Options for change: An opportunity to inform the review of PAS110

Who should read this document?

This document is designed for those who operate, or who are considering operating anaerobic digestion facilities that:

- Accept only source-segregated biodegradable wastes (and/or non-wastes) as feedstock; and
- Are eligible for certification to the PAS110:2010 specification (even if not currently certified)

What is the purpose of this document?

In February 2013, the following note was circulated to a range of UK AD stakeholders:

You may recall that, during December 2011 a series of workshops were hosted by WRAP, the Environment Agency and SEPA to obtain feedback on PAS110:2010, the AD Quality Protocol and the Additional Scheme Rules for Scotland (ASRS). A further workshop to discuss PAS110 and the ADQP was hosted by NIEA in Belfast during July 2012.

As a result of these workshops WRAP procured projects to examine the three aspects of PAS110 that had attracted most feedback from the AD industry:

1. *The digestate stability (RBP) test;*
2. *The near universal pasteurisation requirement;*
3. *The PTE (Potentially Toxic Element) limits.*

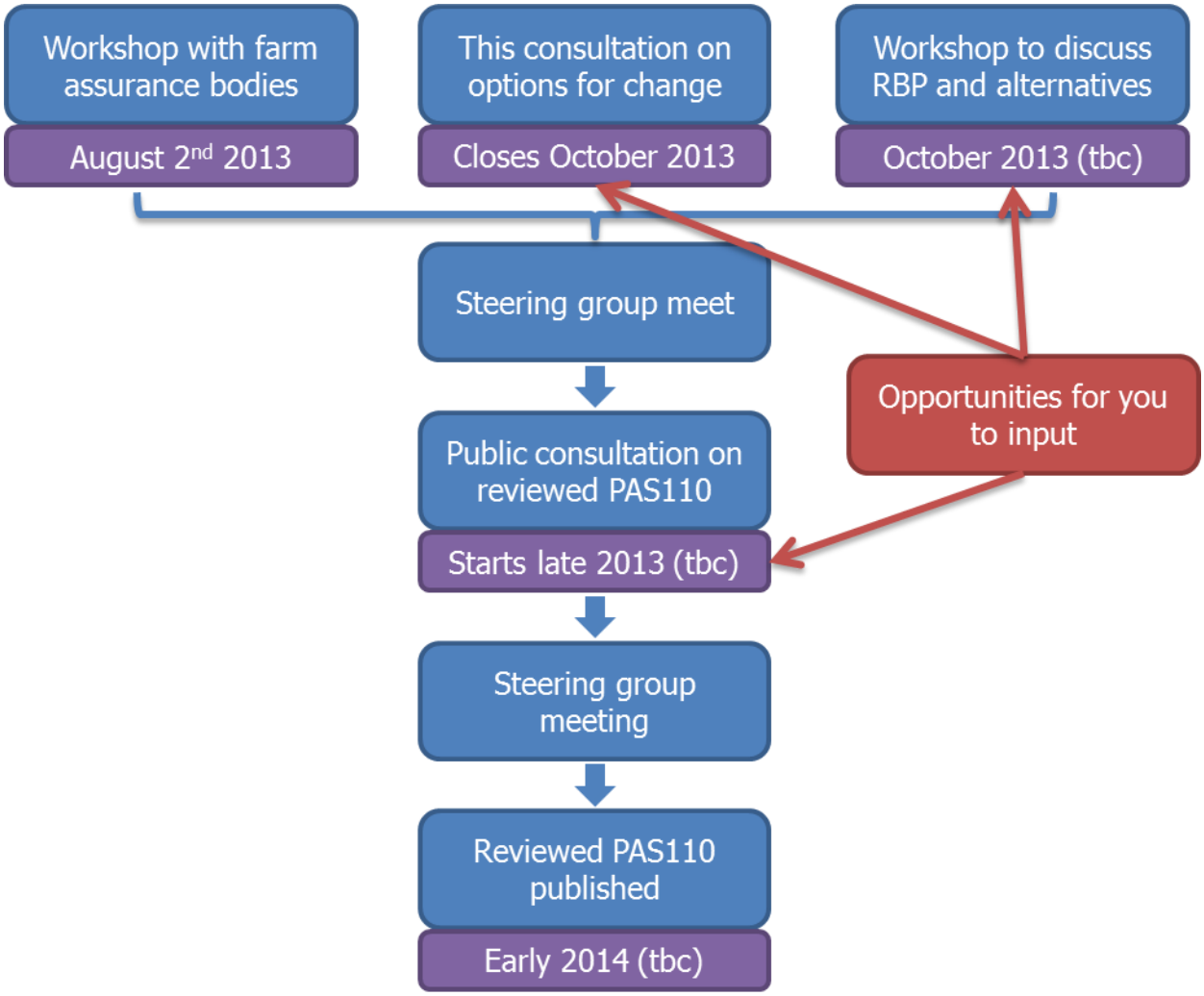
These three projects are now complete, and each project report includes a number of recommendations that (if adopted) could see changes made to PAS110. WRAP is seeking feedback from the UK AD industry on these recommendations and a number of other aspects of the PAS. This feedback will be forwarded in due course to the BSI-convened Steering Group that will oversee the formal review of the specification. We anticipate that the Steering Group itself will be convened during March or April this year.

The Steering Group actually met for the first time on 13th May, and discussed the feedback arising from the exercise described above. In some cases the feedback was clear, and it was possible for the Steering Group to reach consensus on proposed changes to PAS110. In other cases the feedback was less consistent, and consensus could not immediately be achieved on proposed changes. However, the Steering Group were still able to identify a number of options for proposed changes.

This document aims to set out the range of options considered by the Steering Group, and seeks your views on these options.

Your feedback will be discussed by the Steering Group, and final proposed changes to PAS110 agreed by them. The re-drafted PAS110 will then be made available for public consultation by the British Standards Institution (BSI). Feedback from the public consultation will be discussed by the Steering Group and a final re-draft of PAS110 produced ahead of publication. This sequence of events is illustrated overleaf.

Remaining steps in PAS110 review process



Does this document cover all aspects of PAS110 discussed by the Steering Group?

No. The Residual Biogas Potential (RBP) test is also under review as part of the PAS110 review process. A workshop with UK AD industry stakeholders is due to be held in October to discuss the RBP test, its limit, and possible replacement test or tests. Information on this workshop will be circulated separately. This document aims to present a comprehensive overview of options for change on all other aspects of PAS110 – but if you feel that omissions have been made, you are welcome to highlight these in your response.

Since the Steering Group meeting, there have been separate discussions on specific aspects of PAS110, and a formal meeting to discuss options for changes to PAS110 with farm assurance groups. These additional discussions have raised a number of further options for change, which are also set out in this document, in Section 0.

How is this document set out?

This document is colour-coded to:

Provide some background context to the proposed changes
List options for proposed changes
Request specific data or other information to help the Steering Group to reach a decision on each option

What do I need to do, and by when?

Options for proposed changes are listed throughout this document, in numerical order. These options are also listed in the accompanying Excel file 'Options paper feedback form'.

Please consider each option, and – using the Excel file – indicate whether you agree (Y) or disagree (N) with it. There is also space for you to provide comments on each option, should you wish to do so.

This document also includes a number of requests for data or other information. The text clarifies how you should provide this information.

As indicated above – you are welcome to highlight any omissions that you feel should be brought to the attention of the Steering Group. Any requests for change that are not included in the current list of options must be accompanied by information to help the Steering Group reach a decision.

Please email your completed file 'Options paper feedback form' and any other documentation to David.Tompkins@wrap.org.uk by 14th October.

Will my feedback be treated as anonymous?

Upon request. As described above, your feedback will be collated and then forwarded to the PAS110 Steering Group for their consideration. If you would prefer that your feedback were anonymised before forwarding to the Steering Group, then please make this clear in your response.

