

Anaerobic digestate

A technical report for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste

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Executive summary

Introduction

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

- define the point of full recovery from a waste back into a product or material that can either be reused by business or industry, or sold into other markets; or
- confirm to the business community what legal obligations remain to control the reuse of the treated waste material.

The Project Board asked a Technical Advisory Group (TAG) to consider the feasibility of producing a Quality Protocol that would enable the point of recovery of quality outputs from anaerobic digestion (AD) of source-segregated biodegradable waste to be moved closer to the point of production. Throughout this document these outputs are referred to as digestate materials. Outputs that conform to the requirements of the quality protocol are referred to as quality digestate.

Methodology

The TAG brought together representatives from the Environment Agency, the Scottish Environment Protection Agency (SEPA), Waste & Resources Action Programme (WRAP) and industry. Its remit was to produce a technical report setting out the process and controls necessary to consider at which point digestate materials cease to be waste. To do this, the TAG:

- reviewed the applications and developing markets for digestate materials;
- commissioned an exposure assessment to establish how any hazardous agents in wastes might survive an anaerobic treatment process and, through use of digestate materials, be transported to a receptor of concern; and
- considered what measures might be necessary to pre-empt such exposures, taking account of current proposals for a Publicly Available Specification for digestate materials (PAS 110).

Findings

- Digestate materials complying with PAS 110 will be fit-for-purpose in the markets considered. The specification also includes some significant safeguards for human health and the environment.
- Markets for quality digestates exist in agriculture and forestry (excluding horticulture other than soil-grown horticulture). For separated fibre only, there is also a market in land restoration. Both market sectors are currently very limited in the UK because the amount of digestate materials produced is still very small. However, the use of AD is likely to rise substantially due to its environmental advantages, regulatory pressures to reduce the use of landfill and financial incentives available to AD operators. The availability of the proposed Publicly Available Specification and Quality Protocol should help to develop these markets as digestate production increases.
- The relatively new status of the AD industry for waste treatment means there is a lack of data with which to assess confidently the potential use of quality digestates in some markets. The TAG has therefore adopted a conservative approach.
- The characteristics of quality digestates suggest the additional markets could emerge in the future, in particular for use as growing media (or as ingredients in such media) and for landscaping applications. However, evidence was not available to demonstrate that human health and the environment would be adequately protected in these markets if waste management controls were no longer applied. The TAG welcomes any views and evidence that consultees may be able to offer on the potential suitability of quality digestates for these additional markets.

Recommendations

The BREW Project Board and SEPA should issue for consultation a draft Quality Protocol for the production and use of quality outputs from source-segregated biodegradable waste.

This Protocol should include:

- a requirement to comply with the proposed Publicly Available Specification for quality digestates (PAS 110), or any other comparable product standard that may be approved;
- restrictions, additional to those in the draft PAS 110, on the types of waste that may be used as inputs when quality digestates are to be produced;
- designation of two markets in which quality digestates may be safely used, i.e. agriculture¹ and forestry, and land restoration;
- a requirement for third-party certification of compliance with the approved standard and the Quality Protocol;
- a requirement for producers to provide additional specified documentation with each consignment of quality digestates; and
- conditions governing the use of quality digestates, including sampling and analysis requirements, in the designated market sectors.

Other recommendations are to:

- carry out trials on the use of quality digestates in agriculture and forestry in the UK to provide more comprehensive information for potential users on their likely effects (positive results would help to establish confidence in these markets and promote their growth);
- investigate the suitability of quality digestates for use as growing media (or as ingredients in such media) and in landscape applications; and
- undertake further analytical survey work to characterise digestate quality.

1 Defined for purposes of this report so as to exclude horticulture, other than soil-grown horticulture.

1. Introduction

- 1.1 The Waste Protocols Project is a joint Environment Agency and Waste & Resources Action Programme (WRAP) initiative, funded by the Department for Environment Food and Rural Affairs (Defra) Business Resource Efficiency and Waste (BREW) Programme.
- 1.2 Uncertainty over the point at which waste has been fully recovered and ceases to be waste within the meaning of Article 1(1)(a) of the EU Waste Framework Directive (WFD) (2006/12/EC) has inhibited the development and marketing of materials produced from waste which could be used beneficially without damaging human health and the environment. In some cases this uncertainty has also inhibited the recovery and recycling of waste and its diversion from landfill.'
- 1.3 Interpretation of EU legislation is ultimately a matter for the European Court of Justice and there is now a substantial body of case law on the interpretation of the definition of waste in Article 1(1)(a) of the WFD. Drawing on the principles established in this case law, it is possible to identify the point at which certain wastes cease to be waste and thus when the WFD's waste management controls no longer apply. This identification is the purpose of the Waste Protocols Project.
- 1.4 Depending on the circumstances of the sector concerned, the project seeks to achieve one of the following outcomes:
 - to produce a Quality Protocol identifying the point at which waste, having been the subject of a complete recovery operation, may become a non-waste product or material that can be either reused by business or industry, supplied into other markets, enabling such fully recovered products to be used without the need for waste management controls; or
 - to produce a statement that confirms to the business community what legal obligations they must comply with to use the treated waste material.
- 1.5 The waste streams addressed by the BREW Waste Protocols Project include quality digestates from source-segregated biodegradable materials. A Technical Advisory Group (TAG) was set up to consider this waste stream, bringing together representatives from the Environment Agency, the Scottish Environment Protection Agency (SEPA), WRAP and industry. Appendix A contains a list of TAG members and Appendix B gives its terms of reference.
- 1.6 In order for a digestate material to be considered as having ceased to be waste, it is necessary to demonstrate that:
 - the material has been fully recovered; and
 - there is no further need for waste regulatory controls.
- 1.7 To investigate these issues the TAG considered in particular whether the waste is being made into a distinct product, examining the following questions:
 - Does the product: have a market and certainty of use?
 - Does the product meet an appropriate publicly available standard (e.g. an identified specification), requiring no further processing before being used?
 - Is the product capable of being used without undermining the Waste Framework Directive and Water Framework Directive's aims of protecting human health and the environment?
- 1.8 In the case of quality digestates, the coverage of the exercise was extended, with the participation of SEPA, so as to include Scotland as well as England and Wales.

- 1.9 The objectives of this report are to:
- describe the TAG's progress on this topic;
 - set out the TAG's findings; and
 - provide recommendations to the Waste Protocols Project Board, the Environment Agency and SEPA on what steps are needed to meet one of the aims of the project as stated in section 1.3.
- 1.10 In the course of developing the technical report, the TAG:
- reviewed the applications and developing markets for the various digestate materials;
 - commissioned an exposure assessment to establish how any hazardous agents in wastes might survive an anaerobic treatment process and, through use of digestate materials, be transported to a receptor of concern; and
 - considered what measures might be necessary to pre-empt such exposures while taking account of proposals for a Publicly Available Specification for these materials.

2. Production process

2.1 Anaerobic digestion

- 2.1.1 Anaerobic digestion (AD) is a natural process of microbiological conversion of organic matter in the absence of oxygen. The process produces:
- biogas – which is saturated with water vapour and which typically contains 50–80 per cent methane and 20–50 per cent carbon dioxide, with trace amounts of other gases; and
 - digestate (see section 2.2).
- 2.1.2 Approximately 70–80 per cent of the chemical energy in the organic matter is conserved in the methane produced.
- 2.1.3 The conversion of the organic material is mediated by a consortium of different bacterial trophic groups acting in a sequential and co-operative manner. The last of this series of natural bacterial phases produces biogas.
- 2.1.4 The AD process reduces the biological and chemical oxygen demand (BOD and COD respectively) of the biomass and increases the pH. The dry matter (DM) content of the digesting material falls during the process as the carbon is converted to biogas. The remaining carbon in the digested material is mostly structural carbon (e.g. lignin). The removal of solids instigates the conversion of organic nitrogen (organic-N) into ammonium salts (ammonium-N).
- 2.1.5 Anaerobic digesters are designed to create optimum conditions for the conversion process. A digester consists of an insulated airtight tank that is heated and mixed.
- 2.1.6 An AD system can be configured with any one of the following aims as its primary purpose:
- energy generation;
 - waste management;
 - farm management;
 - environmental management;
 - public health; and
 - odour control.
- 2.1.7 Consequently, a wide variety of technology types is available. A generalised diagram of the AD process is given in Appendix C.
- 2.1.8 Biogas produced by AD can be captured and used to produce energy. Biogas can be used:
- in a boiler to produce heat only;
 - in a combined heat and power (CHP) unit to produce electricity and heat; or
 - be further processed to increase the methane content (to >95 per cent) for use as a vehicle fuel or to replace natural gas, or to operate a fuel cell.
- 2.1.9 In well-designed systems, only about 30 per cent of the energy produced in the AD process is required to run the plant.
- 2.1.10 AD can be used to process a wide variety of wastes and other organic materials to produce energy and digestate materials. The design of digester technology needs to suit the type of material to be processed and can vary significantly.
- 2.1.11 AD is used for the treatment of:
- liquids with very low dry matter where the BOD level is high (e.g. sugar processing waters);
 - liquids with a higher dry matter content (e.g. slurry, sewage and food processing sludge); and
 - solid biodegradable materials (e.g. food waste, crops, solid manure).
- 2.1.12 The AD process stabilises wastes by converting readily available carbon into biogas: typically 60–80 per cent of the solids content is removed depending on the material processed and the hydraulic retention time (HRT). The AD process also greatly reduces the level and the pervasiveness of odour, and destroys pathogens, parasites and weed seeds.

