Microbial diversity in a biofilter for the removal of gaseous ammonia and toluene

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1. Introduction
Biofiltration is the biological process to treat odor and volatile organic compounds (VOCs). Biological process is one of the most popular treatment technologies for the removal of odor in industry. It has been recognized as a reliable, cost-effective, and environmentally friendly technology. Biofilters have been successfully used for many applications including food processing, flavor manufacturers, composting facilities, and landfill. Organic and inorganic compounds are removed in the biofilter. However, simultaneous treatment of organic and inorganic compound has been less studied. In the biofilter, microbial diversity, structure, and activity are critical to understand the biofilter performance as well as the biofilter design. In this study, trickle-bed biofilter has been applied to treat ammonia and toluene simultaneously. Biofilter performance with respect to ammonia and toluene removal has been investigated for more than 200 days. Microbial diversity and structure in the biofilter have been also studied by using a PCR-DGGE analysis.

2. Experimental Methods
Experimental work was performed on a lab-scale reactor, which was constructed of six cylindrical acrylic sections with an internal diameter of 0.1 m and a total height of 1.3 m. The reactors were packed with polyurethane foams as biological support media to a depth of about 0.6 m and a total volume of about 0.0047 m³. For seeding of the microorganisms, polyurethane foams were submerged with activated sludge supernatant, which obtained from wastewater treatment plant located in Uijeongbu, Korea. The air inlet were set at gas EBRT of 141 s and airflow of 2 L/min. The clean air provided by compressor was artificially polluted with ammonia and toluene through a syringe pump. The concentration of ammonia and toluene in the inlet gas was set initially at 591 ppm (12.29 g/m³/hr) and 50 ppm (5.63 g/m³/hr), respectively. During the first stage of experimental run, ammonia was a sole inlet contaminant. After 100 days with ammonia as a sole inlet, gas-phase toluene was supplied from inlet gas with ammonia. Details about experimental conditions and strategies of biofilter operation are summarized in Table 1. Microorganism community was determined from biofilm on the polyurethane surface in a biofilter. The media to analysis was sampled from the middle of each biofilter when the biofilter was maintained with consistent removal performance. Bacterial diversity and abundance in the biofilter for the removal of ammonia and toluene was analyzed by a PCR-DGGE analysis.

Table 1. Experimental conditions and strategies of the biofilter operation

<table>
<thead>
<tr>
<th>Phase (Operation days)</th>
<th>I (Day 0-100)</th>
<th>II (Day 101-125)</th>
<th>III (Day 126-143)</th>
<th>IV (Day 144-200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia (ppm)</td>
<td>591</td>
<td>591</td>
<td>591</td>
<td>591</td>
</tr>
<tr>
<td>Toluene (ppm)</td>
<td>0</td>
<td>10</td>
<td>20</td>
<td>50</td>
</tr>
</tbody>
</table>

3. Results and Discussion
The performance of biofilter with respect to ammonia and toluene removal is shown in Figure 1. During the experimental runs up to 200 days, ammonia removal was observed with consistent removal efficiency up to 100%. For toluene removal, the second operation, phase II, was recognized as a start-up period, which demonstrates the acclimation period to remove toluene. Phase III was conducted under a toluene loading of 20 ppm, and Phase IV under a toluene of 50 ppm. The overall toluene removal efficiency reached up to 95% level after a certain period each experimental phase.

The microbial populations in the media sample of the biofilter were analyzed and compared by a PCR-DGGE analysis targeted at eubacterial 16S rDNA. Microbial populations in the raw sludge used for microbial seeding to packed media were also analyzed. PCR-DGGE profiles of each samples shows various band patterns in Figure 2, and presents overall similarity of microbial structure in the DGGE bands. In Figure 2, the intensity of the bands indicates the degree of abundance of each microbial group. It is interesting to observe that the intensity of Band A to H increased in the biofilter for ammonia removal, but those decreased during simultaneous removal of ammonia and toluene while that of Band I to O amplified. Bands of interest were excised and sequenced to understand the differences in microbial diversity.

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diversity. Details about microbial identification will be presented in the conference.

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Figure 1. biofilter performance with respect to ammonia and toluene removals

Figure 2. Denaturing gradient gel electrophoresis (DGGE) profiles of the PCR-amplified 16S rDNA extracted from the packed media in the biofilter. Lanes: a) raw sludge, b) biofilter for ammonia removal, c) biofilter for ammonia and toluene removals