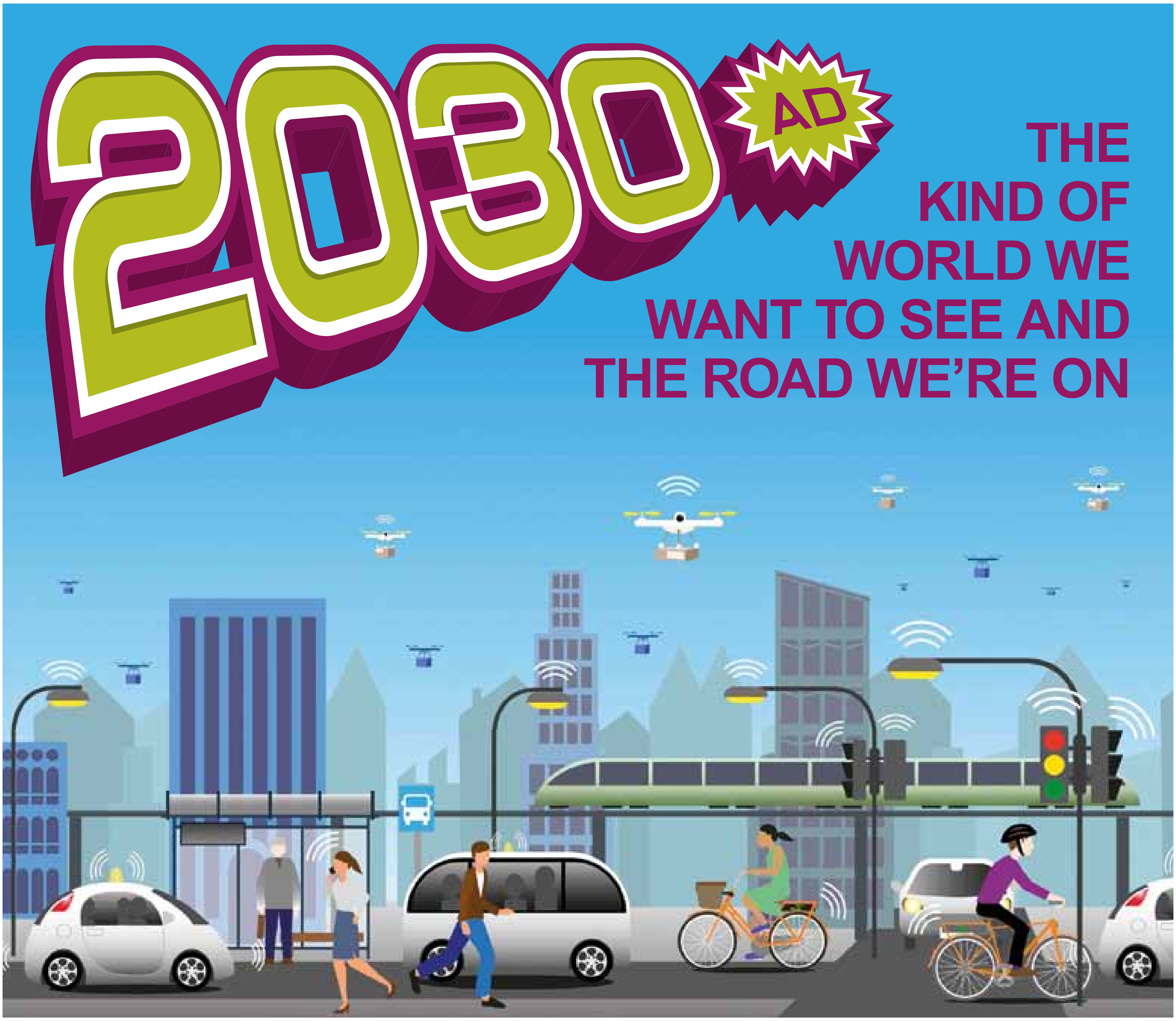
AD&BIORESOURCES NEWS

THE UK ANAEROBIC DIGESTION & BIORESOURCES TRADE ASSOCIATION'S QUARTERLY MAGAZINE

ISSUE 50 WINTER2020/21

adbioresources.org



THE KIND OF WORLD WE WANT TO SEE AND THE ROAD WE'RE ON

AD AND THE METHANE EMERGENCY

OPERATOR GUIDE – PVRVs

FEEDSTOCK QUIZ

NEUTRALISING AMMONIA WITH ACIDIFICATION

ADBA NATIONAL CONFERENCE 16TH & 17TH FEBRUARY https://bit.ly/3stDhPx

REDUCING AMMONIA EMISSIONS FROM DIGESTATE

Farmer and AD operator **Stephen Temple** shares the interim results from trials using sulphuric acid to neutralise ammonia emissions

