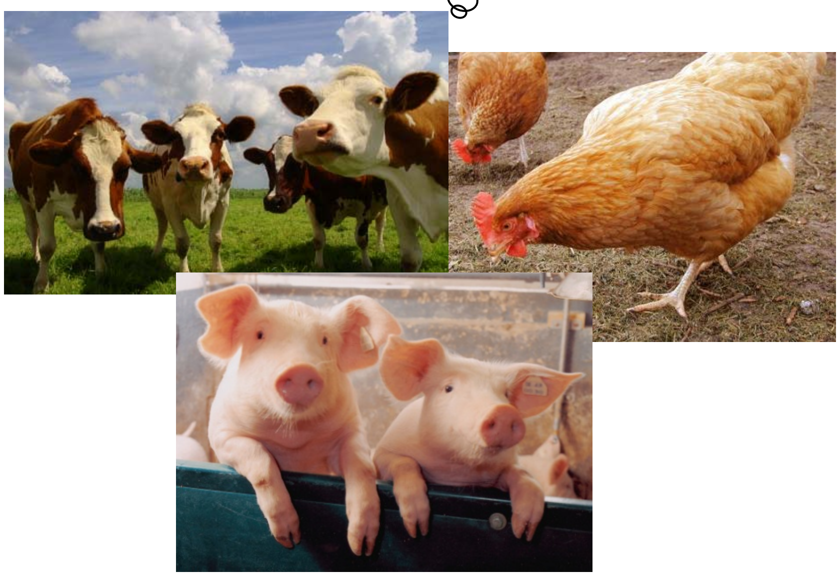
Mitigating strategy of GHG emission from dairy manure composting process

