Good Practice Guide:
Using PAS 100 compost in landscape and regeneration projects
WRAP's vision is a world without waste, where resources are used sustainably.

We work with businesses, individuals and communities to help them reap the benefits of reducing waste, developing sustainable products and using resources in an efficient way.

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1. Introduction

PAS 100 compost is a quality assured source of nutrients

This guidance document forms an update to the 2011 edition to reflect changes in the Publicly Available Specification¹ (PAS 100) and capture updates from recently completed field monitoring studies. It aims to provide good practice advice on the use of PAS 100 compost in landscaping and regeneration applications and, in particular, for the following uses:

- brownfield restoration and habitat establishment;
- highways and waterways;
- sustainable drainage systems (SuDS) and green roofs;
- sports turf; and
- general landscaping.

Agricultural land is not covered within this guidance document, and further information regarding the spreading of compost to agricultural land can be found in the Farming and Growing web pages of the WRAP website.

The introduction section of this guide provides an overview on compost; summarising the benefits and considerations associated with the use of PAS 100 compost, outlining compost types and input materials, regulatory requirements and compost applications in different landscaping sectors, summarised in Table 1-1. Sections 2 to 8 provide practical guidance and recommendations relevant to specific land end uses. A glossary of terms is provided at the back of this document.

What is compost?

Compost is the result of the organic breakdown of green and food waste, under controlled and monitored conditions. It is an important product to the landscaping industry and can provide various benefits in projects involving reclamation, restoration and the improvement of land.

Compost is a source of organic matter and can improve the physical and chemical properties of the soil to which it is applied, enhance plant growth, stimulate biological activity and improve resistance to erosion.

PAS 100 compost is ideal because not only is it a rich source of slow release nutrients, it is also quality assured and therefore reliable and consistent. To find your nearest supplier producing PAS 100 compost visit:

http://compostsuppliers.wrap.org.uk.

<table>
<thead>
<tr>
<th>Applications</th>
<th>Soil manufacture and habitat creation</th>
<th>Housing &amp; mixed use development</th>
<th>Energy crops</th>
<th>SUDDS and green roofs</th>
<th>Slope stabilisation &amp; erosion control</th>
<th>Recreation &amp; sports turf</th>
<th>Landscape maintenance</th>
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</thead>
<tbody>
<tr>
<td>Soil improvement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Topsoil manufacturing</td>
<td>✓</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Erosion control, sustainable drainage (SuDS) and green roofs</td>
<td>✓</td>
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<tr>
<td>Surface treatment</td>
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<td>✓</td>
<td>✓</td>
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Table 1-1: End uses and applications for PAS 100 compost
Decision and support tools for assessing site suitability are given in Appendix 1. A summary of exemplar mixing ratios and application rates are provided in Appendix 2. Specific technical information on the following compost applications are presented in Appendix 3 and 4, respectively:

- compost in soil improvement and topsoil manufacture; and
- compost in surface treatment.

This guide can be accessed online through www.wrap.org.uk/landscapegpg

Why use compost?

Topsoil can be difficult and expensive to source and is a precious, finite resource. PAS 100 compost offers a financially competitive and sustainable alternative to the importing of topsoil.

PAS 100 compost can be mixed with recycled inert materials such as surplus soil, crushed stone or other soil-forming materials. The inert material provides a consistent, stable material and the compost provides the nutrients and minerals required for root development. The mixture of compost with existing indigenous soils can improve soil structure, reduce compaction in the surface layer, improve water holding capacity, improve soil drainage and significantly reduce the loss of nutrients into the groundwater.

When incorporated into and applied onto soils, compost can act as a fertiliser and/or weed suppressant, which improves the soil’s physical properties. It contains nitrogen, phosphate, potash and other nutrients available for plant growth, helping to keep vegetation healthy and increasing nutrient take up. The benefits associated with the use of PAS 100 compost are outlined in Table 1-2.
<table>
<thead>
<tr>
<th>Benefit Type</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Eliminates or reduces costs associated with excavating, transporting and disposing of poor quality soil and other existing site materials and the subsequent purchase of topsoil.</td>
</tr>
<tr>
<td></td>
<td>Reduces plant fertiliser costs.</td>
</tr>
<tr>
<td></td>
<td>Reduces need for herbicides, particularly when applied as mulch.</td>
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<tr>
<td></td>
<td>Aids the growth rate and survival of plants, saving re-planting costs and maximising profit if used for energy crop production.</td>
</tr>
<tr>
<td></td>
<td>Reduces irrigation costs due to the improved water retention properties of the soil.</td>
</tr>
<tr>
<td></td>
<td>Improves soil structure reducing the need for equipment maintenance and repair and reduces cultivation costs.</td>
</tr>
<tr>
<td>Physical</td>
<td>Lowers the bulk density of soils improving aeration and root penetration (particularly in clay soils).</td>
</tr>
<tr>
<td></td>
<td>Improves the water holding capacity and aggregate stability of light soils and reduces the risk of wind erosion during dry periods.</td>
</tr>
<tr>
<td></td>
<td>Compost mulches act as a protective layer to the soil surface, reduce weeds, retain moisture and impede erosion.</td>
</tr>
<tr>
<td></td>
<td>Darkens the soil leading to an increase in the soil temperature that can enhance germination of seeds and plant establishment.</td>
</tr>
<tr>
<td>Chemical and biological</td>
<td>Provides slow-release plant nutrients, such as nitrogen, phosphate and potash as well as minor and trace elements.</td>
</tr>
<tr>
<td></td>
<td>Stabilisation of soil pH leading to increased soil buffering capacity, reduced environmental effects and reduced mobility of certain contaminants (particularly effective in acidic soils).</td>
</tr>
<tr>
<td></td>
<td>The cation exchange capacity of soils can be increased leading to a decreased nutrient loss to leaching.</td>
</tr>
<tr>
<td></td>
<td>Provides beneficial micro-organisms that may contribute towards the suppression of some common plant diseases.</td>
</tr>
<tr>
<td>Ecological and environmental</td>
<td>Poor soils in brownfield sites may provide opportunities for carbon sequestration.</td>
</tr>
<tr>
<td></td>
<td>Promotes habitat creation. Compost addition will increase the population of soil invertebrates and this, in turn, will increase bird populations and biodiversity.</td>
</tr>
<tr>
<td></td>
<td>The production and use of green and food derived compost reduces the amount of waste sent to landfill.</td>
</tr>
</tbody>
</table>

Table 1-2: Benefits associated with the use of PAS 100 compost in landscape and regeneration projects
Considerations

At the beginning of a project there are a number of considerations associated with the use of compost. These should be reviewed during the site investigation stage and discussed with the appropriate environmental authorities. For example, PAS 100 compost that does not comply with the Quality Protocol is still classed as waste in England, Wales and Northern Ireland and its use should comply with the rules of the Environmental Permitting Regulations. Further information can be found on the Environment Agency website.

Equally, if the site is part of an environmental protection area, consultation with the relevant environmental protection bodies is essential.

High application rates of compost may result in phosphorus and potassium release that is greater than plant requirements, and therefore, has the potential to leach into drainage water. Ensuring the correct application rates for the desired plants as well as establishing monitoring procedures will effectively mitigate this risk and be more cost effective. A range of application rates are provided in Appendix 2.

Other site-specific impacts may be present and they should be assessed and investigated on a case by case basis to reduce any risks associated with compost application and optimise its effectiveness. These may be relevant to the composition of compost and soil forming materials, presence of contamination on site, the topography of the site, the properties of the receiving substrate and proximity to surface and groundwater or handling and application practices. Any risks should be considered and weighed against potential benefits.

Compost types and input materials

Green and food derived composts can be used in landscape and regeneration projects. Green compost is solely derived from garden waste and comes from sources such as domestic gardens, municipal parks and recreational areas, and is collected separately from other waste streams. This compost is usually produced outdoors in open windrows.

Food derived compost contains a mixture of garden and food waste collected separately from other waste streams from households and businesses. This compost is produced in enclosed in-vessel systems and must be compliant with Animal By-Products Regulations (ABPR), as well as the relevant waste legislation.

The end result of the two composting processes is a product which is safe and reliable with high organic matter content and significant quantities of nutrients. Both green and food derived composts comply with the PAS 100 standard for quality compost.

PAS 100 specifies that compost shall be of a friable texture without excessive moisture, and shall not exceed limits on stones, weed propagules, and physical and chemical contaminants. The product shall not contain substances toxic to plants, nor shall it possess objectionable odours.

Digested materials complying with the requirements of the PAS 110 specification can also be applied to land for restoration, reclamation and remediation, and guidance on these materials is given elsewhere.

Achieving the benefits of PAS 100 compost use

To achieve the benefits listed in Table 1-2, it is important to have compost supplied that meets the required specifications and is suitable for the intended end use.

Compost performance is dependent on particle size; finer grades are most effectively used as a soil improver, within soil manufacturing or as top dressing, while coarser, woodier fractions provide effective and long-lasting mulch. Therefore ensuring the supply of suitable material will determine the effectiveness of its application.

Cost benefits associated with specific land end uses are discussed in more detail in Sections 2 to 8.
Regulatory requirements

The EU Landfill Directive, the UK landfill tax system and the Landfill Allowance Trading Scheme are the principal policies aimed at reducing the quantity of biodegradable waste sent to landfill in the UK and they have supported the use of compost and other organic materials in landscape and regeneration projects. The application of PAS 100 compost to land is considered a reuse of materials.

Compost that does not meet the Quality Protocol criteria and is applied to degraded land, as part of a land reclamation programme, is considered a waste operation in England, Wales and Northern Ireland and is regulated through the Environmental Permitting Regulations (EPR)\(^4\). Standard Rules Permits for land spreading and land reclamation have been in force since April 2010. This allows for the land spreading of PAS 100 compost and other listed materials. Further information can be retrieved from the Environment Agency website\(^5,9\).

The European Water Framework Directive (2000/60/EC)\(^10\) and associated Groundwater Directive (2006/118/EC)\(^11\) represent the principal legislation for the protection of the aquatic environment. The use of compost in landscape projects and regeneration should cause minimal impact on the aquatic environment. The Water Framework Directive and Groundwater Directive have only limited relevance to the use of recycled organic materials in land reclamation and this will generally be in the case of large projects\(^6\).

The European Nitrates Directive (91/676/EEC)\(^12\) aims to minimise the impact of diffuse nitrate pollution and improve or maintain the ecological status of surface water in line with the Water Framework Directive. The European Nitrates Directive currently sets no designated Nitrate Vulnerable Zones (NVZ) restrictions on non-agricultural land as part of a land reclamation project. Many land reclamation projects require greater quantities of nitrogen to treat highly degraded soils. Compost is less prone to leaching than inorganic fertilisers\(^4\) and so can help minimise diffuse nitrate pollution.

Quality Protocol for compost

Building upon the PAS 100 certification, the Quality Protocol was published in England and Wales in 2008. Compost which complies with the Quality Protocol with a secure market is no longer classified as a waste and as such is not subject to waste regulations. In July 2010, it was updated to enable use in Northern Ireland\(^8\).

The Quality Protocol provides a clear framework for the production, supply, storage and use of quality compost from source segregated biodegradable waste (biowaste). It clarifies which biowaste materials can be used in quality compost production and reinforces traceability throughout the production process by ensuring accurate record keeping.

This guide provides advice on the use of PAS 100 compost, therefore the information included here should not be considered as appropriate for the application of other compost types and compost-like outputs that do not comply with PAS 100 specification.

Control measures

PAS 100 includes controls such as the Hazard Analysis and Critical Control Point (HACCP) measures, to ensure any risks of adverse impacts to the environment, including human and animal health and adverse effects on plant health are minimised.

The PAS 100 composting process eliminates most plant and human pathogens that may be present in the feedstock and quality and regulatory measures are in place to ensure it is a safe and reliable material to use.