Stephen Temple owns Copys Green Farm in North Norfolk. Copys Green is a 500-acre dairy farm combined with an arable and cheese-making enterprise. His 170kWe anaerobic digester was installed in 2009, providing energy for the grid and for farm use – including a couple of electric cars. Here, he shares the interim results he has secured from an ongoing trial exploring the use of acidification to curb ammonia emissions from digestate.

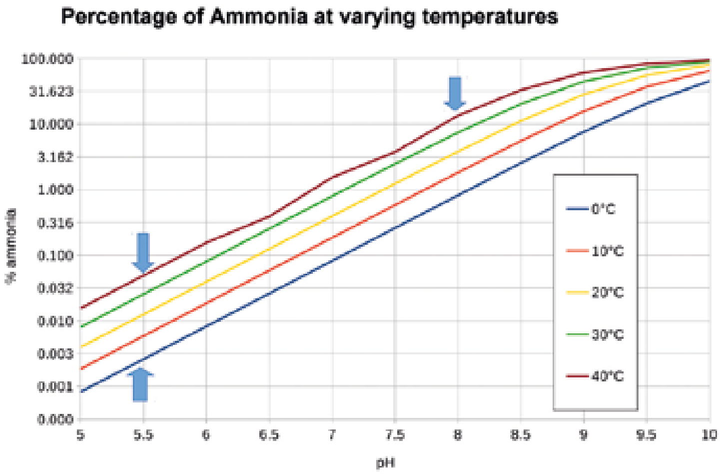
Maximising value

At Copys Green Farm, we are concerned to maximise the fertiliser value of our digestate and are also aware the Government is worried about ammonia emissions from slurry and digestate. I have been looking into doing something about reducing emissions for a while but, as a small AD operator, found that existing commercial solutions were outside our budget. I have therefore been developing my own solution.

This project was inspired and assisted by the Innovative Farmers Field Lab on "Anaerobic Digestate Impacts On Soil Microbiology And Nitrogen Retention" https://bit.ly/38T4zpe Innovative Farmers is an initiative which involves academics, industrial partners and farmers in a range of on-farm trials.

The challenge

Ammonia in digestate and cattle slurry exists in equilibrium between ammonia (NH_3) and ammonium ions (NH_4). As ammonia, it will be lost to the atmosphere. The plot below shows that as pH and temperature increase, the equilibrium is pushed very strongly towards the ammonia side.



Data taken from
United States Environmental Protection Agency EPA-600/3-79-091
Aqueous Ammonia Equilibrium – Tabulation of Percent Un-Ionized Ammonia
Thurston, R.V., Russo, R.C. & Emerson, K. 1979

As digestate comes out of the digester, it tends to be at the point indicated by the upper right-hand arrow. If we can reduce the pH to 5.5, this brings it from almost 20% as ammonia, down to below 0.5%. Reducing the temperature to ambient of about 10°C will further reduce it to 0.05%, thus reducing emissions by orders of magnitude.

The greatest opportunity for loss will be when the digestate is hot, high pH and exposed to the air in a thin layer as shown in the table below.

From rough estimates, we suspect we are losing at least 25% of the ammonia between the digester and the lagoon, as digestate running through the separator and on the way to the lagoon is both hot and in a thin layer.

