

Nutrient removal in wastewater using microalgae

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Abstract

The removal of nutrients is one of the most difficult and high-energy intensive processes in urban wastewater treatment. It is usually achieved with biological systems such as activated sludge. Microalgae have been proposed as an alternative biomass: since they are phototrophic microorganisms, they do not need an organic carbon source and consequently they are able to grow and assimilate nitrogen and phosphorous especially in wastewater with low carbon to nitrogen ratio, contrary to active sludge bacteria.

In a laboratory scale, different methods for the selection of microalgae were evaluated: autochthonic microalgae and cultivation media with high concentrations of ammonium were found to increase the nitrogen removal rate and microalgae growth rate in wastewater. The combination of microalgae with active sludge has shown to increase organic carbon removal and nitrification rates.

Larger scale tests were executed on an urban wastewater treatment plant, where different photobioreactors treated the centrate of the sludge thickening while microalgae growth rate, nutrient removal and operational and external conditions were evaluated. Moreover, experiments have been conducted on separation of microalgae using a flocculation microflotation system and on biogas production using microalgae as a substrate.

The results suggest, that the microalgae are effective in the removal of nitrogen, especially in a tubular reactor design. The use of flocculation microflotation is a cost effective alternative for the separation and microalgae can be used as substrate for biogas production if correctly pretreated and co-digested.

Abstrakt

Der Abbau von Nährstoffen ist einer der komplexesten und energieintensivsten Verfahrensschritte der kommunalen Abwasserbehandlung. Traditionell wird dieser Prozessschritt mit Hilfe von biologischen Systemen (z.B. Belebtschlamm) realisiert. Mikroalgen wurden in der Fachliteratur bereits als alternative Biomasse für den Stickstoff- und Phosphorabbau vorgeschlagen. Da Algen phototrope Mikroorganismen sind, benötigen sie für ihren Stoffwechsel keine organische Kohlenstoffquelle, was ihren Einsatz besonders in Abwässern mit geringem Kohlenstoff zu Stickstoff Verhältnis interessant macht.

Die vorliegende Arbeit beschreibt vor diesem Hintergrund durchgeführte Experimente im Labor- und halbtechnischem Maßstab. Bei der Anreicherung von Mikroalgen haben insbesondere sowohl autochthone Mikroalgen, als auch solche, die in einem Kulturmedium mit hohen Ammoniumkonzentrationen gezüchtet wurden, erhöhte Wachstumsgeschwindigkeiten mit einhergehenden gesteigerten Stickstoffabbauraten im Abwasser aufgewiesen. Durch die Kombination von Mikroalgen und Belebtschlamm konnten der organische Kohlenstoffabbau sowie die Nitrifikationsrate deutlich gesteigert werden.

Drei halb-technische Anlagen wurden auf dem Gelände einer Kläranlage installiert und betrieben. Insbesondere wurden die Wachstumsgeschwindigkeit der Mikroalgen, die Stickstoffabbaurate und der Einfluss verschiedener Betriebsparameter auf die Behandlung von dem Zentrat der Schlammeindickung evaluiert. Darüber hinaus wurde die Algenabtrennung durch ein Mikroflotationsverfahren mit Flockung und das Biogaspotential der Algen überprüft. Die Ergebnisse zeigten, dass die Mikroalgen Stickstoff effektiv reduzieren, insbesondere unter Verwendung eines röhrenförmigen Reaktordesigns. Das Mikroflotationsverfahren ist eine kosteneffektive Alternative für die Separation der Mikroalgen. Mit vorausgehender Vorbehandlung können die Mikroalgen besonders als Ko-Substrat zur Biogasgewinnung eingesetzt werden.

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