Material change for a better environment

Environment Agency

Waste Protocols Project

PAS100 Compost

A technical report for the production and use of PAS100 compost from source segregated bio waste

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Contents

Executive summary

Background

The Business Resource Efficiency and Waste (BREW) Waste Protocols Project aims to produce waste protocols on various waste streams, which will provide guidance to business that will:

- define the point of full recovery from a waste back into a product or material that can be either reused by the business or industry or sold into other markets; or
- define when wastes are recovered to a state where the Environment Agency considers that their use is acceptable in accordance with their Low Risk regulatory principles; or
- confirm to the business community what legal obligations remain to control the re-use of the treated waste material.

The Environment Agency currently considers that all compost remains waste until the point at which it is fully recovered through application to soil. The project board requested that the Technical Advisory Group (for recovery of source segregated waste into compost) consider the feasibility of producing a Quality Protocol which would enable the point of recovery of waste into compost to be moved closer to the point of production. The group was asked to consider the potential for using the British Standards Institute, Publicly Available Standard BS PAS100 for producing compost as part of the Quality Protocol (referred to as PAS100 within this document).

Methodology

The Technical Advisory Group:

- obtained and reviewed analytical data on the quality of compost produced to the PAS100 specification;
- identified the major markets for PAS100 compost;
- identified the current legislative framework for manufacture and use of PAS100 compost;
- identified and subjectively quantified the relative risk to the environment from the use of PAS100 compost in each individual market; namely:
  - as a horticultural grade growing media;
  - in landscaping activities;
  - on land restoration sites;
  - in agriculture; and
- reviewed the potential health risks associated with the use of PAS100.

Findings & Recommendations

The Technical Advisory Group found that a Quality Protocol could feasibly be developed for use in conjunction with the PAS100 standard. For the Quality Protocol to work, it is recommended that the following activities are undertaken:

- **Auditing.** For the approach that is described in this document to work it is essential that there is a fully independent quality assurance auditing system in place. We recommend that the auditing system include a level of independent certification (where a third party independent of the producer undertakes independent verification and provides certification that the product meets the PAS100 standard). Furthermore, it is recommended that an independent party accredit the independent certifying body to ensure that the certification they have undertaken is valid.
- We recommend that the BREW Waste Protocol Board consider the auditing approach for this and the other Quality Protocols to be developed by the programme.
- **Consultation.** We recommend that the BREW project undertake a 3-month consultation on the draft Quality Protocol and on the options for agricultural use of compost at the earliest opportunity. The consultation document should be accompanied by a partial Regulatory Impact Assessment. We recommend stakeholder workshops be held with regulators and stakeholders separately.
- **Communications (including training and promotion).** For the Quality Protocol to become effectively established it will need to be promoted and supported by adequate training (particularly of composters and Environment Agency personnel). We recommend that Environment Agency, The Composting Association and WRAP develop training materials and embark on a programme of training after the Quality Protocol has been finalised.

- **Research.** The Technical Advisory Group has identified some knowledge gaps, which would benefit from medium-term research on the use of compost to support the Quality Protocol in the future. We recommend that the BREW Waste Protocols Project formally recommends that Defra, the Scottish Environment Protection Agency (SEPA) and Department of Environment Northern Ireland (DoENI) should complete this work perhaps initially in partnership with the Environment Agency and WRAP. We recommend that this include:
  - updating the topsoil standard BS3882 to include manufacturing of soils and appropriate PTE limit values;
  - establishing a Quality Protocol for soils arising from brownfield or greenfield sites; and
  - including compost application in RB209 and the Code of Good Agricultural Practice.
- **Review.** PAS100 is to be reviewed and updated in 2007. This review should take into consideration the Quality Protocol and other scientific information. It is recommended that the Quality Protocol be reviewed in January 2008 and biennially thereafter.

1. Introduction

1.1 The definition of waste has been an important part of efforts to protect the European environment from the impacts of waste generation and management over the past 30 years. Objects or substances that are waste[1] are controlled by community waste legislation in order to protect human health and the environment. Processing waste into a product is subject to those statutory controls.

1.2 In some cases it can be difficult to determine the point at which waste has been fully recovered, ceases to be waste and can be used in the same way as a non-waste raw material. This is the point when there is no longer any reason to subject it to the controls and other measures required by waste legislation.

1.3 In general, *compost* derived from waste will only cease to be waste when it is used. In some cases, it is possible for composted waste to be fully recovered and cease to be waste before it is used. This Quality Protocol addresses this issue.

1.4 This document reports on the progress of the technical group on this topic and provides recommendations to the Project Board on certain specific issues. The Technical Advisory Group:

- obtained and reviewed analytical data on the quality of compost produced to the PAS100 specification;
- identified the major markets for PAS100 compost;
- identified the current legislative framework for manufacture and use of PAS100 compost;
- identified and subjectively quantified the relative risk to the environment from the use of PAS100 compost in each individual market;
- reviewed the potential health risks associated with the use of PAS100 compost; and
- has proposed routes forward for each of the major markets so that PAS100 compost may be regarded as fully recovered where strictly defined conditions are met.

These proposed routes are described in more detail in the following sections. There are strong inter-dependencies between markets and as such it is sensible that markets are treated together and not in isolation.

1.5 In the remainder of the document, we outline:

- the main markets for compost;
- the current legislative arrangements for compost;
- how waste could be recovered into a quality compost product; and
- the implications to human health and the environment of using PAS100 compost in the main markets for the material.

1.6 We draw conclusions as to the risk associated with the use of such compost as a recovered product in these markets. Where the risk is low we have made recommendations as to how measures could be implemented within a Quality Protocol to maintain this risk level and to monitor compliance.

1 Waste is any substance or object that the holder discards, intends to discard or is required to discard. There have been a number of judgements by the European Court of Justice (ECJ). A summary of these judgements, which are legally binding, is available on the Defra website at http://www.defra.gov.uk/environment/waste/topics/ecj-definition.pdf The dossier on key environmental judgements by the ECJ published by the European Commission in March 2004 is available on its website at: http://europa.eu.int/comm/environment/law/cases_judgements.htm

2. Key markets for compost

2.1.1 A market analysis (see Appendix B) suggested that there are the following key markets for quality PAS100 compost:

- growing media manufacture;
- material supplied to operators who supply landscaping products (i.e. blended soils, top dressing, and compost);
- direct use of PAS100 on restored sites; and
- direct use of PAS100 material in agriculture.

2.2 The Quality Protocol may discuss these 4 markets separately although it is recognised that there are many commonalities between material supplied to operators who supply landscaping products and the direct use of PAS100 on restored sites. The Quality Protocol may therefore discuss these two markets simultaneously.

2.3 The use of compost in these markets is considered in this paper.

3. Current legislative position

3.1 All PAS100 material is produced at fully authorised sites, that is all sites will hold a waste management licence (or be registered as exempt) and will also be authorised by the State Veterinary Service if they process animal by-products. The current legislative controls on compost are outlined in Table 1.

Table 1: Summary of legislative controls on compost once it has left the production site

Use	Current legislative control	Current regulatory approach
Horticultural grade material	Duty of care/waste carriers	Compost following this route is not regulated. Generally speaking it is not in the public interest for the Environment Agency to take enforcement action unless there is a serious problem.
Use of compost in landscaping activities	Material is delivered to the landscaping site as a waste so duty of care applies. The site receiving the material must be licensed to receive it and process it. The resulting material is no longer waste under some circumstances.	Normal regulatory controls. In most cases, where the topsoil is manufactured to the BS standard for topsoil, the end product is not treated as a waste.
Use on restored sites	Material is delivered to sites as a waste so duty of care applies. Use on site is controlled via planning constraints, Part IIa and/or a paragraph 9 exemption from WMLRs. In some cases soil manufacture on site will be covered by a paragraph 13 exemption.	Normal regulatory controls
Use in agriculture	Material delivered as a waste and then spread under a paragraph 7 exemption (landspreading to derive benefit)	Before the exemptions were revised in 2005 some compost use was registered under paragraph 7 and some was not. Since the revision more compost is now registered.

4. The point at which waste becomes recovered

4.1 To move to a point where a PAS100 material can be considered to be no longer a waste we must be certain that:

- the material meets a standard;
- there is a market for the material; and
- the material will not cause harm to the environment or to human health.