Koki Maeda

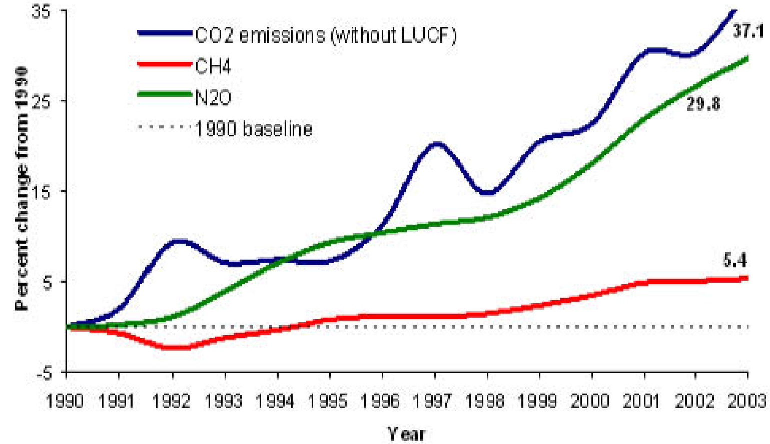
Livestock Production and Global Warming

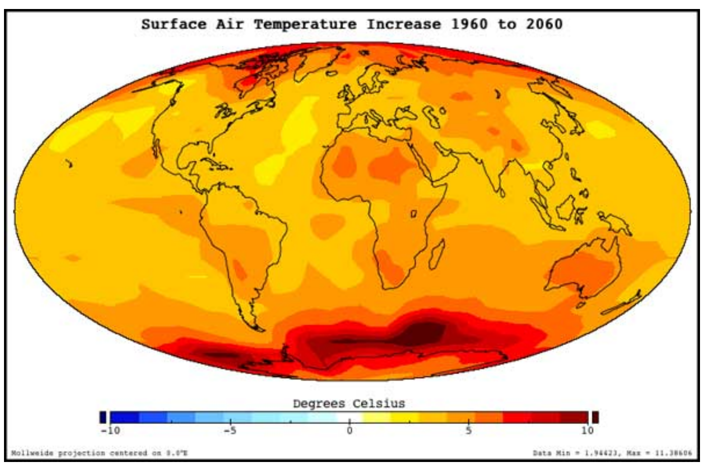
CH_4

N_2O

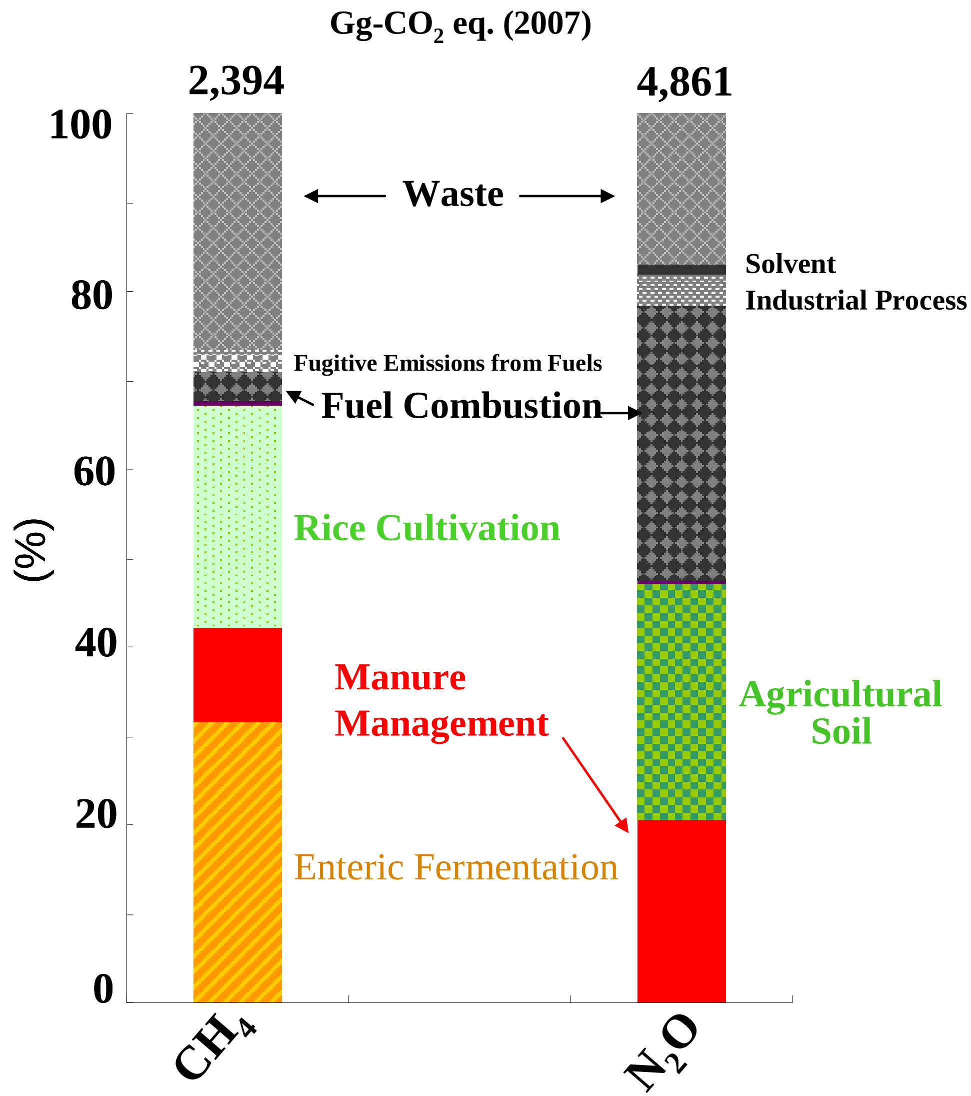


Greenhouse Gas Emission





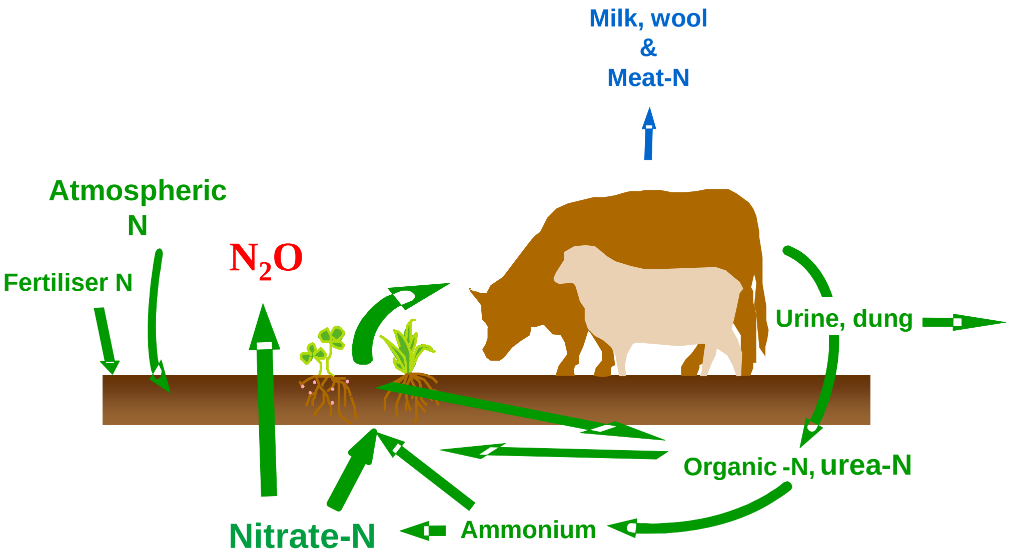
GHG Emission from Agricultural Sector

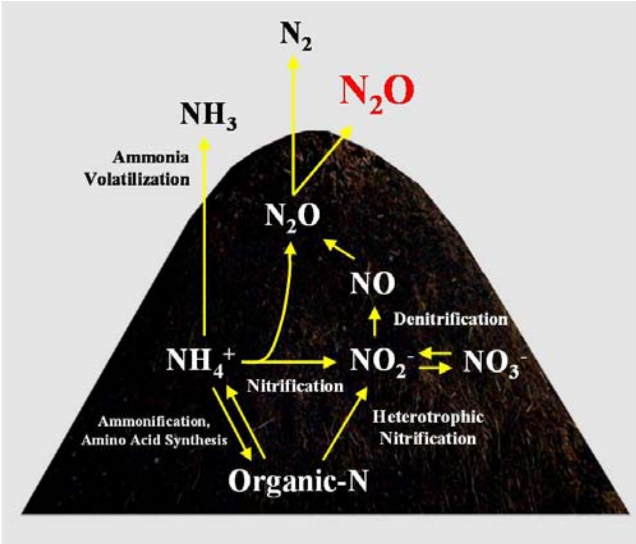


67.1% of CH_4
47.1% of N_2O

From Agricultural Sector

Nitrogen Cycle Relating Livestock Production





Complex microbial community is responsible for N_2O emission

Stable Isotope Analytical Method

Molecular Biological Method

Classical Cultivation Method

For GHG Mitigation Strategy

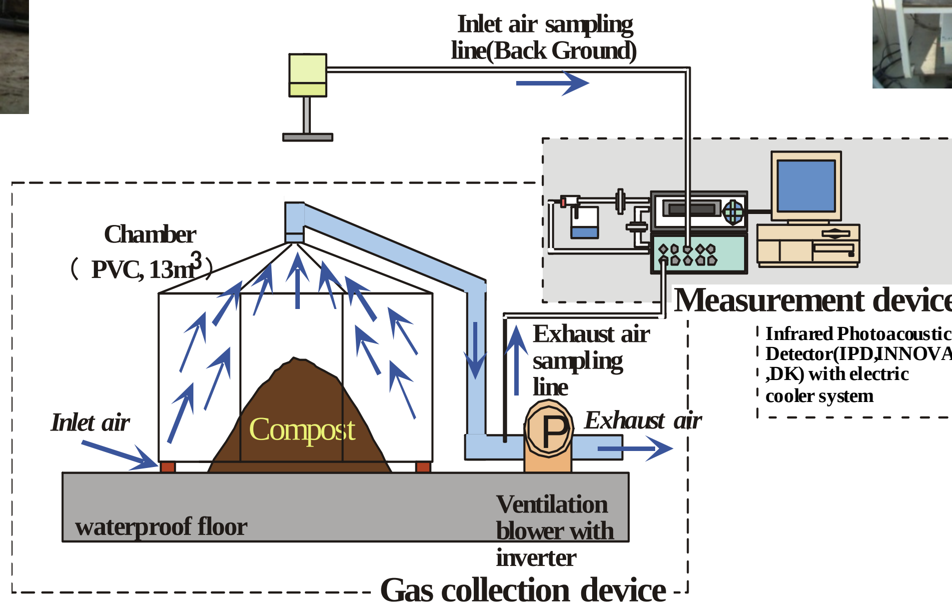
GHG mitigation option using bulking agent

