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Partial Oxidation of Ammonium and Methane by Ammonia Oxidizing Bacteria in a Membrane Aerated Biofilm Reactor

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ABSTRACT: *Although anaerobic wastewater treatment is being evaluated as an innovative technology for the future, to maximize its benefits, a revolutionary post-treatment technology must be developed that consumes less energy and minimizes the supply of external carbon sources. In this study, we implemented both aerobic and anaerobic reactions, without any collision, by forming stratified biofilms on the surface of an aerated membrane. We also investigated the possibility of simultaneous treatment of ammonia, methane, and organic matters in a single reaction tank by adding microaerophilic AME-D biofilms in the middle of the stratified biofilms. Moreover, before seeding methane-oxidizing bacteria, we tested the methane oxidizing ability of ammonia oxidizing bacteria (AOB). Approximately 1.3 mM of methane was oxidized by AOB when approximately 2.5 mM of ammonia was oxidized, indicating an active cometabolic oxidation of methane by AOB.In the future, we plan to study the denitrification of hydrogen sulfide to remove H2S simultaneously. In addition, we will verify the dominant microbial community at each layer of biofilm through a microbial community analysis.*

KEYWORDS: *Aerobic/facultative/anaerobic co-reaction, Anaerobic sewage treatment, Membrane aerated biofilm reactor (MABR), Stratified biofilms*

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I. INTRODUCTION

Anaerobic treatment of sewage can achieve water quality as good as an activated sludge process does (at least in terms of COD), and is expected to be an innovative future technology since it can reduce the energy consumption and sludge production to about 1/3 and 1/10, respectively, against the conventional activated sludge process (Bae et al., 2014). However, the anaerobic treatment of sewage creates critical issues to be resolved. The most critical one is the removal of nitrogen. Most nitrogen in sewage remains as ammonia of which concentration ranges approximately 30~50 mg-N/L. The COD/nitrogen simultaneous removalprocessesbuilt on the activated sludge process cannot be applied in this case due to insufficient organic matter. The second issue might be thehandling of the dissolved methane gas(McCarty et al., 2011). About 50 ~ 60% of methane generated during anaerobic digestion (about 2 mM) is dissolved and discharged with treated water (Bae et al., 2014). The concentration is too low to be extracted for use, but too high to be left. This paper is based on the resultsof operating a gas permeable membrane reactor which simultaneously removed ammonia and methane of low concentrations.

II. MATERIALS AND METHODS

We constructed a membrane aerated biofilm reactor (MABR) witha 30cm longacrylic tubular reactor (internal diameter of 20 mm) within which an oxygen-permeable silicone tube (external diameter of 10 mm)was inserted (Fig. 1). Oxygen was supplied from the inside of the silicone tube and wastewater was injected in between the acrylic outer tube and the silicone inner tube. Aerobic biofilmsare expected togrowon the outer surface of the silicone tube. Ammonia oxidizing bacteria (AOB) was inoculatedfrom an enriched partial nitritation reactor. A synthetic wastewater similar to anaerobic sewage treated water (NH_4^+-N : 50~120 mg-N/L, CH_4 : ~30 mg/L) was fed, and the reactor was operated at about 25 °C and pH 8.

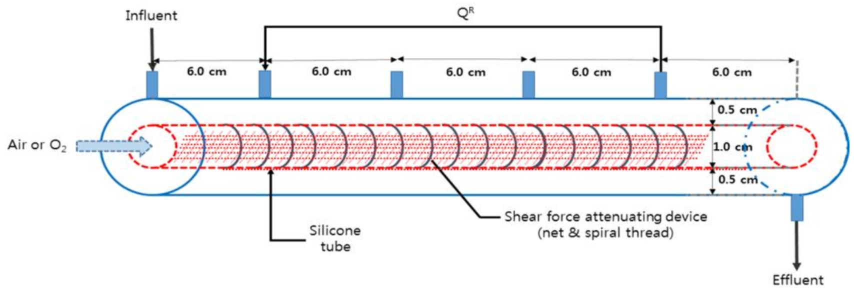

Fig.1 Schematic ofMABR.

