MICRO-AERATION TO IMPROVE ANAEROBIC DIGESTION OF CATTLE SLURRY

Luís Costa[1#], Pedro Esperanço[2#], M. Salomé Duarte[1,3], Verónica Oliveira[2], Carla Rodrigues[2], Ana Júlia Cavaleiro[1,3*]

[1]University of Minho, Centre of Biological Engineering, Braga, Portugal

[2]Polytechnic University of Coimbra, Research Center for Natural Resources, Environment and Society, Coimbra, Portugal

[3]LABBELS – Associated Laboratory, Braga/Guimarães, Portugal

*Corresponding Author: acavaleiro@ceb.uminho.pt

ABSTRACT

Effective management of cattle slurry is essential to mitigate its environmental impact, while simultaneously recovering valuable resources and promoting nutrient recycling. Anaerobic digestion (AD) offers a sustainable solution, allowing energy recovery through biogas production, which can be upgraded to biomethane as a renewable alternative to natural gas. Beyond its energy benefits, AD significantly reduces the organic load and greenhouse gas emissions associated with cattle slurry. Nevertheless, AD of cattle slurry is often constrained by low hydrolysis rate and is prone to inhibition by ammonia, H_2S or volatile fatty acids (VFA) accumulation.

In recent years, micro-aeration— consisting of controlled introduction of small amounts of oxygen (O_2) in AD process—has emerged as a promising approach to enhance microbial activity, promote the degradation of recalcitrant compounds, and improve methane yields. This study aims to investigate the effect of micro-aeration on AD of cattle slurry, as a strategy for process improvement. Cattle slurry samples were collected from a livestock farm in the central region of Portugal. Physical-chemical characterization of cattle slurry was carried out. Biochemical methane potential (BMP) assays were performed under strictly anaerobic and micro-aeration conditions (single dosing of air, corresponding to 2% O_2 in the headspace). BMP values (expressed as volume of methane at standard temperature and pressure conditions per mass unit of volatile solids, VS) of 292±12 L/kg and 232±9 L/kg were obtained in the anaerobic and micro-aerobic assays, respectively. In terms of methanization percentages, 57±2% and 45±2 of the chemical oxygen demand (COD) was converted to methane, respectively. Two semi-continuous bioreactors were operated, one under strict anaerobic conditions and the other with micro-aeration (12.5 mL/(L·d) O_2, by air pulses during feeding) at hydraulic retention time of 20 and 40 days. Cumulative biogas production, methane content, pH, COD, total and volatile solids (TS and VS), and VFA were monitored along the time. Both reactors achieved similar methane production percentages (around 60%) throughout the process. However, micro-aeration proved essential for higher total and soluble COD removal and TS reduction. On average, micro-aeration led to 6% and 16% higher total and soluble COD removal, respectively, compared to strictly anaerobic conditions. In terms of TS, micro-aeration increased their reduction in 2%. The addition of nanobubble (NB), another innovative micro-aeration technology, was also investigated. Characterized by a high interfacial area and prolonged stability in water (lasting over two weeks), nanobubbles enable efficient gas transfer. A new set of BMP assays was then performed using cattle slurry and NB. Methane yields of 388±7 and 343±7 L/kg (and methanization percentages of 64±1% and 56±1%) were attained in the assays with NB and in the controls, respectively. These results underscore the potential of NB technology to enhance AD performance. The applicability of NB technology In semi-continuous bioreactors is currently ongoing (20 days of operation). So far, micro-aeration has increased total and soluble COD removal in 7% and 2%, respectively, compared to strictly anaerobic conditions. TS and VS removal was increased as well, in 8% for both parameters. New data is expected soon, to validate the effectiveness of this approach and pave the way for sustainable livestock waste management solutions.

Keywords

Anaerobic Digestion, Micro-aeration, Cattle slurry; Sustainability; Biomethane