Website address:
https://www.biooekonomie-bw.de/en/articles/news/residues-from-biogas-plants-as-feed-for-algae

Residues from biogas plants as feed for algae

Algae are frugal organisms. They require only light, water, minerals and carbon dioxide to be able to produce biomass. These properties will now be exploited economically in a two-year research project. Dr. Stefan Sebök from the University of Hamburg plans to study the holistic utilisation of degradation products of a biogas plant in Wallerstädten by linking them to land-based algae cultivation.

Dr. Stefan Sebök from the University of Hamburg intends to use Ulva lactuca algae degradation products accumulating in the biogas plant in the city of Wallerstädten.
© Dr. Stefan Sebök

Algae will probably play an increasingly important role in the human diet. This will open up new possibilities for food production and also represents an innovative strategy for the consistent and targeted use of biological material cycles and renewable energies. In a third-party funded research project at the Department of Aquatic Ecophysiology and Phycology at the University of Hamburg headed up by Prof. Dr. Dieter Hanelt, Stefan Sebök is focusing on recycling residues produced in a local biogas plant. His aim is to avoid the use of fossil fuels and artificial plant fertilisers as much as possible. Sebök started working with organic farmer Stefan Ruckelshaußen, operations manager of the biogas plant in Wallerstädten (Stadtwerke Groß-Gerau Versorgungs GmbH), in November 2018 and demonstrated that large algae do not need the sea for breeding. Sebök studied biology, economics and computer science in Jena, and later took distance learning courses in waste and landfill management as well as economic environmental management.

Fermentation residues, heat and CO2 for the algae

Biogas is produced by microbial communities that can degrade almost all organic matter and are thus able to ferment almost any type of biomass. Biogas is a high-quality renewable energy source, and can therefore be converted in combined heat and power plants into electrical energy and heat, and used as fuel or fed into existing natural gas grids. Biogas technology has many advantages: biogas can always be produced whether or not there is sun or wind. At the same time, only the carbon previously bound in plants is released as CO_2, thus contributing to reducing the greenhouse effect. The by-products of biogas production include heat, CO_2 and fermentation residues, the latter as organic and inorganic material that is difficult to degrade.

"The idea is to use these by-products for algae cultivation and to further utilise the raw material of the algae biomass," says Sebök, explaining the alternative recycling approach. This is a perfect combination, as these waste products meet the needs of aquatic plants and therefore stimulate algal growth. The CO_2 can be passed as a carbon source into the algal culture, the fermentation residues provide valuable minerals and nutrients. Sebök now wants to investigate the circumstances under which the algae are most productive.

Residual materials become high-quality products

So far no one has integrated macroalgae cultures into a biogas plant, but it is a clever idea for many reasons. Fermentation residues were previously used as fertilisers, but the Fertilisers Ordinance required them to be stored for three to six months prior to application. "During this time, you cannot exploit the nutrient potential of the fermentation residues," says Sebök, "they cannot be taken on to fields and used on plants." When the fermentation residues are separated into solid and liquid phases, the liquid parts can be fed to the algae without requiring prior storage. As far as biogas production is concerned, a large proportion of valuable plant carbon is lost as CO_2. Biogas has a carbon dioxide content of up to 40 percent. Carbon dioxide cannot be used for producing energy. However, it can be turned into important raw material for producing chemicals. “It would be good if we could fix this 40 percent, just as algae do when they incorporate carbon dioxide into their biomass,” says the ecologist.

The waste heat resulting from the biogas production process can currently only be used for energy purposes. Nevertheless, many biogas production plants lack an effective heating concept and blow the heat into the hall or outside. If the heat is

passed through heat exchangers, it can be used to cool the algae cultures as, depending on the species, algae grow preferentially at temperatures below 20°C. Sebök comments: "That's how we can introduce a new value-added stage and make better use of resources!"

Interplay of all factors so that the biogas plant and the use of waste products works optimally. (BHKW: combined heat and power plant, WT: heat exchanger).

Sea salad as superfood

Algae can be used in many ways. Finding out how is the project's second major goal. Ulva lactuca, a green macroalga commonly known as sea lettuce, grows very fast in the sea and in brackish water. Under good conditions, the biomass of sea lettuce can double in three to four weeks. The algae can then be dried or prepared as a salad. The algal biomass is rich in protein, low in fat and calories and provides many important nutrients. Algae are already widely used as food in Asia. In future, however, algae can also serve as an alternative source of protein. "In terms of dry matter, algae have a very high protein content of up to 40 percent, which is in the range of soya," explains Sebök. Likewise, sea lettuce can be used as cattle feed or fertiliser, or in the cosmetics and pharmaceutical industries for a variety of applications. Even fuel would be conceivable. In contrast to rapeseed, the advantage of macroalgae is that they do not take over agricultural land. You can grow them in your garden, in tanks or even vertically on the sides of houses. There is currently no strategy for the recovery of macroalgae.

Sebök hopes that this will happen automatically if the project shows that large-scale production is possible. "From an economic point of view, we chose the highest-priced recycling method," says Sebök, "When used as food, one kilogramme of algal dry mass costs 180 euros." The fertiliser industry would only be prepared to pay one or two euros per kilo and even if they purchased 20,000 tons a year, it would not be economical. However, there is still a market for algae, including potentially for use as superfood, which is currently still dominated by microalgae.

Inland cultivation

Some varieties of the currently cultivated large algae actually look like crunchy salad leaves bought from a market stall. From left to right: dulse, carrageon moss, sea salad.

Most people who cultivate marine macroalgae do so in the sea. Sebök and his team are cultivating it on land using salted freshwater. "We are the first in the world to do this because we have no other option. The state of Hesse is located in central Germany a long way from the sea," says the biologist. Germany has very little coastline and is unable to use the algae economically. The salt content of the Baltic Sea is far too low for the algae, and the North Sea mud flats are a national park, and hence not available for this type of use. Salinating freshwater is less dramatic than it sounds. While in other countries seawater is collected and passed through tanks 20 times a day, our project only requires the freshwater to be salted and filtered once a week. The project also focuses on the energetic assessment of algae use. Sebök works closely with his project partners; he obtained the first algae for his experiments from an algae farm on the island of Sylt. A company called Ingenia GmbH enriches CO_2 and controls the temperature of the culture medium and the gentle drying of the algae. Palaterra, a manufacturer of soil and compost, is researching the precise separation of fermentation residues into high-quality algae fertilisers.

The project's overall objective is to create an economic re-use model, which will also contribute in the future to increasing the value of further biogas plants in agriculture. "Of course, we still have to examine on a large scale whether this works economically and in practice," says Sebök. He currently has two 2,000-litre tanks of algae in a hall, but in spring he wants to move outside into the sunlight and upgrade the current capacity to five 25,000-litre tanks. "If a sufficiently high biomass yield can be obtained with the CO_2 and the fermentation residues from the biogas plant, it would be possible to use the algae as a substrate for biogas production. That would be a wonderful cycle," says the researcher.

Article

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Further information

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