

Comparison of a CSTR and a cascade of CSTR – PFR for anaerobic digestion of diluted poultry manure

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Continuously stirred tank reactors (CSTR) are commonly applied for the anaerobic digestion of municipal, industrial and agricultural wastes. They are designed with long hydraulic retention time (> 25 d) and low organic loading rate (OLR) (< 3 g L⁻¹ d⁻¹). Plug flow reactors (PFR) are advantageous, compared to CSTR, both concerning stability and treatment efficiency (Eftaxias et al. 2021). Connected in series with a CSTR they can significantly decrease the overall digester volume for the same substrate removal efficiency (Aivasidis, 2011). The objectives of this study were to evaluate process performance of a CSTR and a cascade of CSTR-PFR for the anaerobic digestion of diluted poultry manure (Figure 1). Poultry manure was obtained from an egg producing facility and was mixed with hot water at 70°C with a solid: liquid ratio = 1:3 while screened to remove coarse solids (> 1 mm). The pilot-scale facilities consisted of a CSTR with 42 L and a CSTR connected in series with a PFR having 42 and 26 L working volume respectively. By the applied pre-treatment 75% of the poultry manure organics were recovered in the leachate (Figure 2). The diluted poultry manure was characterized by a total COD = 56 ± 21 g L⁻¹ which consisted 35% proteins, 20% lipids, 15% VFA and the remaining 30% carbohydrates. The CSTR and the CSTR-PFR cascade were operated at similar OLR i.e. between 2 and 7 g L⁻¹ d⁻¹ (Figure 3).

