METHANE PRODUCTION BY ANAEROBIC DIGESTION OF ALGAE

Authors : C.-M. Asinari di San Marzano, A. Legros, C. Piron, C. Sironval, E.-J. Nyns and H.P. Naveau

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Head of Project : Prof. E.-J. Nyns

Contractor : Catholic University of Louvain

Address : Unité de Génie Biologique
Place Croix du Sud, 1, bte 9,
B-1348 Louvain-la-Neuve, Belgium

Subcontractor : Prof. Sironval
University of Liège

Summary

The research aims (1) at improving yields and rates of biomethanation of algae and (2) at correlating composition of algal batches with methane productivities. Previously, it had been shown with *Hydrodictyon* algae that a two step system (liquefaction and biomethanation) gave improved results over a one step, completely-mixed system. In the present work, the influence of environmental factors such as temperature and load on the first step were investigated. Although the results of the liquefaction varied somewhat with the running conditions, these variations were without appreciable effect on the overall methane productivities. Besides, preliminary results of a two step system, a first percolating step followed by an upflow methane digester with active biomass accumulation look promising. Application of the two step biomethanation process to the algae *Tetraselmis* elicited a problem of reliability with time, presumably due to enhanced concentrations in ammonia resulting from increased biodegradation of proteins. Increasing the salt (NaCl) content (presently up to 20 g x l^{-1}) in the mixed liquor of a one step digester had no influence on the process. Biomethanation of six algal species showed good although inequal potential for methane production with yields from 0.20 to 0.33 l CH_4 x g^{-1} VS_o. Monitoring based on volatile solids (VS) contents appears erratic in the two step process because samples contain variable amounts of compounds volatile below 100 °C. Monitoring based on COD appears more reliable. Lagoons for the production of ton amounts of freshwater *Hydrodictyon* algae in industrial luke-warm were constructed. Production and population analyses of the algae are in progress.

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1. INTRODUCTION

1.1. Past results. It has been shown (1) that both rate and yields of methane production from the freshwater algae *Hydrodictyon* can be increased by implementing a two step biomethanation system, each stage of which consists of a completely-mixed, semi-continuous fermentation without active biomass recycle. *E.g.*, the yield at 14 d mean retention time and C_V(*) = 4 g VS_o x l_{ML}^{-1} x d^{-1} increases from 0.20 in the single step process to 0.33 l CH_4 x g^{-1} VS_o in the two step process. Moreover, the reliability of the two step biomethanation system appears improved as compared to the one step, completely-mixed biomethanation system.

1.2. Objectives of the research. Five objectives are assigned to the present research : (1) optimisation of the two step biomethanation system (liquefaction and digestion), applied to the freshwater algae *Hydrodictyon*, (2) optimisation of the biomethanation of the marine algae *Tetraselmis*, (3) evaluation of the potential of other algal species, produced or harvested within the EC Programme, to be bioconverted into methane, (4) nitrogen and carbon mass balances around the biomethanation system for a better assesment of the process and (5) production of freshwater algae and study of variations in their composition.

2. MATERIALS AND METHODS

2.1. Algae. Unicellular marine algae *Tetraselmis* are grown in ponds at Lamezia Terme, (Calabria, Italy) (Prof. K. Wagener and R. Materassi, contract ESE/R/020/D). Once harvested they are oven-dried, air-dried or kept fresh after centrifugation. *Porphyridium cruentum* is cultivated in batch in artificial seawater and *Scenedesmus acutus* grown in continuous freshwater cultures (Dr. Gudin, contract ESE/R/037/F). They are harvested by centrifugation. The freshwater algae are filamentous *Hydrodictyon reticulatum* which grow in luke-warm water flowing through lagoons near the power plant of Tihange (Belgium), and originating from the river Meuse. The later algae are sometimes mixed with other algae such as *Cladophora*, diatoms and even higher plants like *Lemna*. The collected green biomass contains small animals, especially gasteropods which feed on *Hydrodictyon*.

2.2. Population analyses of *Hydrodictyon* algae. Randomised samples are taken each week either from the fresh or the dried biomass and are analysed for population and chemical analyses as follows. For population analyses, fresh 100 g samples collected at random are washed several times with tap water and filtered on paper. The species selected for the analyses (*Hydrodictyon, Cladophora,* other algae, *Lemna,* gasteropods and insects) are separated by hand and dried at 85 °C untill constant weight. Chemical analyses include total volatile matter, proteins, lipids and sugars, ashes and minerals. As a control, the water of the river Meuse is analysed for its mineral content.

2.3. Running conditions of methane digester. Completely-mixed, one step and second step methane digesters are operated anaerobically at 35 °C, with semi-continuous loadings and no active biomass recycle in 2 l all glass vessels described previously (1).

3. RESULTS

3.1. Optimisation of the two step biomethanation system using either *Hydrodictyon* or *Tetraselmis*

3.1.1. Optimisation of the first step (liquefaction) of the two step process

(*) Symbols and abbreviations : see Table VIII