Zukunftsfähige Technologien und Konzepte für eine energieeffiziente und ressourcenschonende Wasserwirtschaft

Comparison of power densities in Microbial Fuel Cells for settled wastewater, centrate after anaerobic sludge digestion and acetate at long term operation

M. Sievers*, M. Niedermeiser*, H. Bormann*, O. Schlaefer*, D. Haupt*, U. Kunz**, B. Jiang**, T. Muddemann**, T. Hickmann***, R. Henkel***

* CUTEC-Institut GmbH, Leibnizstraße 21-23, 38678 Clausthal-Zellerfeld, Germany
** Clausthal University of Technology, Institute of Chemical and Electrochemical Process Engineering, Leibnizstraße 17, 38678 Clausthal-Zellerfeld, Germany
*** Eisenhuth GmbH & Co KG, Friedrich-Ebert-Straße 203, 37520 Lerbach Stadt Osterode am Harz, Germany

Introduction

Over the last decades several studies focused on microbial fuel cells (MFC) as possible application to treat wastewater and to generate electrical power simultaneously.
Wastewater treatment plants (WWTP) have a huge energy demand. Therefore MFC are a great opportunity to recover a part of the energy. However, there is hardly any commercial application of an MFC, as there are several challenges in up-scaling [1]. Therefore this study should prove (additional) locations on WWTP for possible MFC applications. Investigations have been conducted with settled wastewater (WW), centrate (C) of sludge dewatering and for comparison acetate solution (A).

Materials and Methods

The specific design of all electrodes (graphite/polymer compound) allow working as anode or cathode (Fig. 2 a). DuPont Nafion® 117 membrane was chosen to separate the anolyte from the catholyte.

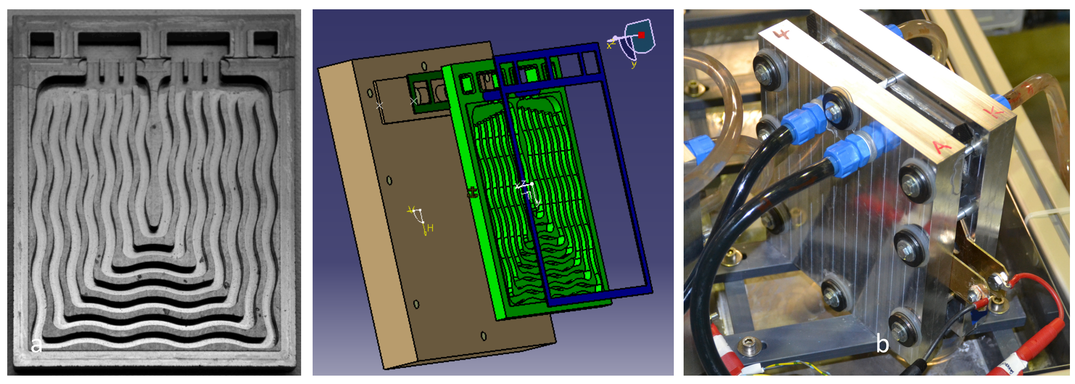

Fig. 1: Photo of modular electrode design (a), exploded drawing (b) [2], complete laboratory cell (c)

All cells are connected in series by a pipe, so that the anolyte and catholyte flow in a own circulatory system through all the cells. Investigated anolytes:
- settled WW taken after primary clarifier (WWTP Goslar, Germany)
- centrate of sludge dewatering (WWTP Goslar, Germany)
- sodium acetate solution

The pH of all anolytes was hold constantly (7.3 to 7.7) by a Na_2CO_3 solution.

The catholyte (also settled WW from WWTP Goslar) was aerated by two membrane pumps (Europet Bernina HI-TECH 1400cc). To obtain a greater power density thermally treated carbon felts (Kynol ACN211-20) were placed between the membrane and the cathode [3].

Voltage and current were recorded individually for each cell. By the use of a constant current source all cells were operated close to their individual maximum power point. All cells were in operation for more than two months with the same configuration.

The COD was determined photometrically (Macherey-Nagel Nanocolor® UV/VIS) by Macherey-Nagel Nanocolor® (COD 160 and COD 1500) tube tests.

Results and Discussion

The power densities (PD) for each of the seven cells were calculated to an average PD for that point when the COD sample was taken. The average values of those seven PD plus their standard deviation are shown in Fig. 2.

