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Effect of pH on Volatile Fatty Acids Production During Anaerobic Fermentation of Dairy Wastewater

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Abstract

The sustainable bioeconomy supports and promotes the conversion of biomass not only into renewable energy but also into high-value bio-products, thus contributing to the goals of the circular economy. Among the various bio-products that can be produced from biomass, volatile fatty acids (VFAs) are of significant interest. VFAs (acetic, propionic, butyric, isobutyric, valeric, and isovaleric acids) and their derivatives are widely used in the food, textile, pharmaceutical, leather, and plastics industries (den Boer et al., 2016). The value of the VFA mixture can range from $50 to $130 per ton (Fei et al., 2015), while for pure substances, the value is much higher, especially for volatile fatty acids with a higher carbon number (butyric acid $2163/ton > propionic acid $2000/ton > acetic acid $600/ton) (Calt, 2015). So far, VFAs have been produced chemically from petroleum by-products, requiring significant energy consumption and having a significant negative impact on the environment. On the other hand, it is known that VFAs are key intermediate products in the anaerobic digestion of biomass. These compounds are produced by acidogenic bacteria and are subsequently degraded by acidogenic bacteria. Therefore, with appropriate techniques, we can direct the process towards VFA production. The techniques used to increase the concentration of VFAs include a) increasing the hydrolysis rate to produce more soluble compounds for fermentation, b) promoting acidogenesis, and c) removing inhibitory factors. Promoting acidogenesis is the critical step in VFA production. The rate of acidogenesis depends on various parameters such as the composition of the substrate, characteristics of the microbial consortium, pH, temperature, hydraulic retention time, and organic loading rate (Zhou et al., 2018). In this context, the main aim of this work, was to examine the effect of pH on the production of VFA from raw dairy wastewater. Batch experiments were conducted in an automated lab-scale reactor (Minifors 2, Infors, Switzerland) at three different pH values (4.0, 5.0 and 6.0). The inoculum used for the experiments originated from a full-scale upflow anaerobic sludge blanket reactor treating domestic wastewater. The temperature was set at 35 ^{o}C and the agitation at 200 rpm. Samples were collected daily from the reactor and analyzed for VFA using a gas chromatography (6890N, Agilent) equipped with an FID detector. The results showed that the maximum VFAs concentration (2.223 mg/L) was achieved at pH 5, while pH 6 resulted in lower VFAs production (994 mg/L). Regarding the composition of VFAs, it was found that pH 4 mainly

promoted the production of propionic acid (61%) and acetic acid (31%). In contrast, experiments conducted at pH 5 promoted the formation of valeric acid (26%), butyric acid (24%) and acetic acid (24%). In conclusion, pH 5 appears to be an interesting option for VFA production from dairy wastewater, offering optimum results in terms of both quantity and quality.

Keywords: acetic acid; propionic acids; anaerobic digestion; acidification; wastewater

References

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