Measurement of Gas Emission from Composting Process

NARO 農研機構

Chamber

Auto Measuring System



Moisture 80.8% 4 t

Moisture 73.7% 4 t ＋400 kg Bulking agent

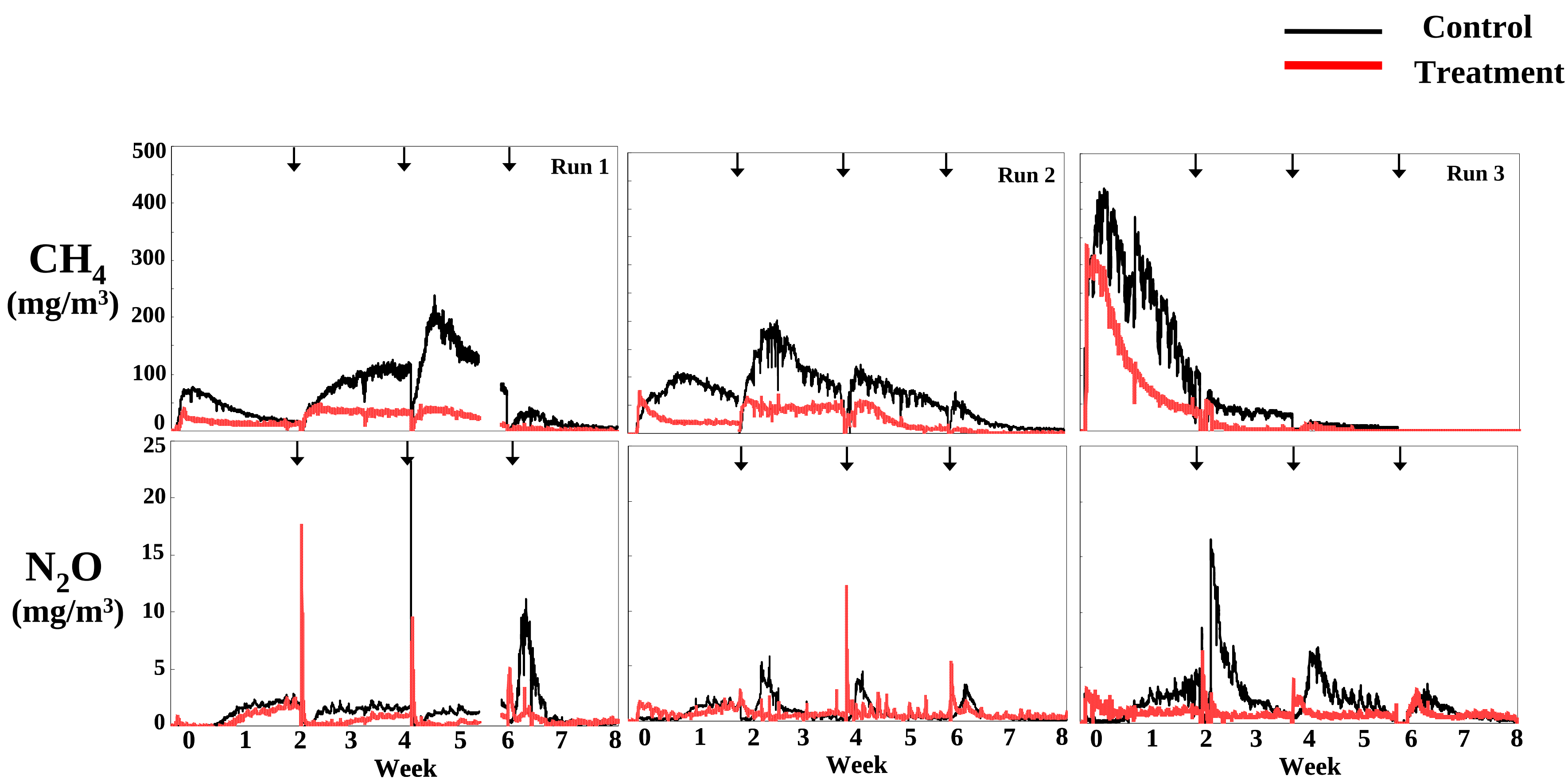
Run 1 7/21-9/17, 2009

Run 2 5/27-7/21, 2010

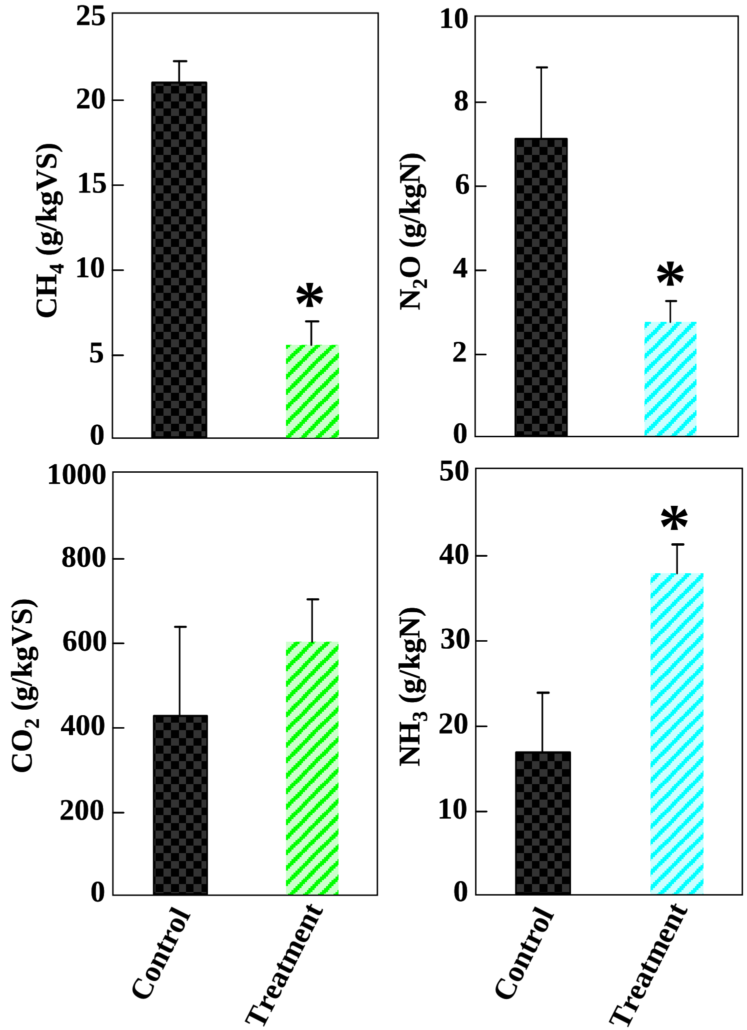
Run 3 9/15-11/10, 2010

Gas Emission

NARO 農研機構



Gas Emission



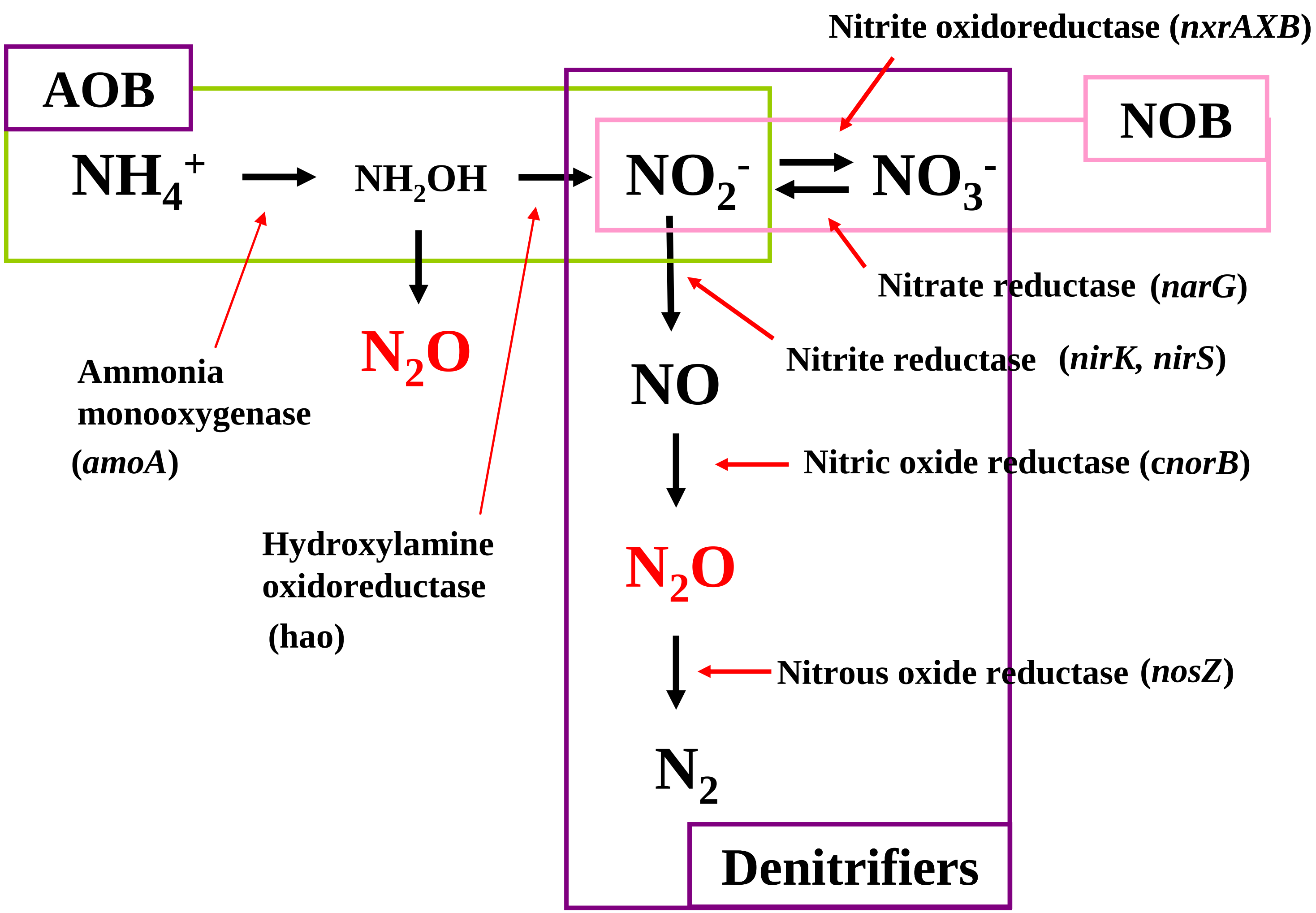
	Mitigation
CH_4	74.3%
N_2O	62.8%

CO_2	-42.2%
NH_3	-126%

Source of N_2O;

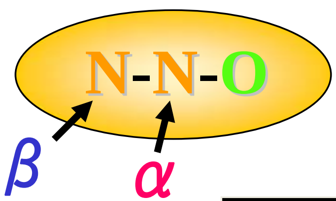
Nitrification or Denitrification?

Nitrification, Denitrification and N_2O



Isotopomer analysis

<N_2O isotopomer>



$^{14}N\text{-}^{15}N\text{-}^{16}O \Rightarrow \delta^{15}N^{\alpha}$

$^{15}N\text{-}^{14}N\text{-}^{16}O \Rightarrow \delta^{15}N^{\beta}$

$\delta^{15}N^{\alpha}$, $\delta^{15}N^{\beta}$ → $\delta^{15}N^{bulk}$

$^{14}N\text{-}^{14}N\text{-}^{18}O \Rightarrow \delta^{18}O$

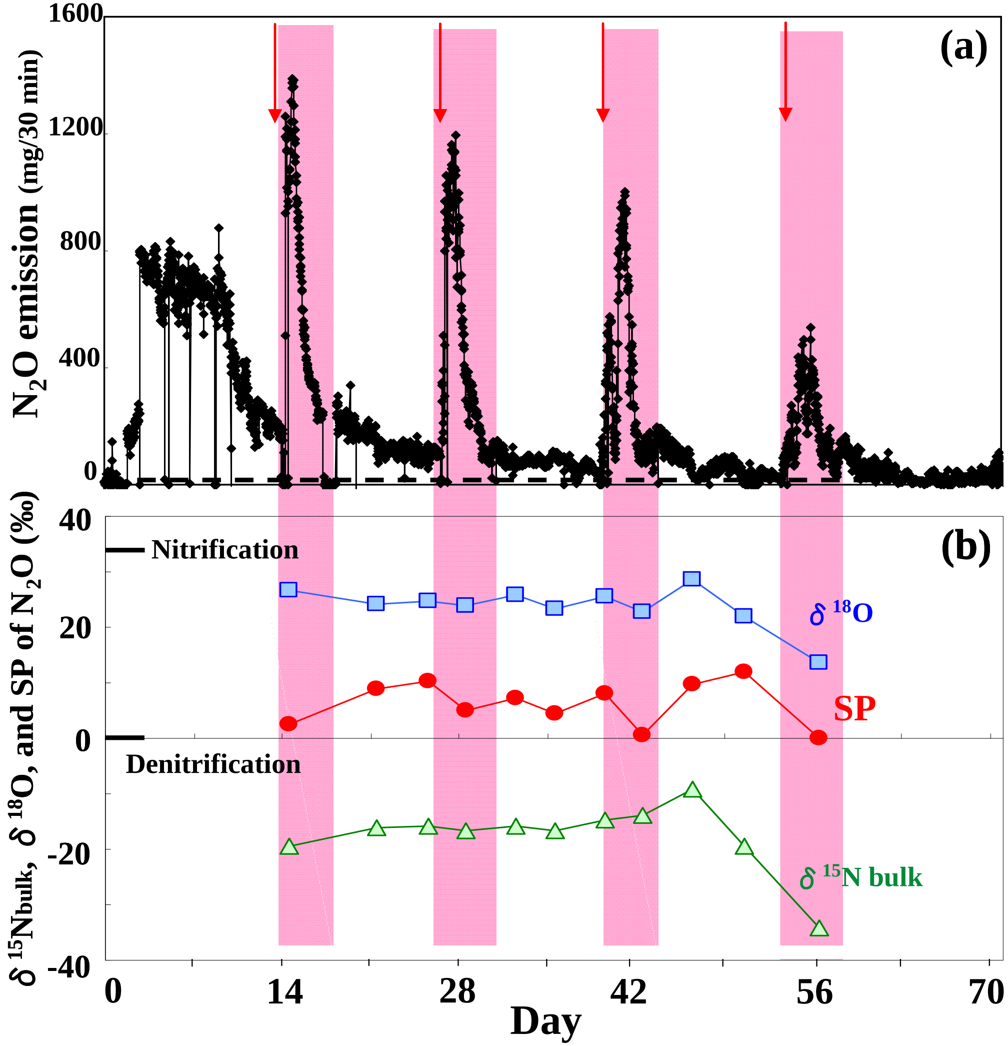
Site preference (SP) = $\delta^{15}N^{\alpha} - \delta^{15}N^{\beta}$

	$\delta^{15}N\text{-}N_2O$ (‰)	SP	
Nitrosomonas europaea	-0.3 (4.9)	33.5 (1.2)	
Nitrosospira multiformis	-0.3 (2.9)	32.5 (0.6)	Nitrification
Methylosinus trichosporium	3.4 (1.9)	35.6 (1.4)	
Nitrosospira multiformis	-22.9 (0.6)	0.1 (1.7)	
Pseudomonas chlororaphis	12.7	-0.6 (1.9)	Denitrification
Pseudomonas aureofaciens	36.7	-0.5 (1.9)	

