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Use of Digestate from Anaerobic Digestion as agricultural fertiliser; InSource Energy position paper for Marks & Spencer commenting on Concerns Expressed by the British Retail Consortium

Overview

In the context of digestate quality, it should be understood that anaerobic digestion (AD) has a transformatory effect but not a purifying effect on the feeds to the process.

Since the biogas liberated from the process comprises only methane and carbon dioxide, with traces of sulphur compounds, everything else contained in the feed to the process remains in the digestate. This means that heavy metals, mineral nutrients (NPK), chlorides, sodium etc all pass through into the digestate.

Therefore in terms of elemental composition, digestate quality is entirely a function of feed composition.

Digestion has a transforming impact on the molecular makeup of the feeds, however. As is the case in the human or animal gut, digestion breaks down the complex organic molecules (proteins, complex carbohydrates, starches etc) into simple fragments like volatile fatty acids which are then further broken down into CO2 and methane to liberate the energy required by the bacteria.

The digestion process in total comprises four stages;

- Hydrolysis, in which enzymes secreted by hydrolytic bacteria break down organic polymers (proteins, carbohydrates) into their monomer components (amino acids, sugars etc).
- Acidogenesis, in which acidogenic bacteria break down the amino acids ans sugars into volatile fatty acids (VFAs) and alcohols
- Acetogenesis, in which acetogenic bacteria convert the VFAs into acetic (and propionic) acid and some CO2 is liberated
- Methanogenesis, in which the acetic acids are converted to methane and CO2 by methanogenic bacteria.

In a single-tank digestion plant the digester will therefore contain four distinct populations of bacteria. It is worth noting that the hydrolysis stage, which is the protein-destruction step, happens much more rapidly than later steps – it is the later stages which dictate the large mean residence times required.

In addition to destroying the complex organic molecules, the process also liberates bound mineral contents. For example, in a typical food waste or energy crop AD process, virtually all of the nitrogen content in the feeds will be in the form of proteins and other organically-bound nitrogen. The AD process will liberate virtually all of this as free ammonia, apart from that portion which is taken up by the growth of the bacteria themselves. A similar effect is seen on other bound minerals in the feed. Indeed, this liberation of nutrients is one of the reasons why AD digestate is an attractive fertiliser – the mineral content is much more readily accessible to the soil compared to that in the feeds.

In general therefore complex organic molecules will be broken down by the AD process. This does not mean that the digestate will not contain any complex organics. There are three reasons why some complex molecules will be present in the digestate;

a) Inherently indigestible compounds. Not all complex molecules in the feed will be capable of being bacterially degraded at all, and others whilst they may be digestible may not be digestible in the residence time available. For example, lignin from woody materials is relatively indigestible in AD units and will survive into the digestate.
b) Unusual compounds in the feed. In general, if a molecule is routinely present in the feed and is capable of digestion in the timescales available, the bacterial population will adapt to be able to consume it. But if a new compound is introduced it may not initially be digested until such time as the bacteria evolve.
c) Pass-through of undigested feeds. The typical AD reactor is what is known as a "continuous stirred tank reactor" or CSTR. This type of reactor is maintained at a constant volume of fully-mixed material into which fresh feed is introduced regularly (either in a continuous trickle or intermittently). For each volume of feed introduced, a matching volume of reactor contents are withdrawn. Such reactors are usually described as having a "residence time" being the ratio of reactor volume to feed rate – a typical AD reactor will have a residence time of 30 to 40 days. However this is in reality a "mean residence time" because by fully mixing fresh feed into the reactor as it is added, inevitably a portion of the feed will pass out almost immediately with the digestate and will not have time to digest. Therefore the digestate will contain a small portion of undigested feeds.

Because of the above factors it is impossible to be certain that any given complex molecule in the feeds will not appear at some concentration in the digestate. For this reason, digesters handling Animal Byproduct-categorised material (ie meats) are required to include a pasteurisation stage which ensures adequate destruction of prions and other pathogenic organisms.

As a final general observation, some AD plants produce two digestate streams by choosing to dewater the raw digestate from the reactor. Raw digestate will typically have a dry matter content below 4%. This can be spread on land directly, but is relatively costly to transport and to store during no-spreading periods (relative to the value of the nutrients as fertiliser). An option is to dewater the raw digestate which will produce a "solid" digestate of 20-25% solids content, which can be handled as a stackable solid, and a liquid. In this case the liquid may be discharged to sewer (under consent) rather than being land-spread. The solid can be more readily stored and transported.

Clearly, the composition of the solid and liquid fractions will differ. Since the solid fraction still contains about 75% liquid, the main change will be in relation to any part of the raw digestate which is present in larger proportions in the solids content of the digestate.

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Specific Digestate Quality Concerns

- Allergen risks

It is probable that allergens will be capable of being broken down by the AD process, however we are not aware of any specific research on this subject which can confirm this. In any case, due to the factors mentioned above, complete removal of allergens is not likely to be guaranteed and so any allergens present in the feeds will be present, but almost certainly at substantially reduced levels, in the digestate.

