B-16.3 Studies of Control and Activities of Greenhouse Trace Gases in Grassland

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Abstract We examined degradation of N_2O emission which derives from fertilization nitrogen at the grassland. With the use of slow N-release fertilizer, coated N fertilizer, calcium nitrate, chemical fertilizer added nitrification inhibitor, it declined than the high analysis mixed fertilizer of the practice. Grass yield was equal to the case with chemical fertilizer added nitrification inhibitor and calcium nitrate, where applied practice fertilizer. The ground temperature was high and the time when there were many rainfalls, the use of slow N-release fertilizer, coated N fertilizer were shown grass yield which is equal to the practice fertilizer was gotten. In the grassland, CH_4 absorption was admitted in any fertilizer examinations. Then, we planned the way of N_2O emission being able to be about 50% degradation to use chemical fertilizer added nitrification inhibitor or slow N-release fertilizer compared with the practice fertilization.

CH_4 emissions were decreased when cow slurry was applied, soil injection, soil mix application and ditch application compared to surface application, but N_2O emissions were increased conversely. CH_4 emissions from stored slurry after aeration were about 1/10 reduced compared with no aeration. However, N_2O emission was admitted by the one of aeration way. When it applied stored liquid after aeration by surface application, CH_4 emission became less than 1/10 compared with no aeration, and N_2O emission became less than 1/2. Therefore, the aeration of slurry before store was effective with the CH_4 emission reduction for field application. The CH_4 emission during aeration was less than 1/4 compared with no aeration, and N_2O emission didn't admitted. When comparing CH_4, N_2O emissions according to the way of slurry treatments, it became the order which is no aeration stored slurry > stored liquid after aeration.

Key Words Grassland, Nitrous oxide, Methane, Animal waste, Nitrogen fertilizer

1. Introduction

Methane (CH_4) and nitrous oxide (N_2O) are long-lived radiatively active trace gases that account for $\sim$ 20% of the total anticipated greenhouse effect. It has been suggested that agricultural productions contribute to the increases of atmospheric concentration of CH_4 and N_2O. Grassland is important agricultural land. But diversity in management of fertilization or cultivation and uneven impacts of animal excreta in pasture, which prevailing in grassland, complicate the quantitative evaluation for emission of CH_4 and N_2O from grassland.

2. Research Objective

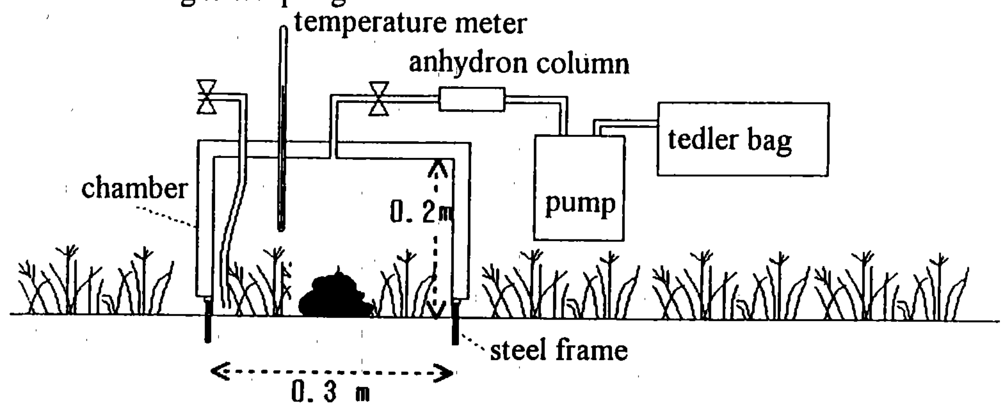
As for the development of greenhouse gas in grassland animal husbandry, CH_4 and N_2O from animal waste, N_2O from nitrogen fertilizer restraining these generation rate much is thought about as the earth anathermal countermeasures when important. So We tried degradation emission of CH_4 and N_2O by improvement of fertilization, treatment method of cow slurry and field application.