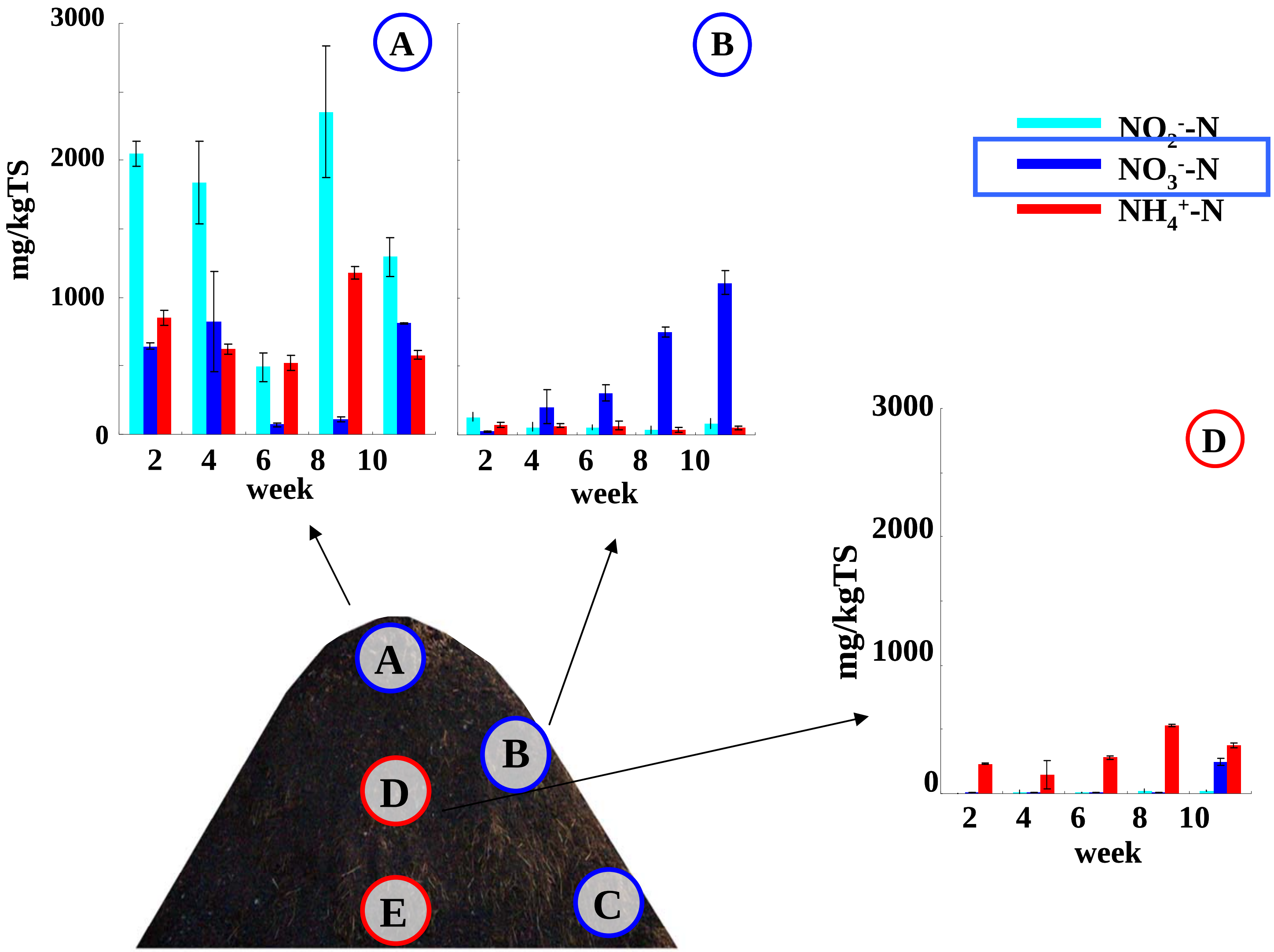
Sutka et al., *Appl. Environ. Microbiol.*, 2006.

N_2O Emission and Isotopomer Analysis

NARO 農研機構



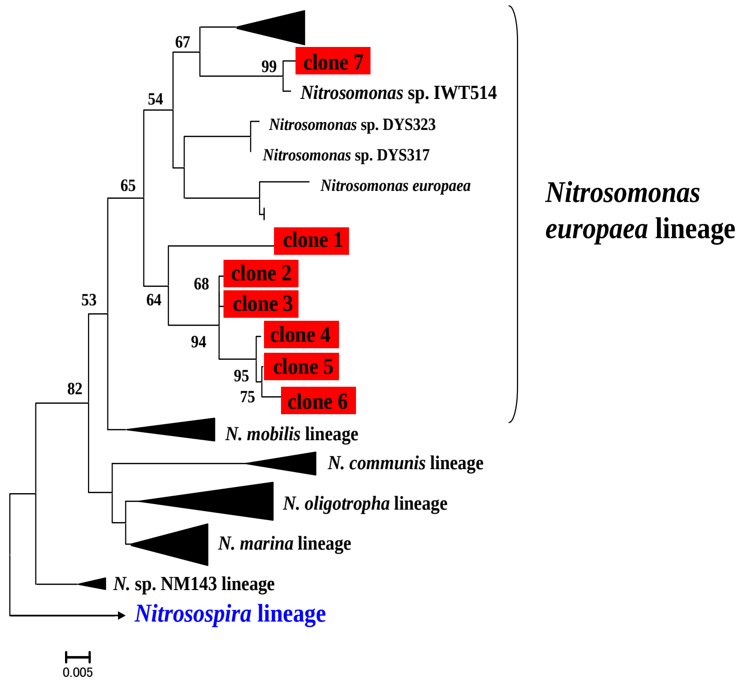
Accumulation of NO_2^--N and NO_3^--N



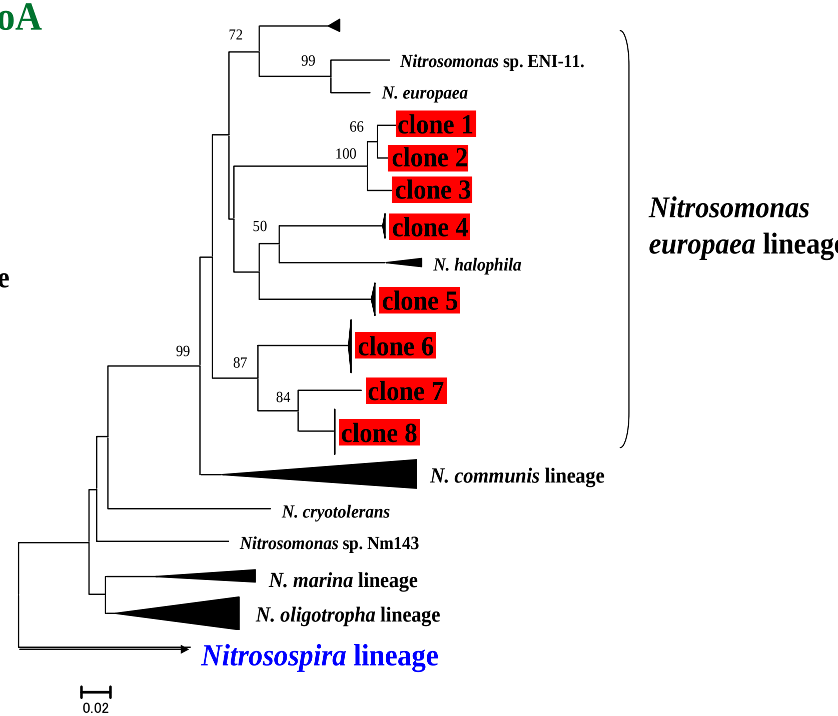
Phylogenetic analysis of 16S rRNA and *amoA* gene

NARO 農研機構

16S rRNA (β -*proteobacteria* AOB)

