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Photocatalytic degradation of waste activated sludge using a circulating bed photocatalytic reactor for improving biohydrogen production

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HIGHLIGHTS

- A sloping trough circulating bed photocatalytic reactor was developed.
- Effective degradation of waste activated sludge using the reactor was identified.
- The reactor could increase the concentration of soluble chemical oxygen demand.
- Photocatalysis pretreated sludge was used as substrate for biohydrogen production.
- The photocatalytic pretreatment effectively enhance biohydrogen production.

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ABSTRACT

In this study, a sloping trough circulating bed photocatalytic reactor (STCBPR) was developed to degrade waste activated sludge (WAS). Effects of the four factors (shape of trough, circulating speed, TiO_2 dosage and dilution multiple of WAS) on the photocatalytic degradation of WAS were examined. Under the optimum conditions, 45% of the chemical oxygen demand (COD) removal and 47% of the volatile solids (VS) removal were achieved in 7.5-fold dilution after reaction for 8 h. Moreover, the WAS was pretreated by STCBPR and then fermented to produce hydrogen. The result showed that the cumulative hydrogen production from photocatalysis pretreated WAS was 3.6 times higher than that from UV-light pretreated WAS, and 17 times higher than that from raw WAS. Therefore, it could be confirmed that the STCBPR has higher photocatalytic degradation efficiency for WAS, and photocatalytic pretreatment could enhance the biohydrogen production.

1. Introduction

With the booming setup of sewage treatment plants, a large amount of sewage sludge is being discharged into the environment, which leads to heavy pollution. Various methods were tried to conduct the water harnessing, but the cost of sewage sludge treatment accounts for about a third of the total cost of water treatment using the conventional treatments (Japan Sewage Works Association, 2009). Waste activated sludge (WAS) refers to a kind of surplus activated sludge which is produced in sewage treatment works by the aeration of sewage effluent. It is a kind of complex heterogeneous mixture consisting of microorganisms, colloids, organic polymers and inorganic pollutants (Yu et al., 2008). As an important way of sludge treatment, anaerobic digestion has been being widely used to degrade the organic matters and to obtain renewable energy. However, because its composition is complex and it contains refractory materials, the WAS is difficult to be degraded in the anaerobic digestion process, especially in the hydrolysis stage (Pilli et al., 2011) which is the first stage of anaerobic digestion. In order to overcome this limitation, various pretreatment techniques, such as thermal treatment (Morgan-Sagastume et al., 2011), ultrasonic treatment (Apul and Sanin, 2010; Feng et al., 2009), microwave treatment (Yu et al., 2010), alkaline treatment (Li et al., 2008), and acid hydrolysis (Appels et al., 2011), were studied to facilitate the hydrolysis of refractory organic substances in WAS. Some of the pretreatment techniques did have some effect on the hydrolysis of WAS. However, several problems still remain: thermal treatment, ultrasonic treatment and microwave treatment would consume a large amount of energy; alkaline and acid treatment would cause secondary pollution.

Photocatalysis technology has been proved to be an effective technique for the removal of organic pollutants from industrial

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