- 2.1.13 Additional processes can be associated with AD before or after the digestion process itself. Examples include:
- cleaning (to remove unwanted physical materials);
 - maceration;
 - pasteurisation;
 - hydrolysis;
 - separation (of fibre from the liquid portion);
 - aerobic stabilisation (of the fibre); and
 - biogas use (as heat only, electricity and heat generation, upgrading to vehicle fuel, or injection into the gas grid).
- 2.1.14 Commercial AD plants operate at either a mesophilic (typically 30–45°C) or a thermophilic (typically 45–60°C) temperature.
- 2.1.15 The advantage of the mesophilic option is that the process is more robust and adaptable to changing environmental conditions.
- 2.1.16 Under thermophilic conditions, all other process conditions and timescale being equal, reaction rates are faster and thus pathogens tend to be killed more quickly and throughput can be faster. However, the thermophilic process requires greater energy input and is more sensitive to variations in operating and environmental conditions, so greater control is needed to avoid instability.
- 2.1.17 To secure optimum results at either temperature, care must be taken to maintain a constant input.

2.2 Outputs from anaerobic digestion

- 2.2.1 Three forms of digestate material arise from the process:
- **Whole digestate:** the processed material as it is unloaded from the digester. Typically this will be a pumpable material containing no more than 12 per cent DM, though some dry AD systems may produce a whole digestate with higher DM. Whole digestate contains a mix of:
 - fibres derived from the structural components of plants;
 - a bio-mineral fraction resulting from mineral particles in the biowaste, the decomposition by-products of anaerobic organisms, and those organisms themselves; and
 - liquid.
 - **Separated liquor:** the liquid resulting from passing whole digestate through a separator or centrifuge to remove the coarse fibre.
 - **Separated fibre:** the fibrous fraction resulting from passing whole digestate through a separator or centrifuge to reduce its liquid content.
- 2.2.2 The nature of the whole digestate and any separated fractions is affected by:
- the choice of input materials (particularly as regards nutrient content);
 - AD process configuration; and
 - any pre-treatment or post-treatment.

For example, pre-processing such as thermal hydrolysis acts to open the structure of the feedstock, allowing the process bacteria better access so that more carbon is transformed to biogas. Separated fibre can be subjected to a further aerobic stabilisation phase.

3. Current legislative position

3.1 England and Wales

- 3.1.1 The principal regulatory authority for wastes in England and Wales is the Environment Agency.
- 3.1.2 The current position is that, if the input materials to an AD plant are wastes or a mixture of wastes and non-wastes, then the output materials are wastes and remain so until put to their final use. This position applies to all the output materials, i.e. whole digestate, separated liquor, separated fibre and biogas.
- 3.1.3 If the input materials to an AD plant are non-wastes, the status of each of the output materials as a waste or non-waste will depend on the circumstances. In order to be considered as a non-waste, an output material must meet three tests. These are that it must be (i) certain to be used, (ii) without any prior processing, and (iii) as part of a continuing process of production. Assuming that the main purpose of the plant is to recover energy from the biogas produced, the biogas will always be a non-waste.
- 3.1.4 Any crop grown specifically for digestion in an AD plant to produce energy is not a waste.
- 3.1.5 Although agricultural manure and slurry is not a waste when used directly as a fertiliser on agricultural premises, it is a waste when it is destined for treatment by AD.
- 3.1.6 The processing of waste or mixed waste/non-waste input materials at an AD plant must be carried out at fully authorised sites, i.e. sites that hold an Environmental permit or a registered exemption.² The type of authorisation required will depend on the scale and nature of the processing carried out at a particular plant (see table 3.1).
- 3.1.7 If the input materials contain any food waste, the AD plant is likely to be also subject to regulatory control under the Animal By-Products Regulations (ABPR). These Regulations require the 'competent authority' to approve treatment of animal by-products. In England and Wales, this approval is issued by Animal Health³ and enforced by the relevant local authority.

Table 3.1: Activities carried out at AD plants and types of authorisation needed

| Activity | Type of authorisation needed |
|---|---|
| The anaerobic digestion of up to 1,000 cubic metres of waste at any time: <ul style="list-style-type: none"> ■ at the place of production; ■ where the digestate is to be used; or ■ at any place occupied by the waste producer or person using the digestate. The storage of waste which is to be digested at the place where it was produced or where it is to be digested. | Registered non-chargeable exemption from permitting under paragraph 12 of schedule 3 of the EP Regulations. |
| Burning biogas in any appliance with a net rated thermal input of up to 0.4 megawatts. | Registered non-chargeable exemption from licensing under paragraph 5 of schedule 3 of the EP Regulations. |
| Burning biogas as a fuel in any appliance with a rated thermal input of 3 megawatts or more. | Environmental Permit (was PPC permit prior to April 2008). |
| Any other waste recovery activity not covered above, including burning biogas in in any appliance with a net rated thermal input of between 0.4 and 3 megawatts. | Environmental Permit (was WML prior to April 2008). |

² The Environmental Permitting (EP) Regulations, which came into effect on 6th April 2008, combine the regulation of Pollution Prevention and Control (PPC) permits, Waste Management Licences (WML) and licence exemptions into a single, simplified permitting and compliance regime. Prior to this sites may have needed a PPC permit and/or a WML.

³ <http://www.defra.gov.uk/animalhealth/>

- 3.1.8 Typically, the digestate materials are applied to agricultural land for the purpose of agricultural or ecological improvement. Under these circumstances, the legislative controls summarised in Table 3.2 apply.
- 3.1.9 The REACH (Registration, Evaluation, Authorisation and Restrictions of Chemicals) Regulation came into force in the EU in June 2007. The Regulation aims to improve the protection of human health and the environment by making more information available about materials and products. It applies to 'substances', 'preparations' (mixtures of substances), and 'articles'. All these exclude waste as defined in the Waste Framework Directive. While compliance with a Quality Protocol will remove the need to comply with waste regulations, it will potentially bring the material or product concerned within the scope of the REACH Regulation.
- 3.1.10 Unless a material is specifically exempted from REACH, it has to be registered by its manufacturer or importer, or else the material can no longer be marketed in the EU. Certain substances are eligible for phased registration over an 11-year period (i.e. if they were on the market prior to 1981) but, to qualify for this, they must be pre-registered with the new European Chemicals Agency between 1 June and 1 December 2008. Otherwise, substances new to the market will be required to be registered after 1 June 2008.