III. RESULTS AND DISCUSSION

Fig.2 shows the resultsof effluent water quality. Numbers in the figure indicate the point of operational changes: (1) transform reactor operation from batch to continuous mode, (2) elevation of the feed ammonium concentration, (3) initiation of CH_4 injection. Nitrite was accumulated by the selective growth of AOB, producing little nitrate (data not shown).About 12 mg/L of COD andnull of methane were detected in the effluent from 12 days after injecting methane. The feed methane concentration was equivalent to ~20 mg-COD/L if all were converted to methanol. Thus, the results indicated that at least 60% of the methane was co-metabolically oxidized by AOB. The missing 40% of COD was provably consumed by anoxic denitrifying bacteria or oxidized by aerobic methanotrophic bacteria, though not inoculated. When ammonium in the feed was removed at day 140, no COD was detected in the effluent, indicating the COD production was by co-metabolic oxidation of methane by AOB. While~3 mM of ammonium was oxidized, ~1 mM of methane was oxidized by AOB, indicating that cometabolic oxidation of the methane by AOB was highly active. Since methane was removed by ~20% without ammonium feeding (data not shown) it was speculated that methanotrophs were also growing. Since the bulk liquid in the reactor was anoxic, the produced nitrite and COD were denitrified when denitrifying bacteria were inoculated (data not shown).

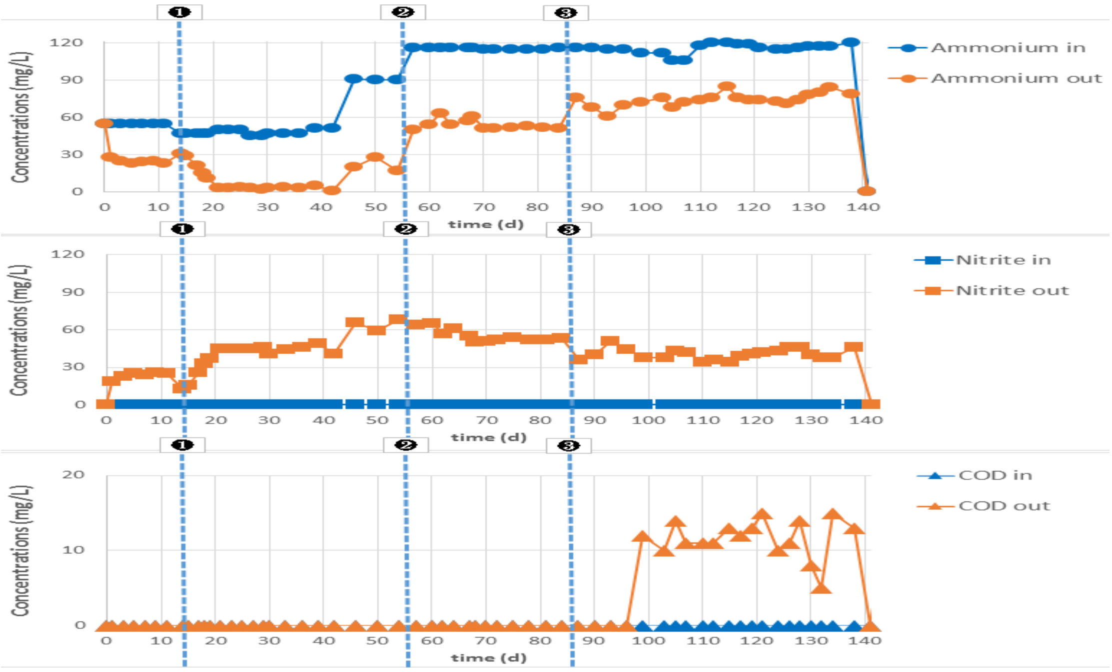

Fig.2Variation of nitrogen and COD concentrations in the MABR.

IV. CONCLUSION

Partial oxidation of ammonium and methane by ammonia oxidizing bacteria was observed in a membrane aerated biofilm reactor. By controlling the oxygen supply into the reactorthe produced nitrite and COD were denitrified effectively. Thus, nitritation, co-metabolic methane oxidation, and denitrification were achieved simultaneously in the MABR.

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