1.0 Scope of PAS110, and inclusion of aerobic digestates

The Scope of PAS110:2010 is currently given as:

This Publicly Available Specification (PAS) covers whole digestate from an anaerobic digestion (AD) system that accepts only source segregated biowastes (see 3.75 and 3.8) and/or biodegradable non-waste materials (see 3.7). It also covers liquor and fibre fractions that may be produced by separating whole digestate, after the anaerobic digestion process.

The Steering Group discussed whether this scope could be extended to include aerobic digestates from processes such as Thermophilic Aerobic Digestion (TAD). At present the separated fibre fraction of aerobic digestates can be certified to the compost specification (PAS100:2011), if it complies with the necessary criteria. However, while whole aerobic digestates and separated aerobic digestate liquors can be used as inputs to PAS110:2010 anaerobic digestion processes, they cannot be certified to a specification in their own right, and have no formal mechanism for being deemed 'end-of-waste'.

To date, no data on the characteristics of aerobic digestates have been provided to the PAS110 Steering Group. Likewise, no suggestions for adjustments to the current PAS110 test parameters have been provided to the PAS110 Steering Group, which might have allowed them to consider extending the scope of PAS110.

Under these circumstances it was suggested that operators of aerobic digestion facilities should approach the environmental regulators to discuss options for bespoke end of waste determinations for their facilities.

Option

[1] Retain current scope for PAS110, which excludes aerobic digestates as outputs eligible for certification to PAS110

2.0 Pasteurisation requirement

2.1 Background

At present any AD process accepting feedstocks that include animal by-products (ABP) must include a pasteurisation step. This is a statutory requirement, and PAS110 provides no opt-out to this requirement. There is no suggestion that PAS110 could provide an opt-out to the statutory ABP pasteurisation requirement. However, there is no such regulatory requirement covering AD processes accepting only crops grown for AD, or other non-ABP such as vegetable processing residues.

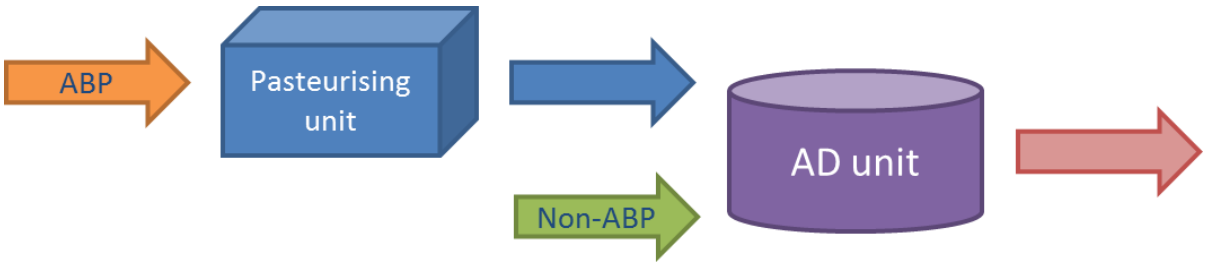
Due to uncertainties around the plant health risks associated with digestates derived from non-pasteurised plant residues, PAS110:2010 processes must include a pasteurisation step for these non-ABP inputs in most circumstances. Exceptions are listed in PAS110:2010 Clauses 7.2.2 and 7.2.4:

7.2.2 Digested materials made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arise within the producer's premises or holding and that are used entirely within the same premises or holding are exempt from the pasteurization step (7.2.1)… This clause does not apply to a farming / horticultural / forestry co-operative (see 3.28).

7.2.4 Exemption from the pasteurization step (7.2.1) is also allowed for manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding (see 7.2.3 for allowed source before use) that arises within the producer's premises or holding, if such input materials are co-digested with pasteurized biodegradable materials / wastes from any source(s) outside the producer's premises or holding. This material source-specific exemption from pasteurization is conditional upon all the digested material being used within the producer's premises or holding, irrespective of whether it is part of a farming / horticultural / forestry co-operative (see 3.28).

In brief, this means that pasteurisation of manure, unprocessed crops, processed crops, crop residues, glycerol and/or used animal bedding is not required – if the resulting digestate is applied on the same premises or holding from which those materials arose. The same exemption applies when these materials are mixed with other feedstocks – so long as those other feedstocks have been pasteurised.

Such a system could be represented like this:



At the moment the use of the digestates from these systems are restricted to the 'premises or holding' from which the eligible non-pasteurised non-ABP inputs arose.

It has been suggested that – now that more information is available on plant health risks – the current PAS110 pasteurisation approach to non-ABP feedstocks could be re-considered. As part of the pre-consultation leading up to the PAS110 review, WRAP circulated a report from Fera (Food & Environment Research Agency) that examined the impacts of AD with and without pasteurisation on a range of plant diseases of interest. This showed that all of the organisms under investigation would be eliminated if subjected to 24 hours under mesophilic anaerobic digestion conditions (without pasteurisation) or within one hour at 70°C (pasteurisation).

Pasteurisation processes are designed not to be by-passed, so that all input material can be guaranteed to have been subjected to the required time at the required temperature.

In continuous or semi-continuous fill-and-draw AD systems, there is a possibility that some of the input material will not be subjected to 24 hours of anaerobic digestion. This means that there is a small (although un-quantified) risk that untreated plant material could be present in the digestate, when produced from systems that do not include a pasteurisation step.

Set against this, it should also be considered that, when the only inputs to an anaerobic digestion process are crops grown specifically for AD (such as maize), the resulting digestate is not considered a waste, and could be used freely on any agricultural land / crop within the boundaries of Codes of Good Agricultural Practice (and other umbrella restrictions, such as those imposed in Nitrate Vulnerable Zones). If manures are added as another feedstock in these systems, then the environmental regulators are also content not to regulate the resulting digestates as wastes[1], which can then be transported and used freely. Pasteurisation is not required for either of these systems.

The discussion in the Steering Group (and subsequently, with farm assurance groups) has focussed on the possible survival of the spores of *Fusarium* fungi during AD, when the system does not include a pasteurisation phase. When certain *Fusarium* species infect wheat crops, mycotoxins can be produced that impact on the quality and usability of the wheat grain. Maize is known to be a host for mycotoxin-forming *Fusarium* species, and the risks from maize crop residues to following wheat crops are factored into the HGCA mycotoxin risk assessment[2]. This risk assessment contains no explicit reference to maize-based digestates.

Evidence suggests that *Fusarium* spores are killed during pasteurisation at 70°C for one hour, or exposure to mesophilic anaerobic digestion conditions for twelve hours. For example, Figure 2-1 presents data showing complete inactivation of *Fusarium* spores in infected grain within twelve hours under both mesophilic and thermophilic conditions.

[1] http://www.environment-agency.gov.uk/static/documents/Research/PS_029_AD_of_agricultural_manures_and_slurry_final.pdf
[2] http://www.hgca.com/document.aspx?fn=load&media_id=8828&publicationId=9293

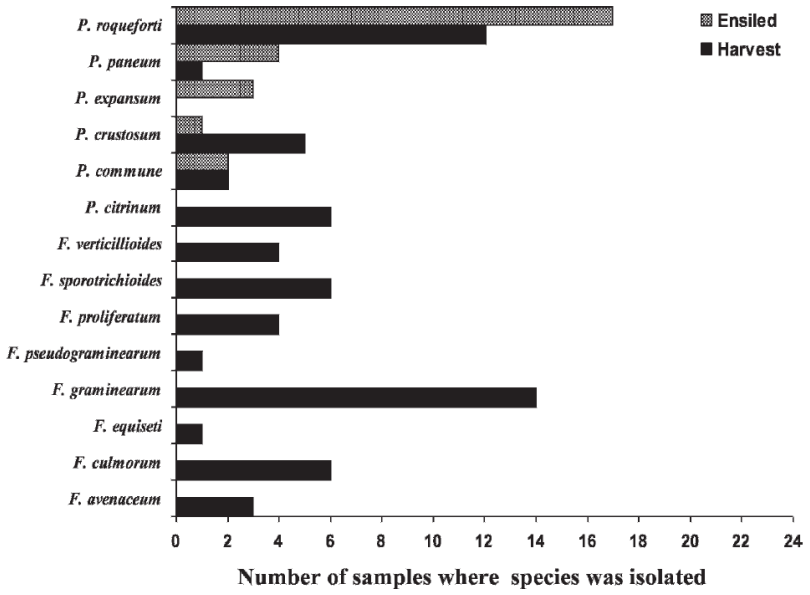
Figure 2-1 Table illustrating the impact of different fermentation / digestion treatments on the survival of *Fusarium* spores in infected grain (from Frauz B, Weinmann U, Oechsner H & Jungbluth T (2007) *Disposing of Contaminated Grain Batches* Landtechnik 5: 334 – 335)