Table 3.2: Summary of legislative controls over waste digestate materials

| Activity | Legislative control |
|--|--|
| Handling and transfer | The Duty of Care applies to all holders of waste, including those who produce, carry, keep, treat or dispose of waste. It requires them to take appropriate measures to prevent the escape of the waste and ensure that it is not illegally disposed of. Under the Duty of Care Regulations, holders have to ensure that a waste transfer note is completed when the waste is transferred and that the transfer is only to an authorised person or a registered waste carrier. Animal by-products collected and transported in accordance with the ABPR are exempt from the Duty of Care and are also subjected to a simplified waste carrier registration system. |
| Application of digestate materials to agricultural land where they result in benefit to agriculture or ecological improvement, and associated storage of the materials | Registered exemption from licensing under paragraph 7 of Schedule 3 of the Environmental Permitting Regulations. Benefit to agriculture or ecological Various conditions apply including: <ul style="list-style-type: none"> ■ the waste must confer agricultural benefit or ecological improvement; ■ maximum spreading limits not exceeding the benefit claimed; ■ maximum storage time 12 months; ■ analysis; ■ certificate of benefit and risk assessment; and ■ compliance with the ABPR. |

3.2 Scotland

- 3.2.1 In general, the legislative position in Scotland is the same. Exceptions are as follows:
- The principal regulatory authority for wastes in Scotland is SEPA.
 - The regulations providing for PPC permits and WMLs in Scotland are the Pollution Prevention and Control (Scotland) Regulations 2000.
 - There is no equivalent in Scotland to the 'paragraph 12' exemption from licensing that applies in England and Wales to the storage and anaerobic digestion of small volumes of waste.
 - As regards handling and transfer, under the Waste (Scotland) Regulations 2005, persons who transport only waste that consists of animal by-products collected and transported in accordance with Article 7(1) or 7(2) of the Community Regulation are exempt from the requirement to register as a waste carrier.
 - The exemption from licensing relevant to application of digestate to agricultural land for agricultural or ecological benefit in Scotland is provided for in paragraph 7, Schedule 3, of the Waste Management Licensing Amendment (Scotland) Regulations 2003. The conditions are broadly similar to those which apply to the paragraph 7 exemption in England and Wales.
 - The Environmental Permitting Regulations do not apply in Scotland. However, the exemption regime in Scotland is currently under review.

4. Quality standards

4.1 Proposed Publicly Available Specification

4.1.1 There is currently no appropriate standard for digestate materials. However, proposals for a Publicly Available Specification (PAS) have been developed, concurrently with the TAG's work, and will shortly be issued for consultation.

4.1.2 PAS 110 will be a voluntary, industry-led specification setting out the quality required for the safe use of the whole digestate, separated fibre and separated liquor as fertilisers and soil conditioners.

4.1.3 The new standard will place requirements on the producer to ensure they produce outputs from the AD system that are fit for their intended purposes. A Hazard Analysis and Critical Control Point plan (HACCP) and the operation of a Quality Management System (QMS) form part of these requirements. The producer must also ensure all digestate materials meet the required standard at all times.

4.1.4 Other proposed requirements in PAS 110 include:

- **Quality control.** There are general provisions for ensuring adequate quality control and documentation of both waste and non-waste input materials (e.g. through formal agreements with suppliers). Input materials must:
 - be biodegradable;
 - have been collected separately from non-biodegradable materials; and
 - not be mixed with or contaminated by other wastes.

Beyond these, there are no specific limitations in PAS 110 on the types of inputs that may be used.

- **Pasteurisation.** Where digestate materials are manufactured from waste materials or from waste materials mixed with animal manures, the process must include a step that ensures effective pasteurisation – the appropriate method will depend on the type of input materials. The only exception is where an on-farm digester uses manure or crops generated on the same holding and its outputs are applied only on land within that agricultural holding. The aim of this requirement is to prevent the potential for transmission of animal and plant pathogens between holdings.

- **Contamination.** Fully treated digestate materials must not be contaminated with partially treated or untreated material.

- **Sampling and analysis.** Sampling requirements are laid down for each form of digestate material. Documented procedures must be followed and samples must be tested by an accredited laboratory. Analysis must cover product characteristics such as nutrient content, pH and dry matter and, with limit values as appropriate, potentially toxic elements (PTEs), physical contaminants, weed seeds, stability, particle size, and pathogens.

- **Corrective action.** This is to be taken if process conditions move outside critical limits or if limit values for the products are exceeded.

- **Miscellaneous requirements.** These include:
 - specified information to be provided to customers with product consignments;
 - training requirements and documentation;
 - provisions on record-keeping; and
 - provisions on dealing with and recording complaints.

4.1.5 The draft specification requires the producer to:

- verify that the process is operating as intended; and
- validate that the quality of the digestate materials is satisfactory.

4.1.6 A producer may self-assess conformance to the PAS and, if all requirements are met, claim conformance with it.

4.1.7 As is the case with all industry standards and Publicly Available Specifications, independent assessment by a third party certification body is recommended. If and when the certification body determines that all requirements have been met, the producer may claim conformance and use the certification scheme's quality mark.

5. Key markets for anaerobic digestate

- 5.1 The UK market for digestate materials is still in its infancy.
- 5.1.1 Apart from the use of AD to treat sewage sludge and wastewaters, there is currently very little waste treatment using this process in the UK. Most existing anaerobic digesters are on-farm systems that recycle agricultural manures, other residues and crops arising on the farm – in some cases together with imported food wastes. The product is mainly used on the farm premises, although there may be limited sales for use as a soil conditioner.
- 5.1.2 There are thought to be only three co-digestion AD plants in England. These handle (variously) animal slurries, industrial and food wastes and household wastes. Total digestate production in the UK is estimated at only 277,000 tonnes/year; much of this is used on its site of origin or on farms that supplied manure to the digester.
- 5.1.3 Use of the process for waste treatment and energy production in the UK is expected to expand considerably. The drivers of growth include:
- awareness of the advantages of AD in terms of reducing greenhouse gas emissions through:
 - efficient capture and reuse of biogas; and
 - substitution of digestate materials for fertilisers manufactured in an energy-intensive process;
 - the need to divert large volumes of organic waste from landfill in order to meet the UK's obligations under the Landfill Directive;
 - perceptions of profit opportunities from the sale of excess electricity and heat generated from AD biogas – increasingly, these are being enhanced through financial incentives such as Renewable Obligation Certificates (ROCs), while landfilling is discouraged by rapidly increasing landfill tax rates; and
 - the need for farms that produce more nutrients than they can use on site to find more environmentally acceptable methods of distributing the surplus.
- 5.1.4 Consequently, the volume of digestate materials produced will increase. Awareness of these in the relevant markets is currently low but, as they become more widely available, their qualities as fertilisers and soil conditioners are likely to become increasingly recognised. The publication of PAS 110 will help to build confidence in the product.
- 5.1.5 Publication of a Quality Protocol would assist further as:
- digestate materials would no longer be regarded as waste (provided they are produced and used consistently with the Protocol); and
 - users would be spared the costs of compliance with waste regulations.
- 5.2 Digestate materials and other comparable materials**
- 5.2.1 The whole digestate can be used as a fertiliser. It has some soil conditioning properties, adding nutrients and organic matter to soils and improving soil structure. It can be used either directly or after composting, or mixing with compost.
- 5.2.2 The separated fibre can also be used as soil conditioner, adding organic matter and nutrients and improving water retention. It can be used fresh or, after further aerobic stabilisation making a high-quality compost.
- 5.2.3 The separated liquor can be used as a fertiliser. Its nitrogen content is nearly all in plant available form. It runs more easily off the leaves of plants than do untreated slurries, leaving virtually no surface residue, and is therefore particularly suitable for application to growing crops. Its application can help to minimise the loss of nitrogen through volatilisation after spreading and through other paths.

- 5.2.4 Other materials which can be used for one or more of these purposes include:
- agricultural manures;
 - manufactured fertilisers;
 - sewage sludge;
 - compost; and
 - certain industrial wastes where these are spread directly on land, e.g. paper waste and dairy sludge.
- 5.2.5 Digestate materials are appropriate for use in agriculture⁴ and forestry, and, in the case of separated fibre, also in land restoration. For the reasons explained in Section 6, the TAG does not currently consider them suitable as growing media or for use in its manufacture.
- 5.2.6 Manures and home or community-produced composts are likely to be used predominantly on their sites of origin and in preference to (non-specialist) competing products. Manures used 'as a fertiliser as part of a lawful practice of spreading on identified parcels of land',⁵ and compost produced and used in accordance with PAS 100 and the compost Quality Protocol, are not regarded as waste. Sewage sludge and industrial wastes are regarded as waste although, when used in agriculture for the growing of food crops, the former is covered by the Sewage Sludge Directive rather than the Waste Directive.