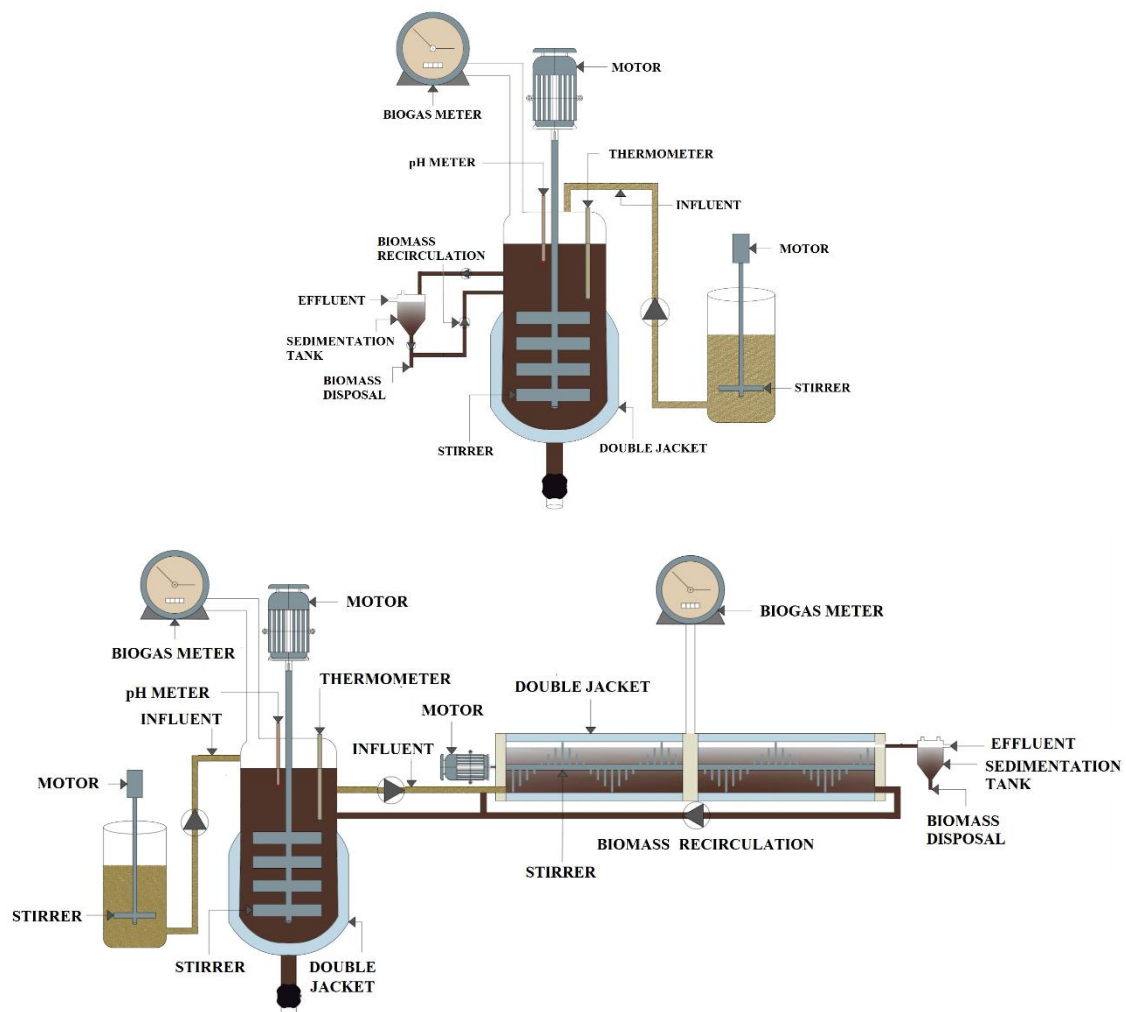


Figure 1. Schematic representation of CSTR and cascade CSTR – PFR.

