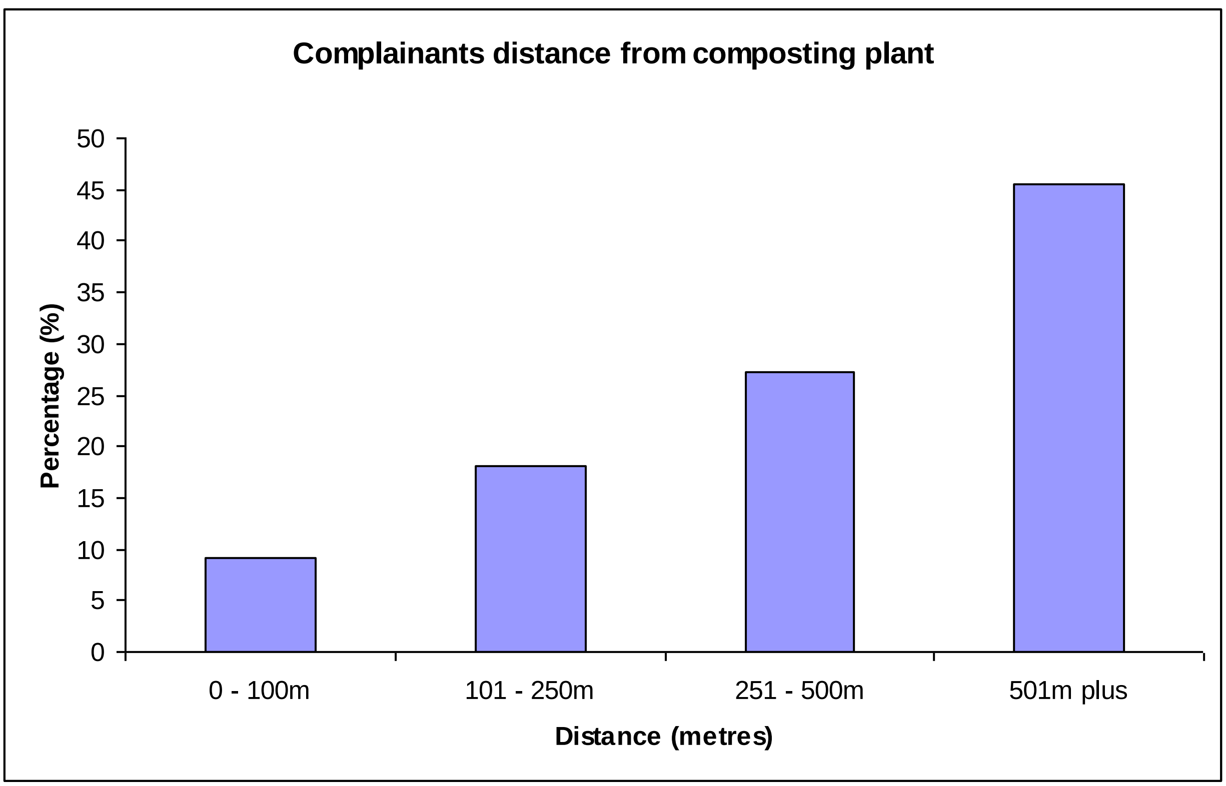
Table A.1: Total number of complaints attributed to composting odours – based on the information provided by LAs in response to the survey

Year	Total Number of Complaints
2008	228
2007	602
2006	473

From discussions with EHPs it is clear that the majority of complaints occur where composting sites are located close to urban areas with higher population densities. Composting plants located in the countryside usually have a smaller volume of inhabitants living nearby and therefore the number of complaints tends to be lower. It is however recognised that complaint numbers are not an absolute measure of nuisance.