Compliance with PAS 100 provides strict control over chemical and physical contaminants likely to be present in compost, for example arsenic, copper, lead, zinc, glass and plastic\(^14\).
References

2. WRAP (2010), Soil Matters 4 Jeff Sorrill - Sheffield Green Roof Centre
3. WRAP (2009), Carbon sequestration in brownfield soils manufactured with compost
5. Environment Agency (2012), Standard rules permits
6. Sniffer (2010), Code of Practice for the use of sludge, compost and other organic materials for land reclamation
9. Environment Agency (2010), New waste exemption system
2. Soil manufacture and habitat creation

Trials have shown that an application rate of 20% by volume is sufficient for woodland establishment

Topsoil manufacture, involves the blending of available soils with inorganic and organic materials such as PAS 100 compost to create a fit for purpose soil for the establishment of vegetation.

Manufactured soils often comprise green and/or food derived compost mixed with in situ or imported soils; and depending on the circumstances, other organic and inorganic materials, such as paper mill crumb, biosolids, and/or waste soils, may be incorporated.

PAS 100 compost has been used successfully in soil manufacturing on various brownfield regeneration projects including the creation of woodlands, amenity grasslands and even golf courses. It provides vital nutrients and organic matter which help to establish vegetation and support healthy growth and in turn promote habitat creation. Where there are sufficient soils or growing media on site, but they are of a poor quality i.e. poor physical structure and insufficient nutrient availability, compost can be incorporated as a soil improver. This differs to soil manufacture as it tends to be carried out in situ rather than blended from stock piles of material.

Cost savings and other benefits

- The use of compost in soil manufacture and improvement reduces the generation of waste by reusing site won soils and other materials. This reduces cost of disposal of on site materials as well as reducing costs associated with importing topsoil.
- The available nutrients and organic matter in compost can promote rapid habitat establishment whether it be amenity grassland, wildflower meadows or woodlands.
- Blending site won materials with compost to manufacture a soil reduces the risk of unwanted seed bank often found in imported soils.

Lambton former coke works

At Lambton former coke works, field trials assessed the benefits of PAS 100 compost mixed with on site materials and paper mill crumb to create a two metre soil profile. The manufactured soil was subsequently used for the creation of 23 hectares of woodland and 10 hectares of grassland.

The use of PAS 100 compost demonstrated significant benefits in tree establishment. The combination of the mix of compost to paper mill crumb using the loose tip emplacement method was shown to be the most effective means of woodland establishment. Whilst the use of wide or narrow track bulldozers resulted in excessive soil compaction1.

Manufacturing soil on site rather than importing natural soils resulted in an estimated cost saving of £434,000 at the Lambton site2. Observed rates of tree survival at similar regeneration sites suggest an estimated cost saving of around £18,000 at Lambton as a result of reduced tree mortality through loose tip emplacement of soils.

The choice of tree species is also an important consideration in woodland establishment on sites lacking natural soil resources. A significant proportion of “pioneer” species such as alder and birch are recommended.
Cronton colliery

At Cronton colliery a low-input restoration approach using PAS 100 green compost was trialled for establishing grassland communities.

Amelioration of the existing colliery spoil involved application of a 30mm layer of PAS 100 compost to the surface using a muck spreader and then incorporating it into the top 120mm of the spoil using a tractor mounted rotovator.

Even during the first growing season, PAS 100 compost greatly enhanced both the growth of existing plants but also considerably improved the establishment and growth of newly sown grassland species. In addition, some indigenous colonising species were becoming more frequent and seedlings had colonised at sufficiently high densities.

Major plant nutrients (N, P, K) in the soil remained well above baseline concentrations but were not too high to jeopardise biodiversity.

The trials demonstrated that this is an extremely cost effective approach. To import sub-soil and spread to a depth of 150mm would have cost approximately £2.25 per square metre or £22,500 per hectare using a conventional approach. In contrast, importing PAS 100 compost, cost £0.28 per square metre or £2,800 per hectare, a saving of approximately 88% to importing subsoil.

Table 2-1: Cost of soil improvement using compost at different rates

<table>
<thead>
<tr>
<th>Depth (cm)</th>
<th>Compost (%)</th>
<th>Rate</th>
<th>Cost (£/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>5</td>
<td>125 m³/ha (64 t/ha)</td>
<td>£1,460</td>
</tr>
<tr>
<td>25</td>
<td>10</td>
<td>250 m³/ha (128 t/ha)</td>
<td>£2,420</td>
</tr>
<tr>
<td>25</td>
<td>15</td>
<td>375 m³/ha (191 t/ha)</td>
<td>£3,365</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>500 m³/ha (255 t/ha)</td>
<td>£4,325</td>
</tr>
<tr>
<td>25</td>
<td>25</td>
<td>625 m³/ha (319 t/ha)</td>
<td>£5,285</td>
</tr>
<tr>
<td>40</td>
<td>5</td>
<td>200 m³/ha (102 t/ha)</td>
<td>£2,130</td>
</tr>
<tr>
<td>40</td>
<td>10</td>
<td>400 m³/ha (204 t/ha)</td>
<td>£3,660</td>
</tr>
</tbody>
</table>

Application of compost

The amount of compost that is appropriate to use for a site will depend on the properties of the compost to be applied, the quality of the soil forming material and the intended land end use of the reclamation project. Application rates will be site specific and influenced by factors such as the topography of a site, the soil infiltration rate, weather conditions prior to application and future weather patterns. Some guideline values are shown in Table 2-2.

To avoid adverse impacts from using compost in soil manufacture and improvement, consider the following:

- **Plant nutrient requirements**: applying the right quantity of compost is essential to ensure the soil has both the correct physical characteristics and nutrients to support healthy plant growth. Applying too much compost will make the soil too fertile which can lead to excessive soft tree growth, and weed growth which can increase maintenance costs. It also leads to reduced species richness of plant communities. If too little compost is applied, then plant growth may be stunted. Trials have shown that an application rate of 15% to 20% by volume is sufficient for woodland. Further guidance on mixing ratios for different soil-forming materials and end uses, is given in Appendix 2.

- **Handling and mixing materials**: it is important that compost and other soil forming materials are handled with appropriate equipment so that the right quantities are applied e.g. farming equipment such as a muck spreader and a tractor mounted rotovator could be used for in situ soil manufacture.
Placement of soils: a soil’s physical structure can easily be damaged during handling and is therefore susceptible to compaction. Using a loose tip method rather than bulldozers will help minimise compaction from trafficking. For more information on soil handling and placement refer to the Construction Code of Practice for the Sustainable Use of Soils on Construction Sites, Defra.7

Drainage: in order that manufactured topsoils can function effectively, the subsoils on which they are placed must provide adequate drainage to sustain healthy root systems. Poor drainage can cause waterlogging which contributes to dieback, particularly for tree rooting.

<table>
<thead>
<tr>
<th>Goal of reclamation</th>
<th>Typical application rate* (t/ha)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat establishment/ amenity land</td>
<td>50-100</td>
<td>Plant growth trials are recommended to ensure nutrient levels are not excessive for the intended purpose</td>
</tr>
<tr>
<td>Soil formation</td>
<td>100-500**</td>
<td>The application rate will vary depending on the condition of the soil</td>
</tr>
</tbody>
</table>

Table 2-2: Examples of application rates

* The application rate of organic materials with low dry solids content (<25%) should be at the lower end of the range shown depending on site-specific conditions.

** Depending on site-specific environmental conditions, particularly in the case of colliery spoil, the maximum application rate may need to be higher than 500 t/ha, depending on the condition of the land, soil pH and the quality of the compost and other organic material(s) to be used. Application rates in excess of 500 t/ha would need to be justified to the environmental regulator and approved in advance.

The restoration of Broughton Craggs former landfill site

PAS 100 compost was mixed in situ with subsoil to manufacture topsoil at Broughton Craggs, a former landfill site. The manufactured soil was used to create a new woodland and meadow grassland landscape.

Monitoring has shown that the manufactured soil, comprising 20% green compost to 80% subsoil (by volume), has sustained a diverse flower rich grassland community and supported tree establishment.

Wildflowers on manufactured soil, Whitehaven
Soil preparation is essential prior to any compost or soil forming material application. This usually includes soil cultivation to some extent. If the site is predominantly made up of subsoil, deep tillage or ripping may be necessary to relieve compaction below the topsoil layer. Compost used for soil improvement is commonly spread over the treatment area and subsequently incorporated into the soil. The material should be incorporated into the soil as soon as possible after application to a maximum depth of 0.4m.

The use of different application methods, for instance, using different depth profiles or the inclusion of rotovation, can provide significant differences to the soil properties and plant establishment. For example, the depth of incorporation of compost with the soil-forming material to manufacture soil is much deeper, compared to the use of compost for soil improvement.

A purpose made single winged-tine ripper can be effective for compost incorporation within compacted soil or soils with a high stone content. It can also be effective on wet surface conditions that reduce traction of heavy duty agricultural equipment.

The plants to be used on a site location should be selected to match the soil conditions. For woodland establishment the choice of tree species must be carefully considered, as the nutrient demand varies between different species. Some trees, such as, alders and other nitrogen fixing species can establish better than others on nutrient deficient sites; therefore, they will require lower application rates of compost.

The vegetation type and site characteristics should be considered when choosing the depth of application. For example, at Cross Lane, north west England, a soil depth of 1m was used to establish woodland; 0.75m for shrub species and 0.5m for meadow grassland.

Developing wildflower habitats on derelict land

Experimental trials were established at a site in Whitehaven to investigate the potential use of PAS 100 compost with crushed building aggregate, textile waste (carpet fibre) and quarry waste for the establishment of diverse wildflower habitats on derelict land. Soil preparation is essential prior to any compost or soil forming material application. This usually includes soil cultivation to some extent. If the site is predominantly made up of subsoil, deep tillage or ripping may be necessary to relieve compaction below the topsoil layer. Compost used for soil improvement is commonly spread over the treatment area and subsequently incorporated into the soil. The material should be incorporated into the soil as soon as possible after application to a maximum depth of 0.4m.

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References

1 WRAP (2010), Lambton former coke works – Final report monitoring 2010
2 WRAP (2008), Lambton former coke works. Final report
3 WRAP (2008), Cronton colliery, Knowsley
4 WRAP (2009), The effect of green compost on the establishment of rough grazing, arable grazing & amenity trees on a restored limestone quarry in South East Scotland
6 WRAP (2010), Greenoakhill trailblazer project
7 Defra (2009), Construction Code of Practice for the Sustainable Use of Soils on Construction Sites
8 WRAP (2011), Trials for the restoration of Broughton Craggs former landfill site, trailblazer project - field trial
9 WRAP (2011), Creative Conservation Trials (Project Ref OBF009-018)
10 WRAP (2010), Establishment of wildflowers on soil platforms using PAS 100 compost
11 WRAP (2009), Development of vegetation communities on manufactured soils at Royal Ordnance Chorley (Buckshaw village) and Cross Lane, Wallasey, Wirral
3. Housing and mixed use development

Using PAS 100 compost to manufacture topsoil saved Blaenau Gwent County Council £450,000 or £15/m²

PAS 100 green and food derived compost can be used in the landscaping of housing and mixed use developments¹. There is a wealth of evidence that demonstrates that compost is a suitable material for topsoil manufacture and soil improvement in the landscaping of housing and mixed use development, particularly on brownfield land. Quality compost offers a financially competitive and sustainable alternative to the importing of topsoil². Applied as mulch, compost can suppress weed growth and increase soil nutrient content.

Cost savings and other benefits

There are many benefits associated with the application of PAS 100 compost, as detailed in the Introduction. Additionally, quality compost application provides specific benefits to housing and mixed use development applications. These include:

- **reduced costs** of importing topsoil and disposal of subsoil and other soil forming materials to landfill. WRAP has developed guidance on ‘Designing out Waste’ for both buildings³ and civil engineering⁴ that can assist to optimise the use of materials and to reduce disposal to landfill;
- **reduced risk of slope erosion** compost improves cohesion and stability of the materials on slopes⁵; and
- **potential for carbon sequestration** in organically poor brownfield soils when existing site materials are blended with a carbon rich compost source.