4.2 The work of the Technical Advisory Group has shown that whilst PAS100 on its own does set a standard for the production of compost and the quality of the finished product, the PAS100 documentation was never designed to determine the point at which compost becomes fully recovered. As such, whilst compost will meet the requirement to meet a recognised standard, it does not satisfy tests 2 and 3. To do this, the solutions listed in the table below must be met for all compost and there are then additional requirements that must be met for each target market.

Table 2: General requirements for all PAS100 compost

Concern	Why?	Solution
Lack of clarity over the precise nature of input materials	PAS100 only states waste must be source segregated.	A Quality Protocol should specify suitable waste types – could be addressed through revision of PAS100.
Lack of clarity over the precise sources of the input materials waste that are delivered to a composting site.	PAS100 has generalised waste acceptance criteria.	A Quality Protocol should be very specific about records to be kept, precise about acceptance criteria and precise about what should be done if a load fails to meet the required criteria – could be addressed though revision of PAS100.
Lack of clarity about the final destination of the compost.	PAS100 does not have requirements for the final destination of a compost to be recorded.	A Quality Protocol must be specific about records to be kept on the final destination for the compost. It is not sufficient to produce a compost that is fit for a market – it must actually be delivered to a market. This could be met through the introduction of a Quality Protocol together with the revision of PAS100.
Lack of overall quality assurance	PAS100 stipulates detailed criteria against which an operator will be inspected for the production of his compost. If they meet the criteria they are PAS100 accredited. But, the accreditation system currently only covers the production of the compost. As noted above, this is not sufficient to determine if compost routinely satisfies all three tests and that it should be treated as being a fully recovered material.	A Quality Protocol must be fully audited by an independent quality assurance system. The quality assurance system must cover waste inputs and product markets as well as the compost quality. This could be met through the introduction of a Quality Protocol together with the revision of PAS100.
Lack of confidence in the level adoption of the Quality Protocol	A substantial amount of work was undertaken to promote PAS100.	The development of any new Quality Protocol should be accompanied by appropriate levels of training, promotion and industry awareness raising. This will require a clear communications and training strategy.

4.3 One approach to implementation is to update PAS100 with the requirements outlined above. This would mean that these additional requirements would then be subject to the PAS100 auditing process.

4.4 In Section 5 we consider the use of compost in each of the target markets. We consider the implications of treating compost as a product in each market. In each case the text describes the key risk pathway. The Technical Advisory Group has also considered other risk pathways in each case and these are discussed in the accompanying scenarios.

5. Use of PAS100 as a horticultural grade growing media

5.1 How is compost used?

5.1.1 A compost manufacturer supplies compost to a growing media manufacturer who then blends the PAS100 material with other components and then sells bagged products to retailers for onward sale to domestic users or sells bagged product or in bulk to professional horticulturists. A compost manufacturer also sells compost in bulk to domestic users.

5.2 What are we protecting?

5.2.1 **Human and animal health.** Growing media and soil conditioners containing compost made from PAS100 materials are being used directly by the consumer. The consumer may use it 'neat' by putting it into pots or may dilute it by digging it into the soil as a soil improver. Either way, the consumer is directly exposed to the compost. In professional horticulture compost is most likely to be used as part of blend (see Appendix B).

5.2.2 **Plant and soil health.** A gardener will expect a benefit to both their soil and to their plants when they use products that contain PAS100 composts. Tests within the PAS100 documentation ensure that there is no harm to plant health, but the PAS100 standard does not require detailed tests for soil microbial function. Thus we should consider the potential build up of potentially toxic elements (PTEs) within garden soils.

5.3 What is the scale of the risk?

5.3.1 Work commissioned by the Technical Advisory Group confirms that the levels of PTEs permitted in PAS100 compost are generally protective of human health so we conclude that the risk to human health is low (see Appendix C & D).

5.3.2 Further work by the group has shown that the time scales that are required to accumulate PTEs to critical levels for soil health in garden soils are generally very long based on the normal level of usage (see Appendix E – horticultural use scenario). We therefore conclude that the risk to soil health is generally low.

5.4 Is the risk acceptable? If not, what can be done to make the risk acceptable?

5.4.1 Where horticultural grade growing media is used in domestic applications, the risk associated with its use is acceptable.

5.5 Conclusion

5.5.1 **Proposed safeguards:**

- the additional requirements for the production of compost described in Table 2 above are met i.e. only listed waste types are accepted, all records are kept and the finished compost is delivered to only horticultural grade markets;
- the compost producer remains PAS100 accredited; and
- all records are available for inspection by an independent auditing system

5.5.2 **Outcome:**

- Compost that leaves a PAS100 site will meet a defined standard; will be delivered to secure markets; and will not harm the environment or human health when used in this context. Thus, it should be treated as a non-waste material when it leaves the site and the material that is used in horticulture should be treated as a non-waste material.
- After leaving the site, quality compost may be blended with other non-waste materials to produce a horticultural grade growing media, which can be used in domestic and professional applications. It is considered that the quantities and frequencies at which the quality compost/horticultural grade growing media will be applied will not pose a significant risk to the environment or human health, and as such will not be subject to regulatory control.

6. Use of PAS100 in landscaping activities

6.1 How is compost used?

6.1.1 A compost manufacturer delivers PAS100 quality material to a landscaping company. The company mixes the compost with other materials e.g. sand to produce a range of products such as topsoil or turf dressing and then sells these products on the open market. In rare cases compost could be sold unaltered as mulch for verges, parks and gardens.

6.2 What are we protecting?

6.2.1 **Human, animal and plant health.** Blended topsoil will be used on sites where there is no topsoil or where additional soil is required for specific needs such as tree planting or turf establishment. Blended topsoil could be used to provide planting areas in public spaces or to provide garden soils on brownfield housing developments. In both cases there will be direct exposure to plants and to humans. It is unlikely that manufactured topsoil will be used where there will be extensive access by grazing animals. In most cases, the use of the topsoil will not be covered by waste legislation. Other products include turf dressing for sports stadia and the use of compost as mulch for verges, parks and gardens in a similar way to its use in amateur horticulture.

6.3 What is the scale of the risk?

6.3.1 Low where compost is mixed with a non-waste material. There could be a high risk where blended material is waste and may contain a high level of contamination. See Appendix F – Use of PAS100 compost to produce soil which can be used for landscaping, tree planting and land restoration.

6.3.2 There is a potential risk for sham recovery to occur if an operator states that they will blend the PAS100 material to make a top soil, but then may simply sell on the compost to other markets such as direct agricultural use. This could potentially happen in other markets as well. To close this potential loop hole the Quality Protocol must applies to all markets and composters must obtain a written undertaking, or a contractual commitment, that the compost will only be used in the landscaping market and a record to this effect is retained.

6.3.3 Manufactured top soils and top dressings are generally used as one off single applications so it is the quality of the material that is applied that is critical rather than the potential for build up of PTEs through repeat applications. The use of neat compost as mulch is likely to be used in a similar way to its use in amateur horticulture.

6.3.4 As noted above, PAS100 quality compost itself does not pose a risk to either plant or human health. In making a new topsoil, if the PAS100 material is blended with a 'clean' non-waste material (e.g. sand) which has low levels of contamination then the resulting top soil will contain lower levels of PTEs than the original PAS100 material. There should therefore be an even lower level of risk to plant and human health than that posed by the original PAS100 material. However, if the compost is blended with a material, which has a high level of contamination such as a waste, then there is a possibility that the resulting topsoil may pose more of a risk to the environment and to human health than the original compost. The compost producer will have little or no control over the quality or the destination of the final product.

6.4 Is the risk acceptable? If not, what can be done to make the risk acceptable?

6.4.1 Where the PAS100 material is blended with a non-waste material and the resulting top soil has levels of contaminant that fall below published Soil Guidance Values for the protection of human health then the risks are low. But, if the compost is to be blended with a waste material then the activity should be subject to normal waste regulatory control.

6.5 Conclusion

6.5.1 **Proposed safeguards:**

- the additional requirements for the production of compost described in Table 2 above are met i.e. only listed waste types are accepted, all records are kept and the finished compost is delivered to bona fide landscaping operations;
- PAS100 compost must only be blended with non-waste materials to retain its product status. If it is blended with waste then normal waste regulatory control will resume;
- records are kept by the landscapers and are sent to the compost producer so that there is an audit trail of all PAS100 material. Alternatively the final use of the compost is limited through the contractual relationship between compost producer and landscaper; and
- the Soil Guidelines Values (SGV) are met for all blended soils and or the manufactured topsoil. This could be ensured if the revised BS3882 topsoil standard incorporates reference to the permitted levels of metal contamination.

