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Laboratory Algae cultivation and BMP tests with *Ulva intestinalis* from the Gulf of Riga

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Abstract

This study aims to quantitatively evaluate the biogas potential of the green alga *Ulva intestinalis* from the Gulf of Riga, using BMP test with sewage sludge as inoculum. Meantime the nutrients role in biomass growth has been explored.
The results from growing rate evaluation show that the growth of macroalgae was observed up to a certain point (typically 6–8 days of exposure) even within samples without any additional nutrients; on the contrary higher concentration has shown no growth effects. This could be explained with too high nutrient concentrations jeopardizing other conditions that are vital for macroalgae growth.
The cumulative CH_4 yields show an important spectrum of cumulative methane yields, with the highest one observed in 1:3 A/I (algae/inoculum ratio) in which the macroalgae were chopped (92.1 ± 33.5 mL CH_4/g VS on average), while the lowest one was observed in 1:5 A/I where the macroalgae had no pre-treatment (36.0 ± 10.5 mL CH_4/g VS). The results do not show a clear impact of the pre-treatments. The scenarios with no pre-treatment exhibited the effectiveness in a range of 9.7–24.6 %, while the chopped ones – 14.56–24.8 %, pre-treated with pestle – 12.9–24.13 %. The results of this study confirm the suitability of *U. intestinalis* for biogas production, especially in the Baltic region.

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Keywords: macroalgae growing; sustainability of algae fuel; gasification of algae; co-digestion; methane yield

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1. Introduction

With the effects of a dramatic CO_2 increase in the atmosphere due to carbon-intensive activities, such as continuous fossil fuel burning, threatening the sustainability and posing multiple risks to the environment, alternative fuel sources have become an important topic both for national leaders and the scientific community. In this direction biofuels, biodiesel and biogas, frequently evaluated as either carbon-neutral or even carbon-negative, when sustainable feedstock, such as Algae, are used represent a viable solution [1] and have gained considerable scientific interest. Nevertheless, not all species are studied sufficiently well, including the feasible and sustainable techniques for wide scale cultivation. Lack of cost-efficient mass scale production routes prevents this feedstock from being economically exploitable [2]; therefore, the use of algae for energy production is still far from being commercialized at large scale, despite the promising potential [3]. Seaweeds have drawn particular attention due to their capability to consume greenhouse gases (GHG) as feedstock, as recent studies have found [4], and many studies have been conducted, including industrial production of not only biogas, but also biodiesel [5, 6], bio-ethanol [7] and hydrogen [8], among others. As most macroalgae species perform photosynthesis, growing and harvesting them results in removal of nutrients from a system, and thus minimizing conditions for eutrophication [9]. This might contribute to solving the problem of high chemical oxygen demand (COD) levels in aquatic ecosystems rich in nutrients. The problem of eutrophication is particularly relevant in the case of the Baltic Sea, where COD level is one of the highest among the seas in the world [10]. Furthermore, growing seaweed does not require a land to grow, or a competition with food crops, while structural polysaccharides and low or no lignin content make macroalgae appropriate for biogas production via anaerobic digestion [11]. All these features make environmental performance of macroalgae significantly more favourable than natural gas from the Life Cycle Assessment (LCA) perspective [12].

Macroalgae using sludge as inoculum have a potential to be used as biogas feedstock and thus significantly minimize the waste products by re-utilizing them and closing the loop. As such, using Algae mixed with sewage sludge for energy recovery can also contribute to enhancing Circular economy, one of the strategies to counter depletion of resources and traditionally carbon-intense economy. Gasifying sewage sludge is proposed by D. Buchholz as one of the measures for achieving Circular economy [13]. Even more importantly, studies that have been conducted so far show that the mixture of sludge and Algae exhibits a better productivity of biogas than the sludge alone [14]. This can be explained by the optimization of C/N ratio by improving it to 20.0 or higher and thus preventing from otherwise [15] inhibiting environment for methanogenic bacteria [16, 17].

Biochemical methane potential (BMP) test is a frequently used method to evaluate the anaerobic biodegradability of a specific substrate and thus assess a specific methane yield [9]. Methane production curves are usually divided into three stages: Lag phase, decomposition phase, and flattening phase [18]. The lag phase is the time from the start of the experiment to the start of the methane production. While the results differ, depending on the experiments, there was no lag phase observed for the bottles with only sewage sludge and with lower (12 % or 25 %) concentrations of algae and only a short lag phase for the bottles with 37 % algae in the experiments, conducted by Olsson et al. [19]. Such behaviour of methane formation could be justified by the fact that microorganisms are disturbed and need time to adjust to the new environment, resulting in lack of methane peaks at the beginning of the incubation.

Conversely, the shorter the lag phase, the more easily microorganisms adapt to the conditions and utilize the substrate efficiently. Some pre-treatment methods, such as drying the cells, could prolong the lag phase, as observed with microalgae samples by Olsson et al. [19]. However, the findings by Wang et al. suggest the opposite tendency, as the lag phase of the microalgae slurry was 20 days [20].

This study is going to evaluate the feasibility of *U. intestinalis* for biogas production through BMP test and the amount of nutrients that it would be optimal for a more efficient biomass growth.