Operation	Operation temperature	Substrate	Arrangement of inoculation	Duration of fermentation	Evidence of complete inactivation
Batch, Liquid-fermentation	mesophil (37°C)	mould-free material	isolated spores	0 - 96 hours	3,5 hours
Batch, Liquid-fermentation	mesophil (37°C)	moulded material	naturally in-fected cereals	12 hours - 35 days	12 hours
Batch, Liquid-fermentation	thermophil (53°C)	moulded material	naturally in-fected cereals	12 hours - 35 days	12 hours
Batch, solidphase digestion	mesophil (37°C)	moulded material	naturally in-fected cereals	12 hours - 35 days	12 hours

There is also some evidence to suggest that the act of ensiling maize (prior to anaerobic digestion) also kills *Fusarium* spores. Figure 2-2 shows the recovery of a range of fungi from maize at harvest and then after ensilement. The *Penicillium* species were recovered from the ensiled maize, whilst the *Fusarium* species were not.

The findings of other authors are more equivocal. For example González Pereyra *et al* (2008)[3] isolated viable spores of various *Fusarium* species from maize silage in Argentina.

Figure 2-2 Mycotoxigenic *Penicillium* and *Fusarium* species isolated from maize at harvest and after ensiling (from Mansfield MA & Kuldau GA (2007) *Microbiological and molecular determination of mycobiota in fresh and ensiled maize silage* Mycologia 99(2): 269 – 278)



[3] Pereyra ML González, Alonso VA, Sager R, Morlaco MB, Magnoli CE, Astoreca AL, Rosa CAR, Chiacchiera SM, Dalcero AM, Cavaglieri LR (2008) *Fungi and selected mycotoxins from pre- and postfermented corn silage* Journal of Applied Microbiology 104(4): 1034 - 1041

It has been suggested that this information should permit the use of digestates derived from maize feedstock on a wider range of premises than is permitted by PAS110:2010. This could mean use of such digestates within co-operatives or other entities that provided the maize feedstock – since this allows those entities to maintain 'line of sight' of the digestate, understanding and managing any residual *Fusarium* risks. It could also mean allowing the use of such digestates on the open market, although the discussions to date have indicated that further evidence would be desirable before this step could be taken.

Since the discussion has focussed on the potential fate of *Fusarium* species associated with maize feedstocks, it is not possible to generalise about the potential fate of other plant pathogens that might be associated with other feedstocks currently exempt from pasteurisation as described in Clauses 7.2.2 and 7.2.4 of PAS110:2010. However, the general principle of maintaining 'line of sight' for such digestates could also be applied to these materials.

Options

[2] Retain current approach to pasteurisation, as outlined in Clauses 7.2.2 and 7.2.4 in PAS110:2010; or

[3] Amend the current exemptions from pasteurisation (listed in Clauses 7.2.2 and 7.2.4 in PAS110:2010) to allow such digestates to also be used within a co-operative (or equivalent) from which the non-pasteurised feedstocks arose; or

[4] Amend the current exemptions from pasteurisation (listed in Clauses 7.2.2 and 7.2.4 in PAS110:2010) to allow digestates derived from non-pasteurised silage maize to be supplied to the open market in the same way as any other 'fully pasteurised' PAS110 digestates.

An additional facet is encountered at AD facilities that accept non-ABP 'waste' materials, such as vegetable off-cuts from produce grown overseas and processed in the UK. At present, such operators have three time/temperature/particle size options for pasteurisation (PAS110:2010, Annex A), including 70°C for one hour at 12mm. If they want to use a different option, then this currently has to be validated by Animal Health (AHVLA) – even though the process is not accepting (and not intending to accept) Animal By-Products.

Could such facilities adopt a specific plant health validation step, which demonstrates the effectiveness of their time/temperature regime by elimination of a pre-determined indicator organism (such as club root of brassicas)? Such an approach is already in place in Germany, which comprises a phytohygiene validation regime based on survival of tobacco mosaic virus, club root of brassicas and tomato seeds[4].

[4] http://www.ramiran.net/doc98/FIN-POST/BOHM.pdf

Options

[5] Retain current options for pasteurisation approaches, as listed in Annex A of PAS110:2010; or

[6] Include a phytohygiene validation regime in PAS110 to allow relevant facilities to adopt novel time/temperature regimes that are not currently listed in Annex A of PAS110:2010.

Furthermore, there are situations where the entire AD feedstock will already have undergone a prior thermal treatment process. Is it reasonable that PAS110 require that these be subjected to a further pasteurisation step, even if they originate from processes that exceed the standard pasteurisation options recommended in PAS110:2010 (Annex A)? Distillery residues would be one example. How would one judge whether or not these materials had undergone treatment that had met or exceeded the standard pasteurisation options recommended in PAS110:2010 (Annex A)? Pasteurisation units (PU) are used in other food processing sectors to determine equivalence between different time/temperature regimes[5]. Could the principle be adopted into PAS110?

Option

[7] Remove the requirement to pasteurise non-ABP inputs, where it can be demonstrated that they arise from (or have previously been subjected to) processes that include a documented thermal treatment phase equivalent to (or in excess of) 70°C for one hour – and where these processes are covered by a suitable Quality Management System that can be made accessible to audit as part of the PAS110 certification process.

Data request A

There is a particular need to obtain data to inform the discussion around Option [7]. Please forward:

- Data demonstrating the equivalence between 70°C for one hour and other time/temperature regimes to deliver similar impacts on a range of plant pests and diseases;
- Data to support a 'Pasteurisation Unit' (PU) approach for AD feedstocks or digestates. The PU approach would apply a simple formula to time/temperature impacts and (in theory) allow an infinite number of options equating to 70°C for one hour to be used.

Please email these data directly to David.Tompkins@wrap.org.uk by 14th October

[5] *http://sizes.com/units/pasteurization_unit.htm*

3.0 PTE limits

3.1 Background

The current PTE (potentially toxic element) limits in PAS110 are directly transposed from the compost specification (PAS100), and are set on a dry matter basis. This was due to lack of data to consider alternatives when PAS110 was first developed. The current limits in PAS110 are listed in Table 3-1.

Table 3-1 Current PAS110 PTE limits

PTE	Limit (mg/kg dry matter)
Cd	1.5
Cr	100
Cu	200
Pb	200
Hg	1.0
Ni	50
Zn	400

When PAS110 was developed it was recognised that these limits could prove difficult to achieve, since the process of anaerobic digestion itself breaks down dry matter. Compost typically comprises 60% dry matter, whilst whole digestates typically comprise 5% dry matter. In practice this means that PTE concentrations in fresh digestate have to be twelve times lower (60/5) than PTE concentrations in fresh compost to have a chance of meeting the current dry matter limits.

