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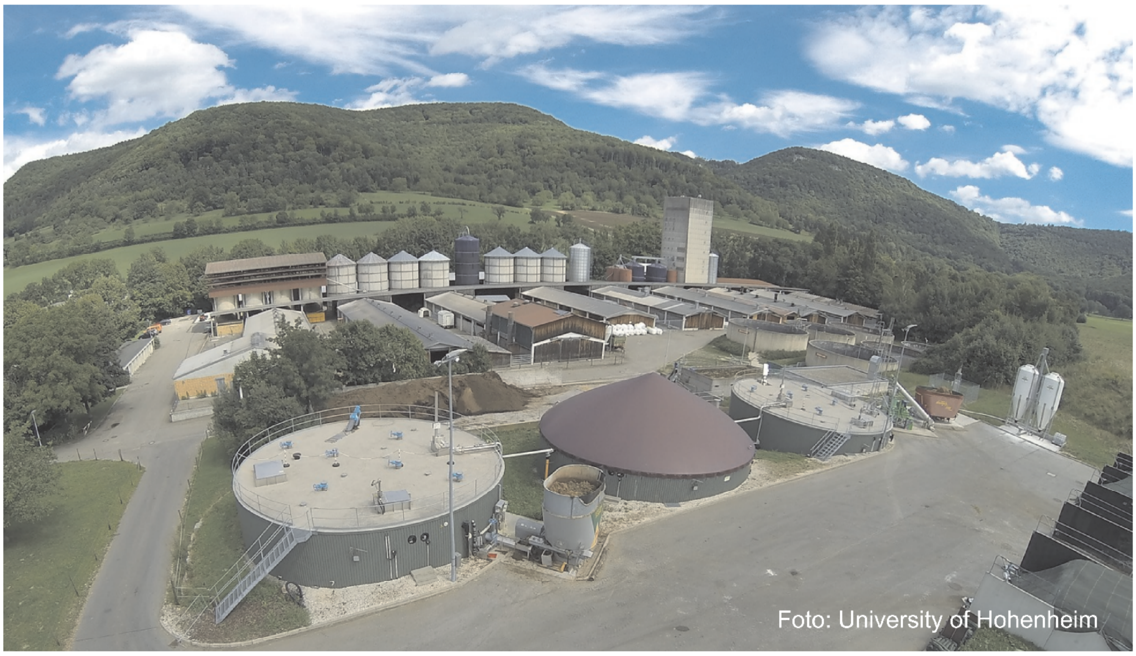

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LONG-TERM NITRIFICATION PROCESS OF THE LIQUID PHASE OF DIGESTATE: EXPERIENCE FROM LABORATORY AND PILOT PLANT CSTR REACTOR

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Keywords: anaerobic digestion, biogas plant, liquid phase of digestate, ammonia nitrogen, nitrification

INTRODUCTION

The production of bioenergy, low-cost treatment of organic wastes and co-production of biofertilizers leads to higher amount of biogas plant stations installation around the world (Mao et al., 2015). Beside the biogas, fermentation residue, so called digestate, with a variable dry matter (DM) content ranging from 2 to 12% represents also the final product of anaerobic digestion (Nkoa, 2014). This digestate is often separated by mechanical separation to solid and liquid fractions. LPD (liquid phase of digestate) is characterized by a low DM content (2-4%) with a relatively high amount of TAN (total ammonia nitrogen) representing the sum of $N\text{-}NH_3$ and $N\text{-}NH_4^+$ (Liu et al., 2019). The handling with LPD is very problematic due to its high demand on storing, nitrogen losses during the storage as well as during the application onto the soil, transport costs etc.

Nitrification is able to transfer part of the TAN contained in raw LPD to nitrate, whereas the pH value decreases during this process. This is beneficial from the point of view of nitrogen losses not only during the storage of LPD or during its application onto the soil but also for potential subsequent thermal thickening of nitrified LPD (Botheju et al., 2010; Chiumenti et al., 2013). However, high sensitivity of the nitrification process to pH fluctuation induced by the acidification of the environment as the consequence of nitrification bacteria activity and the resulting free ammonia and free nitrous acid inhibition represents a very high risk from the point of view of the stability of the nitrification process. Especially, massive nitrite accumulation and strong decrease of TAN oxidation efficiency may deteriorate the process performance (Švehla et al., 2017).

The aim of this study is to define the conditions enabling a long-term stable operation of nitrification process in the environment of LPD. Laboratory CSTR (Completely Stirred Tank Reactor) and subsequently pilot plant reactor simulating the nitrification process in the environment of LPD was constructed and operated in the laboratory conditions. The experiences gained during the start-up and long term operation (one and half year) of the pilot plant reactor applying the nitrification in the environment of the LPD will also be presented.

MATERIAL AND METHODS

The laboratory experiment was carried out in 5 L laboratory CSTR reactor with LPD as an influent under the conditions described in Švehla et al. (2017). The operation of the laboratory CSTR was divided into periods without and with pH control. The value of pH was gradually decreased from 7.0 to 4.75 during the period with pH regulation. Subsequently, the pilot plant reactor (1 000 L) was operated based on the findings resulting from the operation of laboratory reactors. The nitrogen loading rate in laboratory reactor varied between 0.12 and 0.70 kg/(m^3.day) with hydraulic retention time ranging from 4 to 18 days. Concentrations of TAN, $N\text{-}NO_2^-$ and $N\text{-}NO_3^-$ were measured in the raw and the nitrified LPD samples gained from laboratory as well as the pilot plant reactor.

RESULTS AND DISCUSSION

During the initial period without the pH control, pH fluctuated significantly in the range of 5.2 – 8.7. As the consequence, increase of N-NO_2^- up to 1 500 mg/L was observed which was caused by an alternated strong inhibiting influence of free ammonia and free nitrous acid on nitrite oxidizing bacteria (Švehla et al., 2017). During the start-up of the nitrification with the pH control, a fast increase of N-NO_3^- concentration (250 mg/L on second day, 1540 mg/L after three weeks) was observed which is in accordance with Pacek et al. (2016). TAN oxidation efficiency during the long-term operation of the laboratory CSTR never falls below 97 %. Thus, significantly higher TAN oxidation efficiency as compared to Botheju et al. (2010) who performed nitrification of digestate in a sequencing batch reactor (SBR) was achieved with N-NO_3^- concentration around 5 000 mg/L in the effluent. The operation of the pilot plant reactor also confirmed the possibility to operate the nitrification process in the environment of LPD satisfactorily where it was shown that the inhibiting effect of free ammonia and/or free nitrous acid should be prevented by reasonable control of the conditions prevailing in the reactor. Further operation of the nitrification reactor will be aimed to maximizing of its performance and/or the possibility of increasing the performance by using biomass carrier material for cultivating nitrifying microorganisms. The application of the nitrification for the minimization of nitrogen losses as well as a pre-treatment before thermal thickening of LPD seems to be feasible.

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