6.5.2 **Outcome:**

- PAS100 compost delivered to landscapers will meet a defined and accepted standard, will be delivered to a secure market and will pose minimal risk to the environment provided that the blended topsoil meets a revised BS standard for topsoil;
- we recommend that the working group for the revision of the BS standard for topsoil include full references to the requirements for soil contaminant levels; and
- we also suggest that there is significant scope for the development of a Quality Protocol for topsoil manufacture.

7. Use of PAS100 on land restoration sites

7.1 How is compost used?

7.1.1 PAS100 compost can be delivered to a brownfield sites as part of a product already manufactured by a landscaper (e.g. a top soil) and is therefore covered by the discussion in Section 6. It can also be delivered as neat compost where it is to be used to make soil on the site. The PAS100 material may be mixed with existing top soil on the site to improve its quality or it may be mixed with other onsite materials e.g. colliery spoil, mine tailings. Where composts are mixed with contaminated soils and the intention is to clean up a site, the activity is covered by other guidance and legislation and is not considered here.

7.2 What are we protecting?

7.2.1 **Human, animal and plant health.** The materials may be used where there is public access to a site and where there is a requirement for plant growth. In some cases there may be access to grazing animals so we should also consider animal health. The restoration activity is likely to require a one off application of compost so the risk is associated with the concentration of contaminants in the final manufactured soil rather than in the PAS100 compost.

7.3 What is the scale of the risk?

7.3.1 Low. The restoration of sites, the improvement of brownfield sites and the manufacture of new land all tend to be covered by planning law and other legislation. These will control what happens on a site, what can be used, and will consider requirements for topsoil within the consideration of the end use of a site. See Appendix F – Use of PAS100 compost to produce soil which can be used for landscaping, tree planting and land restoration.

7.4 Is the risk acceptable – if not what can be done to make the risk acceptable?

Yes, provided that the compost operator maintains records of where the compost has been sold i.e. has records of secure markets. The use of the material on brownfield sites will be controlled by other regulatory tools – Waste Management Licensing Regulations, planning constraints, Part IIa etc.

7.5 Conclusion

7.5.1 PAS100 delivered to a restoration site should be treated as recovered material. It will meet the required criteria of meeting a defined standard, being delivered to an established market and causing no harm to the environment provided that it is deliver to a site that is operating within an existing waste management and planning framework. Where the compost is then mixed with other waste materials on site, normal waste regulatory controls will apply.

8. Use of PAS100 in agriculture

8.1 How is compost used?

8.1.1 Compost is delivered to a farmer or landowner for use as a soil improver and/or fertiliser for crop production. The compost may be spread by the compost producer or by the farmer. Compost will be applied in small quantities according to crop need, but potentially could be applied to the same land repeatedly.

8.2 What are we protecting?

8.2.1 The risk to human health posed via eating food grown on agricultural land where compost is spread is very low. Similarly PAS100 quality compost will not have an adverse effect on plant or animal health. However, for agricultural use we must consider the potential effect of long-term compost use on soil quality and function. The agricultural use of composts will involve the repeat application of compost to the same areas of agricultural land. There is evidence from long-term trials that have used sewage sludge that shows us that the accumulation of PTEs in soil can have an adverse effect on soil microbial functions. The Technical Advisory Group has undertaken work that shows that the accumulation of PTEs from PAS100 quality compost could reach the same levels as reported in the sewage sludge trials within 20-50 years depending on the initial starting level of metals.

8.2.2 Whilst we accept that there are knowledge gaps in our understanding of how different materials may behave when incorporated into soils, the data that we have so far indicates that we should proceed with caution when considering the unrestricted use of composts in agriculture.

8.3 What is the scale of the risk?

8.3.1 Low if compost use is well controlled, high if use is unrestricted over the long-term. See Appendix G – Use of PAS100 compost in Agriculture.

8.4 Is the risk acceptable – if not what can be done to make the risk acceptable?

8.4.1 The risk from unrestricted spreading is not acceptable, but the Technical Advisory Group has derived guidelines that will ensure that compost is only used in a way that will minimise any potential risk to soil function (Appendix H). It is vital that compost is used appropriately and that auditable records are kept. Specifically, records of compost applications and their location must be kept, together with details of soil analyses to prevent accumulation of PTEs. Some of these requirements will be met where landowners and farmers are members of appropriate farm assurance schemes, but there will still need to be a requirement for records of PTE accumulation in the soil to be kept by the compost producer.

8.5 Conclusion

8.5.1 The Technical Advisory Group recommends that a broad range of stakeholders must be consulted on the way forward for agriculture when the draft Quality Protocol goes out to consultation. This must include farmers, landowners, and growers as well as the composting industry.

9. Recommendations

9.1 The Technical Advisory Group recommends that a Quality Protocol be developed for use in conjunction with the PAS100 standard. For the Quality Protocol to work, the Technical Advisory Group recommends that the following activities are undertaken:

- **Auditing.** For the approach that is described in this document to work it is essential that there is a fully independent quality assurance auditing system in place. We recommend that the auditing system include a level of independent certification (where a third party independent of the producer undertakes independent verification and provides certification that the product meets the PAS100 standard). Furthermore, it is recommended that an independent party accredit the independent certifying body to ensure that the certification they have undertaken is valid. We recommend that the BREW Waste Protocol Board consider the auditing approach in more detail for this and the other Quality Protocols to be developed by the programme.
- **Consultation.** We recommend that the BREW project undertake a 3-month consultation on the draft Quality Protocol and on the options for agricultural use of compost at the earliest opportunity. The consultation document should be accompanied by a partial Regulatory Impact Assessment. We recommend stakeholder workshops be held with regulators and stakeholders separately.
- **Communications (including training and promotion).** For the Quality Protocol to become effectively established it will need to be promoted and supported by adequate training (particularly of composters and Environment Agency personnel). We recommend that Environment Agency, The Composting Association and WRAP develop training materials and embark on a programme of training after the Quality Protocol has been finalised.
- **Research.** The Technical Advisory Group has identified some knowledge gaps, which would benefit from medium-term research on the use of compost to support the Quality Protocol in the future. We recommend that the BREW Waste Protocol Project formally recommends that Defra, the Scottish Environment Protection Agency (SEPA) and Department of Environment Northern Ireland (DoENI) should complete this work perhaps initially in partnership with the Environment Agency and WRAP. We recommend that this include:
  - updating the topsoil standard BS3882 to include manufacturing of soils and to stipulate appropriate limit values for PTEs;
  - establishing a Quality Protocol for soils arising from brownfield or greenfield sites; and
  - including compost application in RB209 and the Code of Good Agricultural Practice.
- **Review.** PAS100 is to be reviewed and updated in 2007. This review should take into consideration the Quality Protocol and other scientific information. It is recommended that the Quality Protocol be reviewed in January 2008 and biennially thereafter.

9.2 The research undertaken has raised a number of specific issues, many of which may apply to other the Quality Protocols under development. The Technical Advisory Group further recommends that these issues be considered not only in relation to the development of a Quality Protocol for the production of compost, but that these should be taken into account when developing subsequent protocols in different sectors.

Appendix A Technical Advisory Group membership

Organisation	Representative
Consultant for Defra	Michael Faulkner
Department of Environment, Food and Rural Affairs (Defra)	Sharon Ellis
Department of the Environment Northern Ireland	Tony Osborne
Environment Agency	Nina Sweet Andrew Harvey Victoria Sturt Aiofe O'Sullivan
Scottish Environment Protection Agency	Peter Olsen Gary Walker
The Composting Association	Jane Gilbert
The Waste & Resources Action Programme (WRAP)	Richard Swannell Anne O'Brien Maggie Newton

Appendix B Production and accessible markets for compost

1. Introduction

As part of the "Developing a Standard for High Grade Compost" project, WRAP has been asked to put together data on the accessible markets for quality compost. This is given below, together with an indication of growth that WRAP is aiming for to help the UK divert organic matter from landfill as part of the UK strategy to meet the first Landfill Directive target in 2010.

