Reduction of $N_2O$ Emission from Livestock Waste Composting by Adding Nitrite-Oxidizing Bacteria

Abstract
During livestock waste composting, a high positive correlation between the concentration of nitrite nitrogen in composting material and the emission of nitrous oxide ($N_2O$), which is one of the greenhouse gases, has been found. By adding nitrite-oxidizing bacteria to inhibit the nitrite nitrogen accumulation in composting material, $N_2O$ emission was suppressed.

Keywords
$N_2O$, nitrite nitrogen ($NO_2-N$), nitrite-oxidizing bacteria (NOB), composting, nitrification, livestock environment

Background and Purpose
It is pointed out that global warming has greatly affected the climate change. The emission control of greenhouse effect gases now becomes a more urgent issue. As a major greenhouse gas from livestock industry, $N_2O$ is produced from the oxidation process of livestock waste, where there is much nitrogen. By the solid oxidizing process, $N_2O$ was greatly emitted from the middle to the latter periods of composting after thermophilic fermentation. It was during this period that the $NO_2-N$ was accumulated in composting material. It has been found there was a high positive correlation between $N_2O$ and $NO_2-N$. When adding nitrite-oxidizing bacteria, which is one type of nitrifying bacteria, to inhibit $NO_2-N$ accumulation, we examined the influence on $NO_2-N$ change in composting material and $N_2O$ emission with the case of pig manure composting.

Achievements and Features
1. The $N_2O$ emission rate in pig manure composting had a high positive correlation with $NO_2-N$ concentration in composting material. On the other hand, because the positive correlation between $N_2O$ emission and $NO_2-N$ concentration has not been
recognized, in order to inhibit N\textsubscript{2}O emission in composting, we could consider that the completed oxidation of NO\textsubscript{2} N in composting material to NO\textsubscript{3} N was effective (Figure 1).

2. The N\textsubscript{2}O emission pattern in the composting (Figure 2: control) agreed with the change in NO\textsubscript{2} N concentration in composting material (Figure 3: control). The detection of NO\textsubscript{2} N became the simple marker of N\textsubscript{2}O emission whose concentration from composting treatment was imperceptible.

3. In order to promote the oxidation of NO\textsubscript{2} N, when the mature pig manure compost (MPMC) (nitrite-oxidizing bacteria: \(1.7 \times 10^6\) MPN/g WM) was added just after the thermophilic phase of composting, compared with that in the control, NO\textsubscript{2} N concentration in composting material was greatly reduced (Figure 3: MPMC addition), and the N\textsubscript{2}O emission quickly ceased (Figure 2: MPMC addition). In this study, the total amounts of N\textsubscript{2}O emission were 88.5 (no addition) and 17.5 (MPMC addition) g N\textsubscript{2}O-N/kg T-N (initial), respectively. A high N\textsubscript{2}O emission reduction effect was confirmed (decreasing rate of N\textsubscript{2}O emission: 80%). In addition, the nitrogen compounds in suppressed N\textsubscript{2}O were maintained in composting material as N\textsubscript{2}O.

4. Based on the enumeration result of nitrifying bacteria, because of the delayed growth of nitrite-oxidizing bacteria (NOB), the incomplete nitrification was considered to cause NO\textsubscript{2} N accumulation in pig manure composting. Moreover, in order to eliminate the NO\textsubscript{2} N accumulation in pig manure composting, the NOB population per gram of composting material should be more than \(10^5\) (Figure 4).

**Application and Notes**

1. This result contributes to the technology development for controlling N\textsubscript{2}O emission from livestock waste composting.

2. Because our data were obtained from small-scale composting apparatus, further study by full-scale experiments will be necessary.
Figure 1. The relationship between the N$_2$O emission rate and the concentration of NO$_2$–N and NO$_3$–N in composting material.

Figure 2. The pattern of N$_2$O emission during pig manure composting when the nitrite-oxidizing bacteria were added into the mature pig manure composting (Experiment with MPMC addition).
Figure 3. Changes in NO$_2$ N concentrations in composting material during pig manure composting (Experiment with MPMC addition)

Figure 4. Changes in the number of nitrifying bacteria during pig manure composting Control (top) MPMC added (bottom), error bar (95% confidence limit)

Notes: Ammonia-Oxidizing Bacteria (AOB)  
Nitrite-Oxidizing Bacteria (NOB)  
Mature Pig Manure Compost (MPMC)  
Dry Matter (DM)