3. Research Method

(1) Measurement method of gas flux

Grassland for gas sampling sites placed at National Grassland Research Institute, in Nishinasuno, Tochigi, Japan. The grassland soil is brown lowland soil containing volcanic ash in the surface layer. We established triplet microplots for each experimental sites by enclosing with open-ended steel frames (0.3m × 0.3m). Flux measurement method was closed chamber method. Chamber height was 0.2m (Figure 1). Each gas sampling was commenced about from 8:00A.M. to 10:00A.M.. After chamber setting, gas samples were taken from the inside chamber into tedlar bag at 0, 15, 30 minutes. CH_4 and N_2O concentration measured by FID-GC, ECD-GC, respectively.

Figure 1. Outline of gas sampling



(2) The outline of vegetation test in the fertilizer experiment for N_2O emission degraded

The measurement of fluxes in field and grass yield investigation were done from March 20, 1995 to April 8, 1998, at the single herbage grassland of orchard glass in the NGRI. Soil of experimental grassland is the brown low land soil which contains volcanic ash in the topsoil.

Grass cutting was done four times annually and fertilizer application was done N-P_2O_5-K_2O= 5kg/10a respectively on early April, last May, middle July and middle September.

Nitrogen fertilizers used at this experiment were high analysis mixed fertilizer as practice fertilization, slow-N release fertilizer, coated urea(fast and slow type), coated calcium nitrate, calcium nitrate and high analysis mixed fertilizer added nitrification inhibitor(dicyanodiamide; DCD, 2- amino -4- chloro -6-methyl pyrimidine ; AM)(Table 1). Grass yield investigation was done by mown area 0.25m2(0.5m × 0.5m), 4 times.

Table1.Nitrogen fertilizers for trial of N_2O emission degraded

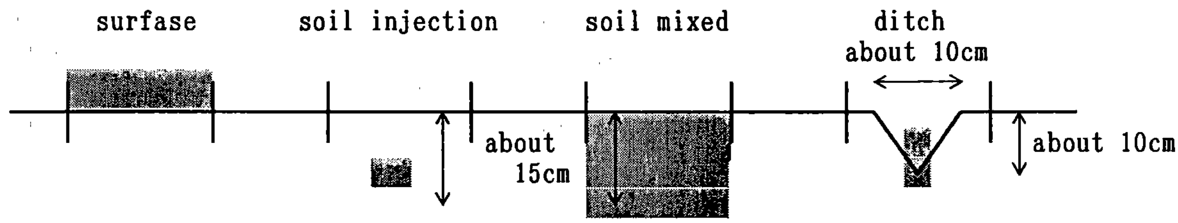
fertilizer	call name	fertilizer	call name
no-N fertilizer	No-N	coated calcium nitrate	long40
high analysis mixed fertilizer	17ALL	calcium nitrate	Ca-N
slow-N release fertilizer	CDU	chemical fertilizer added DCD	DCD
coated urea(fast type)	LP30	chemical fertilizer added AM	AM
coated urea(slow type)	LP70		

In each fertilizer experiments, superphosphate was used as P_2O_5 and potassium chloride was used as K_2O , except for 17ALL, DCD, AM.

(3) The outline of N_2O and CH_4 fluxes measurement at each slurry application

Surface application, soil injection(about 15cm depth), mixing soil application(about 15-cm depth) and ditch application(both the depth and the width are about 10cm) were compared. A concept figure is shown in figure 1. The slurry application is 6t/10a. Soil of experimental grassland is the brown low land soil which contains volcanic ash in the topsoil.

Figure 1. The outline of N_2O and CH_4 fluxes measurement at each slurry application



4. Result and Discussion

(1)The trial of N_2O emission degraded by nitrogen fertilizer

CH_4-C, N_2O-N fluxes among 95/3/20 to 98/4/8 was shown (Table 2). Annually, N_2O was emitted from any fertilizers, and 17ALL showed the most N_2O emission compared with the other.

