Bioresource Technology 127 (2013) 181–187

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Characterization of aerobic granular sludge treating high strength agro-based wastewater at different volumetric loadings

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HIGHLIGHTS

- Fractal dimension averaged at 1.90 indicating good compactness of granules.
- Significant microbial evolutionary shift was observed during aerobic granulation.
- Raup–Crick indices decreased upon formation of mature aerobic granular sludge.

ARTICLE INFO

Article history:
Received 5 May 2012
Received in revised form 11 September 2012
Accepted 15 September 2012
Available online 25 September 2012

Keywords:
Aerobic granular sludge
Palm oil mill effluent (POME)
Denaturing gradient gel electrophoresis (DGGE)
Sequencing batch reactor
Microbial community

ABSTRACT

Understanding the relationship between microbial community and mechanism of aerobic granulation could enable wider applications of granules for high-strength wastewater treatment. The majority of granulation studies principally determine the engineering aspects of granules formation with little emphasis on the microbial diversity. In this study, three identical reactors namely R1, R2 and R3 were operated using POME at volumetric loadings of 1.5, 2.5 and 3.5 kg COD m^{-3} d^{-1}, respectively. Aeration was provided at a volumetric flow rate of 2.5 cm s^{-1}. Aerobic granules were successfully developed in R2 and R3 while bioflocs dominated R1 until the end of experiments. Fractal dimension (D_f) averaged at 1.90 suggesting good compactness of granules. The PCR–DGGE results indicated microbial evolutionary shift throughout granulation despite different operating OLRs based on decreased Raup and Crick similarity indices upon mature granule formation. The characteristics of aerobic granules treating high strength agro-based wastewater are determined at different volumetric loadings.

1. Introduction

Palm oil production has gained significant attention in recent years due to its many competitive advantages over other competing oils i.e. olive, vegetable and sunflower oils, for having low cost production, high yield and being free from trans-fatty acids. The utilization of palm oil has also increased rapidly owing to its multiple uses in both food and non-food industries contributing to greater demand and higher prices for palm oil production. The global aspiration to substitute fossil fuel with renewable fuel has given rise to increased demand for palm oil which is one of the sources for biofuel. The risks of pollution generated from the industry have been escalating following the rapid expansion of palm oil industry worldwide. The production of palm oil generates a large amount of solid and liquid wastes in the form of empty fruit bunch (EFB) and palm oil mill effluent (POME), respectively. Malaysia's palm oil industry produced almost 80 million dry tonnes of solid biomass per annum (Agensi Inovasi Malaysia, 2011). This volume is projected to increase to 85–110 million dry tonnes by 2020. Similarly, the current POME volumes are expected to increase from 60 million tonnes to 70–110 million tonnes by 2020. The untreated POME is to comply with legislation limits of BOD_5 of 20 mg L^{-1} for Standard A as outlined in the Fifth Schedule Paragraph 11(1) (a) Environmental Quality (Industrial Effluents) Regulations 2009 (Federal Subsidiary Legislation, 1974). The new regulations also outlined the effluent discharge standard to comply with color discharge of 100 ADMI. Therefore, color removal is fast becoming an important research parameter in relation to agro-based industrial wastewater treatments. Additionally, in recent years, the significance of technological improvements in handling of res-

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http://dx.doi.org/10.1016/j.biortech.2012.09.047