Abstract

In a general sense, the main concern of this thesis is large-scale bio-ethanol production, particularly the attempt to find a convenient and suitable way to use its by-product known as stillage. Using stillage to produce energy is the main focus subject of this thesis. Large amounts of available by-product stillage with high organic content have been of great interest for many researchers in the search for a better way to utilize it. It is supposed that stillage used as proposed in this study would create more energy efficiency and more positive environmental effects compared with the traditional and popular utilization of stillage as animal feed.

A system was developed during this study for the production of biogas and bio-fertilizer from biomass left after the production of bio-ethanol via the processes of digestion and composting. This system has been named as the E-M-F-System. Stillage and stillage digestate are the main points of connection in these three biological processes. Currently, some related research is being conducted in the combination of bio-ethanol production with biogas production, and biogas production with fertilizer production. In Prasad Kaparaju's study, the thermophilic anaerobic digestion of wheat straw stillage was investigated. Results showed that higher methane yields of 324 ml/g VS added were obtained at stillage concentrations of 12.8 g VS/l [95]. Wilkie, A.C. has done the most research on sugar, starch and cellulosic-based stillages under thermophilic and mesophilic digestion conditions. He has summarized the whole production chain from biomass planting and harvesting to stillage's further utilization to find sustainable and economically viable solutions [4]. The concept of combining all these three processes was proposed in some previous studies; however they did not go as far as detailing the methods or testing the concept [99]. This study aims to address that gap and carry out a basic analysis of feasibility and evaluation of a combined system, the proposed E-M-F-System.

In this study, two ways were utilized in parallel to analyze the feasibility of the E-M-F-System, firstly through theoretical analysis and secondly through laboratory research. Subsequently, a rigorous and thorough balance analysis assessment including mass, energy and $CO_{2\text{-eq.}}$ perspectives was carried out for this system. In order to make further utilization of this system to produce bio-energy easier and more accessible, a case study using sweet potato in China was undertaken as an example. Furthermore, a tool box was compiled in the hopes of creating an innovative platform for the convenient utilization of this system for other projects and the results of assessment and analysis was compiled into an excel spreadsheet.

Overall, through the study of this E-M-F-System, the results reveal that, this system could be of great importance to the current global energy situation. This system has its own particular advantages and strengths. Similar assessment or analysis of it could be easily adopted in other projects due to its broad utilization feasibility and possibility. Moreover, further attempts or important modifications related to the E-M-F-System can be carried out according to the needs of specified projects. This biomass-energy-environment system could be the basis of future studies on the combination of biological processes.