<table>
<thead>
<tr>
<th>Topsoil option</th>
<th>Cost per tonne of soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landfill disposal and import topsoil</td>
<td>£15.07</td>
</tr>
<tr>
<td>Recycle and import topsoil</td>
<td>£12.57</td>
</tr>
<tr>
<td>Reuse soil and create topsoil</td>
<td>£5.08</td>
</tr>
</tbody>
</table>

Table 3-1: Cost comparison of three topsoil options⁴

Three scenarios for cost per tonne of soil were calculated for a restoration project near Chorley (Table 3-1). PAS 100 compost mixed with on site materials, yielded cost savings in excess of £300,000 when compared to the conventional approach of importing topsoil and landfilling existing soil from the 265 hectare site⁶.

<table>
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</table>

Many cost benefits are case specific and they depend on landfill costs, availability and proximity of materials in required quantities and cost of imported materials.
Application of compost

WRAP trials have shown compost to be effective when used for soil manufacturing where soils are depleted, as a soil improver where the existing soils have low nutrient content and poor structure and also as a mulch/fertiliser on housing and mixed use development.

Site won inert materials, such as glacial till, steel slag and gritstone fines can be blended with compost, thereby ensuring the reuse, rather than disposal, of on site materials. Trials confirmed that the addition of compost at rates with higher ratios produced diminishing returns, and actually became counter productive when at a 6:10 ratio (compost to soil).

Forgemasters, Sheffield

Forgemasters commissioned the creation of a biodiversity rich amenity resource for the staff and local wildlife to enjoy. The area was landscaped using a manufactured topsoil comprising subsoil and PAS 100 compost.

The wildflower meadows were particularly successful and had developed into a magnificent display of colour and species diversity.

References

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4. Energy crops on brownfield land

20% and 30% compost mixed with site materials have successfully produced topsoil

The EU has set a target of 20% energy from renewable sources by 2020. To contribute towards this an increase in the production of biomass resources for heat, power and transport is required.

The two main perennial energy crop species planted on a significant scale within the UK are miscanthus and willow. Energy crops are mainly cultivated on agricultural land but can be grown on brownfield or marginal land, providing suitable preparation is undertaken. PAS 100 compost can be used to improve the land and support crop growth.

Miscanthus is a woody perennial rhizomatous grass. Once miscanthus is established it can grow to 3.5m and can be harvested annually for at least 15 years. Miscanthus will grow on a wide range of soil types; however higher yields are achieved on moisture retentive soils which warm up quickly in spring, capitalising on the longest possible growing season. Fertiliser demands for the crop are low, with the addition of nutrients and herbicides usually only required in the first year after establishment.

Willow is suited to a wide range of soil types and can be grown on brownfield and reclaimed land providing suitable preparation is undertaken. It is most productive on well aerated soils that retain moisture, with a pH range between 5.5 and 7.

High-yielding varieties of willow are grown as short rotation coppice (SRC). The willow is densely planted and can be viable for 30 years before re-planting becomes necessary. Willow is harvested on average every 3 years, whereas other less common crops, such as poplar, ash, alder, hazel, silver birch, sycamore, sweet chestnut, lime and eucalyptus can be harvested on a longer rotation.

SRC willow crops require close contact with the surrounding soil and adequate moisture to promote good root development. Failure to obtain adequate moisture at this early establishment stage is the most common reason for plant mortality.

PAS 100 compost can be applied during the preparation of land for energy crop production, and can be applied following cutback and harvesting, but should not be applied during willow establishment.

Other energy crops include grasses such as reed canary grass and energy crops for use as transport fuels including cereals (wheat), oilseeds, sugar beet and fodder beet. Some crops may not thrive in poor quality brownfield soil, therefore, it is important to choose the right crop before proceeding.
Energy crops on brownfield land

A small scale field trial to assess the potential for using PAS 100 food derived and green composts in energy crop production (miscanthus, reed canary grass and spring oilseed rape) was conducted on a brownfield site in Fife10.

Assessment of energy crop on brownfield land

The site was re-graded to form a uniform surface and was covered in a mixture of subsoil and topsoil to the depth of 50cm. The entire site was subsoiled (or ripped) to a depth of 30cm using a tined subsoiler prior to application of fertiliser treatments. Three fertiliser treatments were applied once a year for two years:

- no compost (farm standard fertiliser);
- food derived compost (30 t/ha) + inorganic fertiliser nutrients; and
- green compost (90 t/ha) + inorganic fertiliser nutrients.

Each treatment was applied by hand to the soil surface and cultivated using a power harrow into the top few inches. The trial showed that the reed canary grass was well suited to the site conditions, and grew significantly taller when treated with green or food derived compost. Also soil physical assessments reported less severe compaction and higher quality soil structure where PAS 100 green compost had been applied.

Cost savings and other benefits

The benefits summarised in the Introduction are particularly important for brownfield land that has previously been used for heavy industry or open cast mining. It can take up to ten years to recover from the physical, chemical and environmental damage caused.

The use of PAS 100 compost can help by adding organic matter and decreasing soil bulk density. Increasing the pH and conductivity can lead to increased levels of available plant nutrients, which along with the improvement of a soil’s water holding capacity and root zone aeration can help to enhance vegetation establishment.

The application of PAS 100 quality compost for soil improvement or soil manufacturing is cost-effective when compared to traditional materials used for topsoil manufacture and site remediation. The use of compost with existing site materials (coal washings) and recycled aggregate at the Kinglassie former coal washing site in Fife led to cost savings of between £2.46 and £3.30 per tonne when compared to the import of 100% multipurpose topsoil9, as shown in Table 4-2.

<table>
<thead>
<tr>
<th>Mix</th>
<th>Material</th>
<th>Transport</th>
<th>Mixing</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>100% multipurpose topsoil</td>
<td>£6.00</td>
<td>£1.50</td>
<td>no mixing required</td>
<td>£7.50</td>
</tr>
<tr>
<td>20% compost, 80% recycled aggregate</td>
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</tr>
<tr>
<td>20% compost, 48% coal washings material, 32% recycled aggregate</td>
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<td>£0.75</td>
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<tr>
<td>30% compost, 42% coal washings material, 28% recycled aggregate</td>
<td>£2.79</td>
<td>£0.75</td>
<td>£1.50</td>
<td>£5.04</td>
</tr>
</tbody>
</table>

Table 4-2: The cost per tonne (£) of different topsoil options for remediation at the Kinglassie site
Application of compost

Manufactured soils must be applied with sufficient depth to allow crop roots to develop normally. Roots must be able to extract adequate water and nutrients, and achieve enough anchorage to resist wind throw. For SRC willow production, compost should be incorporated to the rooting depth of the cuttings, which is 20cm deep, since this may help conserve soil moisture during dry spells. This could be best achieved by ploughing, which inverts the soil and places the compost at the rooting depth. Minimum thickness of topsoil should be confirmed and adjusted depending on the mean summer rainfall and the known particle size and stoniness of the soil forming materials used.

Experience has shown that ratios of 20% and 30% by weight of compost have been mixed with existing site materials successfully to produce topsoil which fulfils the requirements for soil forming materials. These mixes have sufficiently low stone content, a suitable pH and contain appropriate quantities of plant nutrients and organic matter to promote energy crop establishment and growth.

Mulch can help prevent weed growth and aid crop establishment, particularly in the first 6 – 10 weeks after application.

Soil Improvement: PAS 100 compost can be used on brownfield sites to improve soil so that it is suitable for energy crop production. Trials have found that optimum crop yields were achieved after applications of 500 or 750t/ha. Application levels above this had no further positive effect on crop growth.

Establishing SRC willow on the former Bickershaw Colliery

In 2010, PAS 100 compost was applied to land on the former Bickershaw colliery for SRC willow production. The trial showed that when used to improve native substrate materials, compost leads to the successful establishment and growth of these energy crops.

PAS 100 compost was incorporated into the existing colliery spoil to a depth of 300mm. The addition of compost at an equivalent rate of 500 t/ha greatly enhanced survival of individual cuttings and enhanced fresh biomass yield.

Established willow, Bickershaw

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5. Slope stabilisation and erosion control

Compost can be used with a range of geosystems to create an eco-engineering solution

Soil erosion in construction activities is moving up the political and legislative agenda. Wind, rain and foot traffic can erode soil, particularly when it contains low levels of organic matter. This reduces the ability of plants to establish, grow and remain healthy. The reduction in plant growth and subsequent plant residue exposes the soil, perpetuating the erosion process, resulting in sediment loss and potentially higher maintenance costs.

Compost can be applied in areas of particular concern in combination with an engineering solution for erosion control and to encourage plant growth. Combining engineering solutions and vegetation is termed ‘eco-engineering’ and can be used to stabilise riverbanks and highway embankments. The use of eco-engineering for stabilising engineered slopes can be environmentally preferable and cost effective compared to traditional ‘hard-engineering’ solutions, such as the use of soil nails or impermeable concrete facings.

Compost can be applied directly or incorporated with a range of products to generate the following eco-engineering solutions:

- **compost blanket**: a layer of loosely applied compost that acts like a blanket covering the surface on which it is applied, and can be used on a slope or flat land. The mixture of fine and coarse particles mat together creating a blanket that has shown to hold on 2:1 slopes, as well as more severe slopes, without slipping;
- **compost sock**: a tubular geotextile mesh which is filled with compost and can be used as vegetated soft armouring systems. They are designed to stabilise banks and prevent erosion from flood waters and precipitation runoff, and used as ongoing stormwater management;
- **compost geosystems**: there is a variety of geotechnical cellular confinement systems (geosystems). They are designed for an array of engineering solutions including soil and slope reinforcement, drainage and erosion control. More information on geosystems can be found on the AggRegain website; and
- **vegetated gabion**: is a square container of galvanized wire, which is filled with stone to protect shorelines and river banks against erosion and stabilise slopes at the toe while at the same time allowing free movement of water to the underlying soil. Compost socks can be placed on the outer face of the gabion which provides a suitable moisture retentive and nutrient rich substrate for vegetation.

Investigating erosion control on the the A421

Between 2009 and 2011 trials took place to investigate the use of compost blankets and compost socks in preventing and controlling erosion on an engineered embankment along the A421 in Bedfordshire.

Initial economic analysis indicated that in all instances, compost based erosion control techniques are priced competitively, or are less expensive than conventional techniques.

Compost blankets and compost socks were applied to the 2:1 slope and compared to other erosion control applications. Results showed that the compost socks alone reduce runoff by 90%. This significantly reduces erosion and sediment loss.

Compost blankets in A421 trial, Cranfield University

The trial recommended that compost socks alone or in combination with compost blankets could be used as a Best Management Practice for storm water management and erosion control on engineered slopes, soil stock piles and highway batters in the UK.
Compost blanket for erosion control

The project examined the effectiveness of compost to stabilise the surface and subsurface of an engineered slope in order to both prevent erosion and enhance vegetation establishment.

Cost savings and other benefits

Compost blankets can increase grass seed germination and re-growth, enabling the swift development of vegetation in order to improve stability. This makes it ideal for use in slope stabilisation programmes, where soil erosion and an inability to support vegetation is a common problem that can lead to slippages – a key concern for highways contractors. Compost offers an economically attractive option to combine with a range of proprietary products to create an eco-engineering solution.

Eco-engineering solutions, such as compost blankets can yield cost savings compared to conventional techniques. For example, at a field trial that utilised compost blankets the following cost benefits were highlighted:

- the cost of compost was approximately £0.50 per m² delivered to the site and the use of geotextile was of similar cost for the same coverage;
- the application of geotextile is considered to be more labour intensive with an approximate associated cost of £200 per day for a 100m² coverage;
- the machinery costs for covering the same area (100m²) with compost was £100 per day; and
- subsequent fertiliser costs for the geotextile could more than double the cost of geotextile compared to the compost treatment.

Application of compost

Compost blankets can be applied on 2:1 slopes however, on severe slopes lock down netting can be applied over the compost to secure it. Compost can be pneumatically blown across the site using specialist equipment or raked and flattened with an excavator to place the compost on the bank.

Compost blankets are most appropriate for use in sheet flow water management situations to reduce rill formation rather than controlling concentrated flows with high velocity flood water. However, compost berms or slope interruption socks can be used in conjunction with this technology to further reduce the flow velocities of the water.