2. Current production and anticipated growth in compost production

Total UK composting capacity doubled between 1999 and 2004 (833kt/y in 1998/99 to 1,972kt/y in 2003/4) and industry predictions suggest it will hit at least 2,800kt by the end of March 2006. Of this, around 2,200kt will be of source segregated municipal waste and this will produce about 1,300kt of compost product. Currently about half of this capacity (1,000kt) is certified to BSI PAS100 producing around 600 kt of high quality compost.

Based on current growth patterns and with continued capital support from WRAP, the target is to grow the sector to a UK capacity of 3,600kt for treating source segregated biodegradable municipal waste by March 2010. This would divert half of the organic waste that needs to be diverted from landfill by 2010, making a significant contribution to the UK hitting the first Landfill Directive target. It would produce around 2,160kt of compost product, which would need to find a market for use. Section 3 describes the current estimates of the accessible markets for quality compost. These estimates are based on research conducted for WRAP by independent consultants.

This growth in capacity is thought to be challenging and potentially achievable given the track record of growth the industry has sustained and the fact that there is still plenty of source segregated material to collect. To quantify this, the UK is estimated to have produced 13,800kt of kitchen and garden waste in 2005/6 of which currently 2,200kt (16%) is collected and composted.

3. Accessible markets for high quality compost

There are thought to be four key markets for quality compost that may generate revenue for a composter:

1. landscaping;
2. horticulture;
3. agriculture; and
4. brownfield site restoration.

Compost is already used in the first three markets and recent research suggests that brownfield sites could be an important market in the future. Compost is also used for some other purposes such as landfill site restoration and landfill cover material.

A summary of the accessible markets for quality compost products is given on the following page in Table 1. These should be regarded as preliminary estimates, which provide an indication of the scale of the opportunity. Currently the penetration of quality compost into these markets is low except for landscaping and horticulture. Customers in these markets are expected to pay a market rate for the compost they use.

Table 1: Estimated accessible markets for high quality composts

Market description	Accessible market in kt compost/y (estimate of market penetration[6])	Repeat application to soil?	Comments on use of compost
Agriculture (fruit and vegetable production only) Total area suitable for compost application = 213,000 ha[1]	3,400[2] (uncertain, probably <10%)[7]	Yes	Application rates are 10-60 t/ha with most applications being at 30 t/ha to comply with NVZ constraints.
Land Restoration	250–500[3] (<10%)	No	Compost tends to be used at 30% (w/w) of the soil mix used on these sites.
Landscaping	1,000[4] (around 45%)	No[5], mostly	Compost tends be used as a mix to initiate vegetation at 20–30% (w/w). For maintenance, unmixed compost can be used at low application rates e.g. for sports turf dressing.
Horticulture (including domestic use)	400 (around 25%)	No, mostly	In professional and amateur horticulture compost is used at 10–30% (w/w). Unmixed compost is sold as a soil conditioner for some applications. Reduced peat or peat free growing media sold in garden centres contains a maximum of 30% compost. This latter product could be used for repeated application to the same soil (max 30% w/w growing media to soil) in domestic gardens.
Total	**5,050–5,300**		

Notes

1. This area excludes silty/peaty soils not thought suitable for compost application. These data were obtained only for the use of compost in fruit and vegetable crop production and exclude potential applications of compost to cereals and for biomass crops. These data were supplied by ADAS under contract to WRAP.
2. Assumed compost can make a maximum penetration of 50% in this market. WRAP does not have an estimate of the total accessible agricultural market which includes the potential use on cereals, sugar beet and on biomass crops. Figures from The Composting Association suggest that 480kt was applied in total to agriculture in 2004/5 of which 440.5kt was produced to BSI PAS100 standard.
3. Data derived from ODPM sources and Enviros survey for WRAP. This focuses on importing composts for land restoration. It does not consider the potential for use of compost in remediation, which is still subject to research.
4. Based on a market assessment by Arthur D Little for WRAP and assuming a maximum penetration into the market of 50%.
5. Sports turf dressing is a high added value market, which calls for twice yearly applications of small amounts of compost or compost/sand mix. Compost can also be used in regular maintenance of parks and gardens and landscapes.
6. The market share figures are based on data from The Composting Association's *State of Composting in the UK 2003/4* report and the ODPM report (2003) *Monitoring peat and alternatives as growing media & soil improvers in the UK 2001*. The penetration on brownfield sites is difficult to judge as it is unclear how much of compost is imported within a finished landscaping product (and therefore is in the landscaping estimates) and how much is imported on site for restoration.
7. WRAP does not have an estimate of the total accessible market size for agriculture. The estimate provided is for fruit and vegetables only (see Note 1). Thus it is not possible to calculate a market penetration. Given the current data it is reasonable to assume that penetration is less than 10%.

For the agricultural and land restoration markets compost will certainly have to be produced close to where it will be used. It is not economic to move material significant distances (for example >30–50 miles). This is less true for bagged horticultural, landscaping and sports turf dressing markets. The proximity of sources of production to the accessible market has not been factored into these assumptions. This is an important consideration that requires future research.

4. Conclusions

Currently the UK is producing 600kt/y of quality compost most of which is being used in one of the added value markets detailed in Section 3. If the production grows as anticipated (and this will only happen if the Quality Protocol for the recovery of compost is completed), then markets will be required for up to 2,160kt of compost by 2010.

Given the estimate of accessible market size outlined in Section 3, there does appear to be sufficient market for a quality product. One of the main challenges for developing these markets will be matching local sources of supply to demand as it is uneconomic to move compost large distances. As with any market development, it will take time and focused effort from the compost industry and others to build and maintain sales to these markets.

There is a need for further work to relate current sources and potential future sources of compost to local markets to ensure that the diversion target is achievable. This analysis should also assess how much further growth in compost production could be accommodated in the UK post 2010.

It is worth noting that currently only 50% of the current organic household waste compost capacity is PAS certified. This proportion is likely to increase after the publication of the Quality Protocol, but it is unlikely to reach 100% of capacity. Thus the estimate of 2,160kt should be regarded as an upper limit for high quality compost production by 2010.

Appendix C Summary statistics for the potentially toxic metal content of PAS100

Potentially toxic metal content of PAS100 (mg/kg)

	Mercury	Cadmium	Nickel	Chromium	Copper	Zinc	Lead
Maximum	1.16	1.32	74.00	229.00	316.00	797.00	1450.00
Minimum	0.00	0.00	3.30	2.20	12.40	1.30	0.70
Median	0.16	0.65	14.75	18.40	44.00	183.00	100.00
Mean	0.19	0.66	15.79	22.63	50.70	194.26	114.17
Standard Deviation	0.14	0.23	7.05	21.98	27.51	73.10	103.55
Mean + 1 S.D.	0.33	0.89	22.84	44.61	78.21	267.35	217.73
Percentile (75th)	0.21	0.80	17.8	22.2	57	222.00	126.75
Percentile (90th)	0.37	0.95	23.00	33.44	72.24	251.00	159.50
Confidence Interval (95 % level)	0.02	0.03	0.82	2.56	3.19	8.46	12.00
Upper Confidence Limit (Mean + 95 % CI)	0.21	0.69	16.61	25.18	53.89	202.71	126.18
Number	285	285	286	284	285	287.00	286
Current PAS 100 limit	**1.00**	**1.50**	**50.00**	**100.00**	**200.00**	**400.00**	**200.00**

Appendix D Advice on whether levels of specified metal contaminants in compost materials pose a risk to human health

This question has been considered in the context of guidance used for assessing the risks to health from contaminants in soil and specifically by using Soil Guideline Values that represent levels of 'minimal' or 'tolerable' risk to health. Specific exposure modelling or risk evaluation specific to how the compost might be used (such as for grow bags in a dry indoor conservatory) has not been attempted because the existing model scenarios used in the derivation of the Soil Guideline Values will be protective of the material being used as a soil amendment in most domestic or brownfield settings.

One question not addressed is whether the addition of compost might tip the balance where background soil concentrations of contaminants are already elevated. Due to the wide regional variation in soil concentrations of cadmium, lead and nickel, this decision can only be evaluated on a site-specific basis.

1. Chemicals of Concern

The following potentially toxic elements (PTE) have been identified under the PAS 100 compost quality standards: cadmium, chromium, copper, lead, mercury, nickel, and zinc. Of these cadmium chromium, lead, mercury, and nickel have published Soil Guideline Values, while copper and zinc do not. However, relative to the other elements in compost, the risk to human health from exposure to copper and zinc are likely to be much lower and they are not further considered here[2].