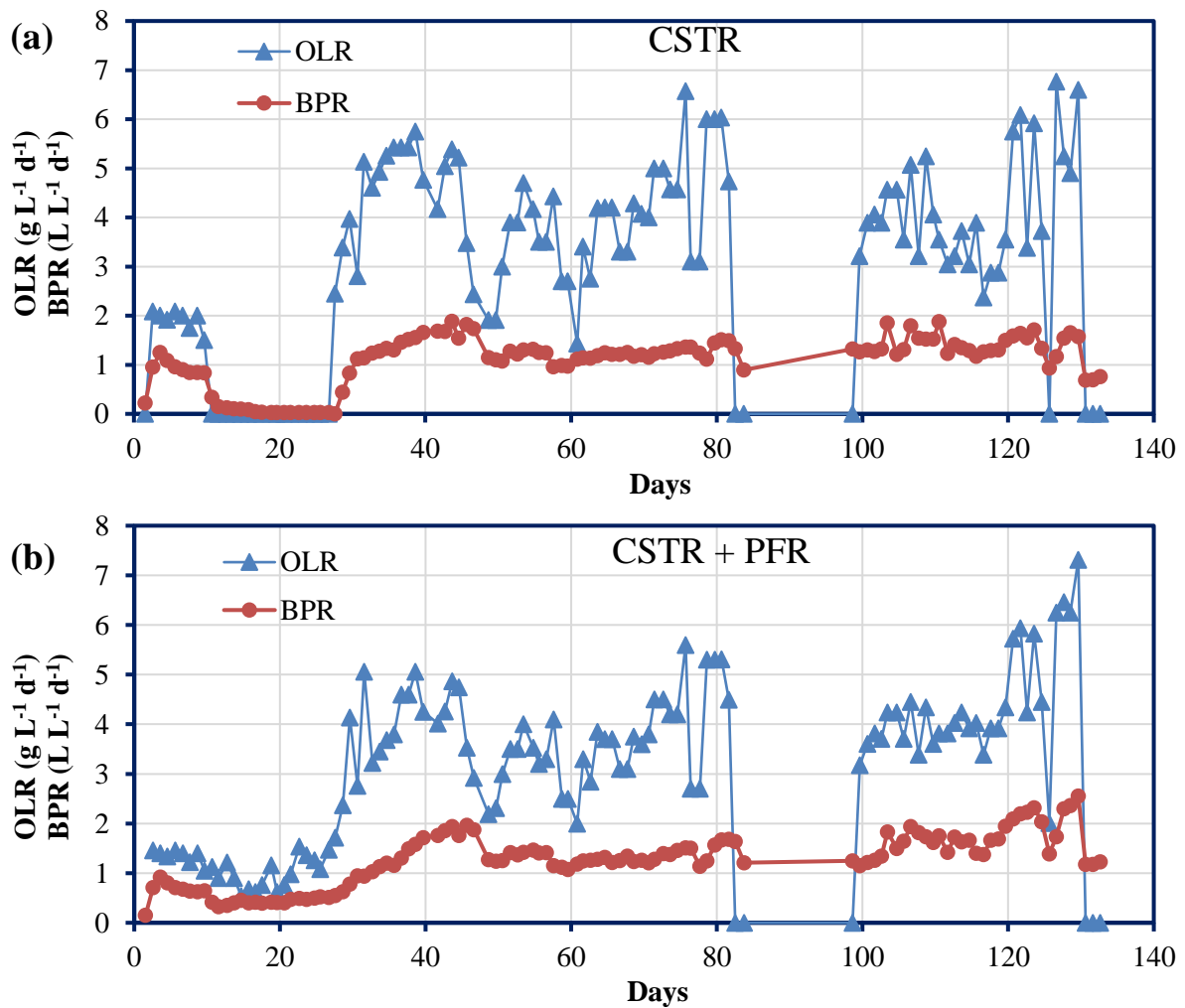


Figure 2. Evolution of the organic loading rate (OLR) and the biogas production rate (BPR) during continuous operation of (a) the CSTR and (b) the CSTR-PFR cascade, using diluted poultry manure.

Figure 3 show steady-state data for the biogas production rate as a function of the applied OLR. Biogas production rate showed a linear increase with the OLR in the case of the CSTR-PFR cascade corresponding to a biogas yield coefficient of $0.40 \text{ L g}^{-1}\text{COD}$. On the contrary, a significant decrease of the biogas production rate was recorded for the CSTR at OLR higher than $3.5 \text{ g L}^{-1}\text{d}^{-1}$. In this case, the average biogas yield coefficient was $0.34 \text{ Lg}^{-1}\text{COD}$. Considering the overall treatment efficiency, higher SCOD removal was recorded for the CSTR-PFR cascade ($81 \pm 9 \%$) compared to the single CSTR ($70 \pm 12\%$). Concluding, the CSTR-PFR cascade was superior compared to the single CSTR for the anaerobic digestion of diluted poultry manure. Accordingly, it is possible to decrease the overall digester volume by 20-30% by implementing a CSTR-PFR cascade.

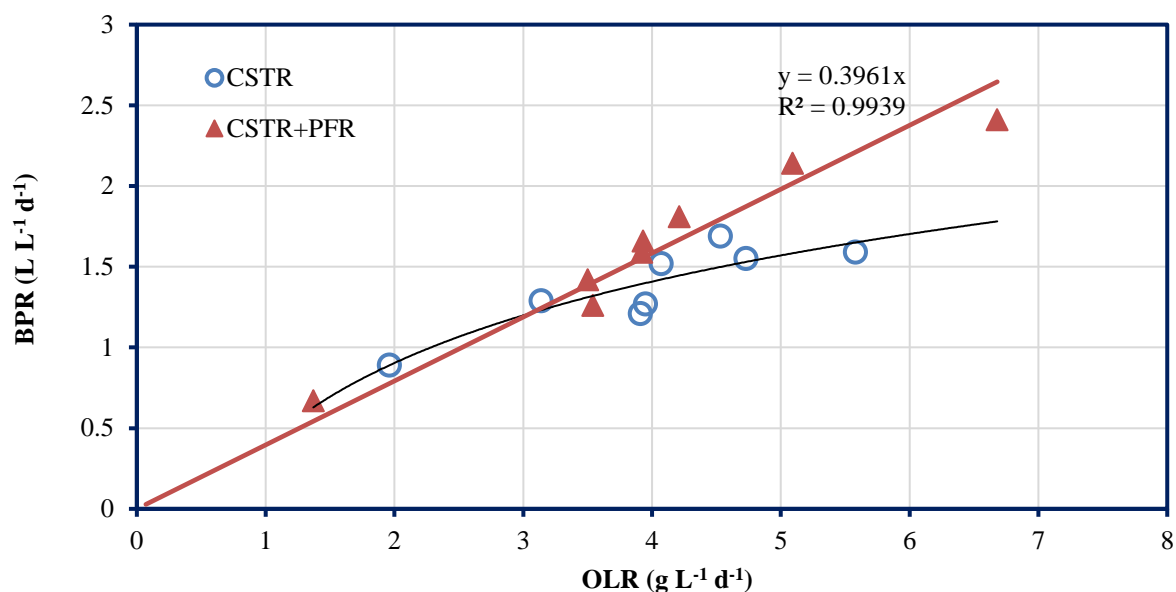


Figure 3. Evolution of the biogas production rate (BPR) as a function of the organic loading rate (OLR) for the CSTR and the CSTR-PFR cascade, treating diluted poultry manure.

Acknowledgements

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