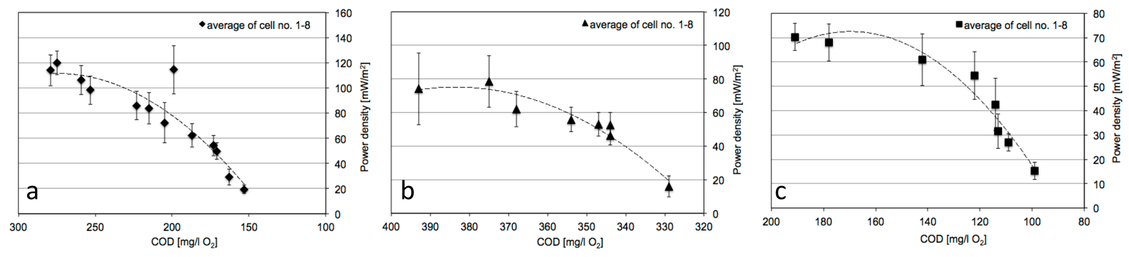

Fig. 2: Power density in relation to the COD of the anolyte for the first measurement series: settled wastewater (a), centrate of sludge dewatering (b) and sodium acetate solution (c)

All three curves of Fig. 2 show almost the same trend, because of the change of biodegradability of remaining COD. It is expected that PD decreases with decreasing COD due to different power production of the diverse substrates [4], which is validated by the curves of Fig. 2 a and b. However, the curve of Fig. 2 c was conducted with acetate and there is no change of the biodegradability.
Comparing the average power production of centrate and acetate (Fig. 2 b, 2 c), it is remarkable that both average PD are almost on the same level (70 - 120 mW/m^2).
The COD of the centrate is much higher than of settled WW, but the composition of the COD is totally different. Whereas settled WW consists of a certain amount of easy degradable COD, it is estimated that there is no easy degradable COD in the centrate.

Conclusion

Summarising, the MFC could be a further opportunity to treat centrate from the sludge dewatering (Fig 3, position A). An additional MFC after sludge dewatering:
- is independent from other MFC (Fig 3. position B) in a WWTP
- could treat the centrate to reduce COD
- could treat the centrate to generate power
- could support the energy turnaround to make a WWTP energy self-sufficient

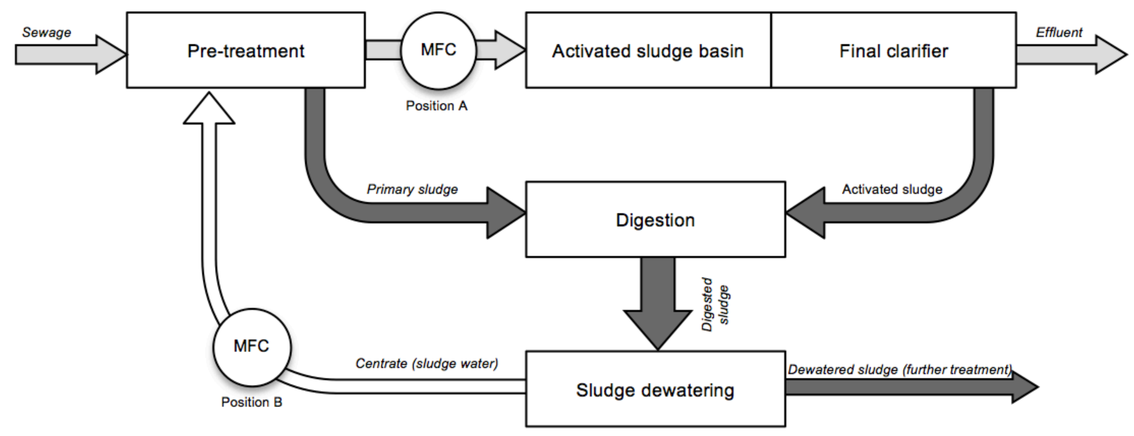

Fig. 3: Possible integration of MFC: after primary clarifier and/or after sludge dewatering; light grey arrows indicate WW flow, dark grey arrows indicate sludge flow, white arrow indicates the centrate flow

References:
[1] Bruce E. Logan, “Scaling up microbial fuel cells and other bioelectrochemical systems”, *Appl. Microbial Biotechnology*, pp. 1665-1671, November 2009.
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[3] Govind M. Arun, “Review on Carbon Electrodes in Mircrobial Fuel Cell”, *International Research Journal of Engineering and Technology*, pp. 424-427, November 2005.

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