To counter this, an opt-out was included in PAS110:2010 (Clause 14.1.6). This meant that – where whole or separated liquor digestates exceeded the dry matter PTE limits, they could still be certified as PAS110-compliant if:

1. The soils to which they were applied did not receive more than the maximum permissible annual average rate of PTE addition over a 10 year period, as specified in the Code of Practice for Agricultural Use of Sewage Sludge; and
2. The soils to which they were applied did not exceed any soil PTE concentration, as specified in the same Code.

In conjunction with Clause 14.1.7 this opt-out would effectively require that PAS110-compliant AD operators kept records for all soils that had received digestates. Whilst this is possible, it does not lend itself to ease of auditability within the PAS, since the accuracy of those records would then fall within the scope of the PAS certification process – and would have to be checked by the certifying bodies.

Removing the 'sewage sludge opt-out' would render the PAS more auditable and robust, but would not remove the underlying difficulty caused by the current dry matter PTE limits. Since the most important aspect of PTEs is the quantity spread per unit area of soil (the 'loading rate'), and digestates are spread fresh (rather than dried), then setting appropriate new PTE limits on a fresh weight basis could overcome the dry matter difficulty, whilst still ensuring that digestates presented very low PTE risks to the environment when used.

3.2 Options for change?

In their report circulated before the start of the PAS110 review process, ADAS examined this question, and suggested fresh weight PTE limits for digestates. To do this, they compared the PTE loading rates from PAS100 composts, with PTE loading rates from digestates, and suggested new fresh weight limits for digestate that would give PTE loading rates well below those allowed for compost but still achievable for the majority of AD operators. Loading rates were based on the total nitrogen (N-tot) contents of the different materials, normalised against typical application rates of 250kg of N-tot per hectare.

Rather than suggest different limits for whole digestate, separated liquor digestate and separated fibre digestate, ADAS proposed two sets of limits – one for digestates with dry matter contents below 15% (Table 3-2), and one for digestates with dry matter contents at or above 15% (Table 3-3). This was in recognition of the current PAS110 distinction between wet and dry AD processes, the way in which laboratories tend to process these materials, and the German approach to digestate quality management – which differentiates between digestates with more or less than 15% DM.

The graphs presented in Figure 3-1 and Figure 3-2 are extracted from the ADAS report, and illustrate the qualitative approach they took to suggest the new limits for zinc (Zn) and copper (Cu) in digestates of less than 15% DM. Whilst they could have (theoretically) suggested higher limits (the 'theoretical limit', which would match the loading rates of PAS100 composts), they have opted for something that is lower – but still achievable for all but one sample. This approach was taken to demonstrate a commitment to quality, with PTE limits lower than those allowed for PAS100 composts. Further data are required to sense-check this thinking, and the suggested limits (see below).

Figure 3-1 Extract from the report *An examination of the limits for potentially toxic elements (PTEs) in anaerobic digestates*, available on request from WRAP

Figure 23. Fresh weight Zn concentrations in samples of whole and separated liquid food-based digestates showing the theoretical limit and proposed precautionary limit concentrations

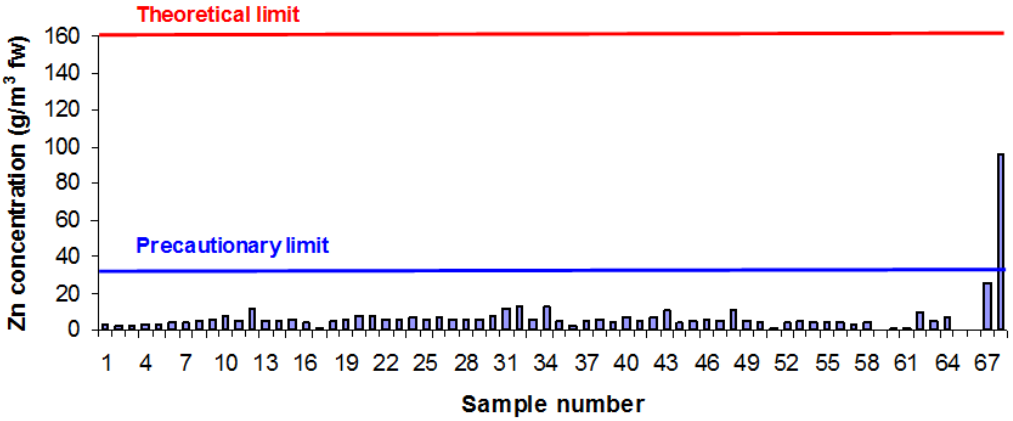


Figure 3-2 Extract from the report *An examination of the limits for potentially toxic elements (PTEs) in anaerobic digestates*, available on request from WRAP

Figure 24. Fresh weight Cu concentrations in samples of whole and separated liquid food-based digestates showing the theoretical limit and proposed precautionary limit concentrations

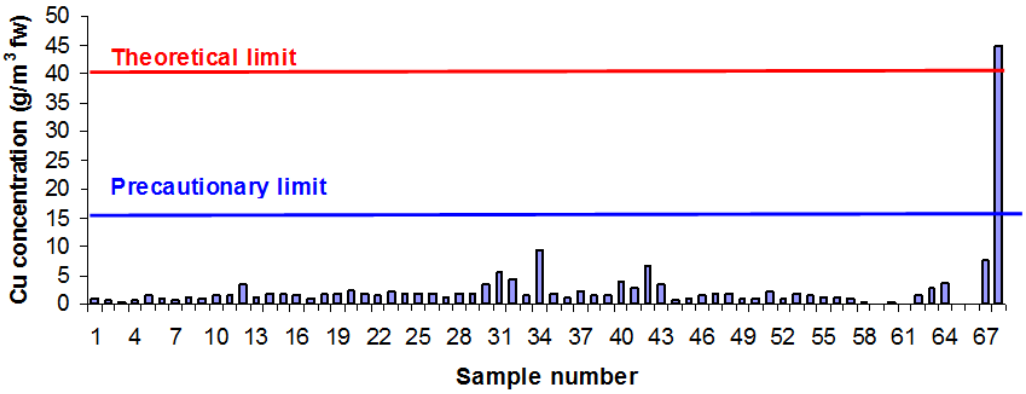


Table 3-2 Proposed fresh weight PTE limits for digestate with dry matter below 15%, and the PTE loading rates that would result, compared with PTE loading rates for compost

	FW limits (mg/l)	Loading rates (g/ha)	
		Compost*	Digestate*
Cd	**0.2**	30	13.6
Cr	**5.0**	2,000	340
Cu	**15**	4,000	1,020
Pb	**5.0**	4,000	340
Hg	**0.1**	20	6.8
Ni	**3.0**	1,000	204
Zn	**30**	8,000	2,040

*Compost N-tot = 7.5kg/m^3; Digestate N-tot = 3.7kg/m^3

Table 3-3 Proposed fresh weight PTE limits for digestate with dry matter at or above 15% and the PTE loading rates that would result, compared with PTE loading rates for compost

	FW limits (mg/kg)	Loading rates (g/ha)	
		Compost*	Digestate*
Cd	**0.2**	30	9.2
Cr	**20**	2,000	920
Cu	**30**	4,000	1,380
Pb	**30**	4,000	1,380
Hg	**0.1**	20	4.6
Ni	**5.0**	1,000	230
Zn	**150**	8,000	6,900

*Compost N-tot = 7.5kg/m^3; Digestate N-tot = 5.4kg/m^3

Options

[8] Retain current (dry matter) limits for PTEs; or

[9] Set new PTE limits for digestates on a fresh weight basis.

[10] Set new PTE limits based on loadings that are achieved by the majority of digestate samples (as determined by the Steering Group); or

[11] Set new PTE limits based on loadings that are allowed for PAS100 composts.

[12] Retain a single set of PTE limits, covering all digestate fractions; or

[13] Adopt two different sets of PTE limits, depending upon whether the digestate dry matter content is above or below a pre-defined threshold; and

[14] Set the threshold for defining types of digestate at 15% dry matter.

