More methane production: Combining alkaline pretreatment and air mixing for anaerobic digestion

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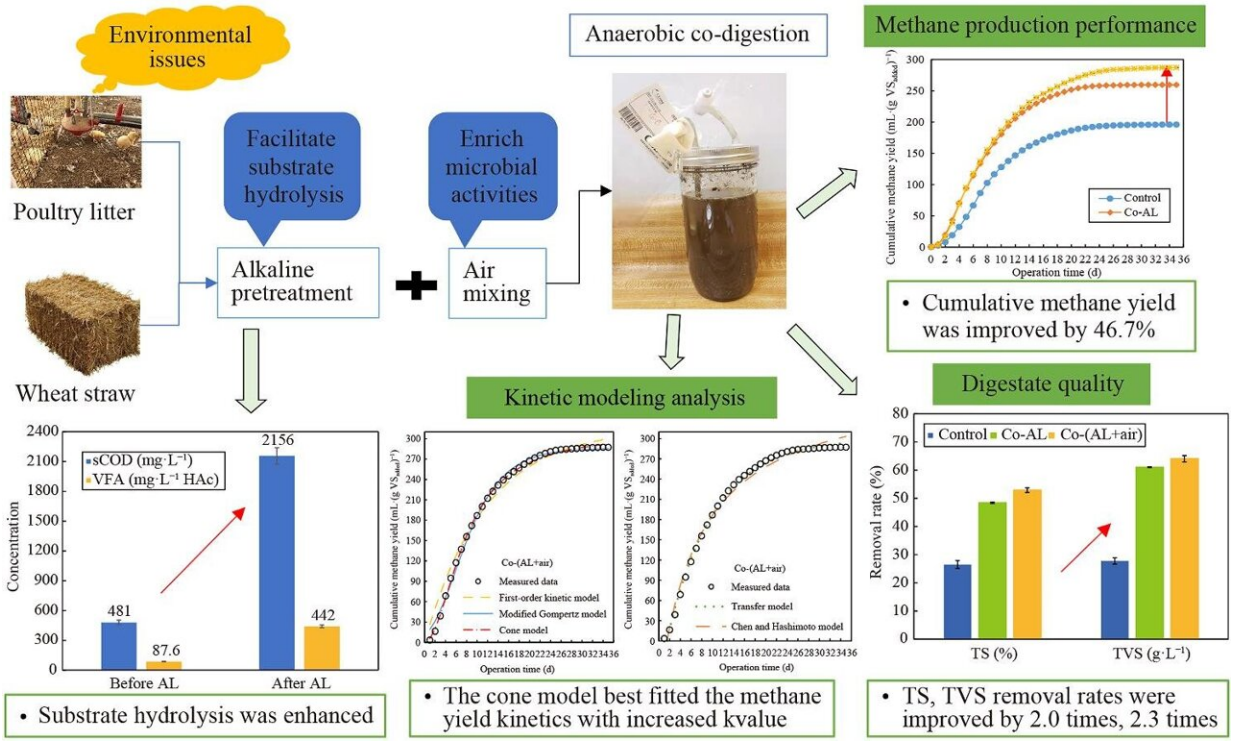

Credit: Yuanhang ZHAN, Jun ZHU, Yiting XIAO, Leland C. SCHRADER

In 2021, the state of Arkansas soared to third place in the United States' broiler production rankings. While this accomplishment brought economic benefits, it also posed a challenge—a surplus of poultry litter

(PL) and growing environmental concerns. So, how do we harness this surplus sustainably?

Enter anaerobic digestion (AD). AD is a well-recognized method for both sustainable waste treatment and biogas production. Yet, when it comes to using PL alone, there's a hurdle to overcome: ammonia inhibition. To balance the carbon-to-nitrogen ratio and tackle this challenge, agricultural straw, such as wheat straw (WS), is introduced through anaerobic co-digestion (Co-AD) with PL. But, there's a catch: WS contains lignin that can impede AD efficiency.

What's the solution? Proper pretreatment

Alkaline pretreatment (AL) proves promising by enhancing biomass digestibility through lignin disruption. Interestingly, it's not alone in this endeavor. Air mixing (AM) shows significant potential too. It enhances microbial communities and processing efficiency, fostering synergistic interactions among microbial groups. But here's where it gets exciting: What if we combined AL and AM for even better results?

While AL occurs during substrate pretreatment and AM operates during fermentation, could their combined power drive higher efficiency in methane yield? That's the hypothesis.

What have we been up to?

Dr. Zhan's team from the Department of Biological and Agricultural Engineering at the University of Arkansas is at the forefront of this research. They're exploring the integration of alkaline pretreatment (AL) with air mixing (AM) for Co-AD of poultry litter (PL) and wheat straw (WS).

The relevant study has been published in the journal of Frontiers of Agricultural Science and Engineering, entitled "Alkaline pretreatment and air mixing for improvement of methane production from anaerobic co-digestion of poultry litter with wheat straw."

By analyzing substrate solubilization, methane yield through kinetic modeling, and digestate quality, they aim to determine if this combination can truly supercharge methane production from Co-AD.

AL was conducted by adding the alkaline solution to the reactor to increase the pH to 12 and then placing the reactor on a shaker at 150 $r \cdot min^{-1}$ in a water bath at 25°C for 12 h. Air was conducted by injecting the same volume of air (12 mL) daily into the reactor. Three groups of reactors (control, AL, and AL combined with AM) with a working volume of 500 mL were operated in a batch mode and continued for 35 days in a programmed incubator maintained at 37°C.

The findings:

- AL makes a remarkable impact, increasing soluble chemical oxygen demand (sCOD) and volatile fatty acids (VFA) concentration significantly. And when AL joins forces with AM, the results are nothing short of impressive.
- The combo leads to the highest cumulated methane yield, soaring 46.7% higher than the control.
- In kinetic studies, the combination group shows enhanced hydrolysis and faster kinetics than the control.
- In the final digestate, the removal of total solids (TS) and total volatile solids (TVS) is significantly improved when AL is combined with AM.

The findings suggest that AL and AM are not just compatible; they're a winning combination. Their synergy promises even greater methane

production, improved methane yield kinetics, and enhanced solids removal in the Co-AD process.

The future of sustainable waste management

With the identification of this potent duo, we are not only advancing our understanding of waste management but also taking a significant stride towards a more sustainable and efficient solution for enhancing methane production from the co-digestion of agricultural wastes.

The implications of this breakthrough extend far beyond the confines of the laboratory; they have the potential to revolutionize the fields of waste management and renewable energy generation on a global scale.

More information: Yuanhang Zhan et al, Alkaline pretreatment and air mixing for improvement of methane production from anaerobic co-digestion of poultry litter with wheat straw, *Frontiers of Agricultural Science and Engineering* (2023). DOI: 10.15302/J-FASE-2023506

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