5.3 Demand and supply in the fertiliser and soil conditioner markets

- 5.3.1 The position that digestate materials can ultimately command in the marketplace will depend on trends in overall demand and in the supply and cost of comparable materials, as well as perceptions of their quality and fitness for purpose. Some relevant factors are outlined below.
- 5.3.2 Use in agriculture of fertilisers and of soil conditioners with a high available nitrogen content is likely to be affected by the extent of restrictions on the use of nitrogen in Nitrate Vulnerable Zones (NVZs) and associated good practice guidance. These restrictions are increasing. On the other hand, use will be encouraged by government policies for maintaining soil organic matter on agricultural land.
- 5.3.3 The Government's policies for urban regeneration and major expansion of housebuilding (particularly on brownfield sites) should sustain a substantial – and probably growing – demand for soil conditioners for use in land restoration.
- 5.3.4 UK livestock numbers are expected to decline, reducing the availability of manure.
- 5.3.5 Costs of manufactured fertiliser have been rising and are likely to rise further due to trends in energy prices and increasing global demand.
- 5.3.6 The supply of sewage sludge is likely to increase due to population growth and because new or additional treatment facilities will be needed to meet the higher quality standards required by European legislation such as the Urban Waste Water Treatment Directive.
- 5.3.7 The industry's preferred route for the treatment of sewage sludge is recycling to land following anaerobic digestion and enhanced treatment. However, water companies may be driven to increase their use of other disposal routes (e.g. incineration) as a result of:
- concerns over the use of sewage sludge on land for food production;
 - reductions in the availability of land; and
 - the issue of the security of this recovery route in the event of an emergency.
- 5.3.8 Production of quality compost should increase substantially in response to pressures for diversion of organic waste from landfill and as a result of the introduction of the compost Quality Protocol.

⁴ For purposes of this report, agriculture is defined so as to exclude horticulture other than soil-grown horticulture.

⁵ European Court judgment: *Case C-416/02 European Commission v Kingdom of Spain*

5.4 Product quality and fitness for purpose

- 5.4.1 There is as yet no direct practical evidence from field trials of the effectiveness in UK conditions of digestate materials as fertilisers and soil conditioners, though some relevant data is available from the Netherlands and Denmark. Market prospects would be enhanced if convincing UK-based evidence were to become available.
- 5.4.2 However, it is possible to assess the potential value of whole digestate and separated liquor as substitutes for manufactured fertiliser from analysis of their nutrient content. A sample calculation is provided in Appendix D.

5.5 Prospects for the market in digestate materials

- 5.5.1 Digestate materials are new entrants to the marketplace and the AD industry is still very small. However, all the material currently produced is being used, successfully, on agricultural land – most of it on or close to its site of origin.
- 5.5.2 Use of AD and thus the volume of digestate materials is likely to increase, perhaps rapidly, for the reasons stated above. Taking account of the variable prospects for other comparable materials, the TAG considers there is the potential for demand for the products to develop in step with this growth, assisted by the publication of PAS 110 and the proposed Quality Protocol.
- 5.5.3 Compliance with an appropriate standard provides a guarantee that a product is fit for its intended purposes, but not necessarily that it will pose no risk to human, animal or plant health or the environment in use. Section 6 considers the additional safeguards that may be required in the case of digestate materials and which, in the TAG's view, should be provided for in a Quality Protocol.

6. Exposure pathway analysis

6.1 Exposure pathway analysis

- 6.1.1 An exposure pathway analysis prepared in consultation with the TAG by the Centre for Resource Management and Efficiency at Cranfield University is being published alongside this technical report.
- 6.1.2 The objective of this analysis was to use a (semi-) quantitative risk assessment methodology to assess the number and extent of available pathways of exposure of humans, plants and the environment to any hazardous agents in digestate materials in each of their possible end uses while taking account of the various barriers available to prevent or limit exposure. These barriers were:
- exclusion of unsuitable wastes from treatment;
 - effective treatment of suitable wastes;
 - appropriate use of the product; and
 - attenuation of any residual hazards in the environment before they reach a receptor of concern.
- 6.1.3 A generic assessment of this nature requires substantive evidence and a large number of working assumptions for it to be both pragmatic and meaningful. In this case this included the following:
- The method of analysis used adopts a broad consideration of the hazards in generic waste categories and the residues used within a suite of generalised end uses.
 - It is assumed that any residual hazard will be transported to the receptor.
 - European Waste Catalogue (EWC) codes were used to determine the waste groupings. However, EWC definitions do not group wastes that present a similar risk together.
 - The exposure pathway analysis assumes that relevant regulatory requirements are met, e.g. any animal by-products are pasteurised.
- 6.1.4 The study has limitations because site-specific factors cannot be taken into account. Its conclusions are therefore drawn on the assumption that a site-specific assessment – including consideration of the environmental setting and the actual waste type – will be undertaken before the conclusions are applied in practice.
- 6.1.5 The analysis methodology and detailed results are presented in the exposure assessment report. The main conclusions are summarised below:
- The more hazardous the potential waste input stream, the greater are concerns about exposure to the resulting AD product. Waste inputs with a high proportion of unpasteurised animal faeces and wastes derived from the leather industry were considered relatively hazardous.
 - The more direct and available the exposure pathway, the greater is the risk of exposure to any relevant hazardous agent. The highest ranked pathways included:
 - direct ingestion of AD residues;
 - ingestion of soil contaminated with these residues;
 - contamination of private water supplies by surface and sub-surface routes; and
 - ingestion of contaminated crops.
 - The end uses presenting the greatest number of highly available exposure pathways were:
 - crops (both ready-to-eat and others);
 - grazing; and
 - animal feed.
 - Organic compounds and heavy metals did not emerge as significant issues in view of the controls that were assumed to apply to the inputs to the AD process.

- 6.1.6 These conclusions offer insights into where preventative measures might be most effective in minimising hazards. These measures include:
- exclusion of certain waste types from AD treatment;
 - systematic management of the AD process; and
 - good practice in application.
- 6.1.7 The TAG identified that many of the risks associated with the use of digestate materials are risks that the use of any organic fertiliser or soil condition would pose. The TAG has considered these and the results of the exposure assessment in its proposals for a Quality Protocol.

6.2 Potential human health impact of potentially toxic elements (PTEs) in digestate materials

- 6.2.1 The TAG considered the potential health effects of using digestate materials in appropriate market sectors, taking a similar perspective to that adopted in previous consideration of other materials with similar applications.
- 6.2.2 In particular, the TAG took account of the work completed for the compost Quality Protocol. The latter concluded that any health risks from the appropriate use of quality compost derived from source-segregated organic wastes were within acceptable limits. From the limited data available to the TAG and its advisers, there is no reason to suppose that appropriate use of digestate materials would pose any greater risk.
- 6.2.3 However, there are significant gaps in the available data for anaerobic digestate. The TAG therefore approached the designation of market sectors for the purposes of a Quality Protocol on a precautionary basis.
- 6.2.4 The TAG has excluded from consideration any market sectors within which there are exposure pathways that the analysis suggests might pose relatively high risks.
- 6.2.5 In addition, the TAG has recommended that safeguards are included in the Quality Protocol measures that will ensure that human health is fully protected, e.g. compliance with the Food Standards Agency's guidance on *Managing Manures for Food Safety: Guidelines for Growers to Reduce the Risks of Microbiological Contamination of Ready-to-eat Crops*.⁶

7. Protecting human health and the environment

7.1 In the light of the results of the exposure pathway analysis, the advice on human health impact of PTEs, and the inherent risks associated with the application of any organic fertiliser to land, the TAG considered what further measures beyond those proposed for PAS 110 are necessary in order that regulatory controls can be removed. The TAG identified the following measures, that a Quality Protocol should follow, which will ensure (and give confidence to users and regulators) that digestate materials complying with the specification will not harm human health or the environment when used for their intended purposes:

- criteria for producing quality digestate;
- designation of market sectors for use of quality digestate;
- precautions for application and use of quality digestate;
- provision of supply documentation;
- certification of producers; and
- evidence of compliance with Quality Protocol.

These additional measures are described in more detail below.

7.2 Criteria for producing quality digestate

7.2.1 The TAG considers that the Quality Protocol should impose additional restrictions on the types of waste used to produce quality digestates. Specifically, wastes from the leather industry should not be allowed as inputs to the production of quality digestates due to their potential pathogen and heavy metal content.