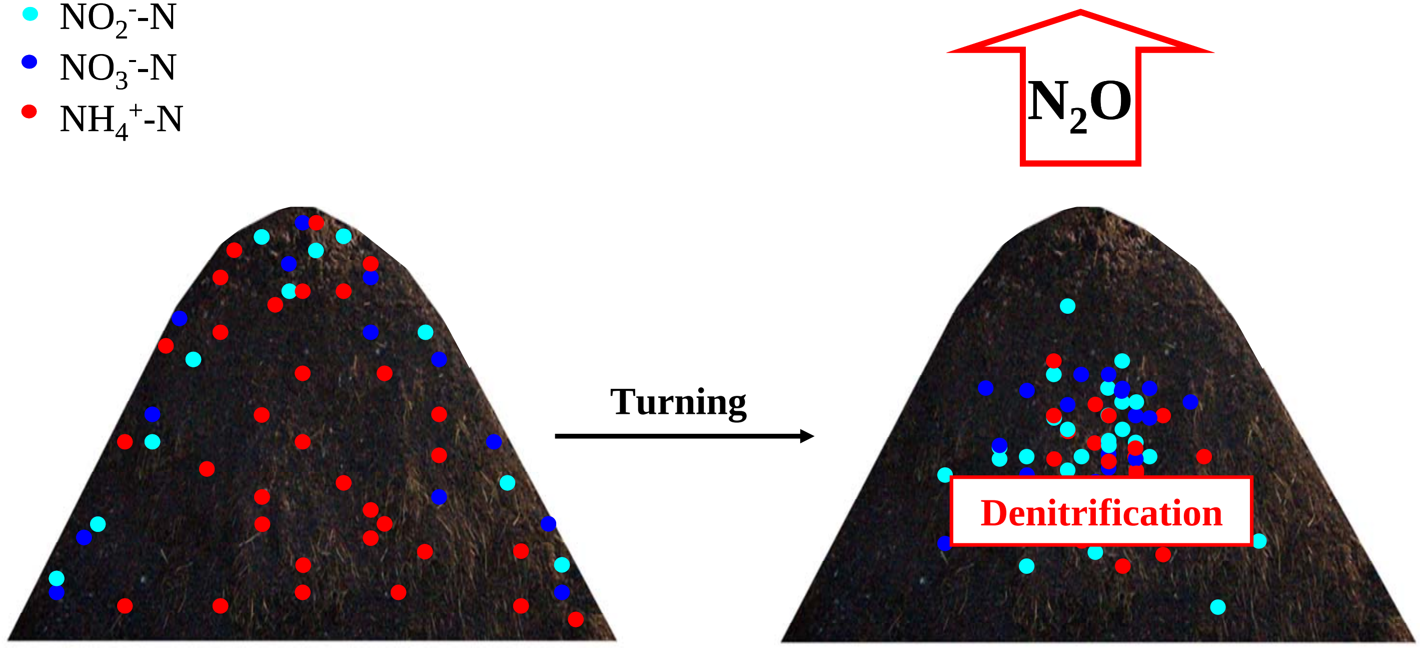


amoA



All sequences of both *amoA* and 16S rRNA specific for β-*proteobacteria* obtained in this study belong to the *Nitrosomonas europaea* cluster. These results suggest that the ammonia oxidizers working in the composting pile are not diverse, but are instead a closely related group contributing to the ammonia oxidation.

The model for N_2O emission



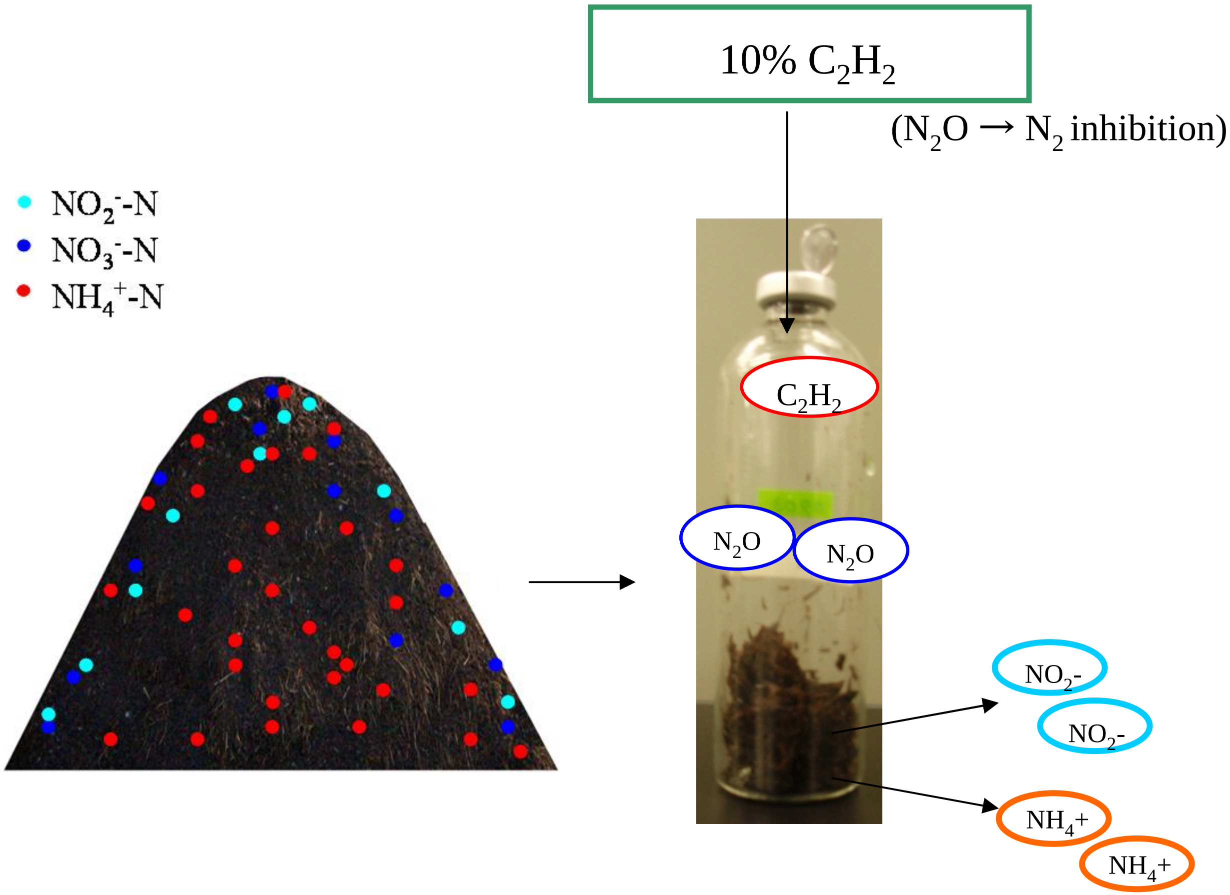
The reduction of accumulated NO_2^--N and NO_3^--N (denitrification) occurred just after the turnings.

Maeda et al. AEM (2010)

NARO 農研機構

- NO_2, NO_3-N accumulation in the surface samples is responsible for N_2O emission?
- Does NO_2 amendment complement the N_2O emission?