The risks to health from chromium and mercury depend critically on the chemical form of the contaminant. In the case of chromium it is the valence state (either III or VI) and for mercury it is whether the chemical is present in an elemental, inorganic or organic form. The PAS100 test methods report only the total content and therefore some guidance needs to be given on the most likely forms of these chemicals in the compost materials. In the derivation of the Soil Guideline Values (SGV), the SGV for chromium assumes that the element is present in the most toxic form (Chromium VI) but the SGV for mercury applies only to the less toxic inorganic form[3].

2. Comparison with Soil Guideline Values

Soil Guideline Values are based on conceptual exposure scenarios that account for reasonable worst-case human activities including gardening, playing in the garden, tracking back of contamination from outdoors to indoors, and the consumption of homegrown produce. These scenarios are also likely to be applicable to the use of compost as a garden soil amendment. Comparison between PAS100 limits and compost concentration data with SGV has been made for the most sensitive land-use, which is considered to be a residential setting where the family routinely consumes homegrown vegetables. No dilution of compost with soil is assumed.[4] Each element is discussed separately.

2.1 Cadmium

The SGV for cadmium depends on soil pH as a result of the plant uptake algorithm and varies between 1mg/kg^{-1} dw at pH six to 8mg/kg^{-1} at pH eight. The proposed PAS100 quality standard is 1.5mg/kg^{-1} dw at any pH. There may be issues with low pH composts and soil-compost combinations.

Review of the compost data provided suggests that most compost materials have a pH greater than seven (pH 7.1 at 5th percentile, pH 8.5 at median). This suggests that for most composts, cadmium levels at the PAS100 quality standard would not pose a risk to human health even where 100% compost mixtures were applied. Observed levels of cadmium in the composts reviewed were typically much lower than the PAS100 quality standard with an average concentration of 0.66mg/kg^{-1} dw.

Additional comments:

- Plant uptake is a key human exposure pathway in the derivation of the SGV and the algorithm is conservative.
- In deriving the SGV, background exposure to non-soil sources such as food and drinking water are taken into account.

2 The PAS 100 levels for these elements are at the high end of permissible concentrations under the Soil Code 1998 for protection of plants and livestock.

3 The Defra and Environment Agency toxicological report for mercury did not recommend a TDI for methyl mercury. However, the US EPA IRIS database recommends a Reference Dose for methyl mercury that is a factor of three lower than the value for inorganic and elemental mercury.

4 This is anticipated to be a conservative assumption but this may not always be the case where soil concentrations are already elevated.

2.2 Chromium

The SGV for chromium is based on the toxicity of chromium (VI). In assessing the risk to human health posed by chromium contaminated soils, the key question is the ratio of chromium (III) to the more toxic chromium (VI). While chromium (VI) is the more stable form in aerobic soils, organic matter can reduce it to chromium (III) which may be precipitated and hence unavailable for re-oxidation. In the absence of specific data on its chemical form in compost, the total chromium value has been compared with the SGV. This is consistent with the analytical method proposed for the PAS100 quality standard but may significantly over estimate the risk if chromium (III) is the dominant form in compost and compost amended soils. The proposed PAS100 quality standard is 100mg kg^{-1} dw. The SGV is 130mg/kg^{-1} dw and therefore it is unlikely there will be significant issues if composts meet the PAS 100 quality standard for chromium.

Observed levels of chromium in the composts reviewed were typically much lower than the PAS100 quality standard with an average concentration of 22.6mg/kg^{-1} dw.

Additional comments:

- Plant uptake and direct soil ingestion are the key human exposure pathway in the derivation of the SGV.
- In deriving the SGV, background exposure to non-soil sources such as food and drinking water are taken into account.

2.3 Lead

The SGV for lead is based on empirical relationships between exposure and blood lead concentrations and takes into account the background blood lead concentrations in the UK population. The SGV makes conservative assumptions about the levels of exposure and the bioavailability of lead in soil through an empirical 'Δ (delta)' value.

The proposed PAS100 quality standard is 200mg/kg^{-1} dw. The SGV is 450mg/kg^{-1} dw and therefore it is unlikely there will be significant issues if composts meet the PAS100 quality standard for lead.

Observed levels of lead in the composts reviewed were typically much lower than the PAS100 quality standard with an average concentration of 114.2mg/kg^{-1} dw.

Additional comments:

- Direct soil ingestion is the key human exposure pathway in the derivation of the SGV.
- In deriving the SGV, background exposure to non-soil sources such as food and drinking water are taken into account.

2.4 Mercury

The SGV for mercury is based on the toxicity of inorganic mercury only. In the absence of specific data on its chemical form in compost, the total mercury value has been compared with the SGV. This is consistent with the analytical method proposed for the PAS100 quality standard **but** may significantly under estimate the risk if organic forms of mercury are the dominant form in compost and compost amended soils.

The proposed PAS100 quality standard is 1mg/kg^{-1} dw. The SGV is 8mg/kg^{-1} dw and therefore it is unlikely there will be significant issues if composts meet the PAS100 quality standard for inorganic mercury. Further consideration needs to be given to risks posed by organic forms of mercury.

Observed levels of mercury in the composts reviewed were typically much lower than the PAS100 quality standard with an average concentration of 0.19mg/kg^{-1} dw.

Additional comments:

- Plant uptake and direct soil ingestion are the key human exposure pathway in the derivation of the SGV.
- In deriving the SGV, background exposure to non-soil sources such as food and drinking water are taken into account.

2.5 Nickel

The SGV for nickel depends significantly on the contribution of background exposure from non-soil sources, greater than 80% for oral exposure and more than 120% via inhalation. The proposed PAS100 quality standard is 50mg/kg^{-1} dw. The SGV is also 50mg/kg^{-1} dw.

Further consideration needs to be given to risks posed by nickel amendments from compost at the PAS 100 level although it is unlikely that there will be significant issues if composts are used as a soil amendment across only a proportion of the garden[5]. However, nickel is a ubiquitous background element in soil and some consideration will need to be given to any augmented soil level.

Observed levels of nickel in the composts reviewed were typically much lower than the PAS100 quality standard with an average concentration of 15.8mg/kg^{-1} dw.

Additional comments:

- Plant uptake and direct soil ingestion are the key human exposure pathway in the derivation of the SGV.
- In deriving the SGV, background exposure to non-soil sources such as food and drinking water are taken into account.

3. Conclusions

The comparison of SGV and PAS100 standards is a relatively crude, but health protective approach, to screening risks to health from adding composts to soil. In most cases, the risks posed by potentially toxic elements at the PAS 100 level are unlikely to be significant. There are two potential exceptions:

- Mercury, where the primary form is organic; and
- Nickel.

It should be noted that the risks associated with nickel are primarily the result of exposure from non-soil sources and therefore represent a part of the aggregated exposure from a range of different sources.

5 Considerations should include the relative importance given to non-soil sources of exposure and the proportions in which compost and soil are mixed.

Appendix E Use of PAS100 horticultural grade compost in domestic gardens

1. Assumed scenario

Gardeners use PAS100 quality compost in an undiluted form to either incorporate into flowerbeds or to use as mulch.

2. Risk pathways

In this case we are protecting human health. The gardener handles the compost directly.

3. We set out to examine the following:

Two scenarios for the use of compost in domestic gardens were calculated to determine potential effects.

1. How much soil would a gardener have to use in a domestic garden to raise the soil Zn value from background to the current Sludge (Use in Agriculture) Regulations Zn limit?
2. If the gardener uses compost as mulch rather than a soil conditioner, will this have a significant effect on the background soil metal concentrations?

Assumptions:

- The material used in the garden is PAS100 quality. It has not been blended with other waste or non-waste materials. *This is a worst case scenario – most garden compost will be a blend of PAS100 material mixed or blended with other non-waste materials such as peat, vermiculite or coir.*
- The average garden size in the UK is 250m^2, has 30% dedicated to soil borders and compost will not be spread on lawn area.[6]
- Average cultivation depth of soil in domestic gardens is 25cm.
- Compost density is 0.6t/m^3.[7]
- Soil density is 1.3t/m^3.
- Average soil background Zn concentration in domestic gardens is 70mg/kg.[8]
- Soil metal limit values for Zn are 300mg/kg at pH7 and 200mg/kg at pH6.5 and below. The Sludge (Use in Agriculture) Regulations[9] values have been used as a surrogate for soil protection. For the purposes of this calculation, the Sludge value was taken to be 300mg/kg at pH7.
- The PAS100 compost will be added at the upper limit for Zn concentration in compost – 400mg/kg[10]. The mean value for Zn in PAS100 compost is 192.4mg/kg.[11]
- 70 litre bag of compost weighs 42kg.
- When PAS100 compost is used as a mulch, it is applied to a depth of 10cm.