Compost blankets can also improve the moisture holding capacity and encourage vegetation establishment. Field trials using 50mm compost blankets have been shown to hold 12.5 to 25mm of water. A recent trial demonstrated that surface application of compost was better than incorporation to 10cm depth.

Compost socks can be specified in a range of sizes and contain a range of growing media, depending on the particular end use. They can be vegetated or non-vegetated, can be left in place to provide permanent protection or cut open and the compost spread across the site when a project is completed and the geotextile removed.

The weight and anchoring systems can withstand storm run-off velocities and hydraulic shear stresses. Soft defences can be cost effective, multi-purpose in nature and can often benefit existing wildlife, by providing suitable habitats. Compost socks can serve as a basis for reed development and be utilised as a filter media to control potential leachate runoff.

‘Greening’ reinforcement on footpaths

Cellular geogrid was used to create a green footpath at Marsden Golf Course. The geogrid area filled with PAS 100 compost and glass sand performed best, providing a substrate for healthy vegetation growth and minimising settlement.

The results suggest that compost-based geogrid pathways reduce surface erosion and run-off in the autumn and winter and provide an excellent alternative to expensive gravel or concrete pathways. Initial high installation costs are mitigated by the large reduction in ongoing maintenance costs.
Compost socks can be manufactured by either:

- **On site filling**: long lengths of compost sock can be created on site using a compost blower or modified bucket with an exit pipe and dropped into place as they are produced. This is possible if the site is accessible.

- **Off-site filling**: where access to the site is limited or where damage from heavy plant is undesirable or the site is too remote for a compost blower to reach, compost socks can be filled off site. Compost socks can be stacked on to pallets and delivered to site in long lengths or short lengths to avoid manual handling issues. Installation of long lengths can be undertaken directly from the pallet using a quad and trailer.

A site-specific methodology should be derived for the transport of compost-filled socks. Once positioned, compost socks can be secured in place with pegs. During placement a cradle can be constructed to aid lifting in a controlled manner.

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**Stabilising the banks of the River Don**

An innovative approach was used to stabilise the clay bank of the Centenary Riverside Wetland Nature Reserve, Rotherham to protect it from scour erosion. PAS 100 compost was used to fill the socks which were sown with a fast growing seed mix to provide vegetation cover.

The compost socks installed along the riverbank have significantly reduced erosion and plants are thriving in the growing medium provided.

Before: Centenary Riverside

After: Centenary Riverside

PAS 100 compost pneumatically blown into sock
New Cut Canal restoration project
Warrington Borough Council

A section of contaminated silted up canal was restored as part of a programme to create an Urban Ecology Park from a problematic post-industrial site.

Bespoke gabions containing socks filled with compost and recycled aggregate form a major part of the canal’s transformation in terms of stabilisation of contaminated silt and the establishment and management of vegetation for conservation value.

The project has led to the successful restoration of a 300m section of canal open water using the bespoke gabion designs (including compost socks as a means of creating a new landscape and habitat). The specification for ‘green’ gabion trials met the practical requirements of the project and led to the establishment of vegetation along the waterside of the canal and new bank.

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6. Green roofs

PAS 100 compost can provide the organic component of a green roof substrate

Green roofs are vegetated layers that sit on top of the conventional waterproofed roof surfaces of a building. They contribute to sustainable drainage systems (SuDS), which serve to reduce peak rates and total volumes of storm water run-off. The substrates used to support vegetation in a green roof commonly comprise aggregates and various sources of organic material. PAS 100 compost could potentially represent a readily available and sustainable source of this organic matter.

There are two distinct types of green roof:

- **Extensive roofs**: have a relatively shallow lightweight substrate which supports low growing, hardy drought tolerant plants such as sedum. They typically have thin substrates of depths up to 100mm.
- **Intensive roofs**: have a relatively deep substrate (>20cm) and as such are heavier. They can support a wide and of plant types from grasses to trees and shrubs. Semi-extensive roofs may have depths of around 100-200mm.

The shallower the substrate becomes, the more important it is for the substrate mix to be correct. Green roofs with low substrate depths can require more exact substrate compositions to ensure vegetation growth.

The high nutrient content of compost may be a limiting factor for the establishment of sedums in extensive roofs, since sedum species do not require a high nutrient input. It is therefore necessary to apply the right amount of compost to ensure plant growth is not excessive.

The Green Roof Code of Practice provides guidance on installing and maintaining green roofs in the UK. Where appropriate it refers to the comprehensive German roof greening guidelines Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL). The FLL guidelines restrict the amount of organic content that can be used. This limitation is to promote sufficient substrate water permeability, long-term stability and oxygen diffusion, together with minimising the risk of fire. However these guidelines state that a higher level of organic content may be required where special forms of vegetation are used. CIRIA has also published guidance on green roofs.

PAS 100 compost in extensive green roofs

Recent research provides an assessment of the potential for using PAS 100 compost as a component of the substrate used in green roof construction. It examined the performance of four different substrates in terms of plant establishment and water retention. The successful substrate mixes comprised:

- 90% crushed brick and 10% compost
- 80% crushed brick and 20% compost.

Green Roof Royal Horticultural Society (RHS) study

A replicated experiment to examine the growth of five plant species, in green roof substrates using PAS 100 green compost, biochar and crushed brick in different proportions was conducted. Substrate mixes that contained both 35% and 50% green compost performed comparably to a proprietary mix.

The trial addressed concerns within the green roof industry about the inclusion of compost and the effect on substrate shrinkage, run off composition and influence on plant communities. It showed that in comparison with proprietary mixes, it performed equally well in terms of supporting healthy plant growth and run off composition.
Cost savings and other benefits

There is a growing realisation that SuDS, including green roofs, can help deliver national, regional and local biodiversity action plan targets in both the urban and the rural context\(^1\). In the UK, some 20,000ha of roof surface are available on existing buildings without the need for structural alteration. The Greater London Authority alone is calling for 100ha of additional green roof by 2020\(^6\). The inclusion of a green roof in an application for Planning Consent is already regarded as a positive feature.

Green roofs offer a range of environmental benefits, including:

- reducing rainfall run-off and creating a lag time effect aiding storm-water management;
- insulating buildings\(^7\);
- prolonging the longevity of the roof surface membrane\(^4\) and building [protecting from UV and temperature fluctuations]\(^5\);
- increasing sound insulation\(^4\); and
- potentially reducing the ‘urban heat island’ effect and improving air quality\(^7\).

Other considerations include:

- The range of suitable plants able to thrive in growing media containing significant proportions of green compost.
- The capacity for green roof substrates containing relatively large proportions of green compost to support healthy plant growth in the medium to long term due to decomposition causing substrate shrinkage and general loss of organic matter\(^6\).

References

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7. Recreation and sports turf

The optimum time to spread PAS 100 compost is when the weather is warm and the soil moist

PAS 100 compost is typically used to promote root zone and turf establishment and as a top dressing agent on football pitches and golf courses. In the creation and maintenance of sports turf, PAS 100 compost can be used to construct a golf course or sports pitch through the manufacture of soil and as a topdressing or fertiliser during maintenance.

PAS 100 compost used on golf courses has been shown to produce a good quality of play due to healthier grass growth and better drainage, helping the course to better cope with the adverse effects of severe weather.

Cost savings and other benefits

There is much evidence to demonstrate that compost is a suitable material for soil manufacture, surface dressing and fertilisation, to aid turf establishment. PAS 100 compost can be combined with the existing indigenous soils to improve soil structure, reduce compaction in the surface layer, improve water holding capacity and improve soil drainage and aeration. It can also be applied as a layer on top of existing surface materials to promote grass and plant growth and reduce the risk of erosion.

When used as a top dressing and/or a soil fertiliser, compost can save money on turf treatments making it a serious alternative to conventional materials. PAS 100 compost application provides specific benefits to sports turf; these include:

- cost savings of around 20% to 30% compared to traditional top dressing materials;
- the promotion of faster turf development but without excessive growth as, unlike sand-based dressings, compost can retain nutrients and make them available to the turf for a longer period;
- improved turf density and colour due to slow release nitrogen, iron and magnesium within the compost;
- enhanced appearance of turf without encouraging a large amount of top growth - thus reducing the cutting frequency;
- increased water holding capacity - leading to cost and labour savings related to irrigation;
- turf protection from nitrogen-sensitive diseases such as dollar-spot; and
- reduced nutrient leaching as compost can retain nutrients and make them available to the turf for a longer period. Grass remains green without excessive growth, or increased mowing frequency.

PAS 100 compost on football turf

When used in football turf applications, PAS 100 compost has been shown to improve the wear tolerance of the turf and also improve surface hardness, whilst remaining within the desired surface hardness range. PAS 100 compost also provides a simple means of greening up football pitch turf quickly and evenly. It also helps to keep the surface aerated, increases turf drought resistance and promotes an even surface.

PAS 100 compost with a particle size <10mm at an application of 6 litres/m² was reported to be the most effective, as higher rates may reduce surface playability.

Carnoustie Golf Club

When used as a top dressing and/or for soil fertilisation, PAS 100 compost not only enhances water retention and turf growth, but can also save money on turf treatments making it a serious alternative to conventional materials, particularly if the temporary aesthetic issues following spreading are avoided by incorporating the compost into a sand-based mix and aerating the turf prior to application.

When compared to the use of traditional top dressing materials (such as fen soil) for turf maintenance and repair at Carnoustie Golf Club, locally sourced PAS 100 compost led to cost savings of approximately 30% or around £13 per tonne. Material costs are about the same for compost and traditional top dressing materials but cost savings are realised through the reduced transport costs for the compost.
Application of compost

The amount of compost that is appropriate for a site will depend on the properties of the compost to be applied, the quality of the existing site material, and the required condition of the site after application. Application rates will be site specific and influenced by factors such as, the topography of a site, the soil infiltration rate, the weather conditions prior to application and future weather patterns, as well as the proximity to surface water courses and groundwater levels.

Compost application during very dry conditions should be avoided as it will not adequately blend with existing materials and may be at risk from wind and traffic erosion.

It is recommended that PAS 100 compost top dressing is applied during the spring or autumn to avoid run off and material loss during periods of heavy rain and to avoid periods of hot and dry weather and drought which would restrict the level of incorporation of the compost into the underlying turf and soil. In summary, the optimum time to spread PAS 100 compost is when the weather is warm and the soil moist.

Where soils are particularly low in nutrients compost may be supplemented with a nitrogen fertiliser. Nitrogen in PAS 100 compost is mainly in a slow-release form and may not provide enough nitrogen in the first few weeks of growth.

Compost application also reduces the risk of turf erosion. Turfed areas can suffer from wear and tear and surface erosion, particularly in heavily trafficked areas. Damage is often most evident during dry summer and drought conditions. The application of an organic material such as PAS 100 compost to these areas aids soil moisture retention and assists the grass to recover from wear and tear. This is particularly beneficial on fescue-dominated turf.

Applying the correct rate of compost is important to avoid reduced traction and playability of turf on football grounds and golf courses, particularly during wet conditions when the surface can become excessively soft due to the moisture retention properties of compost.

Using finer grades of composts mixed with sand and aerating the soil before spreading helps to avoid the muddying effect on turf when applied with compost.

PAS 100 compost product <3 mm in particle size may be necessary for golf course top dressing application, to reduce the evidence of compost on the turf surface a few days after application.

Monifieth Golf Links

At Monifieth Golf Links in Central Scotland, the purchase of PAS 100 compost to mix with sand as top dressing was £10/m³, compared to £51/m³ for the purchase of fen soil dressing. Over the site, this led to annual cost savings of £1,560.
Polkemmet-Heartlands project

PAS 100 compost and crushed colliery spoil were mixed at ratios of 75:25 and 70:30 colliery spoil to compost (by volume), to produce a verdant golf course.

Golf Green applied with compost, Loughgall Golf Course

Polkemmet-Heartlands before

Polkemmet-Heartlands after

References

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8. Landscape maintenance

A 5mm application of fine compost can be an effective soil improver

For landscape applications, PAS 100 quality green and food derived compost are usually applied as mulch or for soil improvement. There is a lot of evidence that demonstrates the suitability of organic materials such as PAS 100 compost for soil improvement applications and it is used in many public and private gardens and tourist attractions.