7.2.2 The Quality Protocol should also require quality digestate to be produced in line with the requirements of an approved standard. At present, the only relevant standard is the proposed PAS 110. However, another standard with broadly equivalent requirements could be produced in the UK or elsewhere in due course. The Quality Protocol should therefore be framed so as to allow products complying with any such standard to be covered.

7.3 Designation of market sectors

7.3.1 The TAG identified that the following two market sectors should be designated in the Quality Protocol:

- agriculture and forestry; and
- land restoration (separated fibre only).

7.3.2 In the TAG's view, these are the markets in which measures are available to minimise or avoid the potential risks highlighted by the exposure pathway analysis. For example, the exposure pathway analysis indicated a potential risk of contamination of private water supplies or of ingestion of contaminated crops when quality digestates are used in agriculture. The TAG has identified either regulatory or advisory controls that will be in place, or which could be put in place, even if the digestate material is not regarded as waste. Two detailed illustrations are given below.

7.3.3 **Case 1: using quality digestates as fertilisers on edible crops.** In this instance:

- the risk of water, soil and air pollution can be minimised if the material is applied in accordance with the Codes of Good Agricultural Practice (COGAP);⁷
- risk to the human food chain can be minimised if the Food Standards Agency guidance on the use of manures on ready-to-eat crops is followed;
- the risk of transmission of human, animal and plant pathogens will be minimised by the proposed inclusion in PAS 110 of a requirement for the material to be pasteurised during processing; and
- any other risk to animal health that might arise through inclusion of animal by-products as inputs to the AD process will be minimised by compliance with the ABPR.

7 See <http://www.defra.gov.uk/farm/environment/cogap/index.htm>

- 7.3.4 **Case 2: using quality digestates for land restoration.** In this instance:
- transmission of human animal and plant pathogens can be prevented by the proposed inclusion in PAS 110 of a requirement for the material to be pasteurised during processing; and
 - environmental impact can be controlled by the inclusion of appropriate conditions in the planning permission for the restoration activity.

7.3.5 The TAG does not currently propose that use of digestate materials as a growing medium or as an ingredient in growing media should be a designated market sector. This is because these uses would appear to present the highest probability of creating a viable pathway of exposure to potentially hazardous agents and there is very limited experience of the use of digestate materials in this sector.

This is an issue on which the TAG would particularly welcome any further evidence that might be presented during the consultation process.

7.4 Precautions for application and use of quality digestate

7.4.1 There are a number of additional risks that need to be managed during the application and use of any organic fertilisers or soil conditioners. These risks are also relevant for the application and use of quality digestates and can be summarised as follows:

- water pollution from a point source;
- diffuse pollution of surface water, groundwater or other sensitive habitats;
- emissions of ammonia and greenhouse gases during and after spreading;
- accumulation of persistent pollutants in the soil as a result of repeated applications to land; and
- biosecurity risks.

7.4.2 Producing quality digestates in compliance with PAS 110 and the proposed Quality Protocol, will ensure that the above risks are relatively low. However, the TAG considers that the precautions detailed in section 7.5 and 7.6 should be taken to minimise the residual risks of applying quality digestates in the designated market sectors. Most of these precautions reflect best practice for the application of any organic fertiliser or soil conditioner to land.

7.5 Precautions for application to agriculture and forestry

7.5.1 In general, the precautions required to minimise the residual risks of applying quality digestates in this market sector are no different in type from those already well established for other fertilising materials and soil improvers. The latter are provided for, variously, in existing regulations, the draft revision of the UK Nitrate Vulnerable Zones (NVZs) Action Programmes, Codes of Good Agricultural Practice and the compost Quality Protocol. In some instances, the scope of the legislation or guidance concerned is general, and covers digestate and other materials equally. Where this is not the case, application of quality digestates should follow the same principles as for comparable materials. The TAG believes that the following additional precautions should be taken when quality digestates are used in this market sector:

7.5.2 Provision of storage

Provisions relating to storage are considered necessary for quality digestates although comparable requirements were not included in the compost Quality Protocol. This is because the available nitrogen content of whole digestate and separated liquor is relatively high and means they cannot be applied to land at certain periods of the year.

The land manager therefore needs to have adequate storage to cover these closed periods, otherwise there would be increased risk of pollution (particularly eutrophication of surface waters). Where manure has been used as an input to the AD process, storage of digestate materials is covered by the following regulations:

- The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991 (SI No. 324), and as amended 1997 (SI No. 547); and
- the advice in *Guidance Notes for Farmers on The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations* issued jointly by the then Department of the Environment and the Welsh Office in April 1997.

Although these provisions relate to manure, the TAG considers the Quality Protocol should specify that they should also be followed in the case of digestate materials produced without any manure input.

7.5.3 Accident management plan

All holdings storing or spreading quality digestates should prepare an accident and emergency plan detailing the actions to be taken to minimise the effects of accidental spillages or equipment failure. Advice is given in:

- Codes of Good Agricultural Practice (COGAP);
- Pollution Prevention and Guidance Note 21 (PPG 21) *Pollution Incident Response Planning*, Environment Agency, February 2004; and
- Integrated Pollution Prevention and Control (IPPC) Factsheet No. 4, *Accident and Emergency Plan*, Environment Agency, 2006.

7.5.4 Sampling and analysis requirements

As with any other fertilising materials, applications of quality digestates should be matched to crop nutrient requirement, growth stage and prevailing weather conditions and made in accordance with a Nutrient Management Plan for the farm and the guidance set out in *Fertiliser Recommendations for Agricultural and Horticultural Crops* (RB209)⁸ (or subsequent guidance).

The TAG believes the Quality Protocol should require advice to be taken from an adviser qualified under the Fertiliser Advisers Certification and Training Scheme (FACTS) before digestate materials are applied. There is a similar provision in the compost Quality Protocol.

In areas designated as NVZs, applications of digestate materials must comply with the Action Programme mandatory under legislation to implement the Nitrates Directive. Such programmes include various requirements limiting application rates and the periods within which particular types of manures and digestate materials can be applied.

The TAG considers that these same requirements should also apply, through the Quality Protocol, to the application of quality digestates outside NVZs. A similar precaution was not included in the compost Quality Protocol, but the TAG believes it to be necessary in the case of digestate materials because of the higher pollution risk posed by both whole digestate and separated liquor.

Without prejudice to the above, any application of digestate materials is subject to the principles set out in COGAP (or subsequent guidance) for air, water and soil. In particular, digestate materials should be applied in accordance with a Manure Management Plan for the farm. They should not be spread on frozen, snow-covered or waterlogged ground, or within 10 metres of a watercourse. Spreading techniques and subsequent soil management that will minimise ammonia emissions should be adopted.

Applications of quality digestates should adhere to the same soil PTE limit values as those set out in the Code of Practice for the Agricultural Use of Sewage Sludge (the 'Sludge Code').⁹ There is a similar provision for quality compost in its Quality Protocol.

Applications of quality digestates produced from input materials that include animal manures to land on which ready-to-eat crops are to be grown should follow *Managing Farm Manures for Food Safety: Guidelines for Growers to Reduce the Risks of Microbiological Contamination of Ready-to-eat Crops* issued by the Food Standard Agency (FSA).¹⁰ Primary food producers must comply with the Food Hygiene (England) Regulations 2006 (SI 2006 No. 14), which while not requiring a formal HACCP assessment, place an obligation on them to prevent contamination of food they produce. Following the FSA guidelines will help them to achieve this.

⁸ See <http://www.defra.gov.uk/farm/environment/cogap/index.htm>

⁹ <http://www.defra.gov.uk/environment/water/quality/sewage/sludge-report.pdf>

¹⁰ Final draft, January 2005 (<http://www.food.gov.uk/multimedia/pdfs/manguidfinaldraft.pdf>)

When digestate materials produced from inputs that include materials subject to the ABPR are applied to agricultural land, the relevant cropping and 'no grazing' intervals specified in the ABPR must be observed.

7.5.5 Sampling and analysis methodologies

All chemical analysis of soil should be carried out by laboratories using appropriate methods that are accredited by UKAS to ISO/IEC 17025 for the Environment Agency's MCERTS performance standard for the chemical testing of soil.

Soil sampling for major nutrients should be carried out regularly in accordance with RB209. Quality digestates should not be applied unless the soil has been analysed within the last five years. The nutrient analysis should include, extractable phosphorus, available potassium, available magnesium and, total sulphur.

