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PARTIAL NITRITATION/ANAMMOX PROCESS FOR NITROGEN REMOVAL FROM MAINSTREAM WASTEWATER IN MBBR AND IFAS SYSTEM

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Increase in energy prices and growing awareness of global warming problem change the perception of sewage from being a waste to being a resource, which can be used for renewable energy production. Maximum use of wastewater organic content for biogas production leads to formation of wastewater with low C:N ratio, which cannot be treated with nitrification/denitrification process without external carbon dosage. Therefore, there is a high interest in application of autotrophic nitrogen removal systems, which are based on partial nitritation and anammox processes. Several studies, presented on the topic, report that anammox bacteria can be sustained in reactor treating low ammonium content wastewater and the biggest challenge still to be solved is how to suppress nitrite oxidizing bacteria (NOB) growth and avoid aerobic oxidation of nitrite to nitrate.

In this study, the mainstream wastewater treatment system, based on combination of upflow anaerobic sludge blanket (UASB) reactor for organic matter removal and moving bed biofilm reactor (MBBR) for deammonification process, was tested. The operation of the MBBR with and without suspended biomass recirculation was compared.

The MBBR was fed with municipal wastewater, pretreated in a UASB reactor during 16 months. During that period different aeration strategies were tested. It was found that continuous aeration and intermittent aeration with 45 min of aerated and 15 min of non-aerated phase, which are successfully applied in systems for anaerobic digestion reject water treatment, could not suppress NOB growth leading to nitrogen removal efficiencies below 30%. However, when intermittent aeration with shorter aerobic phase duration was tested, improvement in NOB suppression was reached. The average efficiency of 40% was reached when the aeration pattern was changed to 15 min aeration phase followed by 15 min without aeration.

The impact of intermittent aeration on NOB suppression was studied in batch tests and different mechanism of suppression, proposed in the literature, were investigated. The investigation showed that the only possible mechanism of NOB suppression is based on low substrate concentration in the beginning of aerated phase. Since nitrite, which is produced in aerated phase, is consumed completely by anammox bacteria in anoxic phase with a start of aeration ammonium oxidizing bacteria (AOB) have both ammonium and oxygen available, while NOB lack nitrite and, therefore, have lower activity.

Activity of AOB and NOB was determined by oxygen uptake rate tests regularly and it was observed that the ratio of AOB:NOB activity was always lower for biofilm than for suspended biomass, which originated from biofilm detachment. It was, therefore, concluded that NOB detachment from biofilm is lower, probably because of its growth somewhat deeper in the biofilm. In order to increase the AOB activity (relative to total aerobic activity), suspended biomass was separated from the outflow by using sedimentation tank and recirculated back to the reactor. Therefore the operation of the MBBR was changed to integrated fixed film activated sludge (IFAS) mode.

By changing the reactor operation to the mode with suspended sludge recirculation it was possible to increase the nitrogen removal efficiency from 38% to 70% with simultaneous increase of nitrogen removal rate from 20 to 52 g N/(m^3·d). The effluent COD concentration after the whole system was 40 mg/L. Application of UASB reactor for anaerobic removal of organic matter combined with IFAS deammonification reactor for nitrogen removal allows maximize the biogas production from wastewater, decrease the aeration requirement, and remove substantial part of nitrogen without external carbon source. However, the effluent quality is still lower than the levels, required in European Union. Therefore a step of polishing nitrification/denitrification is required to further decrease the nitrogen content.

Keywords: mainstream wastewater, ammonium, nitritation, Anammox, MBBR, IFAS.