Cost savings and other benefits

PAS 100 compost application can improve water retention. This is particularly important for young transplanted plants and trees as water loss and shortage can have an adverse effect on their appearance, and can delay their establishment.

Compost acts as a soil conditioner which produces flower beds with less weeds and a higher plant establishment success rate than when compost is not applied

Compost also reduces the need for maintenance, improves a soil’s weather resistance, and produces aesthetically pleasing landscapes.

Organic matter within compost improves the soil’s crumb structure and tilth, making it more workable, and enhancing water infiltration and drainage rates, which can be a particular problem with clay soils that are prone to water logging. When applied in layers at the base of trees to reduce soil erosion problems, compost also encourages worms to come to the surface which helps reduce soil compaction and increase aeration.

PAS 100 offers a financially competitive and effective alternative to the importing of topsoil, and the use of inorganic fertilisers and herbicides. It can be used to improve existing low quality soils or be combined on the site with soil-forming materials to make topsoil.

The cost of compost application as a mulch or fertiliser is similar to that of herbicide or peat application over the long term due to associated management requirements (including irrigation and pest and disease control). However, the cost of compost is typically less than that of herbicide. For example, a saving of £5.98/m³ was realised from the use of PAS 100 compost when compared to peat application on a large-scale ornamental tree growing trial at Barcham (Table 8-1). This represents a 24% saving.

Compost mulch proves its worth in council tree planting scheme in Somerset

Compost mulch was added as a 50mm layer to an area of at least 250mm beyond the edge of the planting pit at a rate of 0.03m³ per tree during a 12-month municipal tree planting trial in North Somerset. Compost was also added as a soil amendment at a rate of 1:5 of excavated soil or 0.15m³ per tree. The rates were based on commonly used application rates and the trees were irrigated on a weekly basis.

Compost offers benefits when compared to the application of ordinary tree bark, as it is rich in nitrogen, and is also less likely to be blown or washed away.
### Table 8-1: Cost comparison of options on the Barcham Trees project

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<td>Nutrients</td>
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A 33% by volume quality green compost was mixed with 67% by volume composted bark and applied at a rate of 4kg/m³ during a large-scale ornamental tree growing trial at Barcham Trees. The mix matched the nursery’s standard growing medium (comprising peat, bark and crushed brick) in terms of commercial performance and handling properties. As compost can be locally sourced and produced, it provides a cost-effective and environmentally attractive alternative to plastic mulches or herbicides.

### Application of compost

There are different size grades of compost available on the market, each of which is suitable for different landscape applications. For example, finer grades of PAS 100 compost can be applied as a soil improver or a top dressing. Coarser, woodier compost types are most effectively applied to provide stable, effective and long-lasting mulch.

PAS compost can be handled with similar ease to peat mixes. One consideration when handling compost is increased bulk density, which can raise concerns regarding the movement of freshly potted stock.

The amount of compost that is appropriate for a site will depend on the properties of the PAS 100 compost to be applied, the quality of the soil forming material available on site, or imported, and the intended land end use. However, WRAP trials have shown compost to be effective when applied as either mulch, as a soil improver or in soil manufacture in landscape applications.

### References

1. WRAP (2006), Island paradise blooms brighter with compost – Case study
2. WRAP (2004), Compost helps Gardenscape to flower in Cove Bay – Case study
3. WRAP (2008), Compost helps to preserve arboretum for future generations – Case study
4. WRAP (2007), Container production of trees in growing medium based on green compost – Barcham Trees
5. WRAP (2008), North Somerset Council - Compost mulch proves its worth in council tree planting scheme – Case study
6. WRAP (2004), Jack Moody Ltd uses compost to create haven for commuters – Case study
Appendix 1 - Tools

This Appendix provides a summary of information on the types of surveys, site investigation and monitoring and aftercare requirements, along with a decision tool and a checklist.

Types of Survey

A soil survey will help to identify the presence and quality of existing suitable site material that can be used with compost to create a useable soil. If soil forming materials are present, and required for development, the site should be sampled according to standard methods. The site should be split into areas which are obviously different (for example due to the appearance of the material, or site topography) and sampled separately. The number of samples and parameters to be tested depends on both history and intended use. Further information can be found at http://www.soilscientist.org/pages/ipss.

A risk assessment should be conducted during site investigation activities to understand the level of need for a buffer zone and to understand the odour and noise implications of the project.

Ecological surveys are often used for baseline data and can be used to compare with further similar surveys conducted the next year or a number of years later. Further information can be found at http://www.iema.net and http://www.ieem.net.

Site investigation

It is important to determine the soil and site characteristics prior to soil preparation and application through a detailed site investigation conducted by a suitably qualified individual or organisation. Determinants that should be assessed to maximise plant establishment and long-term effectiveness during site investigation include:

- site topography;
- risk of site flooding;
- risk of drought on the site; and
- heavily trafficked areas, prone to erosion.

Monitoring and aftercare

Ongoing monitoring and aftercare are essential to ensure good long term performance and to identify any potential problems as soon as possible. The monitoring and aftercare programme should be defined at the start of the project to suit the requirements of the site. The level of aftercare will depend on the individual site and vegetation, as a soil may be particularly depleted in certain nutrients or the plants selected may have a particular nutrient demand.

Typical monitoring and aftercare programmes include:

- checking soil properties and contaminants and comparing results to the baseline values recorded during site investigation;
- assessing vegetation establishment, species variability, growth and health; and
- assessing the overall state of the environment at the site, for example evidence of soil erosion or deterioration, or condition of local watercourses.

The aftercare programme put in place may include the application of weed control substances to enable plant establishment, or the application of additional compost at regular intervals to boost the soil’s fertility. On some sites, nutrients in the compost may need to be supplemented with inorganic fertiliser, to further enhance growing potential.

Monitoring and aftercare surveys should take place at set intervals: for example at 6 months, 1 year, 2 years and 5 years, with an additional optional survey after 10 years. Surveys should be undertaken by qualified individuals.

References

1 Sniffer (2010), Code of Practice for the use of sludge, compost and other organic materials for land reclamation
2 WRAP (2003), Compost specification for the landscape industry
# Checklist

The following checklist includes a number of items to be considered prior to, during and after compost application.

## Prior to compost application

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial site suitability assessment</td>
<td>With identified areas for compost application</td>
</tr>
<tr>
<td>Consultation with relevant authorities and stakeholders</td>
<td></td>
</tr>
<tr>
<td>Any data regarding contamination on site</td>
<td></td>
</tr>
<tr>
<td>Soil profile information readily available</td>
<td></td>
</tr>
<tr>
<td>Information on close proximity and likelihood to contaminant sources, pathways, receptors</td>
<td></td>
</tr>
<tr>
<td>Susceptibility to flooding</td>
<td></td>
</tr>
<tr>
<td>Topography, geomorphology, geology etc. data</td>
<td></td>
</tr>
<tr>
<td>Any opportunities and limitations from initial studies, such as habitats to retain/enhance/remove, assessment of nature conservation significance (if relevant, plant habitats present, other)</td>
<td></td>
</tr>
<tr>
<td>Weather patterns and climate</td>
<td></td>
</tr>
<tr>
<td>Any visibility and aesthetic issues</td>
<td></td>
</tr>
<tr>
<td>Soil properties (chemical + physical)</td>
<td>Key to consider: Nutrients (K, P, N, Ca, Mg, C:N ratio), bulk density, texture, cation exchange capacity (CEC), organic matter, pH, electrical conductivity, compaction, physical and chemical contamination</td>
</tr>
<tr>
<td>Effect of compost application on mobility of contamination</td>
<td></td>
</tr>
<tr>
<td>Compost quantity requirements</td>
<td></td>
</tr>
<tr>
<td>Soil profile and compost incorporation depth</td>
<td></td>
</tr>
<tr>
<td>If soil-forming materials are required, then the following should be considered: availability, type and properties (equally for imported or/and in situ materials)</td>
<td></td>
</tr>
<tr>
<td>Assess the need for an Environmental Permit or exemption, if waste material is to be used on site</td>
<td></td>
</tr>
<tr>
<td>When handling soil, consider the need for a soil management plan – identify if soil handling and storage have been included in the planning permission</td>
<td></td>
</tr>
<tr>
<td>Identify local sources of PAS 100 compost and other soil-forming materials required on site; assess their economic viability</td>
<td></td>
</tr>
</tbody>
</table>

## Quality control during application

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verify that delivered compost meets PAS 100 specification and is suitable for intended use</td>
<td></td>
</tr>
<tr>
<td>Confirm compost application rates and mixing ratios, depth of incorporation, application procedures, machinery and so on</td>
<td></td>
</tr>
</tbody>
</table>

## Post application checklist

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confirm improvement/soil profile depth</td>
<td></td>
</tr>
<tr>
<td>Check soil properties against baseline values (values recorded prior to compost application)</td>
<td></td>
</tr>
<tr>
<td>Monitoring procedures/plan in place</td>
<td></td>
</tr>
<tr>
<td>Assess vegetation growth/health/diversity/weeds</td>
<td></td>
</tr>
<tr>
<td>Contaminants – potential for leaching and toxicity</td>
<td></td>
</tr>
</tbody>
</table>
PAS 100 compost can be utilised for a range of applications. The decision tool, below, can be used to identify in what capacity compost will be required and signposts to further information related to that application.

**Decision tool**

PAS 100 compost can be utilised for a range of applications. The decision tool, below, can be used to identify in what capacity compost will be required and signposts to further information related to that application.

1. **Define your objectives**
   - What are the planned objectives for this site?
     - [for example, reclamation, maintenance of existing vegetation on site, improving brownfield areas]

2. **Is an engineering solution required?**
   - [such as green roofs, slope stabilisation or erosion control]
     - Yes
       - Refer to Sections 5 & 6 of the guide; The GRO Green Roof Code
     - No
3. **Is the requisite vegetation already established?**
   - Yes
     - Maintain soil
     - Refer to Compost in surface treatment Appendix 4
     - Identify relevant data/information from Site investigation
     - Refer to Website of relevant professional body IEMA, IEEM, CL:AIRE
   - No
4. **Is the soil of sufficient quality?**
   - Yes
     - Identify relevant data/information from Site investigation
     - Refer to Website of relevant professional body IEMA, IEEM, CL:AIRE
   - No
5. **Is the soil on site contaminated?**
   - Yes
     - Assess the use of compost for remediation
     - Refer to Website of relevant professional body IEMA, IEEM, CL:AIRE
   - No
6. **Is there sufficient quantity of soil on site?**
   - Yes
     - Improve soil
     - Refer to Compost in soil improvement and topsoil manufacture Appendix 3
   - No
7. **Is there sufficient soil forming material on site?**
   - Yes
     - Manufacture topsoil
   - No
8. **Can economically viable compost and other soil forming materials be sourced locally?**
   - Yes
     - Import compost and soil forming materials
   - No
9. **Import soil**
Appendix 2 - Mixing Ratios

The mixing ratios reported herein are compiled from a range of site trials commissioned to assess different aspects and uses of compost and are therefore case specific. For further information regarding the effectiveness and potential suitability of these mix ratios please refer to the related project report.

