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Extracellular Polymeric Substances Study in an MBR System for Fouling Control

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Abstract : Municipal and industrial wastewaters are often treated biologically, by the activated sludge process (ASP). The ASP not only requires large aeration and sedimentation tanks, but also generates large quantities of excess sludge. An alternative technology is the membrane bioreactor (MBR), which replaces two stages of the conventional ASP—clarification and settlement—with a single, integrated biotreatment and clarification step. The advantages offered by the MBR over conventional treatment include reduced footprint and sludge production through maintaining a high biomass concentration in the bioreactor. Notwithstanding these advantages, the widespread application of the MBR process is constrained by membrane fouling. Fouling leads to permeate flux decline, making more frequent membrane cleaning and replacement necessary and resulting to increased operating costs. In general, membrane fouling results from the interaction between the membrane material and the components in the activated sludge liquor. The latter includes substrate components, cells, cell debris and microbial metabolites, such as Extracellular Polymeric Substances (EPS) and Sludge Microbial Products (SMPs). The challenge for effective MBR operation is to minimize the rate of Transmembrane Pressure (TMP) increase. This can be achieved by several ways, one of which is the addition of specific additives, that enhance the coagulation and flocculation of compounds, which are responsible for fouling, hence reducing biofilm formation on the membrane surface and limiting the fouling rate. In this project the effectiveness of a non-commercial composite coagulant was studied as an agent for fouling control in a lab scale MBR system consisting in two aerated tanks. A flat sheet membrane module with 0.40 um pore size was submerged into the second tank. The system was fed by50 L/d of municipal wastewater collected from the effluent of the primary sedimentation basin. The TMP increase rate, which is directly related to fouling growth, was monitored by a PLC system. EPS, MLSS and MLVSS measurements were performed in samples of mixed liquor; in addition, influent and effluent samples were collected for the determination of physicochemical characteristics (COD, BOD5, NO3-N, NH4-N, Total N and PO4-P). The coagulant was added in concentrations 2, 5 and 10mg/L during a period of 2 weeks and the results were compared with the control system (without coagulant addition). EPS fractions were extracted by a three stages physical-thermal treatment allowing the identification of Soluble EPS (SEPS) or SMP, Loosely Bound EPS (LBEPS) and Tightly Bound EPS (TBEPS). Proteins and carbohydrates concentrations were measured in EPS fractions by the modified Lowry method and Dubois method, respectively. Addition of 2 mg/L coagulant concentration did not affect SEPS proteins in comparison with control process and their values varied between 32 to 38mg/g VSS. However a coagulant dosage of 5mg/L resulted in a slight increase of SEPS proteins at 35-40 mg/g VSS while 10mg/L coagulant further increased SEPS to 44-48mg/g VSS. Similar results were obtained for SEPS carbohydrates. Carbohydrates values without coagulant addition were similar to the corresponding values measured for 2mg/L coagulant; the addition of mg/L coagulant resulted to a slight increase of carbohydrates SEPS to 6-7mg/g VSS while a dose of 10 mg/L further increased carbohydrates content to 9-10mg/g VSS. Total LBEPS and TBEPS, consisted of proteins and carbohydrates of LBEPS and TBEPS respectively, presented similar variations by the addition of the coagulant. Total LBEPS at 2mg/L dose were almost equal to 17mg/g VSS, and their values increased to 22 and 29 mg/g VSS during the addition of 5 mg/L and 10 mg/L of coagulant respectively. Total TBEPS were almost 37 mg/g VSS at a coagulant dose of 2 mg/L and increased to 42 and 51 mg/g VSS at 5 mg/L and 10 mg/L doses, respectively. Therefore, it can be concluded that coagulant addition could potentially affect microorganisms activities, excreting EPS in greater amounts. Nevertheless, EPS increase, mainly SEPS increase, resulted to a higher membrane fouling rate, as justified by the corresponding TMP increase rate. However, the addition of the coagulant, although affected the EPS content in the reactor mixed liquor, did not change the filtration process: an effluent of high quality was produced, with COD values as low as 20-30 mg/L.

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