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Aus der Professur für Abfall- und Stoffstromwirtschaft
der Agrar- und Umweltwissenschaftlichen Fakultät

Zusammenfassung der kumulativen Dissertation

The Demonstration and Adaption of the Garage – Type Dry Fermentation Technology for Municipal Solid Waste to Biogas in China

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Background and aims of the research

As the result of rapid urbanization in China, a large number of new towns have been built in recent years. The waste generated from these new towns present a particular characteristic of a mixture of MSW (mainly food waste) and agricultural waste. Considering the economic situation and the amount of waste within Chinese rural areas, it is not financially viable to develop waste incineration due to the guideline from Chinese government.. Anaerobic digestion is a promising approach to solve the waste problem and produce bioenergy within rural areas in China. In particular, the solid-state anaerobic digestion (SSAD) technology, given its numerous advantages for treating solid waste, is recommended as a most feasible technology for treating the waste generated in Chinese new towns.

However, although numerous SSAD biogas plants were built up and approved for operation in Europe, the ways in which this technology, as used in China, can be demonstrated and adapted, requires further exploration and research.

- The Chinese MSW is characterized by its high content of food waste and humidity, which is not appropriate for the SSAD process because of its poor porosity. In Europe, yard trimmings and wooden material, e.g. prunings, from gardens and parks, as structure materials, play an important role in the operation of the system. In China, the co-digestion between food waste and crop straw not only contributes to an improvement in the biogas yield, it also helps to structure the co-substrates for an effective SSAD operation. This research could also be of practical significance in solving the waste problems facing new towns.

- The traditional single-stage SSAD system suffers from low efficiency that resulting in the following drawbacks: 1) In the traditional single-stage SSAD, the fresh substrate is inoculated by solid digestate before each feeding cycle, and this occupies too much volume within the digester. 2) single-stage AD contains both the acetogenesis and the methanogenesis within one reactor, and they require different optimum operational environments. 3) Because of the poor mass and heat transfer of the solid material, the effective contact between the microorganisms and the substrates is insufficient. 4) The problem of inhibition due to the accumulation of organic acids and the pH decrease at a high OLR occurs more often, which causes a long lag phase at the beginning of the batch run.

- The two-stage SSAD has become a popular topic in recent years, because of its potential to improve the efficiency of SSAD. Separating the acetogenesis and the methanogenesis could create the opportunity for optimum conditions for each stage. The mono-inoculation by leachate reflux could contribute both to a more efficient use of the digester volume and to a lesser workload for the operators, with a higher degree of automatic control.

- Leachate reflux is an important part of the SSAD process. Its function is to improve the mass and heat transfer, to adjust the fermentation conditions (i.e. pH, temperature, etc.) in the digester, and it even works as the inoculation method.

Main research results

- The waste generated in Chinese new towns has special characteristics. It includes large proportions of agricultural waste (straw). The co-digestion of the organic component of municipal solid waste (food waste) and straw through the SSAD technology offers a promising approach in order to solve the waste and energy problems. In the experiments, a ratio of food waste to maize straw of 4:1 was evaluated as the optimum ratio.

- Two-stage SSAD which uses the leachate circulation as the mono-inoculation method, could separate the stages of acetogenesis and methanogenesis with the former in the digester and the latter in the leachate tank. Leachate circulation produces proper inoculation effect and mass transfer by flushing effect simultaneously.

- The leachate reflux ratio and spraying rate jointly influence the VFA production. The stronger the reflux ratio, the more VFA are produced, but there is no significant difference when the reflux ratio is less than 8:1. An intensive spraying rate will promote the VFA production, but it will also potentially cause acidification when the spraying rate is more than 75 mL/min.

- Inoculation by activated sludge and pig manure both showed butyric acid fermentation. The use of pig manure was demonstrated to be a better option for producing VFA, as this produce the best hydrolysis and acidogenesis effect for two-stage SSAD.

- In terms of the methane production, it showed an opposite result to VFA production. It is obvious that the stronger VFA production may cause acidification and lower methane production in the solid-phase digester. The stronger flushing effect presented as stronger reflux ratio caused a higher percentage of methane production from leachate tank. Developing a system that uses the digester as an acid-production reactor and produces methane by use of the more efficient methanogenic reactor will be the solution to overcome the problems of inefficiency of SSAD.

- In terms of the microbial population analysis, in the two-stage SSAD system inoculated by pig manure, *Firmicutes* are common dominant microflora in the anaerobic reactor and the most dominant microflora in the hydrolysis and acidification stage. The results also made a positive contribution to both hydrolytic acidification and methane production.