CONCENTRATION OF MEAT PROCESSING INDUSTRY WASTEWATER BY REVERSE OSMOSIS AND ANAEROBIC DIGESTION OF THE CONCENTRATE

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Abstract

Rural areas in the Northern Finland face unique challenges with respect to their economic development. Due to their remote location and long winters, these areas have been very resource intensive and have traditionally been dependent on fossil energy. The EU Waste Framework Directive has created challenges for all countries in the handling of waste. The challenges weigh even heavier in remote Northern regions due to uneconomic scale and spread of waste amounts and long transportation distances.

The European Spatial Development Perspective stresses the need for economic diversification in rural areas through strategies based on local resources and needs. There are several renewable energy sources which contribute to the achievement of EU policy targets. Among them, waste and biomass are considered the energy source with the largest unexplored potential. Exploiting resources in wastes for bio-fuel and renewable energy through small-scale technical solutions also offers excellent opportunities for decentralized business innovation. Small-scale biomass- and waste based energy solutions are able to answer the challenges of resource availability, while progressively reducing the impact of human activities on the environment.

Meet processing industries generate great amounts of wastewaters due to high flushing and washing needs. A possible application of wastewaters is land irrigation; however, long term application of meat processing wastewater has been reported to be damaging to the soil [1]. Due to the high rejection for organic materials, reverse osmosis (RO) is suitable for recycling of food industrial wastewaters, and has been previously applied for the treatment of meat processing wastewaters [2,3]. Traditionally, when RO is used for water purification, the concentrate is handled as waste. However, in the case of a stream with high and biodegradable organic matter such as meat processing effluent water, it can be a possible feed for anaerobic digestion (AD) [4]. In Northern Peripheral Regions, temperature sensitive biological wastewater treatment could thus be replaced with the RO processes. As well, it would open the possibility of recovering the energy content of the wastewater. Therefore, the aim of our work was to produce an RO concentrate suitable for AD.

Real wastewaters of a medium-sized meat processing company have been first processed by reverse osmosis to concentrate the organic content. Further, the concentrate was mixed in different ratio with solids obtained from the grease trap of the company, and tested in a laboratory scale anaerobic digester.

The reverse osmosis process was designed and optimized for maximum capacity with minimal fouling using the statistical experimental design and data analysis software programme MODDE 8.0. For the experiments a PCI pilot scale membrane filter was used equipped with AF99 tubular RO membranes suitable for high particle containing wastewater. The temperature of membrane filtration varied according to the effluent temperature, the pressure range was chosen based on the membrane and the module characteristic. The retention for fat and proteins achieved was over 98.5% and R_{TOC} was higher than 97%. Based on the response of the fitted model, the optimal conditions for concentrating organic matters was pressure of 38.5 bar, recirculation flow rate of 1000Lh^{-1} and temperature of 40°C. The average TS content of the RO concentrate was higher than 9% with the TOC content of 2.8 gL^{-1}, protein content of 1.2 gL^{-1} and fat content of 0.35 gL^{-1}. The organic matter loss during the concentration was less then 5%.

The batch mode mesophilic anaerobic digestion (AD) experiments were conducted using an OxiTop® Control AN 12 equipment. The biogas production was calculated based on the pressure increase. The RO concentrate samples were mixed with solids from the grease trap in the concentration of 0-25 w/w%. To maintain the stability of colloidal organic matter and to ensure the higher specific surface for anaerobic decomposition, the samples were co-digested with secondary municipal sludge in concentration of 25 w/w% on dry basis. To enhance the rate of anaerobic digestion and to increase the biogas yield, the efficiency of heat treatments combined with acid and alkali dosing prior to AD were also tested. Preliminary results indicate that the specific biogas generation was over the value of 500 mLg^{-1} TS in all cases and the percentage of methane in the biogas was between 50-60%. Additionally, the combination of heat treatments with alkaline condition could increase the rate of biogas production and the amount of produced biogas of RO concentrate samples mixed with grease was also enhanced.

Finally, the paper will evaluate the energy recovery potential of the company, based on the experimental data. The research reported in this paper intends to answer the needs of remote Northern areas by evaluating the recoverable energy potential of food industry waste streams in a small scale.

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References

[1] Luo, J., Lindsey, S., Xue, J., Irrigation of meat processing wastewater onto lad, Agriculture, Ecosystems and Environment, 103 (2004) 123-148

[2] Bohdziewicz, J., Sroka E, Lobos, E, Application of the system which combines coagulation, activated sludge and reverse osmosis to the treatment of the wastewater produced by the meat industry, Desalination 144 (1-3) (2002) 393-398.

[3] Bohdziewicz, J., Sroka E, Treatment of wastewater from the meat industry applying integrated membrane systems, Process Biochemistry, 40(3-4) (2005) 339-1346.

[4] Appels, L., Baeyens, J., Degreve, J., Dewil R., Principles and potential of the anaerobic digestion of waste-activated sludge Progress in Energy and Combustion Science 34 (2008) 755–781.