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Research area: General aims
Environmental technology // Water

Key words:
Membrane, MBR, thermophilic aerobic, wastewater

TITLE:

Energy and water savings in the paper industry trough enhancement of the thermophilic MBR process for integrated treatment of deinking wastewaters

Background/Problem area

A membrane bioreactor (MBR) employs ultrafiltration (pore size of 0.04 – 0.2 microns) to retain solids and micro-organisms in the activated sludge tanks of the biological treatment stage. The ultrafiltration module thus replaces the final sedimentation stage. Topic of the research project were experiments with a thermophilic aerobic MBR (TMBR) at 50 °C. A new and innovative use of submerged MBR-modules to treat paper industry circuit wastewater was studied. Up to now state of the art literature describes thermophilic treatment with conventional sedimentation only, or, if membranes are used, with mainly side-stream type modules. The advantages of the submerged system used in these experiments are a lower energy demand as well as a more compact design. The thermophilic degradation, compared to the mesophilic process, has got the advantages of a lower sludge yield and higher degradation rates. Disadvantage of the thermophilic treatment is a higher sludge volume index due to very fine and loose sludge flocs. In a MBR, the membrane takes care of the separation of solids, so the technological drawback of the critical sludge settleability becomes a thing of the past. Instead, the benefits of the thermophilic process could be utilised. Unlike other industrial sectors, the paper industry benefits from the advantage that its partial flows have a sufficiently high temperature to enable them to profit from this technology.

Objectives/Research results

Overall objective was the further development of an existing technology (MBR) in order to save energy and water by treating hot partial flows from the stock preparation of deinking mills. Because there are almost no experiences with full-scale systems, various aspects of submerged plate-and-frame MBR module operation under thermophilic conditions (45 to 55 °C) were investigated. The studies were performed using a lab scale MBR plant in the laboratory of PTS as well as on-site in a German paper mill over a period of several months.

The elimination rates of the TMBR regarding COD and BOD_5 respectively were 83 % and 99 % at mean COD loading rates of 0.19 to 0.5 kg COD/kg MLSS/d. The permeate was totally free of turbidity and solids but still coloured. Two continuous lab experiments were conducted during a period of each more than 2 months with a flux of 8 to 13 L/m^2/h. The transmembrane pressure TMP in these lab experiments reached only 0.06 bar. No chemical cleaning was performed during the lab experiments. In the pilot trial a higher TMP was noticed due to fouling and scaling. In general, the smaller particle sizes of the thermophilic sludge (50 % were smaller than 28 µm) lead to a more compact fouling layer on the membrane surface and a higher pressure drop than it would be expected in a comparable mesophilic MBR system.

The observed sludge yield of the TMBR was very low with 0.07 – 0.29 g MLSS/g $COD_{eliminated}$. Because of this low sludge yield, also a lower nutrient concentration of ammonia and phosphate is necessary compared to a mesophilic process. Based on the results from the performed experiments, the required ratio of BOD_5:N:P was determined to be 100 : 1-2 : 0.2-0.4 to ensure a sufficient nutrient supply of the thermophilic microorganisms. That means the lower need of the TMBR for nutrient concentration is a further advantage of this technology.

Gene probe sampling revealed a comparable high diversity of microorganisms in the TMBR as in the mesophilic sludge used for the start-up. This result is contrary to the state of the art literature which reports a general reduced diversity in thermophilic aerobic reactors. A high diversity is desirable for wastewater treatment because it leads to a better stability of the process in terms of a more constant effluent quality at unsteady inflow parameters.

Application/Economic benefits

The project has proven the TMBR to be a promising reliable technology with economical benefits in comparison to state-of-the-art aerobic end-of-pipe treatment. Major advantages are a low sludge yield, a high quality permeate with 50 °C, high process stability at fluctuations of feed water parameters and a lower nutrient demand.

By investigating and developing new technologies, the paper industry has the chance to meet the challenges of the future when a further closure of the water circuits and lower energy consumption is needed. The transfer of the expected results could lead to a totally new application of a technology which has already been approved as end-of-pipe solution at mesophilic operating conditions. For SME of the environmental technology sector, economic benefits will emerge from the development of a new application of membrane technology in the industry.

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Remarks

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