<table>
<thead>
<tr>
<th>Topsoil Manufacturing</th>
<th>Land end use</th>
<th>Soil forming materials Ratio by volume</th>
<th>Application method</th>
<th>Comment</th>
<th>Case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Habitat Creation</td>
<td>Woodland</td>
<td>23% green compost 6% paper mill crumb 71% colliery shale</td>
<td>Three methods were trialled, although other placement systems are available: 1) Conventional narrow track bulldozer 2) Low bearing wide track bulldozer 3) Loose tip  The loose tip method gave the best results for this site</td>
<td>As part of a manufactured 2 metre soil profile, 900mm upper subsoil was created using the green compost mix, capped with 100mm depth of site won topsoil</td>
<td>Lambton, County Durham Establishment of woodland in former coke works using PAS 100 compost and paper mill crumb</td>
</tr>
<tr>
<td></td>
<td>Woodland and grassland</td>
<td>30% green compost 40% sand 30% silt</td>
<td>Blending and mixing used 360° tracked excavators with bucket attachment and a tractor and trailer, and then loose tipped</td>
<td>Different depths were used for the vegetation types being established. 1m depth for woodland 0.75m for shrub species 0.5m for meadow grassland</td>
<td>Cross Lane Former landfill restored into a new community woodland</td>
</tr>
<tr>
<td></td>
<td>Woodland and grassland</td>
<td>20% green compost 80% site won material</td>
<td>Compost incorporated with 360° excavator bucket</td>
<td>The optimum compost addition is between 15% and 20%, a 75% increase in growth was recorded with the 25% compost addition, but weed growth and soft growth of trees was observed</td>
<td>Greenoakhill, Scotland Woodland establishment of a restored landfill site</td>
</tr>
<tr>
<td>Forestry</td>
<td>15% green compost 85% clay rich subsoil</td>
<td>Spread and cultivated, secondary rotovation was trialled but did not yield further benefits</td>
<td>Coarse (&lt;40mm) green compost was selected to meet forestry requirements. The coarser particles aid soil drainage, aeration and root penetration, and provide nutrients at a slower rate than fine grade composts</td>
<td>The Dalquhandy former opencast coal site</td>
<td></td>
</tr>
<tr>
<td>Grassland</td>
<td>67% green compost 33% sandy loam subsoil</td>
<td>360° excavators and a large dumper were used to mix the materials</td>
<td>40mm of compost was applied and overlaid with the sand loam subsoil, which was then overlaid with a further 40mm of compost and cultivated</td>
<td>Royal Ordinance, Chorley Former munitions factory transformed into the public open space</td>
<td></td>
</tr>
</tbody>
</table>

Mixed Use Development

| Mixed Use Development | Grassland amenity areas on large scale redevelopment | 30% green compost 70% steel slag | Placement was by loose tipping using a 360° excavator and spread using a toothed bucket. Tracking over placed soils was prohibited | The establishment of grasses has been achieved, and fertiliser spreading to grassland has not proved necessary | Ebbw Vale From steelworks to green space |
|                       | Tree amenity areas on large scale redevelopment | 30% green compost 70% colliery shale | Placement was by loose tipping using a 360° excavator and spread using a toothed bucket. Tracking over placed soils was prohibited | The manufactured soil proved suitable for supporting woodland, however, weed control was required | Ebbw Vale From steelworks to green space |

Recreation and Sports Turf

<p>| Recreation and Sports Turf | Golf course | 30% green compost 70% coal waste | PAS 100 compost was spread over the processed coal waste and incorporated to a depth of 150 mm using standard farm machinery | 25% compost yielded similar grass vigour to the 30% compost addition. 30% is the preferred option to provide nutrients over a longer period | Polkemmet-Heartlands project From coal mine to golf course |
|                           | Football and golf courses | 20% green compost 80% sand 20% food compost 80% sand | A total of 75 litres of sand/compost mix was placed in 1.0m x 0.5m x 0.15m depth plastic trays | The results showed that both green and food-derived compost additions caused an increase in the rate of grass establishment in the first eight months after sowing, as compared to sand alone | STRI, West Yorkshire Comparison of PAS 100 green and food derived composts for turf – root zone manufacture |</p>
<table>
<thead>
<tr>
<th><strong>Soil Improvement</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land end use</strong></td>
</tr>
<tr>
<td><strong>Energy Crops</strong></td>
</tr>
<tr>
<td>Reed canary grass</td>
</tr>
<tr>
<td>Short rotation coppice willow</td>
</tr>
<tr>
<td>Short rotation coppice willow</td>
</tr>
<tr>
<td>Short rotation coppice willow</td>
</tr>
<tr>
<td>Short rotation coppice willow, miscanthus and reed canary grass</td>
</tr>
<tr>
<td>Short rotation coppice willow</td>
</tr>
<tr>
<td><strong>Habitat Creation</strong></td>
</tr>
<tr>
<td>Wildflower grassland development- acid grassland seed mix/ acid wetland seed mix</td>
</tr>
</tbody>
</table>
### Surface Treatment

<table>
<thead>
<tr>
<th>Land end use</th>
<th>Green compost application</th>
<th>Comment</th>
<th>Case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sports Turf</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sports turf&lt;br&gt;Golf course</td>
<td>&lt;5mm top dressing (6 t/ha)</td>
<td>Green and food compost mixed with sand trialled. 100% fine (&lt;3mm) green compost raked in yielded best results</td>
<td>Castle Stuart Golf Course&lt;br&gt;Compost topdressing trials</td>
</tr>
<tr>
<td>Landscape Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Housing development&lt;br&gt;General landscaping</td>
<td>100mm mulch</td>
<td>5cm compost was applied to improve the soil then a 100mm mulch was applied following plant establishment</td>
<td>Cove Bay&lt;br&gt;Compost helps Gardenscape to flower in Cove Bay</td>
</tr>
<tr>
<td>Tree planting scheme</td>
<td>50mm mulch</td>
<td>Compost was also added as a soil amendment at a rate of 0.15m$^2$ per tree</td>
<td>North Somerset Council&lt;br&gt;Compost mulch proves its worth in council tree planting scheme</td>
</tr>
</tbody>
</table>

### Engineering Solutions

<table>
<thead>
<tr>
<th>Land end use</th>
<th>Engineering solution</th>
<th>Material application</th>
<th>Application method</th>
<th>Comment</th>
<th>Case study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope stabilisation</td>
<td>Compost blanket</td>
<td>50mm green compost</td>
<td>Loose tipped and spread manually</td>
<td>The 50mm layer yielded less sediment loss than the 100mm layer or the geotextile, therefore, considered best value in terms of ease of application and low maintenance</td>
<td>Nafferton Farm, Northumberland&lt;br&gt;Engineered slope</td>
</tr>
<tr>
<td>Slope stabilisation</td>
<td>Compost blanket</td>
<td>20mm green compost</td>
<td>&lt;20 mm grade compost was loose tipped and spread manually</td>
<td>300t/ha green compost (equivalent to 20mm surface layer) yielded better vegetation establishment than the 35t/ha or the control sections. The surface applications performed better than the cultivated sections</td>
<td>SIRI, Dundee&lt;br&gt;Compost use for geotechnical stability of engineered slopes</td>
</tr>
<tr>
<td>Slope stabilisation</td>
<td>Compost blanket and compost sock</td>
<td>100% green compost to fill compost sock</td>
<td>Compost applied to slope using a blower which was also used to fill the socks with compost</td>
<td>The 25mm depth compost blanket combined with compost sock also reduced runoff compared to the control</td>
<td>Field-based critical evaluation and demonstration of Compost Erosion Control Blankets and Filtersoxx</td>
</tr>
<tr>
<td>Riverbank stabilisation</td>
<td>Compost sock</td>
<td>Soil mix of: 44% green compost 50% subsoil 6% leaf mould used to fill compost sock</td>
<td>305mm diameter compost sock filled with soil mix using a blower, &lt;10mm grade compost was specified to prevent pipe blockage. Socks were staked at 2m intervals</td>
<td>The rapid and abundant grass growth that occurred in the compost areas stabilised the soils and prevented erosion from precipitation runoff and flood erosion from the river</td>
<td>Centenary Riverside, Rotherham</td>
</tr>
<tr>
<td>Canal bank restoration</td>
<td>Vegetated gabion utilising compost sock</td>
<td>Soil mix of: 15% green compost 85% expanded clay used to fill compost sock</td>
<td>The compost sock was filled with lightweight soil mixture and placed in the front of the gabion, 6N aggregate was used to backfill the gabion</td>
<td>Survival and growth of aquatic plants was considerably better in the compost sock gabion compared with the coir roll faced gabion</td>
<td>Woolston New Cut Canal Warrington</td>
</tr>
<tr>
<td>Footpath stabilisation</td>
<td>Cellular geogrid</td>
<td>Soil mix of: 50% green compost 50% glass sand used to fill geogrid cells</td>
<td>Grid laid on subbase and fill media tamped down into the cells with a straight wooden plank prior to seeding</td>
<td>100% food compost fill yielded good vegetation establishment but suffered excessive settlement. Potential to optimise ratio of compost to mineral component</td>
<td>Marsden Park Golf Course, Lancashire</td>
</tr>
</tbody>
</table>
Appendix 3 - Compost in soil improvement and topsoil manufacture

This Appendix provides technical information on the use of PAS 100 compost for soil manufacture and improvement. Examples of use are given in Chapters 2, 3 and 4 of this guide. Exemplar mixing ratios are provided in Appendix 2.

**Introduction**

Compost is a soil ameliorant and as such it can be used to enhance the conditions of existing soils. Compost can help to increase soil organic matter content, supply nutrients and improve soil physical structure. This is particularly important where land has suffered from past industrial activities. PAS 100 compost has been used as a soil improver on a number of brownfield sites, including former open cast coal mines, quarries, steelworks and landfill sites, and also for a variety of land end uses, such as woodland and grassland development, energy crop production, ornamental parks and gardens and general landscaping.

The aim of soil amelioration is to increase the organic matter of the soil. In some instances, a minimum soil organic matter content of 5% will be appropriate but individual requirements will be determined by end use and pretreated soil analysis.

Compost can also be used to create topsoil. The purpose of topsoil manufacture is to create an effective soil for the establishment of vegetation. The term topsoil manufacture, refers to the blending of soil forming materials with PAS 100 compost to produce a ‘fit for purpose’ soil that suits the requirements of a specific site.

Topsoil manufacture can be applicable in various land end uses, such as in woodland and grassland establishment, energy crop production, general landscaping, housing and mixed use development, and recreation and sports turf. Topsoil manufacturing can take place either in situ, where topsoil is produced at its final location, or ex situ, where the manufacturing process takes place in a designated area of the site. Topsoil manufacturing using PAS 100 compost and site won soil-forming materials can be scheduled to meet construction deadlines and project timescales do not need to be adapted or delayed due to material sourcing and delivery issues.

The procedural specification for topsoil manufacturing suggests that the ex situ manufacturing process is preferred, as it allows for the production of a more uniform product. This is only possible where there is sufficient space on site. Manufactured topsoil or soil-forming materials should be ‘fit for purpose’, capable of supporting vegetation and meet a specification outlined by the landscape architect or project engineer.

Any materials that could potentially interfere with planting and site maintenance, such as large stones and clay balls (above 75mm), roots, rubbish and debris and other materials should be removed prior to mixing. Reducing soil compaction before soil improvement is critical, depending on the soil characteristics, deep tillage or ripping might be needed.

For areas to be seeded or turfed the minimum depth of incorporation is 150mm, and for areas to be planted the minimum depth is 300mm. The application of compost and manufactured soil should be ‘fit for purpose’, capable of supporting vegetation and meet a specification outlined by the landscape architect or project engineer.