Figure A.3 below, shows the distance of the complaints from the composting plant varies greatly although in some cases can be quite large. This clearly highlights the need for careful siting of compost plant and that a high level of odour control is essential to avoid nuisance odour occurring. The majority of these complaints are received in the warmer, summer periods, possibly coinciding with increase amount of raw materials to be processed and/or a higher proportion of grass cuttings within the feedstock. However, often complaints extend into the autumn, probably as the material becomes wetter allowing anaerobic conditions to prevail. One EHP noted that the majority of compost complaints were received when heavy rain is followed by warm weather, a situation that would be avoided if the process were enclosed.

Figure A.3: Displays the distance of complainants from the composting plant – based on the information provided by LAs in response to the survey.



Qualitative descriptions of odour complaints received by the LAs can be summarised as follows:

- Baby sick;
- Sickly;
- Anaerobic;
- Silage;
- Rotting food;
- Old nappies;
- Compost; and
- Onions.

This signifies that various stages within the composting process cause problems in terms of odour. The type of odour being produced can be a useful as an indicator of the source of the problem. For example, rotten eggs or putrid odours often signify anaerobic conditions.

Procedures adopted by LAs

There are a large variety of procedures set in place by LAs: to deal with odour problems:

- A number of LAs said that they pass all complaints on to the Environment Agency to deal with;
- Around 50% of respondents said they had a formal procedure in place for investigating complaints relating to odours, although a number of these procedures relate to general odour complaints rather than specifically related to composting issues;
- A very small number of authorities had procedures in place to investigate source identification, including a small number of respondents who have undertaken odour assessments using odour sampling and analysis;
- Odour diaries had been used by some districts to record complaints;
- Abatement notices had been served on composting sites by two of the respondents in our findings; and
- In other situations close working relationships between the LA and the site operator has led to reductions in the number of complaints related to a specific site.

Conclusions

From the survey it can be concluded that the number and range of complaints varies vastly across districts in the England and Wales, with certain sites causing the majority of the problems. The situation however, appears to be improving over time, as regulators are working with the composting plants to reduce their problems. It is predicted however, that due to the small volume of land available for landfill in the UK and the Governments' present move to encourage people to reduce their waste, the volume of waste diverted to compost it likely to increase. With the greater demand on composting facilities, it is important that regulators put in place formal procedures for regulating composting plants and the odours that they generate.

The use of a standard procedure across the country for receiving, recording and investigating complaints from composting plants would provide a greater understanding of the issues surrounding these problems and the actions that could be instigated to resolve these issues.

The overall conclusions drawn from the survey are as follows:

- The size of compost plants must be considered carefully when siting facilities;
- The quality of raw materials must be managed to minimised odour;
- The compost plant must be fit for purpose to deal with the feedstock;
- Good site management is necessary to minimise compost odour; and
- Complaints can extend over distances of 500m and more.

Appendix B:

Odour Impact Assessment Report Guidelines

Planning permission will need to be obtained for new or substantially changed composting facilities. As part of the planning application process the Local Planning Authority must consider whether the development will give rise to undue harm to the amenity of local residents. All planning applications for composting facilities will need to include some form of odour impact assessment. Such an odour impact assessment will represent a view of how that process will affect its surroundings. The guidelines presented here suggest the elements that are expected to feature in an odour impact assessment report to accompany a planning application.

The report should include general information relating to the assessment, including the purpose of the study, a description of the development and the modelled scenarios considered. The suggested content is as follows:

- **Location Map** – showing the location of the composting facility in relation to nearby features and location of sensitive receptors. Ideally the map should be based on an Ordinance Survey map and should detail local terrain features;

- **Wind Rose** – showing how the windspeed and direction are typically distributed at the location;

- **Potential pathways** – a full list of emission sources should be identified along with how those emissions could reach sensitive receptors;

- **Odour Emissions** – the odour emission rates used in the study should be clearly identified. Where emission factors are being used, justification for selecting specific data should be provided. In assigning odour emission rates for transient events such as delivery, shredding, screening, and movement of compost round the site, the report should make it clear how the short term nature of the event has been incorporated in the model and how this treatment relates to the fact that odour annoyance may be perceived as a result of short term exposure. The report may include two scenarios – the first reflecting a situation where the emission rate data set is 'averaged' over a working week, and where the data set reflects a 'worst case' situation with actual emission rates being applied;

