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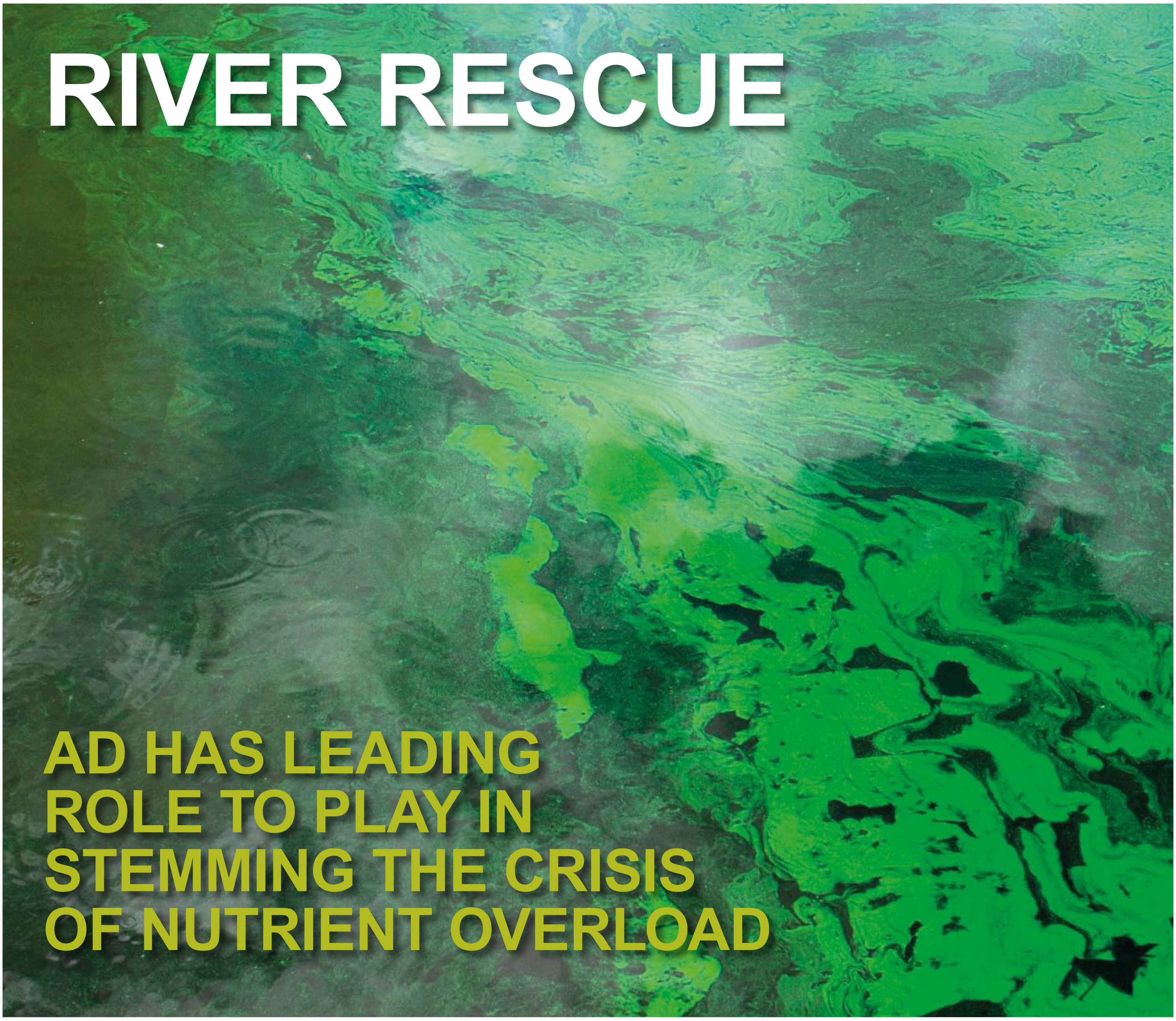


# RIVER RESCUE

## AD HAS LEADING ROLE TO PLAY IN STEMMING THE CRISIS OF NUTRIENT OVERLOAD

### BIOGAS UK – BIGGER THAN NUCLEAR BY 2029

### TEST YOUR KNOWLEDGE IN OUR BIG H&S QUIZ

### WHAT OPERATORS MUST DO TO MITIGATE CLIMATE RISKS

### THE RETURN OF BIOCHAR AND AD APPLICATIONS

# BIOCHAR, AD AND DIGESTATE

Biochar has the potential to boost AD production, sequester carbon, improve soil health and increase crop yield. **Lidia Krzynowek** and **David Vaughan** introduce this ancient yet modern material.

The use of biochar can be traced back to ancient civilisations such as the Amazonians, who practiced slash-and-char agriculture. Today it is enjoying a renaissance and being hailed across a raft of applications.

