

Determining Biogas Yield of Algae

Algae is considered a 3rd generation biofuel that in theory can be grown sustainably in waste streams and ponds. But algae in themselves are only biomass, which for energy purposes need transformation. One of the options is to through anaerobic digestion turn it into biogas, which can be upgraded to biomethane. The advantage of biogas is that it could utilize residues from other processes, e.g. production of nutrition. But how much biogas can be produced from a certain substrate? This is a key figure for any circumstance where there is available biomass, not only algae. But simply looking into literature is seldom enough.

BIOMETHANE POTENTIAL TESTS

How much biogas a material can give is usually given as the biomethane potential (BMP), which is the volume of methane per unit of organic material (either VS or COD). Carbon dioxide is not included due to that it is the methane that carries the energy and it will vary in concentration in biogas.



The German standard VDI 4630 gives rules and specifications to follow when determining the biogas output of substrates. It explains terms to avoid misunderstanding and describes all the connected analyses needed for BMP tests. It acknowledges the fact that test results can be difficult to understand due to different test conditions.

Even though this standard is comprehensive, the correct method for determining BMP is still a matter for debate. Several attempts have been made at standardizing the methodology, as it has been shown that results would vary heavily between laboratories (Raposo et al). One issue, is that since biogas is a gas and generally its energy (or methane) content is related to the volume of the gas, it will vary according to the environment of the experiment. BMP should be given for standard conditions, which is 0°C and one atmospheric pressure. Other issues are for example: Volume of headspace, inoculum to substrate ratio, temperature range, methods for gas measurement, duration, and other differences in practice.

The differences in values due to different conditions of tests might not always seem considerable, but important decisions rely on them, which in the long run will have large implications. Another issue is that when the amount of samples becomes many, the 'traditional' way of conducting BMP tests can be time-consuming, especially if the biogas has to be collected and analyzed. The capacity for running samples simultaneously can also be limited, and BMP tests should always be done in triplicates. The amount of samples in TransAlgae to be investigated are many, and variations in e.g. growth conditions should be possible to observe in the BMP assays.

AMPTS II

An efficient way of eliminating or reducing the risk of errors is to have a dedicated, automated devices for BMP measurements. One such device, which is in use at Novia UAS, is the Automated Methane Potential Test System (AMPTS II) by Bioprocess Control, Sweden, pictured below.



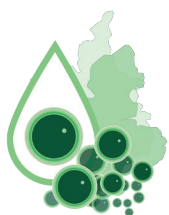
AMPTS II

The system consists of an incubation unit (left), which is a water bath with 15 bottles as reactor vessels with individual stirrers, a CO₂-absorption unit (centre) and a flow cell array with data acquisition unit (right).

The aim of the device is that it allows for standardization of measurement procedures and data interpretation. Its operation is automated and reduces the amount of labor required for basic tasks in the laboratory. The accuracy of the system is high, it normalizes the values to standard conditions and eliminates overestimation caused by the headspace volume. The measuring works with water displacement; the methane will gather and build up pressure in a flow cell that opens, displaces water and registers a certain volume. The accumulated gas is then related to the amount of organic material.

APPLICATION IN TRANSALGAE

In TransAlgae, not only the BMP of algae is determined, but also the effect of pretreatment and co-digestion. BMP can vary heavily, depending on several factors.



For biofuel purposes, microalgae can be put to nutrient stress, which increases lipids (see info sheet #2) and can be turned into biodiesel. But different organic fractions also affect the biogas

yield, as lipids, carbohydrates and protein contain different amounts of energy. This means that the conditions for cultivation affect the energy yield. In the wild, the organic fraction of both micro- and macroalgae will vary naturally. Open pond systems can also vary in species compositions, where the species have different yields. By looking into literature, it can be seen that the reported BMP values for algae can vary greatly. The correct value is attributed to many factors, and for a real evaluation, it is necessary to determine BMP experimentally. How easy it is to anaerobically digest a material can also vary. This 'availability' can for example be seen in the degree of degradation after the transformation, and untreated algae usually has a low degree. Pictured below is AMPTS II setup at Technobothnia, Vaasa, Finland.



AMPTS II

With many possible combinations of substrates due to variations in co-digestion and pretreatment, an automated system will both save time and assure confidence in the results. To manually carry out the procedures for e.g. gas measurement would require much more labor in the laboratory. This time can now instead be focused on other tasks, such as reporting and explaining results. Comparison with other results, done with satisfactory methods, becomes easier. Since the device reports flow rates, down to a quarter of an hour, it is possible to investigate the production rates and possible inhibition in detail.

CONCLUSION

BMP is an established term, which many researchers report and rely on. It is however connected with uncertainties, and it is necessary to check the methods used when looking for a value in literature. Some of these uncertainties can be reduced by using an automated system, such as AMPTS II. The reduced amount of time required for daily tasks allows for researchers to focus on advanced tasks. To be able to refer to the function of the device and the reports it produces makes it also easier to describe the methods used, which is vital when reporting BMP values.

While BMP is a clear way to report how much energy can be produced by anaerobic digestion of a substrate, it still does not necessarily tell the whole story. It does not, for example, say anything about the time or degree of degradation it takes to reach a BMP value. Another aspect is that BMP assays are done batchwise, while full scale anaerobic digestion is a continuous process, where the culture of microorganisms will adapt to the substrates. Harmonizing the experimental methods makes it easier to compare results and thus advance research, which in turn can contribute to increased usage of this biofuel.

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FURTHER READING

Raposo et al., 2011, Biochemical methane potential (BMP) of solid organic substrates: evaluation of anaerobic biodegradability using data from an international interlaboratory study. J. Chem. Technol. Biotechnol., 86: 1088–1098