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AlgaeBioGas

Algal treatment of biogas digestate and feed-stock production

Demonstration centre for biogas digestate treatment with microalgae

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INTRODUCTION: BIOGAS DIGESTATE IS A CHALLANGE

Objective

There are more than 17 000 biogas plants in Europe and the number is still rising. Through the process called anaerobic digestion, biogas (mainly methane and carbon dioxide) is produced and used for electricity and heat production or upgraded to biomethane. Side product of anaerobic digestion is digestate, a liquid substance with high levels of inorganic nutrients. 1MWe biogas plant produces 150 m^3 digestate per day, which poses a problem for biogas plants: digestate needs to be stored, transported or treated as waste water. AlgaeBioGas system (ABG) offers a solution for treatment of biogas digestate with microalgae and bacteria, recycling nutrients and producing biomass, therefore lowering or eliminating costs for digestate treatment, storage and transport.

Biogas production

Biogas technology or anaerobic digestion is used in various ways. Most of the uses are focused to converting biological waste to methane-rich biogas which can be used to produce electrical power, it can be fed to the gas network or it may be used as a biofuel.

To produce biogas, sufficient feedstock is needed. Biogas feedstock can be wastewater sludge, biological waste or agricultural waste (manure resulting from animal farming). Such feedstock is frequently enriched with some amount of energy crops that are specifically cultivated for biogas production. In many situations the energy crops are the main source of energy and bio-waste processing is a side-effect.

Biogas plants convert most of the organic matter in the feedstock to methane (and CO_2); the material that remains from such anaerobic digestion is called biogas digestate.

Digestate and problems with it

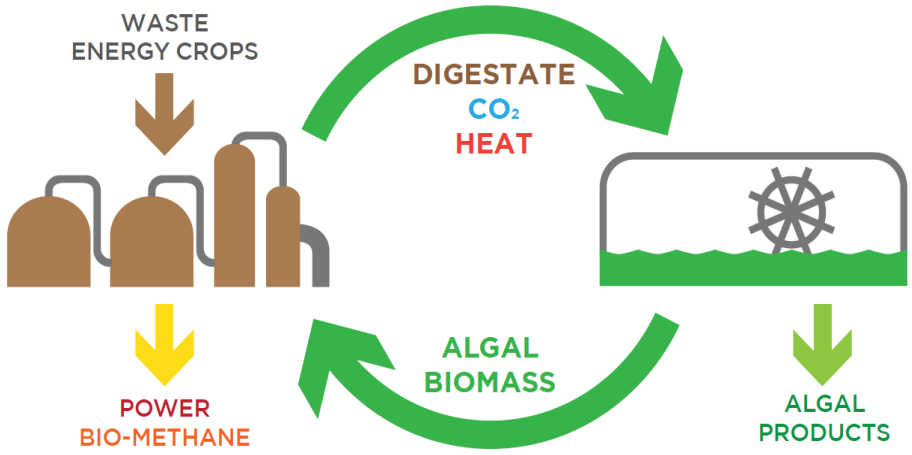
Digestate is a relatively diluted substance with relatively low content of organic matter, but very rich in inorganic nutrients, such as ammonium and phosphate. Digestate presents nutrient-rich waste and needs to be treated accordingly. In some case digestate is separated to liquid and solid fraction. Solid fraction can be used as fertilizer, while liquid fraction containing a significant portion of nutrients is sometimes treated as wastewater on waste water treatment (WWT) plant, which results in high costs for biogas plant operator and loss of nutrients. Depending on biogas plant size and production, liquid amount of digestate presents a problem, since if used as a fertilizer, must be stored until use and transported to the fields. This presents additional costs for biogas operator and can be a problem if biogas plant is operating in an environment where use of fertilizers is restricted by law.

Biogas digestate, when considered as a wastewater, is notoriously hard to treat. Its organic contents is low and even the organics that are contained in the biogas digestate are hard to digest. Other substances mostly pass through the ordinary biological WWT and become a high load for the tertiary WWT treatment.