These limits have been based on loading rates that were calculated by using nitrogen concentrations in digestate (N-tot) as the parameter that restricts the quantity of digestate that can be spread on each hectare. PTE loading rate estimates presented in the tables above are based on the lowest N-tot data points that WRAP have for digestates in each category (<15% DM and ≥15% DM). However, it is possible that digestates are (or could be) produced with lower N-tots, and that loading rates could be higher than estimated. WRAP would like to collate more N-tot data for a range of digestates, and circulate this to the Steering Group, who will then check that the limits proposed by ADAS remain appropriate. Should this not be the case, then one option might be to retain the current dry matter limits for digestates that contain very low N-tot, but to move to fresh weight limits for those in which data give us more confidence that PTE loadings will remain low. Another option might be to model PTE loading rates based on digestate phosphorus (P) contents, and to suggest new PTE limits accordingly.

Options

[15] Set an N-tot threshold, below which different PTE limits would apply; or

[16] Set PTE limits based on P loading rates.

Discussions in Europe to develop EU-wide 'end of waste' criteria for *biodegradable wastes subject to biological treatment*[6] have proposed that, if the dry matter zinc concentration in compost or digestate exceeds 400mg/kg, then this must be declared. An upper limit for zinc concentration is proposed at 600mg/kg. It would be possible to estimate zinc loading rates

[6] http://susproc.jrc.ec.europa.eu/activities/waste/documents/IPTS%20EoW%20Biodegradable%20waste%20Draft%20Final%20Report.pdf

for composts with dry matter zinc concentrations of 600mg/kg, and to set fresh weight zinc concentrations for digestate that would give an equivalent zinc loading rate. This approach could lead to higher zinc loadings in digestate than are currently permitted for PAS100 composts.

Options

[17] Set a zinc fresh weight limit for digestate based on zinc loadings that could result from spreading compost that has a zinc concentration of 600mg/kg dry weight; or

[18] Set zinc fresh weight limits for digestate as described in either of Options [10] or [11] above.

The same European discussions have proposed a dry matter limit for lead (Pb) of 120mg/kg for both compost and digestates. This is below the current dry matter lead limits for PAS100 compost and PAS110 digestate. It would be possible to estimate lead loading rates for composts with dry matter lead concentrations of 120mg/kg, and to set fresh weight lead concentrations for digestate that would give an equivalent lead loading rate. This approach could lead to lower lead loadings in digestate than are currently permitted for PAS100 composts.

Options

[19] Set a lead fresh weight limit for digestate based on lead loadings that could result from spreading compost that has a lead concentration of 120mg/kg dry weight; or

[20] Set lead fresh weight limits for digestate as described in either of Options [10] or [11] above.

Data request B

The ADAS report included data for digestates that had been produced up to the beginning of 2012. The AD industry has grown substantially since then, and it is likely that far more PTE data are now available. WRAP would like to collate this data and circulate it to the Steering Group, so that we can check that the limits proposed by ADAS remain appropriate, and undertake modelling to consider other approaches to limit setting (as described above).

Could you therefore please provide the following data for any digestate samples produced from processes that would be eligible for inclusion within PAS110 (derived from source-segregated biodegradable inputs – which would include wastes and non-waste materials):

- Dry matter content
- PTE concentrations (to include Cd, Cr, Cu, Pb, Hg, Ni, Zn), expressed on a dry matter basis
- Nitrogen concentrations, expressed as total nitrogen (N) on a fresh weight basis
- Phosphorus concentrations, expressed as total phosphate (P_2O_5) on a fresh weight basis
- The test methods used
- Please also provide a generic description of the feedstocks, particularly identifying whether they include any of: farmyard manures, livestock slurries, poultry litter

Please insert these data into the accompanying Excel file 'Options paper feedback form' or email them directly to David.Tompkins@wrap.org.uk by 14th October

3.3 Laboratory implications

At present, the specified method for testing PTEs in PAS110:2010 is BS EN 13650. This requires that samples be air-dried, and the resulting dry matter analysed. Since whole digestates tend to have low dry matter contents, this means that large samples are needed to produce small quantities of dry matter – and that drying the samples takes up time and space in the laboratory.

NRM laboratories have suggested that PAS110 require that low dry matter digestates be tested for PTEs using a method designed for slurries (BS 15587-1:2002), and have provided the following comparison of data for whole digestate samples that were tested fresh (as per BS 15587-1) and dried (as per BS EN 13650):

3.3.1 Comparing PTE data for whole digestates using BS EN 13650 and BS 15587-1 (courtesy of NRM laboratories)

Two approaches were tried for the digestion of whole digestates, the first involved the digestion of 5g of fresh sample in 12ml of Aqua-Regia (based on BS 15587-1) and the second involved the digestion of 1g of dried sample in 12ml of Aqua-Regia (based BS EN 13650). [Aqua-Regia is a mixture of concentrated nitric and concentrated hydrochloric acids.]

3.3.1.1 Overall summary (courtesy of NRM laboratories)

Fresh Sample Digestion

For

- Quick and easy sample preparation
- Minimal sample handling therefore less chance of contamination
- No foaming observed during digestion

Against

- Higher limit of quantification (LOQ) than dried sample
- LOQ is dry matter dependant when reported on a "Dry Matter" basis

Dried Sample Digestion

For

- Generally better repeatability (due primarily to higher dry matter content of digest)
- Lower LOQ than fresh sample
- LOQ is not dry matter dependant when reported on a "Dry Matter" basis

Against

- Long drying times (typically 2-3 days at 30°C)
- Samples with a low dry matter require large amounts of sample to be dried
- Samples with a high oil/fat content don't dry completely and therefore cannot be ground
- More sample handling, therefore more chance of contamination during drying and grinding
- Foaming observed during digestion

3.3.1.2 Results (courtesy of NRM laboratories)

Table 3-4 Data for a range of PTEs in three digestate samples, duplicate subsamples of which were analysed either fresh or dried (RSD is a measure of variability, normally considered to be the standard deviation of a dataset, divided by the mean of the dataset, and expressed in units of percent; LOQ is the limit of quantification). All results are corrected to a "Dry Matter" basis, and presented as mg/kg dry matter.

Sample	Fresh Sample						Dried Sample					
	Cd	Cr	Cu	Pb	Ni	Zn	Cd	Cr	Cu	Pb	Ni	Zn
1	0.215	7.38	28.0	1.23	2.92	118	0.103	7.07	27.4	1.36	2.71	112
1	0.154	7.85	28.5	1.08	2.92	122	0.107	6.98	27.1	1.24	2.67	115
1	0.092	7.08	26.9	1.08	2.92	114	0.101	7.10	27.0	1.31	2.74	112
Mean	0.154	7.44	27.8	1.13	2.92	118	0.104	7.05	27.2	1.30	2.71	113
RSD	40.0	5.2	2.8	7.9	0.0	3.1	2.9	0.9	0.8	4.6	1.3	1.5
2	0.316	22.1	115	3.86	7.37	306	0.298	20.0	103	4.63	6.57	286
2	0.316	21.1	108	2.81	7.72	302	0.321	19.9	108	4.78	6.58	297
2	0.386	21.4	110	2.81	7.37	307	0.320	19.7	105	4.74	6.39	293
Mean	0.339	21.5	111	3.16	7.49	305	0.313	19.9	105	4.72	6.51	292
RSD	11.9	2.5	3.4	19.2	2.7	0.8	4.2	0.8	2.4	1.6	1.6	1.9
3	0.285	10.5	32.0	1.54	11.4	188	0.321	12.2	31.5	2.57	11.0	192
3	0.307	11.8	30.7	1.54	12.1	192	0.253	9.8	27.6	1.99	9.2	164
3	0.307	10.5	27.2	1.10	11.0	172	0.298	11.2	30.6	2.12	10.5	185
Mean	0.300	11.0	30.0	1.39	11.5	184	0.291	11.1	29.9	2.23	10.2	180
RSD	4.2	6.9	8.3	18.2	4.8	5.5	11.9	10.8	6.8	13.7	9.0	8.1
LOQ	0.4	4	4	20	10	20	0.1	1	1	5	2.5	5

Options

[21] Retain current approach, requiring PTE determination in all digestate fractions according to BS EN 13650; or

[22] Adopt BS 15587-1:2002 for whole and liquor digestates, and retain BS EN 13650:2001 for fibre digestates.