Table.2 Annual CH_4 and N_2O fluxes from grassland   unit:CH_4-C or N_2O-N mg/m^2/year

	CH_4-C uptake			N_2O-N emission		
	95	96	97	95	96	97
No-N	140.6±43.7	146.2±28.2	143.6±29.5	42.8±9.2	40.6±7.6	44.4±9.2
17ALL	121.8±36.1	148.6±30.6	155.1±41.2	451.0±80.2	170.7±26.5	275.3±41.2
CDU	171.7±53.1		141.8±32.4	100.9±13.3		152.6±16.5
LP30			149.2±31.1			123.5±20.0
LP70	191.4±29.0		182.0±36.6	103.5±11.3		85.6±10.4
long40			142.0±29.0			120.6±15.0
Ca-N	107.4±25.0		168.5±27.0	116.2±20.4		168.5±26.9
DCD		131.4±27.6	150.2±26.3		111.0±15.8	134.5±24.7
AM		120.9±24.3	144.5±31.0		93.7±19.5	130.6±23.7

measurement span 95:95/3/20～96/3/25 96:96/4/9～97/4/8 97:97/4/9～98/4/8

Table3. The rates of N_2O-N/added N by N fertilizer(%) at every fertilizer application

		17ALL	CDU	LP30	LP70	long40	Ca-N	DCD	AM
	spring	0.3	-0.0		0.0		0.1		
	after 1	1.1	0.1		0.1		0.3		
95	after 2	4.4	0.2		0.4		0.8		
	after3	1.2	0.2		0.2		0.2		
	Annual	2.0	0.3		0.3		0.4		
	spring	0.1						0.0	0.1
	after 1	0.2						0.6	0.4
96	after 2	0.9						0.3	0.3
	after 3	0.6						0.1	0.1
	Annual	0.7						0.4	0.3
	spring	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1
	after 1	0.8	0.3	0.3	0.1	0.4	0.2	0.3	0.4
97	after 2	1.6	1.0	0.7	0.4	0.6	0.2	0.8	0.6
	after 3	1.6	0.4	0.2	0.0	0.1	0.0	0.3	0.5
	Annual	1.2	0.5	0.4	0.2	0.4	0.2	0.5	0.4

measurement span 95:95/3/20～96/3/25 96:96/4/9～97/4/8 97:97/4/9～98/4/8

95 fertilizer application spring:95/3/20 after 1:95/5/9 after 2:95/6/28 after 3:95/8/29

96 fertilizer application spring:96/4/10 after 1:96/5/24 after 2:96/7/16 after 3:96/9/19

97 fertilizer application spring:97/4/10 after 1:97/5/26 after 2:97/7/16 after 3:97/9/10

The ratio of N_2O-N/added N by N fertilizer(%) at every fertilization was shown in Table 3.
Like the annual emission, the each ratio of N_2O-N/added N by N fertilizer(%) were low compared with 17ALL. Therefore, it thought that, it was effective, as for the point for degradation of N_2O emission, use of CDU, LP30 and 70, long40, Ca-N, DCD and AM.
Also, in any fertilizer field, CH_4 absorption was admitted (table 2) and a big difference among the examination wards didn't't admitted.

(2) Grass yield
The result of orchard grass dry matter every cutting was shown in table 4.
In each year, use of fast N release type fertilizer(17ALL, Ca-N, DCD and AM) showed more yield than the other. In annual grass yield, it is attached importance to 1st cutting grass, because 1st cutting grass is good quality and most yield annually. The 1st grass yield with the DCD, AM and Ca-N was equal to 17ALL. Therefore, it was judged difficult to use CDU and LP30, and 70, long40 for early spring fertilization. Also, these fertilizer have the nature that it is easy to undergo a ground temperature and the influence of ground moisture in nitrogen release speed. However, CDU and LP30, and 70, long40 were more yield at 2nd, 3rd grass cutting. This cause is thought of according to the increase of the N release quantity by the rise of last effect of the early spring fertilization, the ground temperature and the amount of rainfall. Therefore, it thinks that these fertilizer can be effectively used in the region of the ground temperature to rise and the increase of the rainfall. Also, it is easy for the calcium nitrate to dissolve in water and it must be careful of the rainfall of several days after fertilization.

