Effect of heat-alkaline treatment as a pretreatment method on volatile fatty acid production and protein degradation in excess sludge, pure proteins and pure cultures

Reasmey Tan\textsuperscript{a,b}, Kazuhiko Miyanaga\textsuperscript{a}, Davin Uyb\textsuperscript{b}, Yasunori Tanji\textsuperscript{a,*}

\textsuperscript{a}Department of Bioengineering, Tokyo Institute of Technology, 4259 J2-15 Nagatsuta-cho, Midori-ku, Yokohama 226 8501, Japan
\textsuperscript{b}Department of Chemical and Food Engineering, Institute of Technology of Cambodia, P.O. Box 86, Russian Federation Boulevard, Phnom Penh, Cambodia

HIGHLIGHTS

- Investigate the effect of heat-alkaline treatment on volatile fatty acid production and protein degradation.
- Quantify bacteria present in the activated sludge by quantitative PCR.
- HAT enhances VFA production only in excess sludge, albumin, and Gram-negative bacteria.
- Gram-negative bacteria are predominant in the activated sludge used.
- Bacteria present in activated sludge comprise only 10% of mixed liquor suspended solids by qPCR.

ARTICLE INFO

Article history:
Received 7 April 2012
Received in revised form 11 May 2012
Accepted 11 May 2012
Available online 22 May 2012

Keywords:
Heat-alkaline treatment
Volatile fatty acids
Protein solubility
Gram staining
Quantitative PCR

ABSTRACT

This study investigated the effect of heat-alkaline treatment (HAT) at pH 11 and 60 °C on volatile fatty acid (VFA) production and protein degradation in excess sludge, soluble and insoluble proteins, and pure cultures. In addition, quantification of bacteria present in the sludge was also examined. Experimental results showed that following acid fermentation under pH 7 and 37 °C, HAT enhanced VFA production in excess sludge, albumin, and Gram-negative bacteria, but not in casein or Gram-positive bacteria. Protein solubility was therefore found not to be the main criteria for VFA production. In the protein analysis, it was shown that the outer membrane protein (OmpC) of \textit{Escherichia coli} K12 was resistant to chemical and enzymatic hydrolysis. Gram staining revealed that Gram-negative bacteria were predominant in the activated sludge used in this study. In addition, the bacteria present in the activated sludge comprised only 10% of mixed liquor suspended solids (MLSS) by quantitative PCR.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

Biological nutrient removal (BNR) is an effective wastewater treatment technique for mitigating the eutrophication of water bodies. For biological removal of total phosphorus and nitrogen, volatile fatty acids (VFAs) are required. The necessary amount of VFAs, however, is not always available in wastewater, particularly when influent chemical oxygen demand (COD) is low. The use of internal carbon sources instead of commercial organic materials would decrease the sludge production in treatment plants (Ucisik and Henze, 2008; Yuan et al., 2009; Wu et al., 2010). The use of VFA-rich fermentation liquid as the additional carbon source for BNR has been considered to be a practical and sustainable solution for increasing BNR performance.

Biological production of VFAs from waste sludge fermentation has gained increasing interest due to the fact that both sludge reduction and VFA production in wastewater treatment plants (WWTPs) are achieved (Yan et al., 2010; Yuan and Oleszkiewicz, 2010). Furthermore, the produced VFAs or short-chain fatty acids (SCFAs) are the preferred carbon sources for BNR microbes (Zhang et al., 2010a,b) and also important substrates for methane production in anaerobic digestion (Ferrer et al., 2008; Dumas et al., 2010; Zhang et al., 2010a,b).

Anaerobic digestion is comprised of three main steps: hydrolysis, acidogenesis, and methanogenesis. Of these, hydrolysis of organic matter to soluble substrates is generally considered to be rate limiting during the acidogenesis phase of this process (Ucisik and Henze, 2008). Various pretreatment methods can be used to accelerate hydrolysis or improve sludge anaerobic degradability. These include mechanical (ultrasonic treatment, lysis-centrifuge, liquid shear, and grinding), thermal, and chemical techniques, as