4.0 Physical contaminants

4.1 Background

The current physical contaminant limits in PAS110 were directly transposed from the compost specification (PAS100:2005), and are set on a dry matter basis. This was due to lack of data to consider alternatives when PAS110 was first developed. The current requirements in PAS110 are:

Total glass, metal, plastic and any 'other' non-stone, man-made fragments > 2 mm;

- *Limit: 0.5% m/m dry matter, of which none are 'sharps'*

Since the process of anaerobic digestion breaks down dry matter, this limit – as with the current PTE limits – can be extremely difficult to achieve, while the loading rate of physical contaminants in digestate remains much lower than is theoretically possible with PAS100 composts.

This problem can be exacerbated by the presence of compostable and biodegradable bags in AD feedstocks, since these do not tend to break down under anaerobic conditions, and would be classified as physical contaminants in digestates – even though they would be likely to break down in soil once the digestate had been spread.

To address these difficulties, it has been suggested that the physical contaminant limits in PAS110 could be moved from the current dry matter basis to a fresh weight basis, which takes into account the typical loading rate of physical contaminants that might result. The approach outlined for PTEs in Section 3.0 (comparing loading rates from digestates and composts) could be used here. To date, no data have been made available to inform this debate.

Options

[23] Retain current (dry matter) limits for physical contaminants; or

[24] Set new physical contaminant limits on a fresh weight basis.

WRAP is not aware of a cost-effective test that is able to discriminate between different kinds of plastic (biodegradable / compostable and other), but if this were available, then it might be possible to exclude biodegradable / compostable plastics from the calculation of physical contaminant levels.

Option

[25] Implement a new test methodology that discriminates between biodegradable / compostable, and other plastics – and excludes the former from calculation of physical contaminant levels.

Data request C

As indicated above, no data have yet been provided to the Steering Group to inform this debate. Without such data it will not be possible to consider changes to PAS110. Could you therefore please provide the following data for any digestate samples produced from processes that would be eligible for inclusion within PAS110 (derived from source-segregated biodegradable inputs, which would include wastes and non-waste materials):

- Dry matter content
- Physical contaminant content (including breakdown into >5mm stones, glass, metal, plastic and any 'other' non-stone, man-made fragments > 2 mm), expressed on a dry weight basis
- Nitrogen concentrations, expressed as total nitrogen (N) on a fresh weight basis
- Phosphorus concentrations, expressed as total phosphate (P_2O_5) on a fresh weight basis
- The test methods used

Please insert these data into the accompanying Excel file 'Options paper feedback form' or email them directly to David.Tompkins@wrap.org.uk by 14th October

Data request D

If you are aware of a commercially-viable test that can discriminate between compostable/biodegradable and other plastics, **please email a copy of (or link to) the methodology to David.Tompkins@wrap.org.uk by 14th October**

The Steering Group was also asked to consider the option of allowing non-biodegradable packaging to be removed after the AD step. At present, AD facilities can accept biodegradable material onto site in non-biodegradable packaging. However, as stipulated in Clause 6.1 of PAS110:2010, any such non-biodegradable packaging must be removed prior to digestion:
The pre-treatment shall remove any non-biodegradable packaging prior to loading those biowastes / biodegradable materials into the digestion system.

Any change to this approach (for example, by allowing non-biodegradable packaging to be removed after digestion) could conflict with permitting / licensing restrictions, which only allow source-segregated biodegradable wastes to be digested on sites that intend to supply the resulting digestates to agricultural land. However, it is possible that incidental contamination of biodegradable wastes with non-biodegradable packaging might occur – and under such circumstances, post-digestion separation would be desirable.

Options

[26] Retain current approach (as set out in PAS110:2010 Clause 6.1); or

[27] Discuss options for and implications of change to PAS110:2010 Clause 6.1 with the environmental regulators, and agree an approach that maintains digestate quality.

5.0 Validation of PAS110 processes

5.1 Background

Validation is intended to demonstrate that the AD system will produce digestate of the desired quality when operated within the conditions set out in the Quality Management System (QMS). This would include the whole range of feedstock materials allowed by PAS110 that the process might be expected to accept for digestion.

The validation approach in PAS110 currently requires that digestates achieve 'three in a row' passes for all minimum digestate quality criteria listed in the PAS (Table 1 and Table 2). The intervals between sampling are listed in PAS110:2010, Clause 10.6:

10.6 The minimum time between taking each representative sample from a portion of production shall not be less than the minimum necessary retention time in the digester

The note to this Clause clarifies that:

NOTE The minimum necessary retention time is determined by the producer, or perhaps the Animal Health vet in the case of animal by-products, as appropriate to the AD system and the nature and loading rates of the input materials that it treats. The HRT and/or OLR operated by the producer partly reflect and influence the minimum necessary retention time in the digester. The producer may use the AD system's minimum HRT or maximum OLR figure as a surrogate for 'minimum necessary retention time'.

In practice, it seems that minimum hydraulic retention times (HRT) are being used to set sampling intervals. If the HRT is 100 days, then a minimum period of 300 days (plus turnaround time in the laboratory) must have elapsed before a plant can hope to demonstrate the necessary 'three in a row' passes for validation in PAS110. Should any digestate sample fail one of the minimum quality parameters during this period, then the 'three in a row' approach would start again for that parameter.

This approach was discussed during the first Steering Group meeting, and there were suggestions that it was excessively onerous. However, while a number of alternatives were considered – that all suggested reduced validation periods – consensus could not be reached due to lack of data illustrating how digestates change over time. Two of these options are listed below.

Options

[28] Monthly sampling over a period of twelve months, testing for a sub-set of PAS110 digestate quality parameters at each interval (pH, total N, total P, total K, ammoniacal N, Cd, Cu, Cr, Hg, Ni, Pb, Zn PTE contents) with remaining parameters tested at quarterly intervals; or

[29] Monthly sampling over a period of three months, testing for the entire suite of PAS110 determinands on each occasion; or

[30] Another approach, to be agreed by the Steering Group, based on the data that are available.

Data request E

As indicated above, no data have yet been provided to the Steering Group to inform this debate. Without such data it will not be possible to consider changes to PAS110. Could you therefore please provide the following data for any digestate samples produced from processes that would be eligible for inclusion within PAS110 (derived from source-segregated biodegradable inputs, which includes both waste and non-waste materials):

- 'Time series' data illustrating how digestate quality varies over a period of at least three minimum hydraulic retention times – and (ideally) over one calendar year. Please specify the sampling dates for each sample for which you are able to provide data.

Such 'time series' data for any of the current PAS110 quality parameters would be useful. These include: pH, total nitrogen, PTE concentrations, physical contaminant contents, Residual Biogas Potential (RBP) values.

Data should only be supplied for samples that have been taken from the same point in the process over a number of weeks or months.