AlgaeBioGas solution: Algae

AlgaeBioGas project is focused on improved digestate treatment, which reduces cost for liquid digestate treatment by recycling nutrients with algae and bacteria and at the same time produces algal biomass, which can be used as feedstock for biogas production. Therefore our technology enables biogas operator to produce energy and/or biomass with added value from waste product, while at the same time solving the problem with digestate storage and transport, since our system is integrated in to the existing biogas plant.

Algae are photosynthetic organisms, turning solar energy into oxygen and inorganic nutrients into algal biomass. These are the features we take advantage of in our process. By producing oxygen, algae also help maintain naturally present bacterial community, which is responsible for organic matter and nutrients removal in classical WWT plants.



Scheme of AlgaeBioGas process

ALGAEBIOGAS DEMONSTRATION CENTRE

Demonstration centre for biogas digestate treatment with algae is located in Ljubjana, Slovenia, next to a thermophilic biogas plant. Biogas plant is treating biodegradable waste and has installed power of 0,52 MWe. Daily production of liquid digestate is 68 m^3. Demonstration centre consists of two algal ponds (main pond 100 m^2 and inoculation pond 10 m^2), located in a greenhouse to ensure optimal conditions for operation and limit seasonal variations.


Biogas plant and greenhouse

Digestate from the biogas plant is introduced to the main pond; quantity varies depending on the type of digestate and operation mode (winter/summer). Nutrients (especially nitrogen and phosphorus) are used by algae and bacteria in the pond, producing algal-bacterial biomass, which is pumped in to the sedimenter and harvested daily. Produced biomass is again used as a substrate for biogas production, but its use can be extended, depending on the local environment and consumer needs. Residual water from the harvesting can be discharged to the environment or reused in the process.

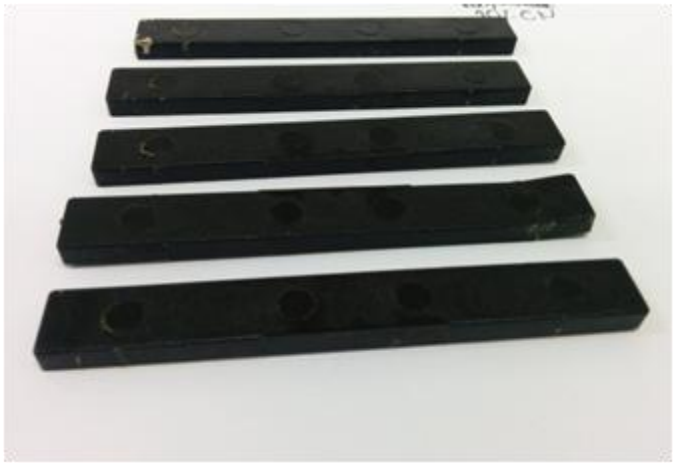
Main pond with paddlewheel


Inoculation pond

INNOVATION

Added value and costumer benefits

Our innovative technology improves digestate handling and relives biogas operator from unwanted waste, while reducing costs and at the same time producing feedstock for further use. By treating digestate with algae, we solve the problem of digestate storage for longer periods and diminish cost for transport to the fields, since digestate is treated on site. This process further ensures nutrient recycling and biomass production, which then represents feedstock, with value on the market. Algal biomass can be used as feedstock in biogas plant or for further exploitation and production of new materials. This technology not just reduces the waste, but enables energy production. Besides that, biomass produced during the process of treatment of digestate has diverse use: as feedstock for biogas production, organic fertilizer or even bioplastic substrate. Additionally, excess heat and CO_2 are used in AlgaeBioGas process.



Composite plastic with 10% algal biomass filling

Our services

We offer service for algal treatment of biogas digestate, which is an innovative approach for biogas plants in search of improved quality of digestate liquid fraction, energetic substrate (feedstock), recycling CO_2 emissions, effective use of excess heat and reduction of odour. Nutrients from digestate can be recovered and cycled on site.

Listed below are some major indicative impacts of algal treatment as an example for a 1 MW biogas installation running on corn silage.