Denitrification Potential Measurement



NH_4^+

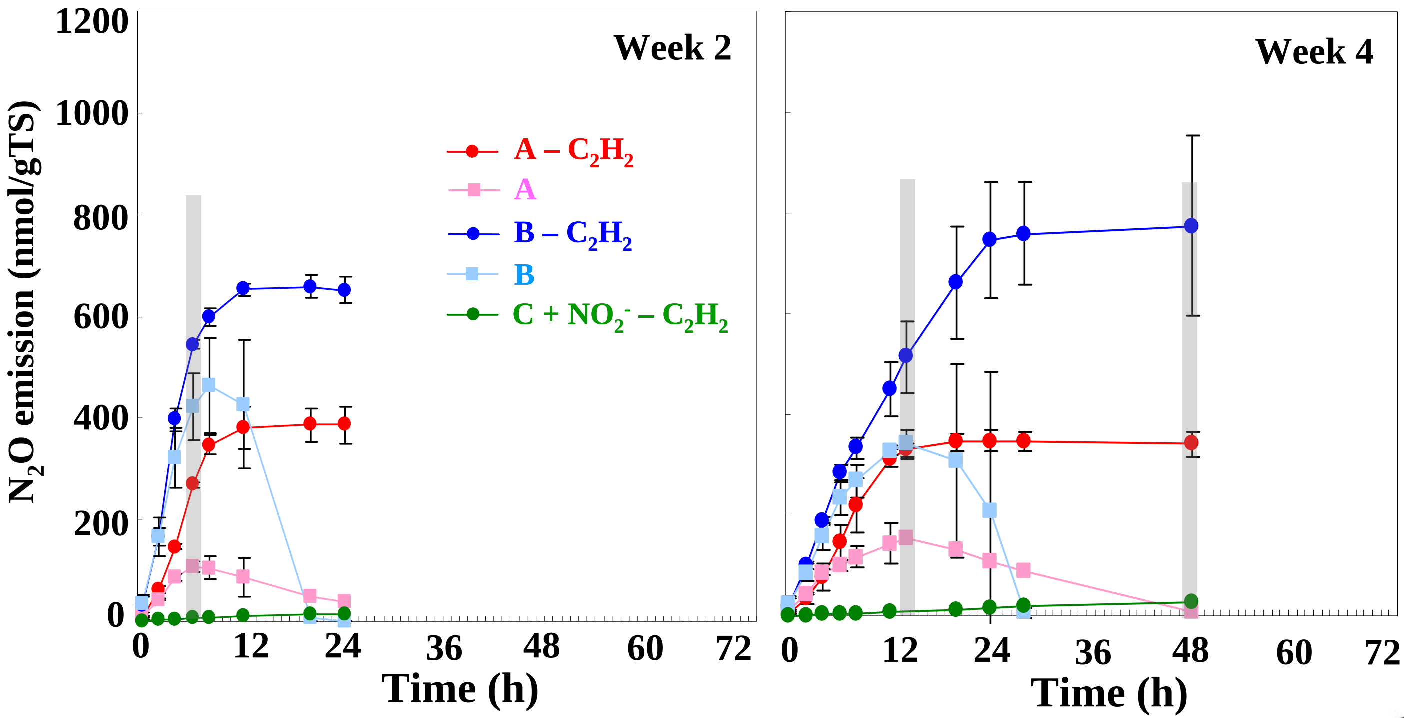
NO_2-

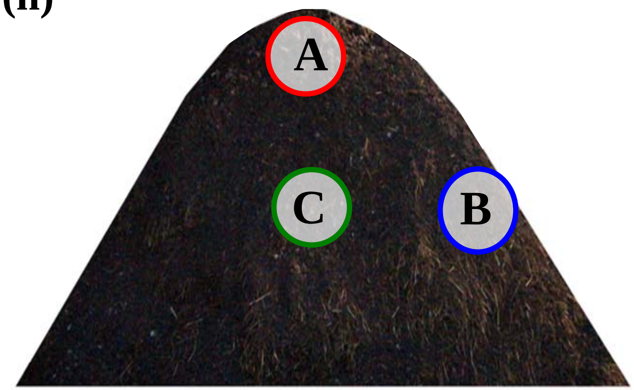
NO_2- reduction

N_2O production

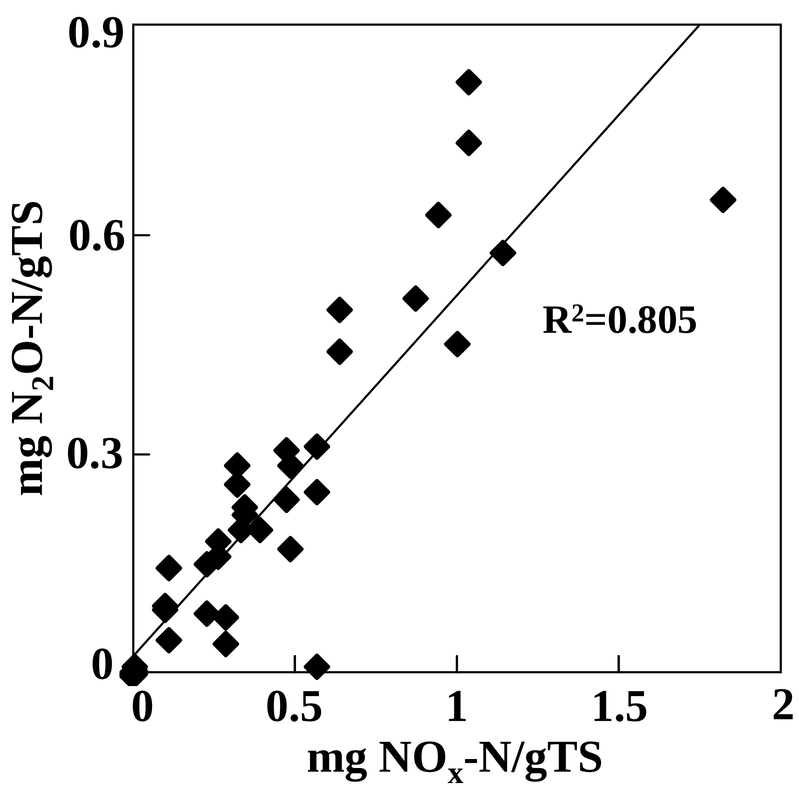
N_2O reduction

Denitrification Potential Measurement





Denitrification Potential Measurement



・N_2O production significantly correlated with NOx- accumulation.

・Surface samples emitted significant N_2O under aerobic condition.

・N_2O emission correlates NO_x^- accumulation

・NO_2- amended core samples did not produced significant N_2O especially in the initial stage of the process.

⇩

? ?

Denitrifiers in the surface zones might be mainly responsible for N_2O production.

? ?

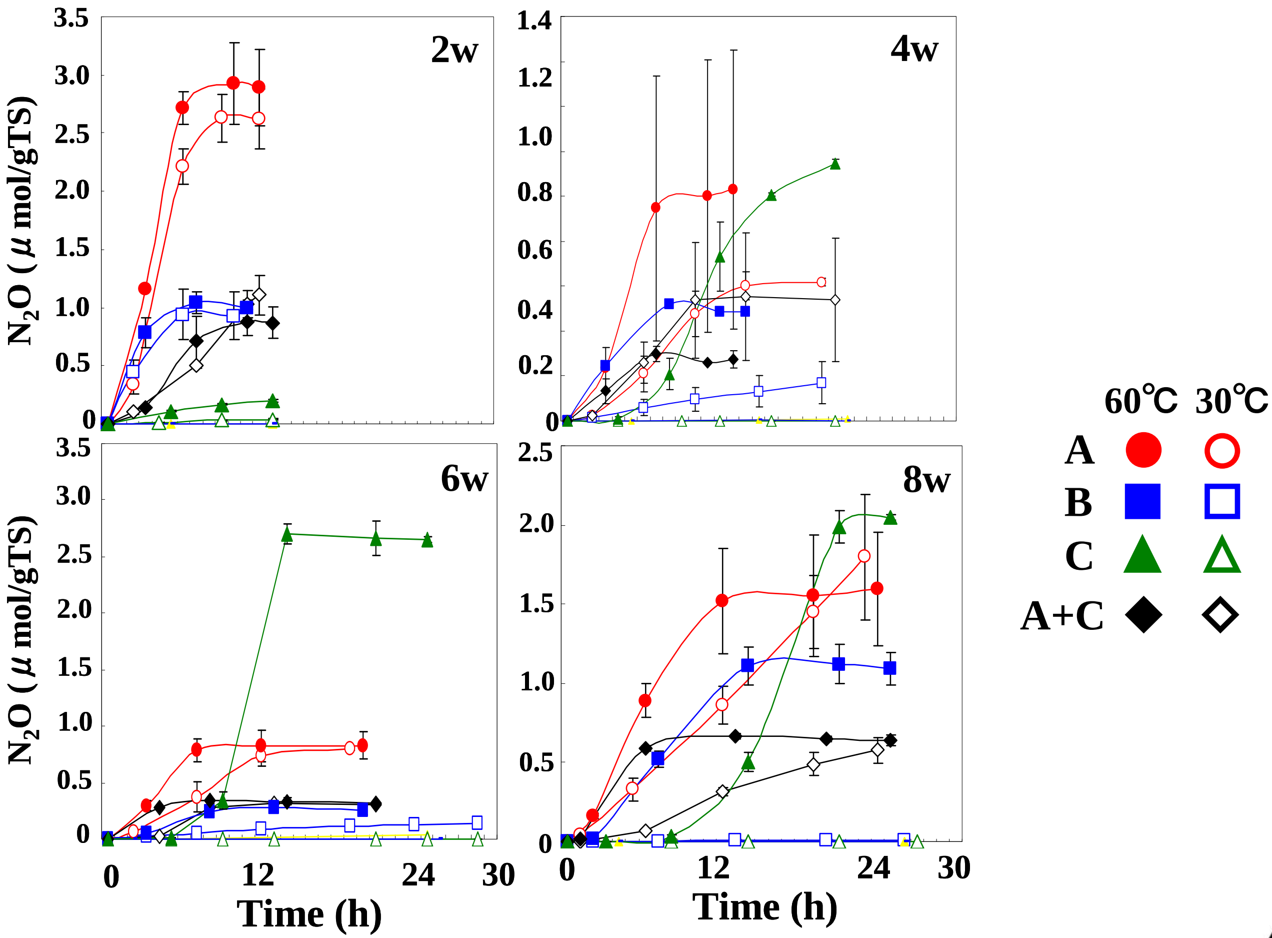
Hypothesis

? ?

Denitrifier in the surface zones are responsible for nitrite reduction and subsequent N_2O emission just after the turnings

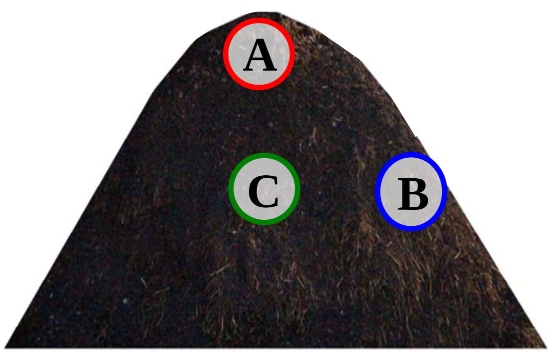
? ?

① surface samples	N_2O with SP value 0-10 occurs immediately
② Core samples	No N_2O production
③ Core samples amended with NO_2^-	Little, slow N_2O production with high SP (>10) value occurs
④ Mix of surface and core samples (model samples of the turnings)	N_2O production occurs immediately with low SP values?