The soil nitrogen supply should be determined by following RB 209 to assess the Soil Nitrogen Supply Index, or from the results of a recent soil mineral N analysis.

Information on the nutrient content of the quality digestates should be provided to the land manager and should include pH, total and available nitrogen and total phosphorus, potassium and sulphur.

The digestate producer should arrange for the digestate to be analysed and the land manager should arrange for the receiving soil to be analysed for PTEs (lead, cadmium, chromium, mercury, copper, zinc, nickel) to ensure that the limit values set out in the Sludge Code are not exceeded.

Soil analysis for PTEs should be carried out before the first application of quality digestates and again when the predicted concentrations approach 75 per cent of the limit values set out in the Sludge Code.

Similar provisions are included in the compost Quality Protocol.

7.6 Precautions for land restoration

- 7.6.1 Separated fibre delivered to a restoration site as a quality digestate should be treated as recovered material. Provided it is delivered to a site operating within an existing waste management and planning framework, the material will satisfy the required criteria of meeting a defined standard, being delivered to an established market and causing no harm to the environment. But if the separated fibre is mixed with waste materials on site, normal waste management controls will apply.
- 7.6.2 The user of the separated fibre (quality digestate) should keep records of its application. These should be sent to the producer of the material so that an audit trail can be maintained of the destination of all separated fibre.
- 7.6.3 It is possible that separated fibre (quality digestate) may be used in the manufacture of topsoil for land restoration purposes. Such use is outside the scope of the proposed Quality Protocol. A separate TAG is considering whether it is appropriate to prepare a Quality Protocol for topsoil. In the meantime, producers of such topsoil are advised to:
- comply with the provisions of BS 3882:2007 *Specification for topsoil and requirements for use*; and
 - refer to Environment Agency guidance as to the waste status of the topsoil produced.

7.7 Provision of supply documentation

- 7.7.1 The TAG believes that the producer should provide the customer with a range of information with each consignment of quality digestate in addition to the documentation proposed for PAS 110. This would help the customer understand the characteristics of the product and how it should, and should not, be used. This information could include:
- data on the nature of the product;
 - its date of despatch;
 - confirmation that the product complied with PAS 110 and the Quality Protocol;
 - statements that the producer was certified under PAS 110 and the Quality Protocol; and
 - guidelines for its use (e.g. references to good practice guidance and advice that the product should not be used outside the designated market sectors).

7.8 Producer certification

- 7.8.1 It is important that producers should be able to demonstrate their compliance with the requirements of PAS 110 (or any other standard approved in due course) and the Quality Protocol through an independent process operated by a third party. The TAG suggests that this should be achieved by obtaining a certificate from an approved certification body.
- 7.8.2 A body seeking approval for this purpose would need to:
- obtain accreditation from the United Kingdom Accreditation Service (UKAS) to BS EN 45011:1998 *General requirements for bodies operating certification systems*; and
 - agree the rules of its certification scheme with the Environment Agency.
- 7.8.3 The certification body would assess compliance, initially and thereafter annually, by:
- considering evidence submitted by the producer;
 - site inspections; and
 - verifying record-keeping, compliance with HACCP and QMS requirements, etc.
- 7.8.4 The certification body, in turn, would undergo annual inspection and accreditation by UKAS.
- 7.8.5 For purposes of certification, producers would need to keep detailed records of wastes delivered to the site and materials leaving the site. These records should cover a minimum of two years.
- 7.8.6 Producers would not normally be responsible for ensuring their products were used in a way that protected human health and the environment other than where they were employed to apply them to the land. In the case of the use in quality digestates in agriculture and forestry, however, the TAG considers the manager of the land should be required to keep records of how and where the quality digestate was applied, and of related soil analyses. These records should be made available to the producer and in turn, the producer would make them available to the certifying body. The certifying body would then be able to audit these records as part of its certification procedures.

7.9 Evidence of compliance

- 7.9.1 The TAG consider that the Quality Protocol should contain requirements for compliance with the Protocol to be demonstrated as follows:
- third party certification of compliance with PAS 110 (or other approved standard) and with the Quality Protocol; and
 - producers to provide customers with supply documentation to accompany each consignment of quality digestates giving additional information about the product and the inputs to the production process and guidance on its use.

8. Findings and recommendations

8.1 Findings

- 8.1.1 An appropriate Publicly Available Specification for quality digestates (PAS 110) will be available shortly. Digestate materials complying with this specification will be fit for purpose in the markets considered. The specification also includes some significant safeguards for human health and the environment.
- 8.1.2 Markets for quality digestates exist in agriculture (as defined for purposes of this report) and forestry. For separated fibre only, there is also a market in land restoration. Both market sectors are currently very limited in the UK because the amount of digestate materials produced is still very small. However, the use of AD is likely to rise substantially due to its environmental advantages, regulatory pressures to reduce the use of landfill and financial incentives available to AD operators. The availability of the proposed Publicly Available Specification and Quality Protocol should help to develop these markets as digestate production increases.
- 8.1.3 The relatively new status of the AD industry for waste treatment means that there is a lack of data with which to assess confidently the potential use of quality digestates in some markets. The TAG has therefore adopted a conservative approach.
- 8.1.4 The characteristics of quality digestates suggest that additional markets could emerge in the future, in particular their use as growing media (or as ingredients in such media) and for landscaping applications. However, evidence was not available to demonstrate that human health and the environment would be adequately protected in these markets if waste regulatory controls no longer applied. The TAG welcomes any views and evidence that consultees may be able to offer on the potential suitability of quality digestates for these additional markets.

8.2 Recommendations

- 8.2.1 The BREW Project Board and SEPA should issue for consultation a draft Quality Protocol for the production and use of quality digestates from source-segregated biodegradable waste. This Protocol should include:
- a requirement to comply with the proposed Publicly Available Specification for quality digestates (PAS 110), or any other comparable product standard that may be approved;
 - restrictions, additional to those in the draft of PAS 110, on the types of waste that may be used as inputs when quality digestates are to be produced;
 - designation of two markets in which quality digestates may be safely used, i.e. agriculture and forestry, and land restoration;
 - a requirement for third party certification of compliance with the approved standard and the Quality Protocol;
 - a requirement for producers to provide additional specified documentation with each consignment of quality digestate; and
 - conditions governing the use of quality digestates, including sampling and analysis requirements, in the designated market sectors.
- 8.2.2 Trials on the use of quality digestates in agriculture and forestry in Britain should be carried out to provide more comprehensive information for potential users on their likely effects. The results, if positive, would help to establish confidence in these markets and to promote their further growth.
- 8.2.3 Research should be undertaken into the suitability of quality digestates for use as growing media, or ingredients in such media, and in landscape applications.
- 8.2.4 Further analytical work should be undertaken to characterise digestate quality.

Appendix A Technical Advisory Group membership

| Organisation | Representative |
|--|---|
| AD Technical Specialist | Vicky Heslop |
| BREW Waste Protocols Project Team | Amy Colson/Laura Battle-Welch Sarah Clayton Suzanne Laidlaw |
| Consultant advising WRAP | Roger Unwin |
| Consultant to BREW Waste Protocols Project Team | Michael Faulkner |
| Department for Environment, Food and Rural Affairs | Iain Notman |
| Environment Agency | Victoria Sturt Viv Dennis |
| Environment & Heritage Service (Northern Ireland) | Tony Osborne |
| Environmental Services Association | Justin French-Brooks |
| Renewable Energy Association | David Collins |
| Scottish Environment Protection Agency | Peter Olsen |
| The Composting Association | Emily Nichols/Jane Gilbert |
| Waste & Resources Action Programme (WRAP) | Nina Sweet |
| Welsh Assembly Government | Aoife O'Sullivan |

Appendix B: TAG terms of reference

1. Mission statement

To produce a technical report, recognised by (and produced with the support of) industry, that defines when the outputs from an anaerobic digester that treats biodegradable waste have been reprocessed to such a level that they can be considered to be fully recovered and no longer subject to the requirements of the regulatory waste regime.

If this is not achievable, the technical report will provide guidance to business that will:

- define when anaerobic digestion products are recovered to a state where the Environment Agency considers that its use is acceptable in accordance with its low risk regulatory principles; or
- confirm to the business community what legal obligations remain to control the re-use of the treated waste material.