Question 1 – How much soil would a gardener have to use in a domestic garden to raise the soil Zn value from background to the current Sludge (Use in Agriculture) Regulations Zn limit?

- Area of borders in an average domestic garden to which compost can be added
  250m^2 x 30% = 75m^2 borders.
- Quantity of soil in borders at 70mg/kg background Zn concentration
  75m^2 borders x 1 x 0.25m cultivation depth = 18.75 tonnes soil (18,750kg).
- Quantity of Zn required to reach upper limit value for Zn in soil
  300mg/kg limit – 70mg/kg background = 230mg/kg additional Zn.
- Total Zn added to average domestic garden to reach limit value
  18,750kg soil x 230mg/kg Zn = 4.31kg Zn (4,312,500mg Zn).
- Quantity of compost required to reach limit value
  4.31 Zn added x 1000 x 1000 /400 PAS100 Zn limit value = 10.8 tonnes compost.
- Number of bags of compost required to reach limit values
  10.8 tonnes x 1000 / 42 kg bag = 256.7 70 litre bags of compost
  This equates to more than three 70l bags of compost per m^2 of border.

6 WRAP funded research on the impact of Home Composting.
7 PAS100 documentation (Appendix I).
8 NSRI data 1995.
9 Sludge (Use in Agriculture) Regulations 1989.
10 PAS100 documentation (Appendix I).
11 WRAP data (Appendix C).

- The mean Zn value for PAS100 compost is 194mg/kg. If the maximum Zn value is substituted with the mean Zn value:
  4.31 Zn added x 1000 x 1000 / 194 = 22.23 tonnes compost.
  This equates to 22.23 tonnes x 1000 / 42 kg bag = 530 bags or 6.4 bags per m^2 border.

Question 2 - If the gardener uses the compost as a mulch rather than a soil conditioner, will this have a significant effect on the background soil metal concentrations?

- Mulch is applied to all borders
  75m^2 borders x 0.1 m application depth = 7.5m^3 or 4.5 tonnes compost.
- Quantity Zn added to average domestic garden at 10cm application depth
  4.5 tonnes x 1000 x 1000 x 400mg/kg Zn = 1.8kg/Zn or 24g/m^2.
- Application rate of Zn as a percentage of existing background Zn
  70 mg/kg background Zn x 18750kg soil in borders / 1000 = 1.3 tonnes Zn.
  1.8 kg Zn in mulch / 1300 kg Zn in borders x 100 = 0.13% increase in Zn concentration.

Context

Atmospheric deposition will add 221g/ha/yr Zn = 0.0221 g/m^2.
Chicken litter application will add 2734g/ha/yr Zn = 0.27g/m^2.[12]

12 Nicholson et al. *Science of the total environment 311* (2003) 205–219.

Appendix F Use of PAS100 compost to produce soil which can be used for landscaping, tree planting and land restoration

1. Assumed scenario

PAS100 compost is mixed with soils to produce manufactured topsoil suitable for landscaping applications.

2. Risk pathway

Human health and soil microbial function. We must ensure that the blending of PAS100 compost with other materials will not lead to significant metal additions to soil over and above the Soil Guideline Values (SGV)[13] or those quoted in the Code of Good Agricultural Practice for Soil. We have worked with Zn as this poses the most immediate risk.

3. We set out to address the following questions:

1. What level of Zn will be present in soils manufactured from PAS100 quality compost where the compost Zn level is at the upper limit value for PAS100 quality compost (currently 400mg/kg Zn)?
2. If the compost used is average quality PAS100 compost (194mg/kg Zn), what will the Zn level be in a blended soil?
3. What are the likely impacts on background metal concentrations when using soil manufactured from PAS100 compost and other materials?

Assumptions:

- Maximum rate of incorporation of PAS100 compost in blending operation will be 30%.[14]
- The other material used in soil manufacture will have a Zn concentration equivalent to mean background soil Zn concentration.
  Note – it is not possible to manufacture a soil that has Zn levels below background concentration unless the additional mixture (ad-mix) material is significantly below the background concentration.
- Average soil background Zn concentration is 70mg/kg[15].
- Compost density is 0.6t/m^3.[16]
- Soil density is 1.3t/m^3.
- Average Zn concentration in PAS100 quality compost is 194mg/kg.[17]
- Once manufactured these materials will be used in a wide range of applications – landscaping, land restoration, tree planting etc.
- The current British Standards Institute (BSi) Standard for topsoil is not appropriate to use in this situation as it does not include quality criteria.
- The Sludge (Use in Agriculture) Regulations values have been used as a surrogate for soil protection.[18] For the purposes of this calculation, the Sludge value was taken to be 300 mg/kg at pH7.

Soil manufacture

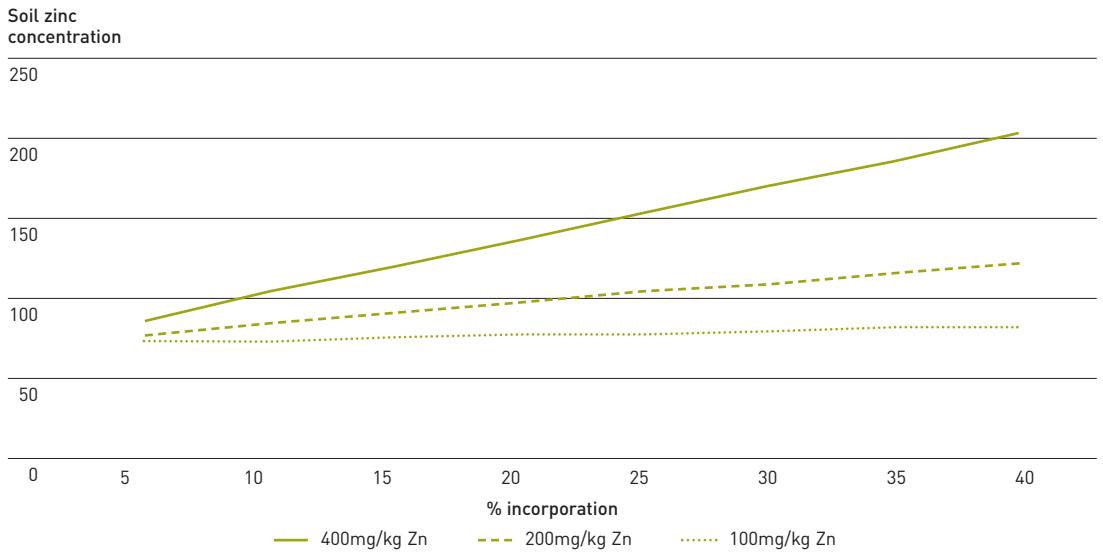
Question 1 – How much Zn will be present in 1 tonne of blended soil where the compost contains Zn at current PAS100 limit?

- Manufactured soil consists of 30% PAS100 compost
  300kg PAS100 compost x 400mg/kg Zn = 120g Zn.
- Manufactured soil consists of 70% ad-mix material
  700kg ad-mix material x 70 mg/kg Zn background concentration = 49g Zn.
- Total Zn in 1 tonne of manufactured soil
  120g Zn from compost + 49g Zn from ad-mix = 169g Zn or 169mg/kg concentration.
- Manufactured soil consists of 30% PAS100 compost
  300kg PAS100 compost x 194mg/kg Zn = 58.2g Zn.
- Total Zn in 1 tonne manufactured soil made from 30% average quality PAS100 compost
  58.2g Zn from compost + 49g Zn from ad-mix = 107g Zn or 107mg/kg concentration.

13 Soil Guideline Values – http://www.environment-agency.gov.uk/subjects/landquality/113813/672771/675257/?version=1&lang=_e.
14 WRAP data (Appendix C).
15 NSRI data 1995.
16 *Soil Use and Management* March 1004 20(1) pages 40-47 taken from Boon (1984).
17 PAS100 documentation (Appendix I).
18 Sludge (Use in Agriculture) Regulations 1989.