Please email these data directly to David.Tompkins@wrap.org.uk by 14th October

6.0 Other Steering Group discussions

6.1 Determining compliance with threshold values

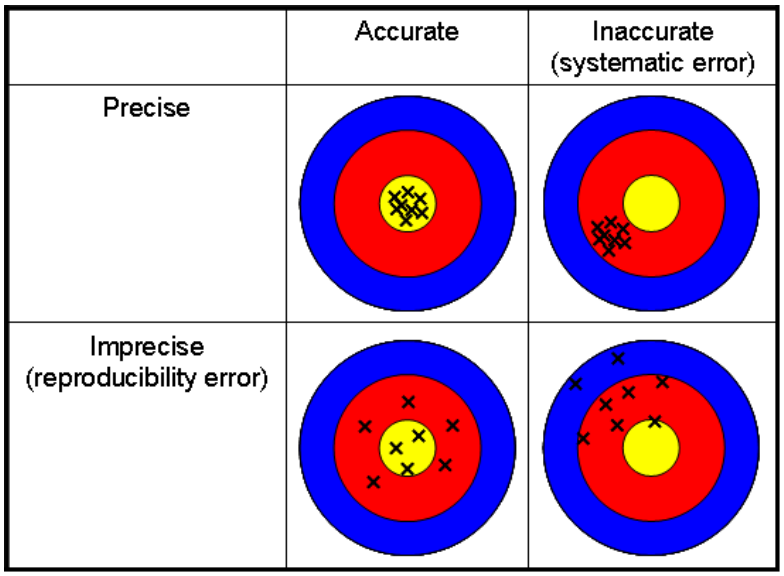
The business implications of the current pass/fail approach to quality parameters have also been raised. The relationship between PAS110 and the UK end of waste positions for digestate means that non-conformances can result in digestate returning to 'waste' status at very short notice, with associated environmental permitting or waste management costs. The PAS110:2010 requirement to demonstrate absolute conformance against the various test thresholds, and the impact that even a minor non-conformance can have on digestate product status has been described by some in the AD sector as a 'cliff edge'. Smoothing this edge could be achieved through a number of approaches.

Errors can arise during digestate sampling, digestate sub-sampling, and digestate analysis. At present, PAS110:2010 includes no consideration of measurement variances associated with sampling or analysis. Such variances are likely to be site/process/laboratory specific, but at present are unknown.

Understanding the variances within and between laboratory measurements would allow tolerances around the limit for each parameter to be built into PAS110. However, such variances may well be far less than those arising from the sampling of material for testing.

At the time of writing, only one laboratory has been appointed by the Biofertiliser Certification Scheme to undertake digestate analyses for the purposes of determining compliance with PAS110:2010. Other laboratories offer the same suite of tests, but at present there is no formal proficiency scheme in place for laboratories analysing digestates. This means that while it should be possible to determine the variability in precision for each test, it is unlikely that data are currently available to determine the accuracy of each test (Figure 6-1).

Figure 6-1 The differences between precision and accuracy (from http://academics.wellesley.edu/Chemistry/Chem105manual/Appendices/uncertainty_analysis.html)



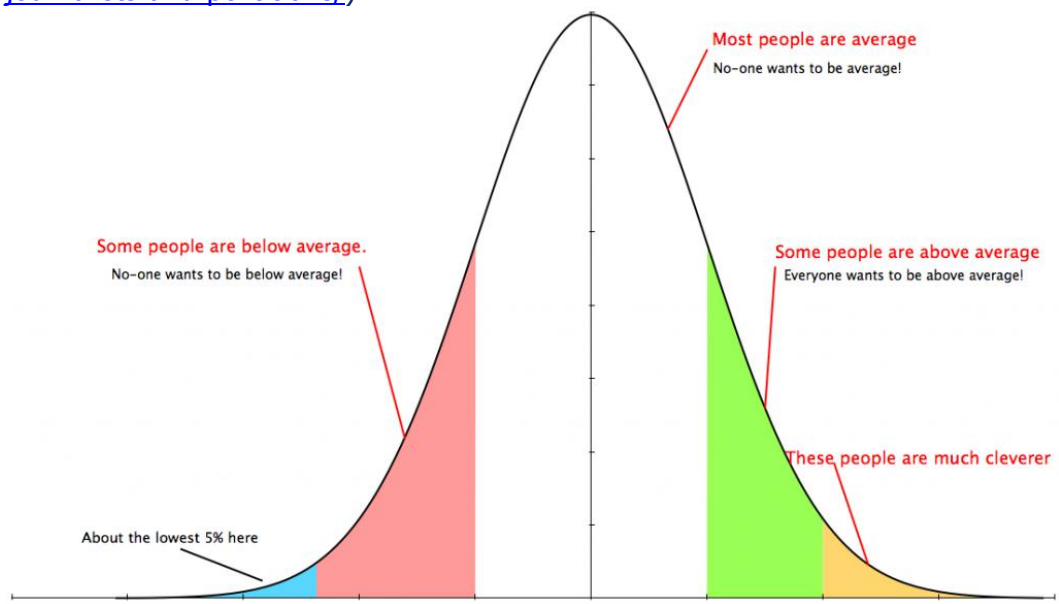
Improving sampling procedures might be a way to reduce the variance between a sample parameter and the 'true' value of that parameter for the material from which the sample is drawn. Similarly, taking multiple samples on each sampling occasion may allow for a closer approximation to the 'true' value for each parameter. This approach could help to 'smooth out' sampling errors associated with (for example) a small fragment of metal that could be present in one digestate sample as a result of equipment wear, but which would not be representative of the quality of the majority of the digestate in the vessel being sampled. This approach would require multiple sample testing, which would have a direct impact on costs.

In order to understand the impact of variances arising from sampling and testing, data would need to be collated across as wide a variety of AD plants and laboratories/tests as possible. In particular, it is essential to avoid using a large number of data points from a small number of sites, as measurements taken at different times for any one site will have a high degree of correlation.

Another approach to managing variability in the setting of (and subsequent judgment of adherence to) limits is to adopt target and upper thresholds. Compliance with the target limit could be judged on a rolling average basis, with no average allowed to exceed the upper threshold. This approach would not avoid the 'cliff edge' impact that would result from a high test value pushing the average above the accepted threshold, but the selection of target and upper thresholds could help to reduce the likelihood of this happening.

Ideally, upper thresholds would be specific to the risk posed by exceedance. Using AD plant sample data to set such upper thresholds should only be considered if there is sufficiently comprehensive data available. The data available to date (for example, on PTE concentrations in digestates) show the measurements not to be Normally distributed in a statistical sense (Figure 6-2), so that standard parametric tests of statistical significance are not applicable.

Figure 6-2 A generic illustration of the Normal distribution (from http://www.musttryharder.net/2012/02/a-brief-primer-on-the-normal-distribution-for-journalists-and-politicians/)



Above all, there is a need for more data, since it is robust data that will give the best foundation for recommendations on the application of thresholds.

Options

[31] Retain current approach to (absolute) limits for quality parameters; or

[32] Make allowance for variability resulting from testing procedures, and build this around limit values (this would require precision data from laboratories); or

[33] Retain current thresholds but apply 'error bounds' to both testing and sample parameters (this would require data for multiple samples at each point of testing from a number of different AD facilities); or

[34] Another approach, to be agreed by the Steering Group, based on the data that are available.

Data request F

A wide range of data are needed to inform the Steering Group's discussion on this topic:

- To consider the adoption of boundaries based on laboratory performance, data are required on both precision and (ideally) accuracy from analytical laboratories undertaking tests required by PAS110:2010 on digestate samples that are accredited to (or eligible for accreditation to) PAS110:2010.
- To consider the adoption of boundaries based on sampling error, data are required from multiple facilities where suitable studies have been undertaken.
- Information on the identified causes of occasional test failures.

Please email this information directly to David.Tompkins@wrap.org.uk by 14th October

6.2 Odour

A note to Clause 5.2 in PAS110:2010, states that:
NOTE Input materials should be digested to such an extent that when digestate is spread as per good practice, by the producer or a different user, the activity does not release offensive odours that are deemed by the regulator or other relevant authority to be a 'statutory nuisance'

However, the PAS does not seek to apply any kind of formal odour limit to digestates. When this was discussed by the Steering Group it was agreed that agronomic practices (such as rapid incorporation of digestates after spreading) should suffice to minimise odours while maximising agronomic value of the nutrients present in digestate.