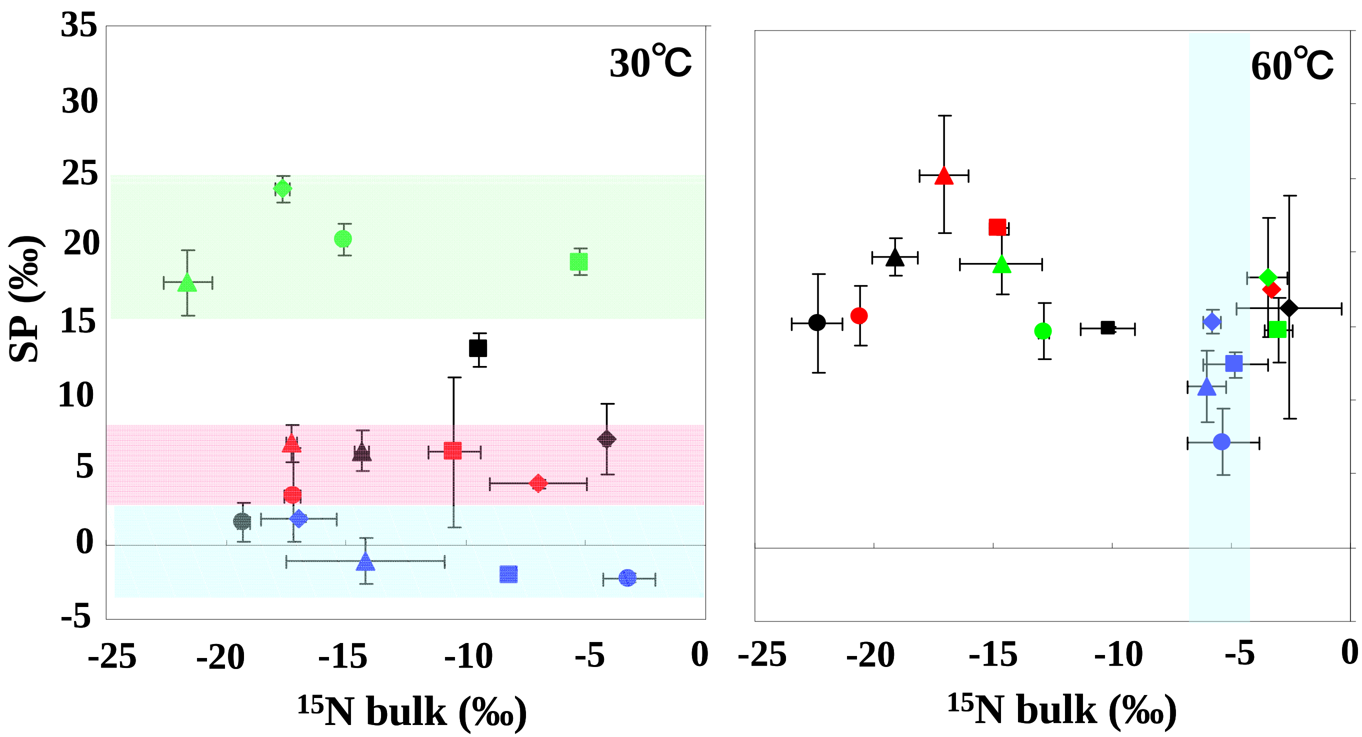


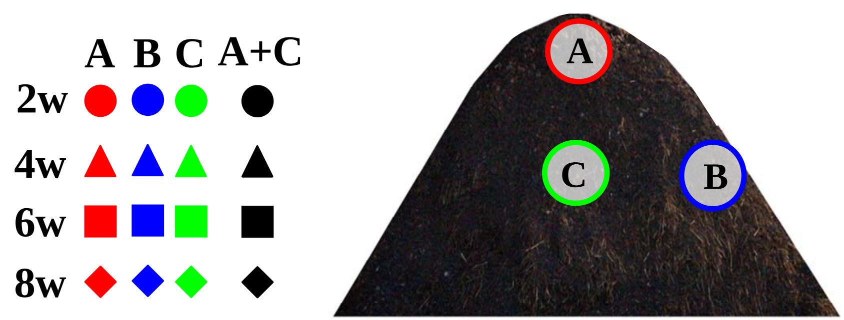
Thermophilic >>> Mesophilic

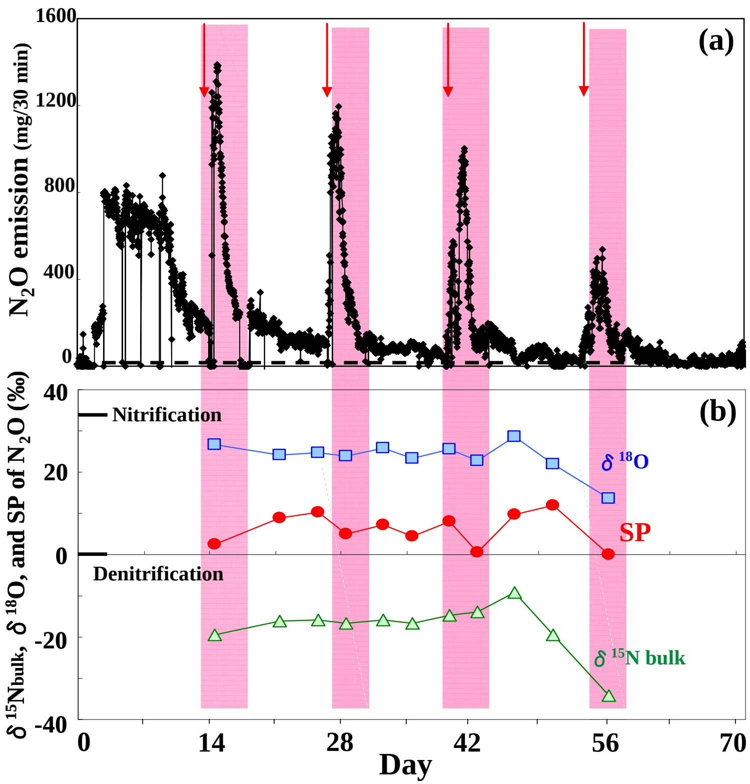
Surface > Core + NO_2

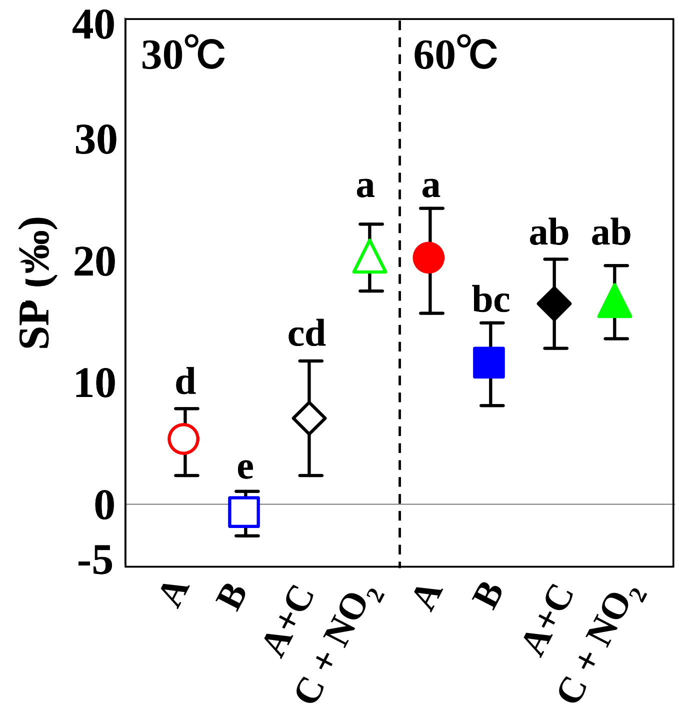


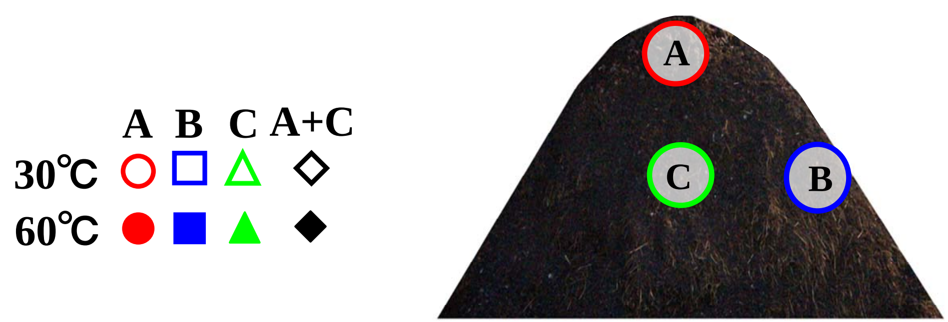
N_2O Isotopomer Analysis



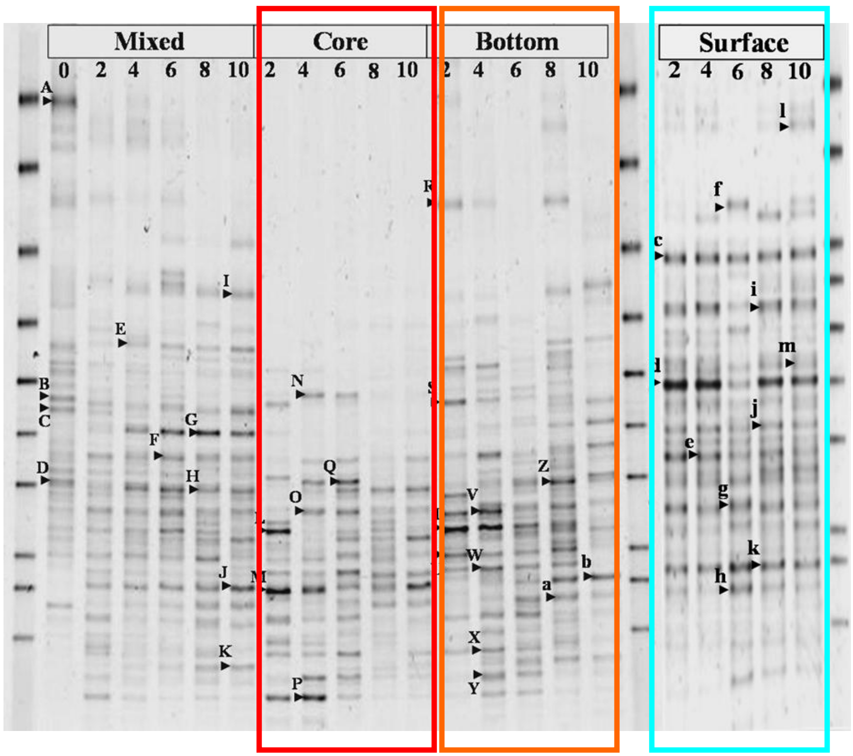


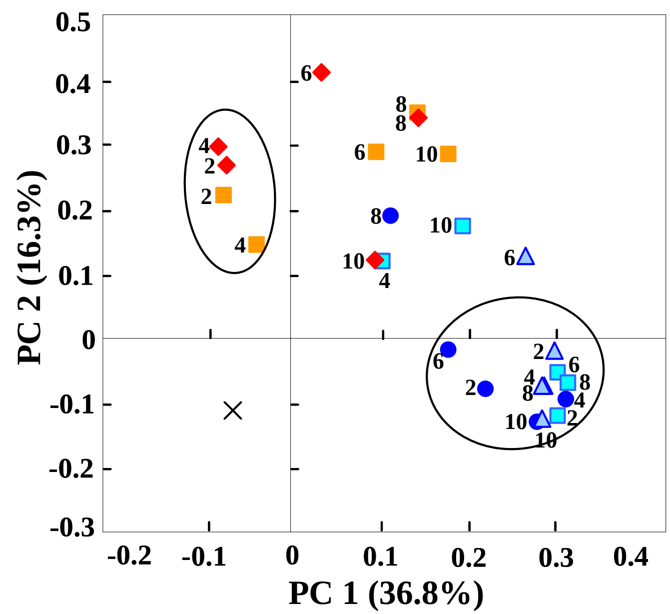

(a)
(b)
N2O emission (mg/30 min)
1600
1200
800
400
0
40
20
0
-20
-40
Nitrification
Denitrification
δ 18O
SP
δ 15N bulk
δ 15Nbulk, δ 18O, and SP of N2O (‰)
0
14
28
42
56
70
Day


SP (‰)
40
30
20
10
0
-5
30℃
60℃
d
e
cd
a
a
bc
ab
ab
A
B
A+C
C + NO2
A
B
A+C
C + NO2


A
B
C
A+C
30℃
60℃
A
C
B

What's Going On?- Overall Bacterial Community





Some *Bacillus* species and strictly anaerobic thermophilic *Clostridium* species were dominant only in the core and bottom zones.

In contrast, mesophilic bacteria such as *Bacteroidetes*, *Clostoridia*, *alpha* and *gamma-proteobacteria* were detected in surface zones, even in the initial thermophilic stage of the process.

Maeda et al., BITE (2010).

NARO 農研機構

What's Going On?- Overall Bacterial Community

Core-Bottom Zone

Thermophiles

Clostridium