Table 4. Grass yield (dry-matter g/0.25 m^2)

		No-N	17ALL	CDU	LP30	LP70	long40	Ca-N	DCD	AM
	1st	27.5	65.4	41.2		21.7		72.1		
	2nd	28.2	76.9	72.3		54.9		70.3		
95	3rd	46.4	94.1	98.9		94.7		89.9		
	4th	41.7	67.4	72.7		55.2		48.2		
	sum	143.8	303.8	285.1		226.5		280.5		
	1st	37.9	118.7	81.4		66.8		113.4	115.1	105.5
	2nd	40.6	85.5	91.6		93.3		103.4	79.7	103.3
96	3rd	37.8	91.4	90.1		88.7		105.2	90.7	86.2
	4th	12.9	58.2	41.7		30.9		49.2	45.0	44.7
	sum	129.2	353.8	304.8		278.7		371.2	330.5	339.7
	1st	31.4	131.3	82.9	70.3	67.0	63.4	137.2	99.1	110.2
	2nd	32.1	97.1	90.1	116.9	94.5	141.9	94.7	95.2	89.9
97	3rd	31.7	77.4	84.2	92.6	88.4	110.0	82.1	75.3	80.0
	4th	15.5	53.9	62.1	32.9	44.2	49.5	44.9	63.4	48.1
	sum	110.7	359.7	319.3	312.7	294.1	364.8	358.9	333.0	328.2

95 cutting date 1st:95/5/8 2nd:95/6/27 3rd:95/8/28 4th:95/10/23
96 cutting date 1st:96/5/22 2nd:96/7/15 3rd:96/9/17 4th:96/11/12
97 cutting date 1st:97/5/22 2nd:97/7/14 3rd:97/9/9 4th:97/11/11

(3)Grass compounds
We measured quantity of crude fiber in grass(NDF) in sample in 96 and other constituent (N,P,Ca,Mg,K).
We compared NDF value (table 5) and dosage of other constituent (N,P,Ca,Mg,K) thought that methane generation rate of Ruminantia origin included influence with numerical value of mention

in feeding standard and judged it when there was it in field of normality value. We thought that a change of fertilizer did not influence grass constituent for the this reason.

Table. 5 NDF value(NDF g/dry matter sample g %) of orchard grass in 96

	No-N	17ALL	CDU	LP70	Ca-N	DCD	AM
1st	57.9	63.4	59.9	61.4	61.2	63.3	62.4
2nd	60.8	65.0	61.6	65.5	62.7	66.7	64.5
3nd	64.3	65.2	64.5	69.2	63.5	69.5	64.9
4th	59.4	54.1	57.0	49.8	48.9	51.0	47.4

96 cutting date 1st:96/5/22 2nd:96/7/15 3rd:96/9/17 4th:96/11/12

(4)The plan of effective fertilization in N_2O degradation

From or greater, We planned effective fertilization in N_2O discharge depression in question with a little in procurement and easiness of handling, yield and calculated the diminution factor as a test (table 6). With custom method is simple and easy because put it, and put a change with the principal objective, did not do that changed a kind of fertilizer in every fertilization. A combination to make depression rate the this reason more exists in others. For example, it was thought if put coated N fertilizer together when it was raised diminution factor furthermore, but judged what we built in it project when included a risk by weather in consideration when careless.

Table 6. Fertilizer application management for N_2O emission to degrade

Fertilizer application management	rate of N_2O emission to degrade
All fertilizer application time, use of chemical fertilizer added nitrification inhibiter(DCD,AM)	43～57%
All fertilizer application time, use of slow-N release fertilizer(CDU), except for spring time, by high analysis mixed fertilizer	47%

Every fertilizer application timefor grassland, N-P_2O_5-K_2O=5-5-5kg/10a

(2) The measurement of N_2O and CH_4 emission of each application methods of slurry

We showed measurement resultant of N_2O and CH_4 emission of each application methods of slurry by table 7. Slurry surface application reduced N_2O emission in field most and subsequently was soil mix application and ditch application, and there was the most soil injection. On the other hand, it was soil injection that CH_4 emission was a most little adversely and subsequently was soil mix application, order of ditch application, and there was the most surface application. The most exist in inorganic nitrogen in slurry with morphology of ammonia nitrogen (NH_4-N). Because it was spreaded ammonia in slurry during atmosphere with surface application, and it was not absorbed by soil, so it is thought that there was a little N_2O formation in the soil inside wwith surface application.

