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Publication date: 2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

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Bioflocculation of green microalgal biomass using activated sludge and potential for biogas production

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1. INTRODUCTION

New technologies are developed to recover wastewater resources and increase energy yields in form of biogas [1].
- Potential energy recovery using microalgae.
- Available harvesting methods are costly and energy intensive [2].

Objectives:
- Developing cost-efficient way of harvesting microalgae via bioflocculation using activated sludge from a short-SRT EBPR system.
- Assess the potential of energy recovery via biogas production from the harvested activated sludge-algal biomass.

2. METHODS

1. Flocculation experiments

Microalgal biomass:
Mixed green microalgal culture cultivated on effluent wastewater: Chlorella sorokiniana and Scenedesmus sp.

Activated sludge:
Taken from a short SRT (3.5 d) EBPR system [3]:
- Solid-liquid separation after the aerobic phase (ASco)
- Solid-liquid separation after the anaerobic phase (ASAN)

Flocculation strategies:
Strategy I: Flocculation of microalgae and activated sludge

Strategy II: Step 1: Coagulation of microalgae with a cationic polymer (PDADMAC)
Step 2: Flocculation with activated sludge

2. Biomethane potential tests

Mesophilic conditions (37 °C)
Digestion scenarios:
I. Algae
II. Algae + polymer (20 mg/g algae)
III. ASco/ASAN alone (activated sludge removed after the aerobic and after the anaerobic phase)
IV. ASco/ASAN + algae (10% ratio of algae/AS)
V. ASco/ASAN + alg + polymer (10% ratio of algae/AS, 20 mg polymer/g algae)

3. Flocculation

1. Polymer dosing

- 27 mg polymer/g algae dosing results in 92% microalgal recovery
- Restabilization effect results in lower recovery at high polymer dosages
- Microalgal recovery with activated sludge used as flocculant (strategy I) is low (40%) ↔ we need a coagulation aid (strategy II)
- 16 mg polymer/g algae dosing results in 97% recovery

2. Mixing ratio

- AlgAE + alg activated sludge + polymer (16 mg/g algae)

3. Activated sludge settleability

- With increasing algae/activated sludge ratios more polymer dosing is required to reach optimal recovery
- Optimum dosage should be estimated for the specific operation conditions of the process
- Bulking events in activated sludge systems cause poorly settling sludge → The biomass volume after settling is high
- The efficiency of the flocculation does not deteriorate, the microalgal recovery stays sufficient (>90%)

4. Biogas potential and energy recovery

1. Biogas potential of biomass

- Co-digestion of microalgae with activated sludge removed after the anaerobic phase produces significantly higher methane than co-digestion of activated sludge taken after the aerobic phase → due to stored PHA by PAO in the anaerobic phase of the EBPR and balanced nutrients due to co-digestion with microalgae

2. Energy recovery

- Effective preservation of organic carbon via the EBPR → up to 40% of the influent organic carbon is converted into methane
- Only up to 10% of the incoming COD is lost to the effluent of the EBPR

5. CONCLUSIONS

- An effective solution is proposed to harvest microalgal biomass and to significantly decrease the amount of polymer coagulant required;
- 97% microalgal biomass recovery was reached with 16 mg polymer/g algae
- Poorly settling sludge did not affect microalgal biomass recovery, however, due to bulking the biomass volume was increased;
- Optimum polymer dosing depends on the mixing ratio of algae and activated sludge;
- Co-digestion with biomass taken after the anaerobic phase enhanced biogas potential;
- Up to 40% of the influent COD of the EBPR was recovered as methane;
- Most of the COD was assimilated into biomass or mineralized to CO2, and only up to 10% is lost in the effluent of the EBPR.

ACKNOWLEDGEMENTS

The research was financially supported by the European Commission (E4WATER Project, FP7-NMP-2011-3.4-1 grant agreement 280756) and the Integrated Water Technology (InWaTech) project (http://www.inwatech.org/www2.ssl.no/)

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