Option

[35] Rely on good practice to minimise potential for release of offensive odours from digestate during use.

6.3 Need to cover stored digestates

Clause 7.1.5 in PAS110:2010 states that:
Any portion of whole digestate and any separated liquor or separated fibre fractions for which PAS 110 conformance is claimed shall be stored under cover at the digestion facility until the producer has dispatched it for use outside the producer's premises or holding.

When this was discussed by the Steering Group, it was considered that there are obvious agronomic benefits to covering digestate (since ammonium can be diluted by rainwater, and ammonia can be lost to the atmosphere), but that any requirement to cover digestate should be left to:

- The discretion of the digestate producer; and
- The requirements of any permits / licenses under which the AD plant operates.

Option

[36] Remove requirement for digestates to be covered at the digestion facility from PAS110.

6.4 Definition of 'significant change'

The expression 'significant change' appears at various points in PAS110:2010, for example in Clause 4.8.5:
If any significant, non-temporary, change in input materials, production process management or required quality of digested materials occurs, the production process shall be re-validated. An addition or removal of one or more input material types represents a significant, non-temporary change (see note for guidance).

The expression 'significant change' is not clearly defined in PAS110, and there was a discussion within the Steering Group as to whether this should be remedied – particularly as it can invoke considerable expense on the part of digestate producers (for example, if they

have to revalidate their processes as a result of significant change). However, the Steering Group considered that the current note to Clauses 4.8.2 and 4.8.5 in PAS110:2010 was sufficient, and that no change was necessary:

NOTE to 4.8.2 and 4.8.5 Significant change is a matter of interpretation, and can relate to input materials, production process management, required quality of digested materials or other factors that affect their quality. If the producer has applied to a certification body for initial or renewal certification, an interpretation of the certification scheme rules may be sought.

Option

[37] Retain flexibility in the definition of 'significant change'.

6.5 Sampling point

At present, whole digestates, separated fibre digestates and separated liquor digestates must be sampled when they have been processed to a point at which they would normally be dispatched for use.

In some cases, digestate producers may wish to dispatch whole digestate straight from the AD vessel, when they might normally dispatch whole digestate from a storage tank or lagoon. The Steering Group felt that this flexibility was appropriate, so long as the digestate met the PAS quality requirements at the point it was intended to be sent for use.

Option

[38] Retain current approach to sampling for digestate quality at the point where it is intended for supply to the customer.

6.6 Sodium (Na^+) and chloride (Cl^-) measurement in digestates

Tables 1, 2, 3 and 5 in PAS110 require that digestate is tested for soluble sodium (Na^+) and soluble chloride (Cl^-). No limits are applied to these determinands, but their concentrations must be declared. The Steering Group were unable to understand the benefit of making such declarations. It was suggested that the requirement to declare sodium and chloride concentrations in digestate be removed from PAS110.

Since the Steering Group meeting, the question of fibre digestate use in growing media has been raised. In these circumstances, knowledge of the digestate's sodium and chloride contents could become essential. However, such a use for digestate would be likely to be accompanied by a series of specific quality requirements (such as thresholds for electrical conductivity (EC) and salt content), that might not be appropriate for a baseline specification such as PAS110.

Option

[39] Remove requirement to declare concentrations of water soluble sodium (Na^+) and chloride (Cl^-) from PAS110

7.0 Further topics for consideration

Since the Steering Group meeting on May 13th, various other meetings have taken place between Steering Group members and interested stakeholders – including farm assurance bodies and AD operators. These meetings have raised a limited number of points / questions that did not form a substantive part of the Steering Group's discussion. These points are covered in this section.

7.1 Phytotoxicity screening and fitness-for-purpose

At present there is no test in PAS110 to screen for possible herbicide residues or other phytotoxic compounds. This is because typical PAS110 feedstocks are not expected to harbour such contaminants. However, previous research[7] has suggested that there is the (un-quantified) potential for livestock slurries to contain traces of persistent herbicides that have been applied to grazing land. The potential for problems to arise from such sources when used as a feedstock in AD is unknown.

One way of reducing this potential could be to introduce a screening test. To date, only a 'cress root elongation' test has been proposed by one AD trade body, although no data have been provided in support of this[8]. Such a screening test would not be quite the same as a fitness-for-purpose test, although could suffice in terms of demonstrating that digestates would not be harmful when applied to grass or arable crops.

Options

[40] Retain current PAS110 suite of digestate quality parameters; or

[41] Introduce a fitness-for-purpose test or tests, to be agreed by the Steering Group, based on the data that are available.

Data request G

If you consider that a fitness-for-purpose test or tests could be beneficially included within PAS110, please provide a copy of (or link to) methods that you consider suitable, together with a proposed limit value and detailed justification for this limit.

Please email this information directly to David.Tompkins@wrap.org.uk by 14th October

[7] *http://www.wrap.org.uk/sites/files/wrap/Clopyralid%20report%20FINAL1.pdf*

[8] This paper provides a useful overview of different options: Maunuksela L, Herranen M, and Torniainen M (2012) *Quality Assessment of Biogas Plant End Products by Plant Bioassays* International Journal of Environmental Science and Development **3(3):** 305 – 310

7.2 Reduced testing requirements for digestates *made from the producer's / co-operative's own materials and used by the producer / co-operative*

In Section 2.0 it was highlighted that PAS110:2010 includes an opt-out from pasteurisation for digestates that are *made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arise within the producer's premises or holding*.

PAS110:2010 requires that such digestates be tested against a shorter list of determinands than other digestates. These lists are presented in Table 2 and Table 5 of PAS110:2010. To simplify the PAS, these tables could be removed – although this would have an impact on operators complying with (or intending to comply with) these tables.

Options

[42] Retain reduced suite of determinands for digestates that are *made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arise within the producer's premises or holding*; or

[43] Remove reduced suite of determinands for digestates that are *made only from manure, unprocessed crops, processed crops, crop residues, glycerol, and/or used animal bedding that arise within the producer's premises or holding*, and require that all digestates be tested against the same suite.

7.3 Requirement for 'non-waste' digestates to comply with a test or tests within PAS110 that are specifically required to meet 'end of waste' requirements

A food-industry trade body with members operating AD facilities has asked whether there are elements of PAS110:2010 that are included solely to demonstrate end of waste for digestates. The question was raised in the context of AD facilities that do not accept waste inputs, and might not therefore produce digestates that would be considered wastes. If such digestates are not considered wastes, then the argument being put forward is that they should not have to demonstrate end of waste.

Options

[44] Require that all digestates be subject to any specific 'end of waste' test (or tests) in PAS110; or

[45] Exempt 'non-waste' digestates from any specific 'end of waste' test (or tests) in PAS110.

7.4 Setting limits for PTEs based on their bioavailability

Section 3.0 above includes discussion on PTE limits for digestates. Whether testing dried or fresh digestate samples, the methods listed in Section 3.0 rely on digestion of the samples with strong acids – providing an estimate of the 'total' concentration of each PTE present in the sample.

It has been suggested that such an approach does not necessarily reflect the behaviour of PTEs in the environment, since only a small fraction of the 'total' concentration is likely to be bioavailable – and therefore a risk to the environment, humans and animals. To date, no data have been provided to the Steering Group to allow such an approach to be considered.

Options

[46] Retain current approach to setting PTE limits, based on 'total' concentrations; or

[47] Where data support the approach, set PTE limits on a bioavailable basis.

Data request H

As indicated above, no data have yet been provided to inform this debate. If you would like the Steering Group to consider a bioavailable approach to PTE limit setting, please provide evidence to support this.

At present there is no suggestion that the current PTE suite (Cd, Cu, Cr, Hg, Ni, Pb, Zn) will change, and it would be more practical if a change in limit-setting approach could be applied across this entire suite, rather than to a sub-set or single element.

Please email this information directly to David.Tompkins@wrap.org.uk by 14th October