When volatilized ammonia receive nitrification in the soil inside when descended on ground by rainfall, the ammonia occurs N_2O. For the this reason, We need to restrain ammonia volatilization of slurry application.

We became resultant with a little CH_4 emission in much application methods of N_2O emission adversely, and in the final examination, the method to reduce N_2O and CH_4 emission simultaneously did not become clear. So we bestowed pretreatment in store before casting slurry into a field and examined the device which reduced N_2O and CH_4 with application.

Table 7. The amount of CH_4 and N_2O emission and the rate against total C and N after cattle slurry application

	N_2O evolved (mg-N/㎡/43day)	CH_4 evolved (mg-C/㎡/43day)	N_2O-N/T-N ratio(%)	CH_4-C/T-C ratio(%)
surface application	72.3	489.4	0.09	0.24
soil injection	142.0	114.3	0.33	0.05
soil mix application	102.0	184.9	0.19	0.09
ditch application	100.0	360.6	0.19	0.17

cattle slurry composition(T-C:3.4%, T-N:0.5%) slurry application amount : 6t/10a

(3) The examination for the degradation CH_4 and N_2O emission at stored slurry

Slurry is that feces and urine are not divided, and that solid and liquid joined is a heavy liquid state thing. There is a thing done, no-treated stored slurry or stored slurry after the compulsion fermentation which did aeration, and the configuration is not uniformity, but it is applied to farmfield after several months store. CH_4 is formed so that it is put with anaerobic condition while it is done the reservoir, and the all is discharged during atmosphere. So we tried that it degrade by aeration processed CH_4 and N_2O which occurred during slurry reservoir.

1)The measurement of CH4 and N2O emission during aeration

We measured CH_4 and N_2O emission at aeration treatment of slurry, with fermentation control tank. Fermentation control tank is impeller stirring aeration apparatus of closed mold, and the specification are table 8. The emission was multiplied from concentration difference with air through pressed air and fermenter.

Table 8. Apparatus specification of fermentation experiment

max. tank volume	200 litter
treatment volume	150 litter
mixing motor	1 (0.4kw/200v, invertor controlled)
foaming cut motor	1 (0.4kw/200v)
aeration	air from compressor, aeration volume controlled by valve

CH_4 emission in aeration degraded in 1/4 compared with no aeration (table 9), and it was not accepted the influence of aeration treatment about N_2O emission.

As for the fermenter, there was a little temperature variation during the final examination, it was guessed that fermentation phenomenon did not happen, but CH_4 emission degraded. So it was not always necessary that fermentation did not occurred for CH_4 degradation in slurry store, and it was effective to remove anaerobic condition of slurry was suggested.

Volatilization of NH_4 -N is not avoided by aeration (table 10), and some countermeasures is necessary.

Table 9. The amount of CH_4 and N_2O emission at aeration and stored time after aeration

aeration	15l/min			
state	aeration*		stored**	
	CH_4-C	N_2O-N	CH_4-C	N_2O-N
aeration	9	0	1	0
no treat	41	0	15	0

aeration time 15l/min: 15day aeration tank volume: 200liter(treated volume: 150liter)

stored time 15l/min: 58day stored tank volume: 11liter unit: *:g/days **:g/㎡/days