2. Desired outcomes/outputs

The Technical Advisory Group (TAG) will produce a technical report that will identify and establish:

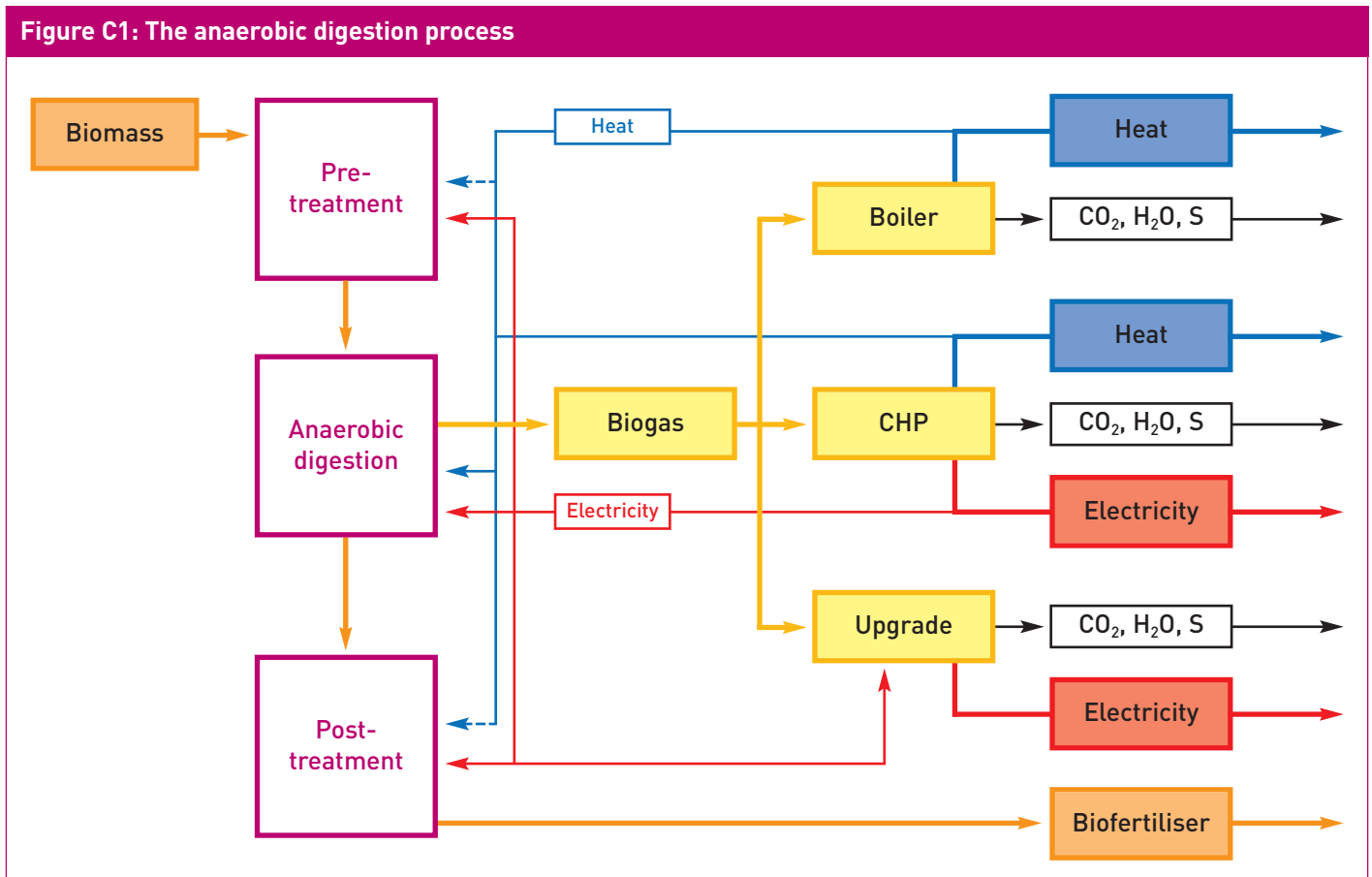
- which end products a Quality Protocol should address;
- whether there are any existing standards and specifications for each end product;
- whether the material can be collected and reprocessed to meet existing standards and specifications;
- where existing standards and specifications do not exist, to identify alternatives and/or to scope out project for producing a new standard or specification;
- what the potential environmental and human health impacts are, and what mitigation methods may be used to maintain or reduce those impacts;
- costs and benefits of the different end uses (with the aid of project economist); and
- a standard terminology.

3. Limitations

- In relation to the output of this TAG, the Environment Agency must be satisfied with the TAG's determination of the point at which the outputs of anaerobic digestion have been fully recovered.
- If the point of full recovery cannot be defined or agreed, the TAG will refer this matter to the Environment Agency for it to produce guidance on when waste regulatory controls apply.
- Where specifications and standards do not exist and are required, financial or time implications may result in the TAG being delayed.

Appendix C: Generalised diagram of anaerobic digestion process

Figure C1: The anaerobic digestion process



Appendix D: Example of digestate contribution to fertiliser requirements

The following information has been provided by AnDigestion Ltd, with explanation by David Collins (Renewable Energy Association).

This example illustrates the value of a mixed substrate digestate for first cut silage when it is used to replace inorganic N fertiliser and part of the requirement for phosphate and potash.

Analysis of anaerobic digestate by Imperial College, London, has allowed both its total and available nutrient content to be estimated. The cash values for these nutrients have been derived by direct comparison with the latest fertiliser prices (Cornwall Farmers). The digestate values are based on four-month rolling values of the analysis of digestate in the storage tank at the AD plant. These values can change if the intake to the plant changes.

The total N/ha required by the crop is taken as 120kg/ha. This can be provided by an application of about 22m³ of digestate per hectare, entirely replacing inorganic fertiliser and also providing 10 per cent of the phosphate requirement and nearly 50 per cent of the potash requirement. This particular digestate can therefore supply about £120/ha or 72 per cent of a total nutrient cost of £165/ha.

Note that RB209 advises limiting the proportion of nitrogen supplied in organic manures to less than 70 per cent of the total application to minimise the risk of variations in availability reducing yield.

In this example, a further application of digestate would be planned for the second cut silage. In this way, the maximum 250kg total organic N per year is used and is then topped up with P and K from other sources.

Table D1: Metric for determining the value of quality digestate as a fertiliser replacement

| Fertiliser prices as at 6 January 2008 | % | Price/tonne* | Price/kg |
|--|------|--------------|----------|
| Ammonium nitrate | 34.5 | £260 | £0.75 |
| Muriate of potash | 60.0 | £280 | £0.47 |
| Phosphate | 46.0 | £320 | £0.70 |

| Based on Imperial College's mineral nitrogen comparison for fresh digestate | | | | |
|---|--|--|---------------------------|---------|
| 1st cut silage | Spreading rate = 21.6 m ³ /ha | | | |
| | Nitrogen (N) | Phosphate (P ₂ O ₅) | Potash (K ₂ O) | Value |
| Estimated total nutrients in digestate (kg/m ³) | 7.5 | 0.3 | 2.0 | £7.20 |
| Estimated available nutrients in digestate (kg/m ³)* | 5.5 | 0.2 | 1.8 | £5.53 |
| Requirement for 1st cut silage (kg/ha) | 120.0 | 40.0 | 80.0 | £164.75 |
| Calculate digestate supply of potentially plant-available nutrients (kg/ha) | 120.0 | 4.0 | 39.0 | £119.55 |
| Calculate inorganic fertiliser need (kg/ha) | 0 | 36.0 | 41.0 | £45.20 |
| Total organic N applied (kg/ha) | 162.0 | | | |

* Source: Cornwall Farmers

Notes

The TAG is grateful to AnDigestion Ltd for kindly supplying the field information. The information is not intended as a guide to any other operator and is purely indicative/illustrative. On farms where a supply of animal manures is available, there will be less opportunity for using digestates from imported input materials and the potential savings will be less. Where the farm's animal manures are included in the digested materials, their fertiliser value before treatment should be deducted from the apparent financial benefit.