Figure 1 illustrates the effects of using different quality PAS100 composts and different percentage combinations of compost: ad-mix on the soil Zn concentration.

Figure 1 Blended soil zinc concentrations



Use of manufactured soils in landscaping, land restoration and tree planting

Question 2 - What application rate of PAS100 containing composts can be applied to land to ensure adequate protection?

- When any manufactured soil is used, we must ensure adequate protection of human health and the environment.
  - To protect the environment we must ensure that Potentially Toxic Elements (PTEs) are below those where damage to the soil will occur. PTEs in the soil must not exceed Soil Guideline Values (SGV).[19]
  - To protect human health, we must ensure that PTE levels do not exceed the Soil Guideline Values[20], the Soil Code or the Sludge (Use in Agriculture) Regulations[21] (whichever is the lower).
- Manufactured soil containing PAS100 material must comply with specified PTE requirements, which are protective of human health and soil function.
- Applications of manufactured soils containing PAS100 compost should only be applied at rates which ensure that:
  - Soil Guideline Values will not be exceeded in the soil as a result of application;
  - Soil Code limits will not be exceeded in the soil as a result of application; and
  - Soil metal limits in the Sludge (Use in Agriculture) Regulations will not be exceeded as a result of application.

19 Soil Guideline values – http://www.environment-agency.gov.uk/subjects/landquality/113813/672771/675257/?version=1&lang=_e.
20 Soil Guideline values – http://www.environment-agency.gov.uk/subjects/landquality/113813/672771/675257/?version=1&lang=_e.
21 Sludge (Use in Agriculture) Regulations (1989).

Appendix G Use of PAS100 compost in agriculture

1. Assumed scenario

Compost is used in agriculture as a soil improver and fertiliser. Application rates are controlled through compliance with fertiliser application recommendations for phosphate.

2. Risk pathway

Agriculture differs from the other compost markets that we have examined in that here we are concerned about long-term protection of soil microbial function. There is potential for harm to occur where compost is repeatedly applied to the same areas of agricultural land.

3. We set out to examine the following:

Three typical scenarios for the use of PAS100 in agriculture have been examined with the aim of determining the long-term impacts of repeated applications of compost. Compost is applied to agricultural land for soil improvement as well as its fertiliser value. For the purposes of these scenarios we looked at the application in terms of its phosphate fertiliser value. The calculations for crop fertiliser requirement in the scenarios all come from Defra's RB209 Fertiliser Recommendations publication[22]. We carried out the scenarios based on three major crop types where compost is used in England and Wales: winter wheat; potatoes (main crop); and brassicas.[23]

Using the scenarios we set out to address the following questions:

1. What application rate of PAS100 would a farmer need to apply to satisfy the phosphate requirements of wheat, potatoes and brassicas?
2. Using an annual application of compost, how long would it take to reach the current Zn limit under the Sludge (Use in Agriculture) Regulations?
3. How much nitrogen is supplied to each crop type when applying compost to satisfy phosphate requirements?

Assumptions:

- The compost added will be at the upper limit for Zn concentration in PAS100 compost – 400mg/kg[24]. The mean value for Zn in compost is 192.4mg/kg[25].
- Average background Zn concentration in agricultural soils in England and Wales is 70 mg/kg[26].
- Soil Zn limit under the Sludge (Use in Agriculture) Regulations is: 300mg/kg Zn at pH7 and 200mg/kg Zn at <pH7.
- Application will be driven by phosphorous additions. RB209 values are used to determine crop phosphate crop requirement. For most crops, the target is index 2 for P. RB209 suggests that P can be applied to a soil at index 2, but to crop requirement only and not lead to an increase in the index of the soil. Brassicas have a target P index of 3.
- Crops chosen are those that have the largest hectarages in England and Wales[27] and a wide range of P requirements.
- All phosphorous requirement and application rates are quoted as P_2O_5.
- P content on PAS100 compost is 2,179 mg/kg (aqua regia – soluble) or 0.23%[28].
- PAS100 compost is 60% dry solids.
- Conversion factors used in the scenario P x 2.29 = P_2O_5.[29]
- Plough depth is 20cm.
- Soil density is 1.2t/m^3.
- Volume of soil per ha is: 1,000m x 1,000m x 0.2 = 2,000m^3.
  Soil mass per ha is: 2,000m^3 x 1.2t/m^3 = 2400t = 2,400,000 kg/ha soil.

22 RB209 Fertiliser Recommendations (Defra)
23 Agricultural census data 2000
24 WRAP data. (Appendix C)
25 WRAP data.(Appendix C)
26 NSRI data 1995
27 Agricultural Census data (Defra)
28 WRAP summary data (Appendix C)
29 Direct Labs conversion factors – E Nichols

Scenarios for using PAS100 compost in agriculture

Scenario 1 – Winter wheat – straw removed

- RB209 recommended P application rate at index 2 = 70mg/kg.
- PAS100 compost is 0.23% P which is equal to 0.53% P_2O_5.
- Quantity of compost required to satisfy 70 kg/ha P at index 2
  (70 kg/ha P_2O_5 / 0.53% P_2O_5) x 100 = 13207.54kg/ha or 13.2 tonnes/ha (Dry solids).
- Application rate of PAS100 compost per hectare in fresh weight
  13.2 tonnes/ha dry weight /60 x 100 = 22 tonnes/ha.
- Total Zn applied at 13.2 tonnes/ha PAS100 compost dry weight
  13.2 tonnes/ha x 400 mg/kg Zn x 1000 = 5,280,000 mg Zn or 5.3 kg Zn.
- Application rate Zn
  5,280,000 mg Zn/2,400,000 kg/ha soil = 2.2 mg/kg Zn per application.
- How long will it take to reach the current soil limit values for Zn if PAS100 compost is applied annually at an application rate 70 kg/ha P?

  At pH7 –
  Soil limit 300mg/kg – 70 mg/kg background Zn = 230mg/kg
  230 mg/kg/2.2mg/kg application rate = 104.5 years.

  At pH <7 –
  Soil limit 200mg/kg – 70mg/kg background Zn = 130mg/kg
  130 mg/kg/2.2mg/kg application rate = 59.1 years.
- Application rate N
  PAS100 compost is 1.24% N
  1.24% of 13207.54kg/ha compost = 163.77kg/ha total N.

Scenario 2 – Winter wheat straw incorporated

- RB209 recommended P application rate at index 2 = 60mg/kg.
- PAS100 compost is 0.23% P which is equal to 0.53% P_2O_5.
- Quantity of compost required to satisfy 60 kg/ha P at index 2
  (60kg/ha P_2O_5/0.53% P_2O_5) x 100 = 11320.75kg/ha or 11.3 tonnes/ha (Dry solids).
- Application rate of PAS100 compost per hectare in fresh weight
  11.3 tonnes/ha dry weight /60 x 100 = 18.8 tonnes/ha.
- Total Zn applied at 11.3 tonnes/ha PAS100 compost dry weight
  11.3 tonnes/ha x 400mg/kg Zn x 1000 = 4,520,000mg Zn or 4.5kg Zn.
- Application rate Zn
  4,520,000mg Zn/2,400,000kg/ha soil = 1.9mg/kg Zn per application.
- How long will it take to reach the current soil limit values for Zn if PAS100 compost is applied annually at an application rate 60kg/ha P?

  At pH7 –
  Soil limit 300mg/kg – 70mg/kg background Zn = 230mg/kg.
  230mg/kg/1.9mg/kg application rate = 121.1 years.

  At pH <7
  Soil limit 200mg/kg – 70mg/kg background Zn = 130mg/kg.
  130mg/kg/1.9mg/kg application rate = 68.4 years.
- Application rate N
  PAS100 compost is 1.24% N
  1.24% of 11320.75kg/ha compost = 140kg/ha total N.

Scenario 3 Potatoes (Maincrop)

- RB209 recommended P application rate at index 2 = 180mg/kg.
- PAS100 compost is 0.23% P which is equal to 0.53% P_2O_5.
- Quantity of compost required to satisfy 180 kg/ha P at index 2
  (180kg/ha P_2O_5/0.53% P_2O_5) x 100 = 33,962.24kg/ha or 34 tonnes/ha (Dry solids).
- Application rate of PAS100 compost per hectare in fresh weight
  34 tonnes/ha dry weight/60 x 100 = 56.7 tonnes/ha.
- Total Zn applied at 56.7 tonnes/ha PAS100 compost dry weight
  34 tonnes/ha x 400mg/kg Zn x 1000 = 13,600,000mg Zn or 13.6kg Zn.
- Application rate Zn
  13,600,000mg Zn/2,400,000kg/ha soil = 5.7 mg/kg Zn per application.
- How long will it take to reach the current soil limit values for Zn if PAS100 compost is applied annually at an application rate 180 kg/ha P?

