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Biogas production from forage and sugar beets - process control and optimization - ecology and economy

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Summary

The limited resources of fossil energy in addition to the environmental pollution caused by their generation and use has made the production of energy from renewable resources very interesting in the last decades. A currently available and potential alternative energy source is the anaerobic digestion (biogas production) from energy crops which has been encouraged in German policy (REA, 2000). Forage and sugar beets, due to their high organic dry matter (oTS) yield per hectare, are energy crops which are thought to have high biogas production.

Moreover, they can be easily ensiled and stored to be used for the whole year. Until now there has been no accurate data available at the anaerobic digestion of forage and sugar beets. Furthermore, the combination of ensiling and digestion is considered to be a new technology. The first objective of this thesis was to exactly examine the anaerobic digestion of forage and sugar beets silage. Therefore, laboratory scale tests (17 batch reactors and 16 semi continuous reactors) were performed to determine the anaerobic capacity of forage and sugar beets silage (FB S & SB S) and to determine their methane yield and the biogas properties under different process conditions. The feasibility of co-fermentation of beets with cow manure (CM) was also included in this study. The effect of the digestion process an parameters such as chemical oxygen demand, ammonium nitrogen and volatile fatty acids was determined. The second objective of the thesis was to compare biogas production from beets to conventional electricity production with respect to energy balance, ecological balance and economy, so that a possibly optimized balance methods with all measurable and affecting factors could be determined.

Generally, the results show that FB S and SB S are suitable for mono- and co-fermentation. The results of the batch experiments show that forage and sugar beets contain fast degradable substances and have a high degradation efficiency. On the other hand, the lower degradation efficiency of manure resulted in lower degradation efficiency of the mixture of beets with cow manure and hence lower methane production.

The experiments also Show an increase in NH4-N content to more than 50 % which increased the efficiency of using the digested Substrates as fertilizer. The high concentration of organic acids resulting from ensiling process did not affect the pH of the digestion process indicating a high Buffer capacity. The study also provided Information an the effect of plant denaturation agent an the process of FBS.
Regarding energetic aspects, it was found that producing only electricity from forage and sugar Beets can have an Output/Input factor of 1.36 compared to 0.32 from conventional energy. The Output/Input factor of Biogas from beets increases to 3.06 when the heat production is taken into account. Substituting conventional energy with Biogas energy which has higher Output/Input factor and positive energy Balance, can save up to 2 80 GJ (264 GJ) fossil energy per hectare and year. Furthermore, the use of the whole plant and the application of reactor effluent as fertilizer characterize the energy gain from beets Biogas as a simple and close energy Balance System.

In comparison to fossil energy the application of Biogas from Beets results in better ecological Balance. The use of Biogas from 1 hectare forage (sugar) Beets for electricity Gould avoid the release of 21 (20) tons C02-equivalent when using fossil energy. Generally, the anaerobic digestion of forage and sugar Beets indicates low contribution to global warning gases. From today's perspective, the Biogas production from beets can not be economically recommended. This Gould be changed by including the heat energy in the System and/or by increasing the price of Biogas electricity (> 0.1 Euro/kWh). However, an assessment of energy balance, ecological Balance and economy of Biogas production from forage and sugar beets came out in favor of forage beets.