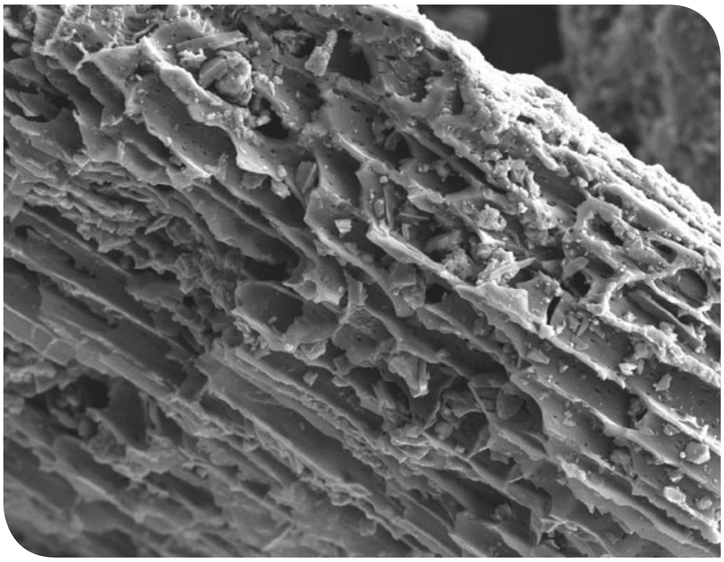
Biochar is a special kind of charcoal made from organic materials like wood chips, agricultural waste and secondary biomass products. It is made through a process called pyrolysis, which involves heating the organic material in a zero-oxygen environment to produce biochar and renewable energy.

The physiochemical properties of biochars can vary dependent upon different parameters e.g. feedstock and production temperatures. This means not all biochars carry the same characteristics and can, therefore, be produced to be optimal for a given application. Quality and customisation are paramount in harnessing the full potential of biochar, to meet the distinct requirements of various applications and ensure consistent quality.

Biochar is perhaps best known for its ability to improve soil health and fertility. Among the key physicochemical properties of biochar are its porous structure and high surface area. Typically, biochar boasts a surface area of 100-500m$^2$/g. As such, a single gramme of char has roughly the same surface area as a tennis court.

When added to soil, it helps retain moisture, nutrients, and beneficial microbes, which can enhance plant growth. It also helps reduce greenhouse gas emissions by sequestering carbon in the soil, which can contribute to combating climate change.

The carbon in biochar is highly stable and can endure in soils for thousands of years without being degraded by microorganisms. When produced to meet quality standard i.e. European Biochar Certification (EBC standard) biochar represents a long-term $CO_2$ sink that can sequester carbon in the soil virtually indefinitely. This makes biochar a promising Carbon Dioxide Removal (CDR) technology that can contribute to the mitigation of climate change and help work towards net zero goals.



Biochar, after organic material has been treated in a patented drying and pyrolysis oven known as PyroDry

At the time of writing, one tonne of biochar-based carbon fetched between €100 and €500 on the voluntary carbon trading platform Puro.Earth. The additional income from carbon credits can enable biochar makers to offer their product at a lower price, thereby contributing to the economic viability of the biochar industry.

## Biochar and AD

As AD is often likened to tending an animal, it is perhaps telling that biochar is already in use as a feed additive for a range of farm animals including cows, pigs and poultry, where it can prevent or treat digestive problems. This leads to improved feed conversion and hence to faster weight gain and better meat quality.

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## BOOSTING MICROBIAL COMMUNITIES IN AD

There is lots of ongoing research around how biochar mediates several bio-electrochemical interactions, including in the AD process, especially by mediating and even accelerating (bio)-electrochemical interactions such as Direct Interspecies Electron Transfer (DIET).

DIET is a microbial interaction mechanism in which different species of microorganisms exchange electrons directly between each other as part of their metabolic processes. In microbial communities, DIET enables the transfer of electrons from one microorganism to another without the need for intermediary molecules such as hydrogen or formate.

In DIET, certain microorganisms possess the ability to form conductive structures, such as pili or nanowires, which facilitate the transfer of electrons between cells. These conductive structures act as conduits, allowing electrons to move from the electron donor microorganism to the electron acceptor microorganism.

DIET is particularly significant in anaerobic environments, such as those found in sediments, wastewater treatment systems, and the gastrointestinal tracts of animals, where microbial communities play crucial roles in biogeochemical cycling and organic matter degradation.

By facilitating direct electron transfer between different microbial species, DIET enables more efficient energy metabolism and enhances the overall metabolic capabilities of microbial communities. This mechanism has implications for various biotechnological applications, including bioenergy production, bioremediation, and wastewater treatment.

Understanding and harnessing DIET could lead to the development of novel strategies for sustainable energy production and environmental management. **Dr Anjali Jayakumar** *Lecturer in Chemical Engineering, Fellow of the Higher Education Academy, Deputy Degree Program Director MSc Sustainable Chemical Engineering, Newcastle University*

Similarly, biochar of high quality and designed to meet key specifications can enhance the performance of anaerobic digestion (AD) plants in several ways:

**Improving Digestion Efficiency:** Adding biochar to the AD process can increase the surface area available for microbial colonization. This provides a habitat for beneficial microorganisms that help break down organic matter more efficiently, thus enhancing digestion rates and overall biogas production.