In this example, the availability of phosphate and potash is assumed to be the same as in cow manure – a major source of the nutrients in the digestate. The crop requirements are taken from RB209 and assume Soil Index 2 for P and K. The P and K requirements are therefore maintenance requirements. In such situations, the total quantity of phosphate and potash would normally be considered for determining applications and the value of the digestate would rise accordingly.

Appendix E: References and bibliography

Legislation

European Union legislation

Available from <http://eur-lex.europa.eu>

- The Waste Framework Directive: Council Directive of 15 July 1975 on waste, as amended (consolidated text CONSLEG: 1975L0442 – 20/11/2003).
- The Nitrates Directive: Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC).
- The REACH Regulation: Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC.

England and Wales legislation

Available from <http://www.opsi.gov.uk>

- The Environmental Protection Act 1990
- The Waste Management Licensing Regulations 1994 (SI1994/1056)
- The Waste Management Licensing (England and Wales)(Amendment and Related Provisions)(No.3) Regulations 2005 (SI 2005/1728)
- The Pollution Prevention and Control (England and Wales) Regulations 2000 (SI 2000/1973)
- The Animal By-Products Regulations 2005 (SI 2005/2347)
- The Animal By-Products (Wales) Regulations 2006 (SI 2006/1293 (W.127))
- The Environmental Protection (Duty of Care) Regulations 1991 (SI 1991/2839, as amended by SI 1996/972 and as further amended, as they apply to England and Wales, by SI 2000/1973 and 2002/1559)
- The Environmental Permitting (England and Wales) Regulations 2007 (SI 2007/3538)
- The Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations 1991 (SI 1991/324), as amended 1997 (SI 1997/547)
- The Food Hygiene (England) Regulations 2006 (SI 2006/14)

Scottish legislation

Available from <http://www.opsi.gov.uk>

- The Pollution Prevention and Control (Scotland) Regulations 2000 (SSI 2000/323)
- The Waste Management Licensing Amendment (Scotland) Regulations 2003 (SSI 2003/171)
- The Waste (Scotland) Regulations 2005 (SSI 2005/22)

Guidance etc

Available unless otherwise specified from <http://www.defra.gov.uk>

- *Guidance Notes for Farmers on the Control of Pollution (Silage, Slurry and Agricultural Fuel Oil) Regulations*, Department of the Environment/Welsh Office, April 1997.
- *Codes of Good Agricultural Practice (England and Wales): Air Code, Soils Code and Water Code* (Defra, revised 1998). *Addenda to Air Code and Water Code* (Defra 2002).
- *Code of Good Agricultural Practice to Protect Water, Soil and Air Quality* (consultation draft of revised version for England: Defra, August 2007).
- *Nitrate Vulnerable Zones: Guidelines for Farmers* (Defra, 2002).
- *Consultation on the implementation of the Nitrates Directive in England* (Defra, August 2007).
- *Guidelines for Farmers in Nitrate Vulnerable Zones* (available from <http://www.scotland.gov.uk>)
- *Manure Management Plan: a Step-by-step Guide for Farmers* (Defra, June 2003).
- *Fertiliser Recommendations for Agricultural and Horticultural Crops* (RB 209) (7th edition, MAFF, 2000).
- *Code of Practice for the Agricultural Use of Sewage Sludge* (2nd edition, (Department of the Environment).
- *Managing Farm Manures for Food Safety: Guidelines for Growers to Reduce the Risks of Microbiological Contamination of Ready-to-eat Crops*. Final draft (Food Standards Agency, January 2005) (available from <http://www.food.gov.uk>).
- *Performance Standard for Laboratories Undertaking Chemical Testing of Soil*. Version 3. (Environment Agency, March 2006) (available from <http://publications.environment-agency.gov.uk>).

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WRAP and Environment Agency, 2008 *The Quality Protocol for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable wastes*.

Further reading

Monson KD, Esteves SR, Guwy AJ and Dinsdale RM, 2007 *Anaerobic digestion of biodegradable municipal wastes*. Sustainable Environment Research Centre (SERC), University of Glamorgan.

Appendix F: Definitions

The terms used in this document have the following meaning as agreed by the members of the TAG. They do not constitute the Environment Agency's interpretation of these terms.

| Term | Description |
|--|--|
| Accreditation | Third-party attestation related to a conformity assessment body conveying formal demonstration of its competence to carry out specific conformity assessment tasks. |
| Agriculture | Includes: soil/field grown horticulture (see below), fruit growing, seed growing, livestock farming, the use of land as grazing land, meadowland, osier land, land used for growing arable crops (such as cereals, oil seed rape and some types of vegetables) and biomass grown for non-food purposes, market gardens and nursery grounds, and woodlands where the land used is ancillary to the farming of land for other agricultural purposes. |
| Approved certification body | A third party, independent of any producer, accredited by the United Kingdom Accreditation Service (UKAS) for the operation of a product certification scheme. |
| Assessment/certification code | A unique assessment (before certification) or certification code specific to type of output from a specific process, awarded by the certification body to the producer of that output. <i>Note: The whole digestate from a specific anaerobic digestion process, and any separated fibre or separated liquor fractions derived from that whole digestate, must each have a unique assessment/certification code.</i> |
| Biodegradable | Capable of undergoing biologically mediated decomposition. |
| Biowaste | Source-separated waste that is biodegradable |
| Certification | Third-party attestation related to products, processes, systems or persons. |
| Digestate materials | Whole digestate resulting from an anaerobic digestion process, and any subsequently separated fibre or liquor. Includes any separated fibre that undergoes a subsequent aerobic stabilisation phase, without addition of further materials. |
| Quality digestate | Whole digestate resulting from an anaerobic digestion process, and any subsequently separated fibre or liquor, that conforms to the requirements of the Quality Protocol for the production and use of quality outputs from anaerobic digestion of source-segregated biodegradable waste. |
| Exposure | The contact of a receptor with a chemical, biological or physical hazard. |
| Exposure assessment | The qualitative and/or quantitative evaluation of the likely intake of biological, chemical or physical agents. |
| Forestry | The art and science of controlling the establishment, growth, composition, health and quality of forests. |
| Growing medium | Material, other than soil in situ, in which plants are grown.* |
| Hazard Analysis and Critical Control Point (HACCP) | A system used for the identification, evaluation and control of hazards which are significant for the production of materials that can be used without harm. |

* PD CR 13456: 1999 *Soil improvers and growing media. Labelling, specifications and product schedules.*

| Term | Description |
|---------------------------------|---|
| Horticulture (soil-grown) | <p>The raising of plants in soil in situ, in a field or under protective cover.</p> <p><i>Note: Includes the commercial raising of plants referred to in the definition of 'agriculture' and some types of vegetables, fruit, flowers and bulbs, hardy and other nursery stock, herbs as well as some protected crops grown in soil in situ.</i></p> |
| Land restoration | <p>This includes:</p> <ul style="list-style-type: none"> ■ land reclamation (the recovery of land from a brownfield or underutilised state to make it suitable for reuse achieved through the stabilisation, contouring, maintenance, conditioning, reconstruction and re-vegetation of the land); ■ land remediation (the process of making a site fit for purpose through the destruction, removal or containment of contaminants); and ■ soil conditioning (see below). |
| MCERTS | <p>The monitoring certification scheme established by the Environment Agency to deliver high quality environmental measurements, including a performance standard for the chemical testing of soil samples.</p> |
| Potentially toxic element (PTE) | <p>Chemical element that has potential to have toxic effects on humans, flora or fauna.</p> |
| Soil improver/soil conditioner | <p>Material added to soil in situ primarily to maintain or improve its physical properties, and which may improve its chemical or biological properties or activity.*</p> |
| Source-segregated | <p>Materials of the types and sources specified that are stored, collected and not subsequently combined with any other wastes, or any potentially polluting or toxic materials or products, during treatment or storage (before or after treatment).</p> <p><i>Note: Can include collection of a mixture of biodegradable material types from more than one source.</i></p> |

* PD CR 13456: 1999 *Soil improvers and growing media. Labelling, specifications and product schedules.*

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**Waste & Resources
Action Programme**

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The Old Academy
21 Horse Fair
Banbury, Oxon
OX16 0AH

Tel: 01295 819 900
Fax: 01295 819 911
E-mail: info@wrap.org.uk
www.wrap.org.uk

Helpline freephone
0800 100 2040



www.environment-agency.gov.uk

Tel: 08708 506 506

E-mail: enquiries@environment-agency.gov.uk