Continued>>

Source / Effect	Duration Long = high emissions	Temperature High = High emissions	Surface Area: Volume High = High emissions	Possible mitigation measures Low pH = Low emissions
Storage of livestock manures before feeding	Short / medium	low	Medium	Feed as soon as possible, do not store
Solid / liquid separation after digestion	Short	High	High	Reduce pH
Storage of seperated liquids	Long	Low	Low	Lagoon covers or reduce pH
Storage of separated solids	Long	Low	Medium	Cover heap or reduce pH
Application to field	Short / medium	Low	High	Injection or trailing shoe

Method of treatment

To reduce pH, we need to treat with acid. From an agricultural point of view, we need sulphur as a fertiliser, so sulphuric acid makes sense as it can be the cheapest source of sulphur, especially if it can be obtained as second-user acid. Second-user acid can be obtained from suppliers such as Brenntag and Aguachem.

Obviously, sulphuric acid needs to be treated with great care and appropriate precautions. Pipework and pumps for handling it must be of suitable materials and enclosed in an outer protective bund with leak detection.

If we can treat the digestate as it leaves the digester, before separation, then we have the potential for maximum nitrogen savings. Our configuration pumps a batch of about 2 m^3 of digestate into a tank, adding acid as it goes in and thoroughly mixing. Then further acid is added until the pH has reached the target of around 5.5 before pumping the batch to the solid/liquid separator. The process then repeats. We will then be massively reducing losses from the digester all the way through to application in the field.

Problems with treatment

We were anticipating the foaming which occurs when the acid is added to the digestate and allowed space in the tank for the foam. However, foaming has a side effect on whole digestate, as the bubbles seem to attach to the particles of fibre, clumping it together and making a fibrous mat on the surface of the liquid.

This change in nature of the fibre caused issues with pumping the treated liquor. To solve this, we have tried two different progressive cavity pumps; a submersible sewage pump designed for solids, and two diaphragm pumps. Finally, however, we have been using an external centrifugal chopper pump. Even this has moments when it fails to pump, due to the foam causing cavitation, so we have fitted a flow sensor after the pump.

If we try to pump and there is inadequate flow, we can divert the flow to recirculate to the tank, and if it still does not pump, wait for the foam to disperse. Once the material reached the screw-press separator, there were no problems with separating the liquid from the fibre.

Current state of the project

Each step of the treatment process has been tested, and we are now integrating the steps into the digester PLC programme. When this is tested, we will install an on-line pH meter to allow fully automatic operation. Initial calculations show we should need about 4 kg acid per tonne of digestate, but we need to do more extensive trials to verify this. It will depend on the buffering capacity of the digestate.

Costs and benefits

The cost of the acid can be directly offset against the cost of sulphur fertiliser (commonly ammonium sulphate), leaving the capital and maintenance costs to be covered by the savings in nitrogen. Preliminary calculations show the payback on our small-scale digester to be in the order of 4 years, but until we have operational data and validated ammonia savings, it is difficult to be more precise.

Conclusion

Acidification can have multiple environmental and financial benefits. Not only are ammonia emissions greatly reduced, almost eliminated, but the saving in purchased nitrogen fertiliser saves the substantial carbon emissions associated with its production, as well as the purchase cost.

Appropriate precautions are required when handling the acid and selection of appropriate equipment is also necessary. Additionally, by applying acid-treated digestate to land, occasional liming will be required on lower pH (acid) soils. Our soil is high pH (alkaline), so this doesn't cause us any issues.

Further reading

Life cycle assessment of biogas digestate processing technologies:
www.sciencedirect.com/science/article/pii/S0921344911001686

Net and Gross Nitrogen Turnover in Soil Amended with Acidified and Differently Dried Solids from Biogas Digestate:
https://acsess.onlinelibrary.wiley.com/doi/full/10.2136/sssaj2016.03.0059

Advanced Processing of Food Waste Based Digestate for Mitigating Nitrogen Losses in a Winter Wheat Crop:
www.frontiersin.org/articles/10.3389/fsufs.2018.00035/full

The Research Corner is co-ordinated by the Environmental Biotechnology Network (EBNet), a free-to-join network of academics, industry and government, funded by the Biotechnology and Biological Sciences Research Council (BBSRC). EBNet's remit is in the area of engineered microbial systems for environmental protection, bioremediation and resource recovery. These microbial systems include anaerobic digesters, systems used in wastewater treatment, microbial systems used in remediation of contaminated soils and much more.