**Buffering pH Levels:** Biochar has a neutral to slightly alkaline pH, which can help stabilize pH levels within the AD system. This buffering capacity can mitigate fluctuations in pH that may occur during digestion, maintaining optimal conditions for microbial activity and biogas production.

**Reducing Inhibitory Compounds:** Biochar has been shown to adsorb or immobilize certain inhibitory compounds present in the feedstock or produced during digestion, such as ammonia and fatty acids. By reducing the concentration of these inhibitory substances, biochar can improve the stability and performance of the AD process.

**Enhancing Methane Yield:** Studies have indicated that the addition of biochar to anaerobic digesters can increase methane yield per unit of feedstock input. This improvement in methane production efficiency can result in higher biogas yields and greater energy generation from AD plants.

Finally, **Enhancing Nutrient Recycling:** Biochar acts as a carrier for nutrients and helps retain essential elements like nitrogen, phosphorus, and potassium during the digestion process. This nutrient retention capability of biochar can improve the quality of the digestate produced, making it a more effective fertilizer for agricultural use. It could also have the potential to reduce leaching of nutrients when digestate is added to soils, but this will require additional biochar incorporation after the digestion process. The production parameters may not need to be as specific as for the AD process-enhancing char.

Overall, incorporating biochar into anaerobic digestion systems has the potential to optimize process efficiency, increase biogas production, and improve the quality of digestate, thereby contributing to the sustainability and effectiveness of AD operations (see Boosting Microbial Communities in AD).

## Future options

Biochar is an old material, but a relatively young market, with extensive research being conducted into its possible uses. Due to its diverse attributes, biochar has found itself connected to a lot of potential markets.

One line of research being carried out is on circular economy approaches such as the Sequential Biochar Systems, where several thermochemical and biological pathways are efficiently integrated to valorise waste biomass. These include the use of biochar in water or air purification followed by its use in AD. Ultimately, at the end-of-life, the spent biochar finds application in soils, ensuring that the biochar from each step is tailored for the next. This not only generates more revenue strands, but also reduces the carbon footprints of each application.

In a recent EB Network webinar on biochar, hosted by the Biochars for Pollution Prevention Working Group, Distinguished Professor Andy Ball from RMIT University (Royal Melbourne Institute of Technology) outlined a study which showed that the addition of biochar generally enhanced the removal of petroleum hydrocarbons from contaminated soils, but that the biochar pyrolysis temperature, biochar application dose and fertiliser dose affected the hydrocarbon removal efficacy. The study has been demonstrated at pilot scale in Singapore.

## ECOCHAR FROM DIGESTATE

At the time of going to press, Carbogenics announced it had won Innovate UK funding to undertake research into a new product derived from the pyrolysis of digestate, EcoChar (Emission Control Organic-Char). The project seeks to validate the potential for EcoChar to be used as a low-cost, efficient and eco-friendly alternative to traditional Anaerobic Digestion (AD) lagoon cover materials.

The Clean Air Strategy aims to tackle emissions from open slurry and digestate stores, mandating the use of emission abatement measures, particularly for lagoons currently exposed to the elements.

While new constructions will require fixed covers, existing infrastructure can utilise various options, including organic layers of lightweight aggregates. Biochar is one, which can not only suppress emissions but can also serve as a fertiliser and soil conditioner, contributing to carbon sequestration.

Professor Fred Coulon of Cranfield University explored the bioremediation concept further by describing work they are doing using biochar from sewage sludge pellets and wheat straw pellets which had been dosed ("bioaugmented") with microbes, including *Bacillus sonorensis* and *Pseudomonas aeruginosa*. These were applied to remediate soil contaminated with crude oil. They found that the bioaugmented biochars degraded the total petroleum hydrocarbons (TPH) more effectively than the plain biochar.

As with any new product, some of these applications will need to overcome legislative hurdles and it remains to be seen under which scheme that biochars will be certified in the UK. Biochar is a growth industry and is set to play a large role in tackling climate change, the race to net zero and carbon sequestration.

Lidia Krzynowek is COO-Cofounder and David Vaughan R&D Director at Carbogenics.

## INTERESTED IN BIOCHAR?

Join the Environmental Biotechnology Network Biochars for Pollution Prevention Working Group, led by Dr Meredith Rose Barr, Lecturer, Division of Chemical and Energy Engineering, London South Bank University. Read more about the working group here https://ebnet.ac.uk/wg-details/wg-biochar, where you can also view research papers and view our webinars and upcoming events.

## INTERESTED IN FINDING OUT MORE ABOUT USING BIOCHAR IN YOUR DIGESTER?

Contact Lidia Krzynowek, Lidia lidia.krzynowek@carbogenics.com or visit www.carbogenics.com