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Bulk-Density and Lignocellulose Composition: Influence of Changing Lignocellulosic Composition on Bulk-Density during Anaerobic Digestion and Implication of Compacted Lignocellulose Bed on Mass Transfer

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Abstract : Lignocellulose, as an alternate feedstock for biogas production, has been an active area of research. However, lignocellulose poses a lot of operational difficulties- widespread variation in the structural organization of lignocellulosic matrix, amenability to degradation, low bulk density, to name a few. Amongst these, the low bulk density of the lignocellulosic feedstock is crucial to the process operation and optimization. Low bulk densities render the feedstock floating in conventional liquid/wet digesters. Low bulk densities also restrict the maximum achievable organic loading rate in the reactor, decreasing the power density of the reactor. However, during digestion, lignocellulose undergoes very high compaction (up to 26 times feeding density). This first reduces the achievable OLR (because of low feeding density) and compaction during digestion, then renders the reactor space underutilized and also imposes significant mass transfer limitations. The objective of this paper was to understand the effects of compacting lignocellulose on mass transfer and the influence of loss of different components on the bulk density and hence structural integrity of the digesting lignocellulosic feedstock. 10 different lignocellulosic feedstocks (monocots and dicots) were digested anaerobically in a fed-batch, leach bed reactor -solid-state stratified bed reactor (SSBR). Percolation rates of the recycled bio-digester liquid (BDL) were also measured during the reactor run period to understand the implication of compaction on mass transfer. After 95 ds, in a destructive sampling, lignocellulosic feedstocks digested at different SRT were investigated to quantitate the weekly changes in bulk density and lignocellulosic composition. Further, percolation rate data was also compared to bulk density data. Results from the study indicate loss of hemicellulose (r^2=0.76), hot water extractives (r^2=0.68), and oxalate extractives (r^2=0.64) had dominant influence on changing the structural integrity of the studied lignocellulose during anaerobic digestion. Further, feeding bulk density of the lignocellulose can be maintained between 300-400kg/m³ to achieve higher OLR, and bulk density of 440-500kg/m³ incurs significant mass transfer limitation for high compacting beds of dicots.

Keywords : anaerobic digestion, bulk density, feed compaction, lignocellulose, lignocellulosic matrix, cellulose, hemicellulose, lignin, extractives, mass transfer
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