- **Odour Exposure Criterion** – discussion of the relevant odour exposure criterion should be provided. Reference should be made to PPG23 and the requirement to avoid harming amenity, as well as to list relevant odour exposure that could be applied (e.g. as detailed in the Environment Agency's draft Horizontal Guidance Note IPPC H4[31] (2002). Due consideration needs to be given to the degree of sensitivity of receptors, i.e. where local population density is high there is greater chance for receptors with higher odour sensitivity to be present. The report may make reference to existing odour sources in the area but unless the existing sources give rise to the same odour (e.g. compost odour) background sources are likely to be irrelevant;

- **Background Levels** - where existing sources of the same type of odour do exist, then these should be taken into account within the dispersion modelling and the combined impact should be compared against the appropriate odour exposure criterion;

[31] Environment Agency Integrated Pollution Prevention and Control (IPPC) DRAFT Horizontal Guidance for Odour Part 1 – Regulation and Permitting (IPPC H4) (2002)

- **Model Description -** The choice of model used in the assessment should be justified and a description of the chosen air dispersion model given. Information should include model name, type of model (Gaussian, new generation, etc.), supplier and version of model used. Models must be fit for purpose, based on established science, and be validated and independently reviewed;

- **Emission Parameters** – the following information including relevant units should be presented in a table:

Parameter	Units
Source location	Grid reference
Discharge height	m
Odour emission rate[1]	ou_E/s or $ou_E/m^2/s$
Exit diameter	m
Exit temperature	K, ^oC
Efflux velocity and/or volumetric flow rate (actual)	m/s and/or m^3/s
Surface source area	m^2

1- odour emission rates for transient events should be presented as a average and peak or worst case value

- **Modelled Domain/ Receptors**

    - The extent of the modelled area, and the resolution of the model receptor grid used should be reported and justified. The assumed height above ground level for the receptors (flagpole height) should be reported if appropriate; and

    - Details of any discrete receptors used to assess impact at sensitive locations should be reported.

- **Meteorology/ Surface Characteristics**

    - The choice of meteorological data used in the model should be discussed in detail and justified by the applicant. Information should include the location of the chosen met station in relation to the modelled domain, the number of years included in the assessment, and the source of the data. The format of the met data used e.g. hourly sequential should be reported and justified and a windrose presented for purposes of clarity; and

    - Information relating to the surface characteristics at both the meteorological station and within the modelled domain should be reported. This is usually related to the relevant land-use classification(s) however the values of parameters (e.g. roughness and length,) describing the classifications used in the model should also be reported.

- **Treatment of Terrain** – the justification for the inclusion or not of terrain treatment in the assessment and report, the source, format and processing of digital terrain data used in the model;

- **Treatment of Buildings and site plan** – the justification for the inclusion or not of building treatment in the assessment and report the location and dimensions of all buildings included in the model (i.e. OS grid reference, height, width, rotation). A site plan showing the location and relative orientation of buildings and their dimensions should be included;

- **Sensitivity Analysis** - a brief discussion and quantification of model sensitivity should be provided. This may include scenarios for normal (average) emission rate and peak (worst case) emission rate and treatment of terrain and buildings;

- **Assessment of impacts** – impact of odour should be presented as ou_E/m^3 as 98th percentile of 1 hour averages.

- Results should be presented in tabular form, indicating the odour impact concentration at the sensitive receptors;

- Contour plots showing the odour impact concentration over the modelled area for both normal and peak emissions; and

- Discussion should address any potential exceedences of the selected odour exposure criterion and take into account an assessment of different emission characteristics and different process operation scenarios.

➢ **Mitigation Measures -** a summary of management and operational practices and abatement plant to be used on site should be included. This may take the format of an Odour Management Plan. The information should provide contingency arrangements for responding to any unforeseen or unusual odour emission episodes.