- Heavy metal contamination

The AD process will have no effect on the quantity of heavy metals. The quantity present in the digestate (prior to any dewatering process) will be the same as in the feeds.

In this respect the RF Brookes project should generate excellent quality digestate because all the feeds to the plant are drawn from RF Brookes process wastes which in turn are all created from food products "fit for human consumption" and which will therefore contain low levels of heavy metals. This is a distinct advantage compared to AD units processing mixed wastes from municipal or commercial waste collection activities where heavy metal contamination is much more difficult to predict or control.

Dewatering is not likely to result in a major partition of heavy metals between solid and liquid fraction, as most heavy metal content is likely to be in the liquid phase rather than being bound to solids after digestion. Since a typical "solid" fraction still contains around 75% liquid as noted above, the solid digestate fraction and the liquid digestate fraction will show similar heavy metals levels.

- Pesticide residues

We do not have any specific data on the survival of pesticide residues through an AD process. Low levels of pesticides are probably capable of being broken down by the bacteria. High levels of pesticides, if encountered, would probably have a poisoning impact on the bacteria and would adversely impact digester performance.

Once again the origin of the waste for the RF Brookes plant is helpful since foodstuffs fit for human consumption will have low levels of pesticide residue in the first place and the AD process is not going to lead to an increase in these levels.

- Ensuring adequate and consistent enforcement of PAS 100/110

There are three aspects to conforming adequately with both PAS110 and indeed the Animal Byproduct Regulations which require pasteurisation of any ABPR-listed/meat-containing wastes;

- Origin of the wastes being processed, so that the risks of unexpected and unacceptable contaminants in the feeds and hence the digestate are known and controlled
- Design of the facility – for example, in the case of demonstrating ABPR compliance, by being unable to bypass the pasteurisation stage, or by having proper layout of plant to achieve good segregation of incoming wastes from outgoing digestate.
- Operation of the facility to an appropriate standard

Since PAS110 requires that HACCP be implemented and that a proper EMS is in place, demonstrating an appropriate operational standard should be straightforward. In addition, for the RF Brookes project, it will be subject to ABPR checks to ensure adequate management of pasteurisation and segregation/no bypassing.

The RF Brookes facility is designed to ensure good segregation and no pasteuriser bypass.

Finally as previously highlighted the origin of the wastes for the RF Brookes project is known and consistent and poses very low risk of unexpected contaminant or unusually variability of composition.

- Biological Oxygen Demand of digestate / potential environmental Pollutant

BOD is a method of measuring the amount of biodegradable organic material in a sample. Since the whole object of the AD process is to seek to biodegrade as much of the feed solids as possible, the digestate typically has a very low BOD level. Environmental pollution from the BOD of digestate spread to land is not considered a major issue, even when spread as liquid without dewatering.

- Crop specific PAS 100

This is not something we have a position on and it relates to compost rather than digestate, although one could anticipate a parallel requirement under PAS110 coming into existence.

However as noted elsewhere, the traceability of digestate from the RF Brookes project back to the source of feed for the process will be excellent which would make compliance with any crop-specific requirements simple to demonstrate.

- 'Glass free' PAS 100

The AD process will not remove glass, but any glass present in the feed will be finely ground by passage through the process. In this respect the RF Brookes project will offer glass-free digestate since all the feeds are drawn from the RF Brookes factory which has stringent procedures to control the risk of glass contamination.

- **Environmental contamination (from digestate)**

From a digester which is fed purely with clean food wastes, the digestate will be a weak mineral fertiliser containing some indigestible organic fibrous solids solids (lignins and other indigestible, but organic, materials). As such provided it is stored, spread and transported properly, it poses no significant risk to the environment. Indeed due to the low concentrations of nutrients, it poses much less risk in the event of accidental release than would be posed by a regular artificial fertliser.

However the AD process will not inherently remove non-desirable items and as explained earlier the composition of the waste will be reflected in the composition of the digestate. Depending on any additional processes (such as plastics removal) provided as part of plant designs, digestate could contain plastics, metals, heavy metals, or other items contained in the wastes fed to the process.

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As such the whole purpose of PAS 110 is to provide a protocol for being able to characterise digestate quality based on knowledge of the origin of the wastes used. Once again the RF Brookes project will provide "clean" digestate in this regard as it uses human foodstuff wastes as feeds, and includes a plastics/metal packaging removal section.

- Compost/digestate matrix - similar to sewage sludge matrix

There is no reason why a matrix cannot be developed (or the existing matrix amended) to incorporate AD digestate. Our view would be that this may need to focus more on the waste feeds used in a given AD process than on any inherent property of the process itself since it is t he parts of the waste which cannot be transformed by the AD process which are likely to drive concerns.

- Cumulative effects

To provide a position it would be helpful if the specific type of concern could be explained.

- Improved provision of traceability information to producers for green waste composts

We are not sure this point of concern is relevant to digestate.

InSource Energy
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