- We can recycle 95% of nutrients in liquid phase of digestate on 3-5 ha of algal bacterial treatment facility
- Biomass production in such plant would be 120 t/y

- 240 t of CO_2 emissions yearly could be recycled, out of 13000 t cycled through corn silage
- In addition to the algal biomass an approximately equal weight of carbon rich residues can be used as a gas substrate
- Biomass production in such plant would replace 9-27 ha of corn out of 335 ha if only corn was used as a substrate
- Reduction in CO_2 emissions from bacterial treatment of digestate up to 1100 t CO_2 annually; with NO_x and N_2O emissions significantly reduced

The wide ranges of numbers above depend on other substrates used, quality of solid/liquid separation, area and depth of algal subsystem, climatic conditions and differences in estimates.

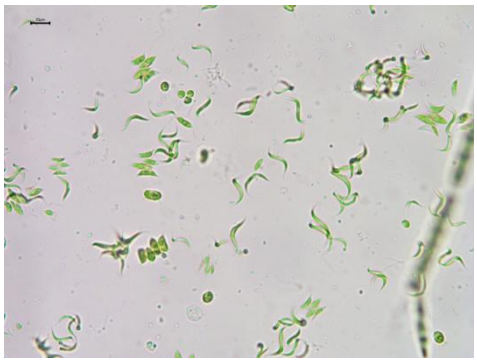
AlgaeBioGas technology is innovative because:

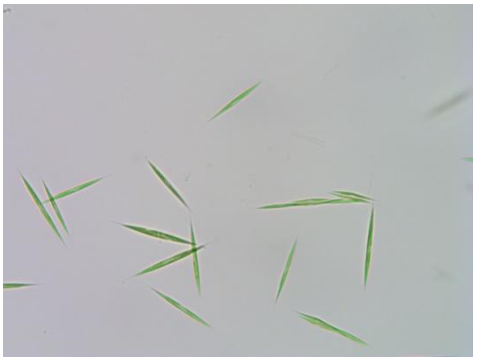
- it ensures CO_2 recycling,
- enables high area efficient production of biomass (expected efficiency is 3-5 times the efficiency of corn), this alleviates the alternative food or energy, degraded land may be used, due to continuous process, there is less need for crops storage leading to better area utilization and lower cost,
- nutrient recycling, which is also done when digestate is used as fertiliser, but liquid phase of digestate may be detriments to soil fertility and it is never as efficient as its use for algal growth: fertilisers spread to soil are washed into ground water (thus polluting drinking water by nitrates), lost by evaporation of ammonia and similar; organic mass in liquid digestate (some 4%) is converted to (uncaptured) CO_2 in soil (or during composting); in our case it is mostly converted to bacterial biomass thus increasing the recycling efficiency,
- significantly decreases use of electrical power for WWT (aeration).

RESULTS

The demonstration centre is in full operation since September 2014 and the optimization of plant operation is still on-going, but results of digestate treatment are well aligned with oxygen balance. The digestate treatment capacity is directly proportional to algal production thus replacing aeration required in ordinary aerobic water treatment plant.

Preliminary performance results show that approximately 30 m^3 of liquid digestate with COD content 8000 mg O_2/L can be treated daily per hectare of ponds with cleaning efficiency 94 %. Performance largely depends on amount of available light and digestate quality; its colour is one of the main limiting factors. Biomass production is in the range of 30-40 t DM per hectare per year. Result show effective removal of phosphate and nitrogen, as well as odour reduction. Microbial community has established itself and we have one species of algae dominating for the greater part of the year.





Microalgal species dominating in the ponds in2015

MARKET

AlgaeBioGas technology is at the moment most suitable for smaller biogas plants, up to 0,5MWe, running on food waste or similar. Our main markets are European countries with greater number of biogas plants and/or legislation which restricts the use of digestate as fertilizer, such as Germany, Italy and Sweden.

CONCLUSION

Algal-bacterial treatment of liquid biogas digestate presented in AlgaeBioGas project introduces alternative eco-friendly solution for excessive nutrient rich digestates. By using natural processes such as algal photosynthesis and bacterial respiration and biomass growth, we are able to recycle nutrients from digestate to the point where residual water from the process can be discharged to the environment and at the same time we produce algal biomass which can have multiple uses, depending also on the type of digestate used. With this process we reduce costs for traditional waste water treatment process with aeration and solve problem with digestate use for smaller biogas plants.

Technology is being further developed and adapted for other types of waste water, such is salty water from the food industry.

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