Appendix C

Odour Management Plan

A compost site, be it new or existing, has the potential to release odorous emissions and the requirement should be that an odour management plan (OMP) is produced by the operator. An OMP is a documented operational management system detailing the measures employed to anticipate the formation of odours and to control their release from the site. The OMP should show how odours are being managed and controlled so as to prevent or minimise the release of odours from the site.

An OMP is there for the benefit of the site operator, regulator and local community. For the operator of a permitted installation, the OMP helps demonstrate to the regulator that the site is employing Best Available Techniques (BAT). It will help the operator demonstrate a commitment that they will employ Best Available Techniques to control odours from the future operation of the premises. This will help instill confidence with the Regulator and neighbouring community that odours from the site will be proactively managed.

An OMP is a working or live document for managing odour issues at the installation. As a working document its contents must be reviewed on a regular basis and updated to reflect changes on site. Examples would include an analysis of complaints, site investigation reports and information from staff that could inform and prevent future occurrences of nuisance odour. The plan should allow the anticipation of problems such as equipment failure, as well as recognise the routine requirements of odour control system maintenance. Staff training, the sharing of complaint information and mechanisms for gaining feedback from the community are all relevant. Maximising the information available to a process operator on when and where odour is emitted can provide the basis for improved intervention. Where investment choices need to be made to improve odour control on a large process the OMP can be used to help inform these decisions.

An odour management plan should cover all aspects of odour management at an installation, in particular it should identify foreseeable events or practices which may lead to an increased odour impact at sensitive receptors. An odour management plan should also identify any emission events that are outside the control of the operator. The plan will also contain a description of actions to be taken in the case of any event or incident to minimise all impacts.

The nature of such abnormal events and subsequent actions should be agreed with the Regulator at the time of drawing up the document. A means of recording any failures and demonstrating that the appropriate actions were taken must be put in place by the Operator. It should be stressed that such events would be infrequent; if they occur regularly then BAT needs to be re-evaluated in the light of the degree of environmental impact.

In order to prepare the odour management plan, the following must be considered.

- All activities which produce odour and the point(s) of odour release under both normal operation (intentional) and abnormal operation (unintentional);
- All odour control measures in place to mitigate odour. Justification for selecting a particular control measure should also be given;
- All possible process or control failures or abnormal situations which could lead to an increased level of exposure;
- All management procedures. These should describe the roles and responsibilities of personnel on site and the procedures for materials handling, storage, use of equipment etc.

- Repair and maintenance of plant and equipment. These should be undertaken in accordance with manufacturer's recommendations. The availability of equipment and spares should be considered;

- Monitoring. This should be systematically planned and address what, where, when and how such monitoring should be undertaken. Monitoring may include source sampling of emissions, site inspections and surveys, complaints, meteorological conditions, etc;

- The impact of the odour emission from the site under normal and abnormal operation on sensitive receptors. In the simplest form this may consider the number of justified odour complaints attributed to the process, although numerical quantification may be of more use[32];

- Communication with relevant interested parties. This should include methods used, content and frequency of communication with, for example, the local authority and local community;

- Emergency and incident response procedures. The OMP must consider the potential for odour emissions being released. It should describe the types of scenarios that could happen and the measures to be employed to reduce their impact. Scenarios may include breakdown of abatement equipment, spillages, 'extreme' meteorological conditions etc;

- Complaint investigation. The OMP should include procedure to investigate the cause of any complaint event and the actions taken to prevent recurrence;

- Staff Training Records. The records should detail training required and undertaken by site personnel; and

- Record keeping. Throughout the whole of the OMP, accurate and thorough record keeping are essential. Records should include maintenance of plant, monitoring results, communication, incidents, training etc.

The level of complexity required of an OMP will be dependent on the complexity of the processes and on the potential impact of a release of odour on neighbouring premises. Where a process may produce particularly offensive odours, then the OMP will necessarily be detailed and thorough. Conversely, for a process with a lower potential for odour impact, a simpler OMP should suffice.

