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A Study of the Effects of Temperatures and Optimum pH on the Specific Methane Production of Perennial Ryegrass during Anaerobic Digestion Process under a Discontinuous Daily Feeding Condition

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Abstract : Perennial ryegrass is an abundant renewable lignocellulosic biofuel feedstock for biomethane production through anaerobic digestion (AD). In this study, six anaerobic continuously stirred tank reactors (CSTRs) were set up in three pairs. Each pair of the CSTRs was then used to study the effects of operating temperatures – psychrophilic, mesophilic, and thermophilic, and optimum pH on the specific methane production (SMP) of the ryegrass during AD under discontinuous daily feeding conditions. The reactors were fed at an organic loading rate (OLR) ranging from 1-1.5 kgVS.$L^{-1}d^{-1}$ and hydraulic residence time, HRT=20 days for 140 days. The pH of the digesters was maintained at the range of 6.8-7.2 using 1 M NH_4HCO_3 solution, but this was replaced with biomass ash-extracts from day 105-140. The results obtained showed that the mean SMP of ryegrass measured between HRT 3 and 4 were 318.4, 425.4 and 335 N L CH_4 $kg^{-1}VS.d^{-1}$ for the psychrophilic (25 ± 2°C), mesophilic (40 ± 1°C) and thermophilic (60 ± 1°C) temperatures respectively. It was also observed that the buffering ability of the reactors increased with operating temperature, probably due to an increase in the solubility of ammonium bicarbonate (NH_4HCO_3) with temperature. The reactors also achieved a mean VS destruction of 61.9, 68.5 and 63.5%, respectively, which signifies that the mesophilic reactors achieved the highest specific methane production (SMP), while the psychrophilic reactors achieved the lowest. None of the reactors attained steady-state condition due to the discontinuous daily feeding times, and therefore, such feeding practice may not be the most effective for maximum biogas production over long periods of time. The addition of NH_4HCO_3 as supplement provided a good buffering condition in these AD digesters, but the digesters failed in the long run due to inhibition from the accumulation of free ammonia, which later led to decrease in pH, acidification, and souring of the digesters. However, the addition of biomass ash extracts was shown to potentially revive failed AD reactors by providing an adequate buffering and essential trace nutrient supplements necessary for optimal bacterial growth.

Keywords : anaerobic digestion, discontinuous feeding, perennial ryegrass, specific methane production, supplements, temperature
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