  At pH7 -
  Soil limit 300mg/kg – 70mg/kg background Zn = 230mg/kg
  230mg/kg/5.7mg/kg application rate = 40.4 years.

  At pH ←7
  Soil limit 200mg/kg – 70mg/kg background Zn = 130mg/kg
  130mg/kg/5.7mg/kg application rate 22.8 years.
- Application rate N
  PAS100 compost is 1.24% N
  1.24% of 33,962.24kg/ha compost = 421.1kg/ha total N
  Note – this application rate is in excess of NVZ allowable rates. Effective applications rates in this scenario would therefore be controlled though nitrogen addition rather than through phosphate requirements.

Scenario 4 - Brassicas

- RB209 recommended P application rate at index 3 = 50mg/kg.
- PAS100 compost is 0.23% P which is equal to 0.53% P_2O_5.
- Quantity of compost required to satisfy 50 kg/ha P at index 3
  (50kg/ha P_2O_5/0.53% P_2O_5) x 100 = 9434.0kg/ha or 9.4 tonnes/ha (Dry solids).
- Application rate of PAS100 compost per hectare in fresh weight
  9.4 tonnes/ha dry weight /60 x 100 = 15.6 tonnes/ha.
- Total Zn applied at 11.3 tonnes/ha PAS100 compost dry weight
  9.4 tonnes/ha x 400mg/kg Zn x 1000 = 3,670,000mg Zn or 3.7kg Zn.
- Application rate Zn
  3,670,000mg Zn/2,400,000kg/ha soil = 1.5mg/kg Zn per application.
- How long will it take to reach the current soil limit values for Zn if PAS100 compost is applied annually at an application rate 50kg/ha P?

  At pH7 –
  Soil limit 300mg/kg – 70 mg/kg background Zn = 230mg/kg
  230mg/kg/1.5mg/kg application rate = 153.3 years.

  At pH <7 –
  Soil limit 200mg/kg – 70mg/kg background Zn = 130mg/kg
  130mg/kg/1.9mg/kg application rate = 86.7 years.
- Application rate N
  PAS100 compost is 1.24% N
  1.24% of 9,434kg/ha compost = 117kg/ha total N.

Appendix H Impact on soil function from use of PAS100 compost in agriculture

What do we need to have in place for a Quality Protocol to operate?

If the Quality Protocol approach is to work when compost is used in agriculture, we must have certainty that its use will not result in harm to the environment through the over application of potentially toxic elements to the soil. We know that the risk to soil function will not occur in the first year of use where compost is applied according to nutrient requirements. However, we also know that the risk to soil function increases where compost is repeatedly applied to the same soil. If the Quality Protocol aims to provide a route for the use of fully recovered materials then we need it to ensure that the risk to soil function is controlled. To do this the compost use in the agriculture element of the Quality Protocol must require:

i. Compliance with all regulation and guidance relating to the application of nutrients (RB209, COGAP (water, soil and air). Compost application rates must be determined using properly qualified advice (eg a FACTS qualified adviser);

ii. Membership of an appropriate farm assurance scheme;

iii. Testing of both the compost and the receiving soil for PTEs to ensure that safe limit values are complied with;

iv. Record keeping for all compost use – quantities used, location of sites where compost is spread, date of spreading etc. Records must be kept by the compost producer for audit purposes; and

v. Independent auditing to ensure compliance with all Quality Protocol requirements.

Consultation choices

The Quality Protocol approach for the agricultural use of compost is more complex than that proposed for the other three markets that have been considered as part of this work programme. The technical group proposes that there should now be a consultation exercise to test and verify the most appropriate way forward. The consultation should test the merits of taking the Quality Protocol approach compared to remaining with the waste management licensing exemptions for the recovery of compost to land. The exercise should ask compost operators to effectively choose between the use of an exemption for the land spreading of compost and the use of a Quality Protocol. It is therefore useful to lay out what the requirements would be for both regimes.

Comparison of controls between existing exemption regime and proposed Quality Protocol
Scenario: Compost is produced at a licensed site. Compost is moved from the site of production to the site of spreading.

	Licensed or exempt site	Paragraph 7 landspreading exemption	Quality Protocol
Control over input materials	Yes – via licence or exemption registration	Only compost made from source segregated biodegradable waste may be spread to land under the exemption	Yes – detailed requirement for waste types
Control over the way in which compost is produced	No – other than environmental controls to prevent emissions to the environment	N/A	Yes – HACCP controlled process to ensure quality compost production
Control over compost quality	No	N/A	Yes – standard will set limits for specific determinands
Control over market destination	No	Yes – the exemption relates to the use of compost at a particular site	Yes – the producer must have clear markets for use of the product
Control over movement of compost from the site of production	Yes via duty of care		All movements of composts from a site must be recorded and records must be in an auditable form
Controls over the use of compost:		Yes – anyone proposing to spread compost must provide evidence that the compost will confer ecological improvement or agricultural benefit as well as evidence that any potential contaminants will not build to levels where they will cause harm	Yes – must be a member of an appropriate farm assurance scheme. Must comply with RB209, CoGAPs, NVZ Regs. Advice should come from FACTS qualified advisor
Nutrients		Yes	Use must be compliant with RB209, NVZ regs, COGAP water, soil and air
PTEs in soil		Yes	The operator must test and record PTEs in soil before compost is applied
PTEs in compost		Yes	Compost must be tested for PTEs
Quantity limits	Yes – the site licence will limit the quantity of waste that can be processed. Sites that are registered as exempt are limited to a total capacity of 1000 t of material at any one time	Yes – max 250 tonnes/ha. But application rates will be limited via nutrient addition	Yes – application of compost must be determined by crop requirements

continued overleaf

Comparison of controls between existing exemption regime and proposed Quality Protocol continued
Scenario: Compost is produced at a licensed site. Compost is moved from the site of production to the site of spreading.

	Licensed or exempt site	Paragraph 7 landspreading exemption	Quality Protocol
Other contaminants		Sometimes – depends on input materials	No
Requirement for risk assessment	N/A	Yes – an operator must ensure that his activity does not cause harm to the environment	No
Record keeping		Yes – quantity, nature, origin, destination, method of recovery of waste must be kept for 2 years and made available for inspection on request	Auditable records of all compost use must be kept
Regulatory compliance inspection	Yes	Yes – inspection of all applications to land of organic waste applied under a paragraph 7a exemption where a single registration will cover use of a material on up to 50 ha of land	No – no regulatory controls over application
Registration costs paid to Environment Agency	Yes – Licence application costs or registration of exemption	Yes – £546 registration fee for 50 ha in first year (reduced fee for repeat applications)	No
Registration and auditing costs	N/A	No	Yes – compost producer will have to pay a fee to cover registration and auditing costs in order to be compliance with the Quality Protocol
Independent auditing		No	Periodic auditing must take place

Appendix I Links to useful documents

1. PAS100

Introduction to PAS100:2005 – Summary of the BSI specification for composted materials

Full BSI PAS100:2005 Specification – available on request from WRAP

2. Market assessments

Assessment of the Demand for Green Waste Compost in the UK Landscaping Industry (2004/05) Arthur D Little

Annual UK Market Assessment for Composted Materials in Organic Agriculture (2004/05) Organic Resource Agency Ltd

Uses of compost in regeneration and remediation of brownfield sites in the UK (2006) Enviros Consulting Limited & CL:AIRE

3. Guidance documents

Guidelines for the specification of composted material used in the Landscape Industry

Agriculture – guidance document not yet published but the following is available:
Using Compost in Agriculture and Field Horticulture Compost Information Package 1

Guidelines for the specification of composted green materials used as a growing medium component 2004

4. Case studies

Agriculture – *Organic Compost Bears Fruit for Whitehorn Farm*

Landscaping – *Jack Moody Ltd Uses Compost to Create Haven for Commuters*

Horticultural – *Compost Plays Royal Role at Duchy of Cornwall Nursery*

Land Restoration – *Restoring The Land with compost*

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