There are a number of situations that may lead to emissions of odour. Within all of these situations there are actions the operator could undertake to limit the emission of malodorous chemicals substances. These are as follows:

- Those which have potential to affect the process and the generation of odour, i.e. changes in process conditions leading to greater odour generation or a change in the odour characteristics;

- Those which affect the ability to abate/reduce odour, i.e. failure or reduced performance of odour arrestment equipment;

- Those which affect the ability to contain odour, i.e. conditions which result in fugitive releases due to reduced odour containment; and

- Those affecting dispersion between the source and sensitive receptors.

[32] Numerical quantification may be achieved by a number of means e.g.:

- A record of daily observations made at agreed locations around the process boundary;
- Regular monitoring of key emission sources using colorimetric tubes (e.g. for hydrogen sulphide, mercaptans and amines)
- Olfactometry assessment in accordance with BS EN 13725:2003. 'Air quality – Determination of odour concentration by dynamic olfactometry'

Table C1: Issues to Consider in an OMP

Nature/cause of failure	Example of issues to consider on a compost facility
Those which have potential to affect the process and the generation of odour	➢ Material inputs (e.g. seasonal variation in composition and/or degree of rotting prior to delivery); ➢ Process parameters (changes in temperature and moisture levels); ➢ Rate of throughput; and ➢ Anaerobic conditions developing.
Those which affect the ability to abate/reduce odour	➢ Poor performance of biofiltration or poisoning (may be the result of poor maintenance or mis-operation); ➢ Flooding of the biofilter due to abnormally high rainfall; ➢ External failure of other utilities, e.g. water supply; ➢ Mechanical breakdown of arrestment equipment such as pumps, fans etc; ➢ Power failure; ➢ Compaction of the biofilter or surface fissures; and ➢ Saturation of scrubber liquor, blocked injection nozzles etc.
Those which affect the ability to contain odour	➢ Building damage which affects integrity (due to storms for example); ➢ Power failure; ➢ Failure of automatic doors, i.e. in open position; and ➢ Failure in procedures to maintain containment (human error).
Those affecting dispersion between the source and sensitive receptor	➢ Short term weather patterns which fall outside the normal conditions for that area and are highly unusual (not just the normal meteorological pattern) - inversions and other conditions unfavourable to dispersion should be considered in designing the process; ➢ Weather - wind direction, temperature, inversion conditions if these are normal variants of local weather.

Table C2 –OMP: Example Entries

Where does odour occur and how is it generated	Identify the release point	Nature / cause of emission	Potential outcome if emission occurs	Risk of occurrence	What measures have been put into place to prevent or reduce risk of occurrence	What actions are taken
Raw material area during the delivery of certain material	Raw materials area	➢ when green waste is delivered after a weekend ➢ when kitchen waste from Council X is delivered	Local residences may experience nuisance odour Duration – time taken to incorporate material into process	Potentially following each delivery	Raw material management plan in place. Rapid incorporation of material into process	Review material management plan on regular basis, reassess odour acceptance criteria
Leachate storage	Storage, and during wetting	Failure of aeration pump causing liquor to become septic	Local residences may experience nuisance odour Duration – time taken to wet material and to re-establish aerobic conditions	Infrequent	Frequent inspection of aerator, maintenance schedule in place	Monitoring oxygen and carry out olfactory observation of leachate tank daily
Transfer of compost from windrow to maturation area	Maturation area	➢ anaerobic odorants emitted ➢ disturbance of active composting mass	Local residences may experience nuisance odour Duration – time taken to re-establish aerated windrows in maturation area	Potentially during each movement to maturation area	Ensure that initial composting has reached its end point	Monitoring temperature and oxygen before compost is moved to maturation area

The OMP should contain entries for all potential emissions however trivial. On a compost facility with good odour management the number of odour incidents should be low, however where control is poor more complaints regarding nuisance odour can be expected. In this situation the operating regime must be re-evaluated and the necessary improvements made