**Soil forming materials**

The physical properties of soil-forming materials determine how they will behave and give an indication of how they will perform when they are mixed with other materials. Physical properties can be split into structural and behavioural properties. Structural properties include: texture and stoniness, bulk density, porosity, air permeability, particle size distribution and material consistency. Behavioural properties include infiltration, hydraulic conductivity, heat capacity and strength. The physical limitations of commonly used soil-forming materials are presented in Table 1. These limitations should be considered during project planning and design. Chemical limitations of commonly used soil-forming materials are shown in Table 2. These limitations should also be considered during project planning.
### Table 1: Physical limitations of soil-forming materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Light texture</th>
<th>Heavy texture</th>
<th>Low AWC</th>
<th>Poor drainage</th>
<th>Stones</th>
<th>Boulders</th>
<th>High surface temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>0</td>
<td>+++</td>
<td>+</td>
<td>+++</td>
<td>0</td>
<td>0</td>
<td>+/0</td>
</tr>
<tr>
<td>Sand and gravel quarry waste</td>
<td>+++</td>
<td>0</td>
<td>+++</td>
<td>/0</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Limestone and chalk</td>
<td>+</td>
<td>0</td>
<td>++</td>
<td>0</td>
<td>+++/0</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>Dolomite</td>
<td>+</td>
<td>0</td>
<td>++</td>
<td>0</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Acid hard rock</td>
<td>++</td>
<td>0</td>
<td>++</td>
<td>0</td>
<td>+++/0</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>China clay waste</td>
<td>++</td>
<td>0</td>
<td>+++</td>
<td>0</td>
<td>++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Colliery shale</td>
<td>+</td>
<td>0</td>
<td>++</td>
<td>+++</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Open cast coal spoil</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>++</td>
<td>+++/0</td>
<td>+++</td>
<td>0</td>
</tr>
<tr>
<td>Drift deposits</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dredgings</td>
<td>0</td>
<td>++</td>
<td>0</td>
<td>+++</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Silt bed/ tailing pond material</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Civil engineering waste</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>+++/0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Key:** +++ severe limitations, ++ moderate limitations, + slight limitation, 0 no limitation AWC = Available Water Content

### Table 2: Chemical limitations likely to be encountered in soil-forming materials

<table>
<thead>
<tr>
<th>Material</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>Ca</th>
<th>Mg</th>
<th>pH</th>
<th>CEC</th>
<th>Na</th>
<th>Toxicities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>↓↓↓</td>
<td>↓↓/*</td>
<td>*/↑</td>
<td>↓/↑</td>
<td>↓/↑</td>
<td>↓/↑</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Sand and gravel quarry waste</td>
<td>↓↓/↑</td>
<td>↓/↑</td>
<td>↓/↑</td>
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<td>Civil engineering waste</td>
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</table>

**Key:** ↓↓↓ severe deficiency, ↓↓ moderate deficiency, ↓ slight deficiency, * adequate, ↑ slight excess, ↑↑ moderate excess, ↑↑↑ severe excess
The texture of a soil can be defined using the classification triangle in Figure 1. Identifying the texture of the soil and the content of clay, sand and silt is essential in determining fit-for-use mixing ratios for the soil-forming materials and determining mixing ratios for soil improvement.

![Soil Textural Classification Triangle](image)

**Figure 1: Soil textural classification triangle showing limiting percentage of sand, silt and clay constituents for major soil types**

### Site investigation and preparation

The Forestry Commission has produced guidance on the minimum standards for soil-forming materials acceptable for woodland establishment; these are presented in Table 3. The soil characteristics should be tested directly after the compost amendments or the manufacturing of soil and in set intervals after that to ensure adequate monitoring of the conditions on site.

If the project takes place on a brownfield site that is potentially contaminated further investigation is required and consultation with a specialist organisation is recommended. Such a soil survey will help to:

- Understand the type and composition of existing soils and soil-forming materials on site.
- Identify potential locations for stockpiling blending in the case of on site topsoil manufacturing.
- Identify the appropriate soil improvement activities to be conducted to suit the requirements of the plant species to be established.

When planning for restoration/reclamation of a site using in situ materials, it is critical to investigate the availability of soil reserves and soil forming material. The following should be taken into consideration when planning for a woodland and grassland restoration project:

- Soil types and volumes needed to achieve the intended landscaping.
- Soils and soil forming materials present on the site.
- Procedures needed to produce the required soils.

Water availability, weed control, light and temperature are key determinants that should be assessed to maximise plant establishment and long-term effectiveness. Areas with low soil moisture availability and also very wet soils are best avoided, since these conditions do not promote successful growth.
Table 3: Minimum standards for soil-forming materials acceptable for woodland establishment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Standard</th>
<th>Comments on method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>No limitations; (preferred textures include materials with &gt;25% clay)</td>
<td>Texture (% sand, silt, clay) determined by pipette method</td>
</tr>
<tr>
<td>Bulk density (after placement)</td>
<td>&lt;1.5 g cm^-3 to at least 0.5m depth</td>
<td></td>
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<tr>
<td></td>
<td>&lt;1.7 g cm^-3 to below 1m depth</td>
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<tr>
<td>Stones</td>
<td></td>
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<tr>
<td>Clay or loam</td>
<td>&lt;40 % by volume of material &gt;2mm &lt;10% by volume of material &gt;100mm</td>
<td>Measure mass of stone &gt;2mm and &gt;100mm in a known mass / volume of soil; volume of each calculated by dividing 1.65</td>
</tr>
<tr>
<td>Sand</td>
<td>&lt;25 % by volume of material &gt;2mm &lt;10% by volume of material &gt;100mm</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>Must be within the range 4.0 to 8.0</td>
<td>Based on a 1:2.5 soil: CaCl2 [0.01 M] suspension</td>
</tr>
<tr>
<td>Electrical conductivity</td>
<td>&lt;0.2 S m^-1</td>
<td>Based on a 1:1 soil : water suspension</td>
</tr>
<tr>
<td>Iron pyrite content</td>
<td>&lt;0.05%</td>
<td>British Standard 1016 method</td>
</tr>
<tr>
<td>Topsoil nutrient and organic content</td>
<td>N &gt;200kg N ha^-1</td>
<td>N determination using the Dumas method</td>
</tr>
<tr>
<td></td>
<td>P &gt;16 mg l^-1 (ADAS Index 2)</td>
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<tr>
<td></td>
<td>K &gt;121 mg l^-1 (ADAS Index 2)</td>
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<tr>
<td></td>
<td>Mg &gt;51 mg l^-1 (ADAS Index 1)</td>
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<tr>
<td></td>
<td>Organic matter content &gt;10%</td>
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</table>
Soil improvement

Compost use in grass establishment and in planting beds should be applied uniformly over the treatment area at an average depth of 25 to 50mm, followed by rotavation to a minimum depth of 150mm to incorporate the compost.

Additional fertilisers or adjusting agents, such as lime, might be necessary depending on the soil conditions and they should always be applied prior to incorporation. Compost spreading and incorporation should be undertaken using a loose tip method to avoid unwanted excessive soil compaction. The soil should be raked prior to seeding, hydro seeding, planting, or laying turf.

Tree pits

Where compost is blended with excavated soil and used as backfill for planting pits, a planting hole equal in depth to the root ball and 2 to 3 times its width, should be excavated. The root ball should be placed on firm soil and the blended soil placed around the root mass ball and firmed occasionally. It is preferable to water the area after planting.

The application of compost should be avoided at times that are likely to cause greater nuisance to the general public, or when the climatic conditions are liable to cause disturbance. Application on slopes will require careful consideration. As a general guideline, application on slopes greater than 25 degrees should be avoided. However, specific engineering solutions, such as compost blankets or socks may be utilised for steeper slopes and erosion control. Plant as soon as possible after preparation of the site is recommended.

Topsoil manufacture and placement

In ex situ topsoil manufacturing, required quantities of subsoil are loosened by cultivation and then stripped ready for the blending process. The stripped subsoil is stockpiled and subsequently blended with the compost and other organic or inorganic materials to be included in the mixture. This can be achieved accurately using a 360° tracked excavator with bucket attachment. Thorough blending should be conducted to ensure a homogeneous mixture is achieved, without destroying the structure of the soil. When using ex situ manufactured soil, the subsoil may require additional ripping prior to the application of the soil-forming mixture, or before the full quantity of the manufactured topsoil is applied.

Two methods of emplacement are commonly used during compost/topsoil application; loose tipping, with limited or no traffic during emplacement and the bulldozer method with traffic during emplacement. Loose tipping is the preferred method for engineering soil as it retains low bulk densities, and enhances root penetration potential, aeration, drainage and moisture holding capacity.

For both in situ and ex situ topsoil manufacturing, compliance with BS3882:2007 and other soil grade and textural requirements are desirable.

Prior to in situ soil manufacturing, excess site soil should be used to grade the soil to smooth contours that are within 25 – 75mm from the specified finished soil level. Any large stones (above 25mm) should be removed at this stage. It is recommended that the compost is applied uniformly at suitable rates and the soil is cultivated to a depth of between 300mm and 900mm in two directions obliquely when ground conditions are reasonably dry. The application rate will be governed by the current soil conditions and the land end use. Some exemplar projects are provided in Chapter 2 Soil manufacture and habitat creation, and mixing ratios from various case studies are given in Appendix 2.

References

1 WRAP (2003), Compost specification for the landscape industry
2 WRAP (2009), Review of the soil development strategy at the former Lambton Cokeworks
3 WRAP (2008), The potential for biofuel crop production on a former coal washing site in Kinglassie, Fife
5 http://www.claire.co.uk/
7 WRAP (2010), Compost in erosion control, Sustainable Urban Systems and green roofs
8 Sniffer (2010), Code of Practice for the use of sludge, compost and other organic materials for land reclamation.
9 WRAP (2009), Cross Lane & Chorley former Royal Ordnance Facility
10 BSI (2007), BS 3882:2007 Specification for topsoil and requirements for use
Appendix 4 - Compost in surface treatment

This Appendix provides information on the use of PAS 100 compost for surface treatment, including top dressing and mulch. Examples of use are given in Chapters 7 and 8 of this guide and exemplar application rates provided in Appendix 2.

Introduction

PAS 100 compost acts as a fertiliser when added to a soil as top dressing, because it contains major nutrients, including nitrogen, phosphorus and potassium which help to keep vegetation healthy and increase available nutrients for plant take up, it can also be used as a mulch, to suppress weeds and provide a protective cover. Top dressing is generally <10mm and will release nutrients quicker than mulch, which has a grading up to 50-70mm.

Site preparation

If the site is predominantly made up of subsoil, deep tillage or ripping may be necessary to relieve compaction, more information on soil improvement can be found in Appendix 3.

Prior to the application of compost as a top dressing or mulch, the following activities are recommended:

- evaluate the adequacy of existing site drainage and correct if necessary;
- remove perennial weeds and bury annual weeds;
- thoroughly water the ground;
- if soil surfaces are compacted, prick up and aerate the soil, particularly around root areas;
- break any surface crusting, reduce the size of soil lumps to a crumb and level off. Take care not to damage plants and their roots; and
- remove the previous season’s bedding, including bulbs, litter and debris.

Top dressing

Parks, lawns and sports grounds often suffer from poor visual appearance as a result of channelled pedestrian and vehicle traffic. The application of compost as a surface treatment mitigates this wear and reduces the potential for damage from pedestrian and vehicle traffic. Compost top dressing and seeding can improve grass swards that are suffering from compaction and consist of weak vegetation. This practice is often used on sports turf in the autumn. Nutrients supplied will often replace the need for any autumn fertilisation by other organic or inorganic fertilisers.

Benefits

When applied as a surface treatment, compost:

- provides a simple means of greening up turf quickly and evenly;
- improves the visual appearance of turf;
- helps increase the wear-tolerance of the turf;
- reduces surface hardness in dry periods and helps to protect players when applied at sports grounds;
- protects the turf from nitrogen-sensitive diseases, such as dollar spot; and
- provides the turf with some drought resistance in dry conditions.

When applied as a fine mulch/top dressing to planting beds, compost:

- reduces evaporation from the soil and maximises available water for plants;
- acts as a long term soil improver; and
- provides nutrient release as an alternative to inorganic fertilisers.

Application and considerations

Compost is a competitive alternative to top dressing materials typically used in sports turf and landscape applications. It can be blended with other materials, including sand, to make it suitable for applying to closely-mown fine turf and on planting beds. Compost with a grading of less than 10mm is recommended. In locations where compost may be evident on turf surfaces some time after application, material can be pushed into the turf surface using a mower roller or the back of a rake, or alternatively, through the use of smaller graded compost materials. It is recommended a <5mm maximum particle size is used for turf top dressing, with a <3mm graded material used if possible.

For most projects the application of a 5-10mm layer of compost over the area to be treated is appropriate. However, application rates will depend on current soil conditions, available nutrients in the compost, the grass/turf species requirements and site activity level. Depending on site requirements monthly or annual applications of top dressing, might be necessary. Monthly applications of top dressing composed of as little as 20% compost by volume and applied at rates of 488kg compost per hectare have shown to be sufficient to suppress plant diseases such as red thread, brown patch, dollar spot, Typhula blight and Pythium blight in sports turf applications. In the short term, disease control may be less effective with composts than with fungicides. However, in the long term, turf quality and the level of
disease control obtained using composts can be better than when fungicides are used.