Degrade Cellulose, Producing organic acid under thermophilic and anoxic conditions.

Bacillus

Utilize easy-degradable organic compounds under thermophilic conditions

Surface Zone

Mesophiles

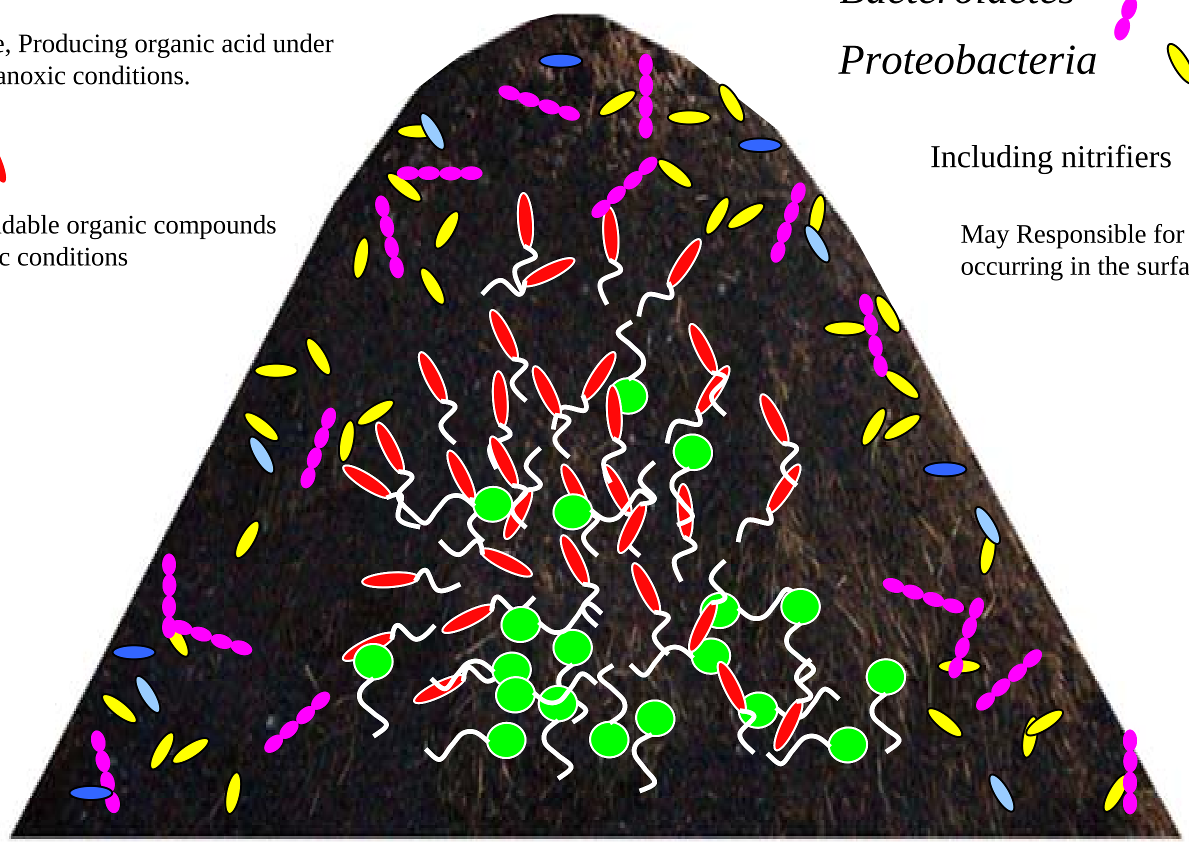
Bacteroidetes

Proteobacteria

Function unknown

Including nitrifiers

May Responsible for Nitrification mainly occurring in the surface.



Maeda et al., BITE (2010).

Conclusion

▪CH_4 and N_2O can be mitigated up to 74 % (CH_4) and 62 % (N_2O) by adding appropriate bulking agent.

▪N_2O just after the turnings derives from denitrification of NOx-N accumulated in the pile surface.

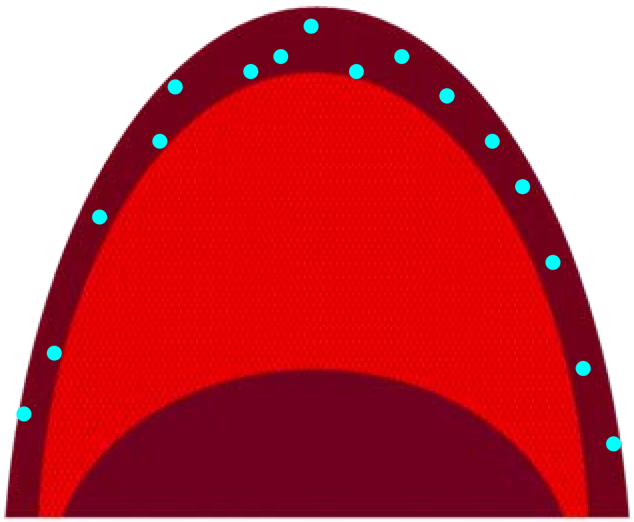
▪Nitrosomonas-like AOBs are partly responsible for surface nitrification.

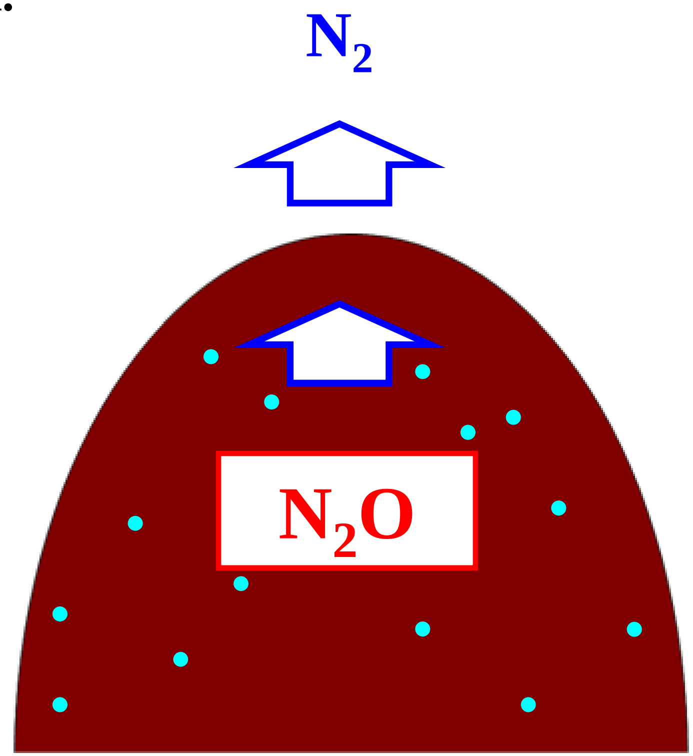
▪Denitrifiers in the surface zones are primary responsible for N_2O production under mesophilic condition just after the turnings.

▪Pile surface are dominated by mesophiles belong to *Bacteroidetes* or *Proteobacteria*,

GHG mitigation strategy

▪Use the bulking agent to enhance aeration.





▪Control nitrification on the pile surface

▪promote N_2O reduction after the turnings

TRUTH IS WHAT STANDS THE TEST OF EXPERIENCE

…Any Questions?