Where grass seed is sown along with top dressing, the chloride content of the compost can be specified at a maximum of 800mg/l to help avoid germination delays. For fine turf where an alkaline pH may be associated with fungal disease, a sand:compost mix should have a pH below 7.0 to avoid raising the root zone pH. For the top dressing of sports pitches, the compost should be free of any sharp materials such as glass.

It is recommended that top dressing is not carried out during the growing season in which plants are established. A layer of compost can be applied at the beginning of the second growing season. Application when the soil and weather conditions are unsuitable for example during periods of frost, snow, heavy rain, drought or strong winds is not recommended. When applied in planted areas, compost can be lightly firmed around plants by raking and forking without damaging their roots. Watering before and after compost top dressing application is recommended.

Benefits can be experienced even at low application rates of compost. Around 10 – 15% of the phosphorus and 80% of the potassium in compost are likely to be available to plants in the year that the compost is applied. However, nitrogen content is generally lower in green compost than compost made from food. Therefore, the application rate of compost may need to be increased to compensate, especially if the plants present have a high nutrient demand.

In these circumstances it may also be necessary to apply additional inorganic nitrogen to provide adequate nutrients for optimal plant growth. This will still be at a reduced rate when compared to fertiliser requirement when compost is not used, thus leading to reduced fertiliser costs over the project. Fertiliser application rates may also need increasing in soils prone to nutrient leaching, such as those that are sand and gravel based. In these instances it is important to consider whether the site is in a Nitrate Vulnerable Zone (NVZ).

Weed growth may be an issue in areas treated with compost (due to its nutrient content) in the early stages after compost application and during plant establishment. Therefore, herbicide may need to be applied in the short term. However, this requirement reduces after a few months and weed growth is reduced and prevented by the end of the growing season.

**Benefits**

When applied as a coarse mulch, compost:
- provides a simple, non chemical, means of weed control in planting beds;
- improves the visual appearance of planting beds;
- reduces evaporation from the soil and maximises available water for plants; and
- degrades and acts as a long term soil improver.

**Application**

Application for the establishment of new plants is most effective in March or April. It is recommended that compost is spread evenly and any previously applied mulch materials are carefully lifted and replaced. Compost mulch can be applied straight after planting around plant stems - watering plants thoroughly before and after mulching is important.

A 25-75mm layer of mulch spread over the area to be treated, or in a one metre circle around a single plant (20-60 litres per tree) is suggested although application rates may vary between locations.

Compost grading will depend on the visual appearance required. For example, it is recommended that a 75mm screen is used for coarse roadside mulch and a 50mm screen is used for medium grade mulch. The removal of fine particles is recommended to reduce the bulk density of the mulch to aid transport and spreading and also to reduce the germination of wind-blown weed seeds. A low fines content compost can often be requested from the supplier or fine particles can be removed by passing the material over a 5mm or 10mm screen with the screened ‘fines’ used for other applications, such as top dressing.

In most landscape applications, the addition of pre-plant fertiliser can be eliminated when compost is applied as mulch at the recommended rate. For example, a 50mm layer will supply up to approximately 200-400kg/ha of nitrogen, 380kg/ha of phosphate, and 1200kg/ha of potash in the first year following application. Nitrogen in compost applied in the autumn is less likely to be leached out over the winter. Additional nutrition provision may be required from other organic or inorganic fertilisers if the compost contains a lower nutrient content, or has a high carbon:nitrogen ratio (over 20:1), or if the plant species require high nutrients. Compost application rates should be modified based on current soil conditions, available nutrients in the compost, and plant species requirements.

**Mulch**

PAS 100 compost can be used as a mulch to suppress weeds and establish planting areas. Coarser, woodier fractions are most suitable to act as stable, effective and long-lasting mulch.
treatment, and to identify the need to add further organic materials or an inorganic fertiliser, the following characteristics can be assessed:

- turf colour;
- ground coverage by grass;
- turf height;
- incidences of fungal disease;
- number of weeds;
- earthworm casting;
- surface traction;
- soil moisture content; and
- soil pH.

References

1. WRAP (2010), Sherborne Golf Club – Case study
2. WRAP (2006), Demonstration trials of the utilisation of composted materials in the maintenance of sports and amenity turfgrass
3. WRAP (2008), Monifieth golf links – Landscape and regeneration case study
4. SAC (2009), Compost as components of topdressings on golf courses – a literature review
5. WRAP (2006), Using composted products for energy crops in agriculture & bioremediation
6. WRAP (2009), Establishment of short rotation coppice willow on restored soils at the St Ninians Open Cast Coal
7. WRAP (2004), To support the development of standards for compost by investigating the benefits and efficacy of compost use in different applications
Glossary

Aggregation: refers to the way in which sand, silt and clay particles come together to form a soil structure

Ameliorant: substance added to soil to improve growing conditions for plants

Attrition: as part of soil remediation technology, removes fine particles and contaminants from the surface of primary material (soil)

Biomass: refers to the mass of biological organisms in an area or ecosystem at any given time

Bioremediation: is a process which uses micro-organisms or enzymes to breakdown or remove contaminants

Biowaste: source-segregated biodegradable waste

Brownfield: refers to both known contaminated sites and any land or premises which have previously been used or developed and not currently fully in use (this excludes agricultural land)

Bulk density: the mass of a unit volume of soil, generally expressed in g/cm3. Light and porous soils have low bulk densities, whereas heavy and compacted soils have high bulk densities

Carbon sequestration: long-term storage of carbon dioxide or other forms of carbon to mitigate global warming

Cation exchange capacity (CEC): the total amount of exchangeable cations that a particular soil, or soil forming material can adsorb at a given pH. Light textured soils (in the sandy categories) possess low cation exchange capacities (CEC) and adding compost raises the CEC of these soils. This enables the soil to better hold onto nutrients, such as potash and nitrogen, which would otherwise leach beyond the rooting depth.

Compost: solid particulate material that is the result of composting, that has been sanitised and stabilised and that confers beneficial effects when added to soil, used as a component of a growing medium, or is used in another way in conjunction with plants. This definition refers to PAS 100 compost for the purposes of this document

Composting: process of controlled biological decomposition of biodegradable materials under managed conditions that are predominantly aerobic and that allow the development of thermophilic temperatures as a result of biologically produced heat

Domestic use: compost use by members of the public in their own gardens, communal or shared gardens, and allotments

Electrical conductivity: measurement relating to the concentration of soluble ionic constituents, particularly ammonium, calcium, chloride, magnesium, nitrate, phosphate, potassium, sodium and sulphate

Food derived compost: compost that has been made from suitable low-risk food wastes such as household and commercial kitchen wastes. Facilities producing such composts are authorised by Animal Health to ensure that they achieve appropriate conditions to ensure their safety

Fertiliser: soil amendment containing nutrients (macronutrients and micronutrients), added to promote plant growth
Green compost: the feedstock used to produce green compost is source segregated material collected independently from other waste streams from sources such as domestic gardens, municipal parks and recreational areas.

Green waste: arboreal and other botanical residues such as grass clippings and other plant residues derived from parks, gardens, nurseries and amenity areas and sometimes waste from vegetable or fruit processing activities.

Growing medium: material, other than soils in situ, in which plants are grown.

Land reclamation: the recovery of land from a brownfield or underutilised state to make it suitable for reuse achieved through stabilisation, contouring, maintenance, conditioning, reconstruction and vegetation establishment.

Land remediation: the process of making a site fit-for-purpose through the removal or containment of contaminants. Environmental damage is reversed or treated through the management, removal, sealing or treatment of dangerous substances or stabilisation in order to render the site safe for a specific use, but not necessarily for all possible uses.

Land restoration: the process of making a site fit-for-purpose through (among activities carried out), amelioration of the site’s soil or soil forming materials.

Micro-organisms: include bacteria, algae, fungi and protozoa. They recycle nutrients and actively decompose organic matter.

Mulch: substance spread and allowed to remain on the soil surface to conserve soil moisture, suppress weeds and shield soil particles from the erosive forces of raindrops, run-off and wind.

Oxygen diffusion capacity: the capacity of the soil to transfer oxygen to plant roots.


Rotovator: a machine designed to break up soil using rotating blades.

Sewage sludge cake: dewatered, organic-rich sewage sludge that is an output from the sewage treatment process.

Soil amendment: material added to soil to maintain or improve its physical properties, and which may improve its chemical and/or biological properties or activity.

Stable, stabilised: degree of processing and biodegradation at which the rate of biological activity under conditions favourable for aerobic biodegradation has slowed and microbial respiration will not significantly resurge under altered conditions, such as manipulation of moisture and oxygen levels, or temperature or the addition of a source of water soluble nitrogen.

Subsoil/substrata: the layer of soil below the layer of topsoil.

Sustainable Drainage Systems (SuDs): surface water drainage systems developed in line with the ideals of sustainable development are collectively referred to as Sustainable Drainage Systems (SuDS).
**Topsoil manufacture:** blending of soils available on site and potentially other organic or inorganic materials with BSI PAS 100 compost to produce a soil that suits the requirements of the site and which provides the same function as topsoil.

**Tilth:** state of aggregation of soil and its condition for supporting plant growth.

**Topsoil:** the uppermost layer of soil, where the majority of biological soil activity, concerning micro-organisms and organic matter, occurs.

**Water holding capacity:** the ability of soil to retain water and thus making it available for a longer period of time in dry conditions.

**Wetlands:** an area where the soil is saturated with moisture either permanently or seasonally.
Frequently asked questions

What is PAS 100 compost?
PAS 100 compost is a natural product, the result of the organic breakdown of green and food waste, produced under controlled and monitored conditions in accordance with BSI PAS 100, which is a Publicly Available Specification. Compost is an important product to the landscaping industry and can provide various benefits in projects involving reclamation, restoration and improvement of land.

Why use compost?
PAS 100 compost is a source of organic matter and can improve the physical and chemical properties of the soil to which it is applied, to enhance plant growth, to stimulate biological activity in the soil and to improve resistance to erosion. PAS 100 compost suppliers can be identified in the WRAP Compost Suppliers directory.

PAS 100 compost is ideal because not only is it a rich source of nutrients, it is also quality assured and therefore reliable and consistent. Topsoil is difficult and expensive to source and it comprises a precious resource. Therefore, compost offers a financially competitive and effective alternative to the importing of topsoil. PAS 100 compost can be mixed with recycled inert materials such as surplus soil or crushed stone, existing low quality soils or be combined on site with soil forming materials. The mixture of compost with existing indigenous soils can improve soil structure, reduce compaction in the surface layer, improve water holding capacity, and improve soil drainage.

Is PAS 100 compost safe to use?
The composting process eliminates most plant pathogens that may be present in the feed stock. In addition, PAS 100 and the Hazard Analysis and Critical Control Point (HACCP) measures, ensure risks of adverse impacts to the environment and human health are minimized.

Can using PAS 100 compost harm water courses?
High application rates of compost are thought to result in nitrogen release that is greater than plant requirements which may leach into drainage water. However, compost provides a slow-release of nutrients, and nutrient leaching is generally lower than in the case of inorganic nutrient (fertilizer) application. As such, PAS 100 compost has been used to remediate contaminated water and safeguard water quality.

It is good practice to use the correct application rates for the soil and vegetation types, and establish monitoring procedures, to ensure that leaching does not cause harm to water courses.

How can I use PAS 100 compost?
PAS 100 compost can be used as a mulch or top dressing or incorporated into the existing soil to improve the soil properties. BSI PAS 100 compost can also be used in soil manufacture to create topsoil that complies with BS 3882:2007.

Where can I get PAS 100 compost from?
Go to the compost supplier directory: compostsuppliers.wrap.org.uk

Where can I use PAS 100 compost?
PAS 100 compost has been used successfully in the following sectors:
- soil manufacture and habitat creation;
- housing and mixed use development;
- energy crop production;
- slope stabilisation;
- recreation and sports turf;
- SuDS and green roofs; and
- general landscaping.
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