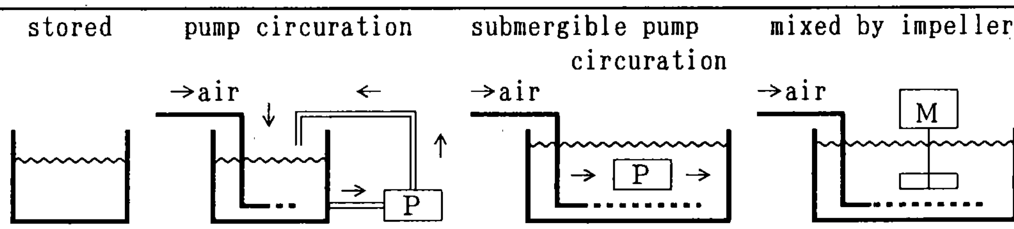
Table 10. Cattle slurry composition

	15l/min before aeration	after aeration
water(%)	93.1	93.2
pH	7.6	9.3
T-N(%)	0.46	0.4
T-C(%)	2.74	2.73
NH_4-N(%)	0.28	0.21
NO_3-N(%)	ND	ND

2)The trial of aeration treatments for degraded CH_4 and N_2O emission in time of slurry stored and field application

We examined 3 method of aeration treatment, pump circulation aeration, submergible pump circulation aeration, impeller mixing aeration (figure 3). We got every 11 liters of liquid after treatment by these methods and measured gas flux from liquid face. The operation was done a treatment quantity of 1m^3, aeration continues for 6m^3/ hr/t, 168 hours.

Figure 3. The outline of aeration treatment



specification	pump circuration	submergible pump circuration	mixed by impeller
treatment volume	1 m^3	1 m^3	1 m^3
pump discharge velocity	0.6m^3/min	1.35m^3/min	------
pump head	5.3m	17.0m	------
motor power	2.2kW/200V	7.5kW/200V	3.7kW/200V
aeration volume	6 m^3/hr·ton	6 m^3/hr·ton	6 m^3/hr·ton

CH_4 emission in reservoir reduced it in about 1/10 compared with no treatment after treatment end by aeration treatment.

N_2O emission did reduction with submergible pump circulation aeration and impeller mixing aeration, but increased with pump circulation aeration (table 11).

Table 11. The amount of CH_4 and N_2O emission of stored cattle slurry after aeration treated

	no-treated stored slurry	pump circulation	submergible pump	mixed by impeller
CH_4-C (g/m^2/162day)	48.16	0.05	0.87	0.57
N_2O-N (g/m^2/162day)	0.39	118.03	0.08	0.00

measurement span : 94/11/7～95/4/18 stored volume : 11 liter

We needed to dilute slurry offered in pump circulation aeration in 2 times with aqua in relation of pump output. Therefore, in table 12, character of treated liquid is different remarkably compared T-N with another treatments.

And, in pump circulation aeration, we supposed that much oxygen incorporation dosage compared it with the other treatments in order to do showering necessarily, and so, formed nitrate nitrogen (NO_3^--N) during aeration much. So we supposed that denitrification of this NO_3^--N occurred N_2O emission increased.

Therefore, submergible pump circulation aeration, impeller mixing aeration were effective methods of aeration treatment for degraded CH_4 emission in slurry store, it was judged than or greater.

Table 12. Cattle slurry composition

	before aeration	after aeration		
		pump circulation	submergible pump	mixed by impeller
water(%)	89.9	95.5	86.7	90.5
pH	7.0	6.4	7.2	7.7
T-N(%)	0.46	0.15	0.47	0.46
T-C(%)	4.25	1.81	5.83	3.80
NH_4-N(%)	0.22	0.01	0.11	0.14
NO_3-N(%)	ND	0.08	0.01	0.00

before application

	no aeration	pump circulation	submergible pump	mixed by impeller
water(%)	90.1	94.7	84.7	90.1
pH	7.2	7.6	7.13	7.07
T-N(%)	0.44	0.14	0.48	0.41
T-C(%)	4.08	2.05	6.17	3.55
NH_4-N(%)	0.20	0.01	0.11	0.11
NO_3-N(%)	0.00	0.01	0.00	0.00

We measured CH_4 and N_2O fluxes at field by surface application of stored liquid after aeration treatment, with rate of 6t/10a (table 13).

CH_4 emission degraded in 1/10 or less compared each treatments with no aeration treatment, and aeration treatment before store was effective for CH_4 degradation of field application.

N_2O emission degraded in 1/2 or less by aeration treatment, but we supposed that this degradation originated from volatilization of NH_4^+- N in aeration treatment, because the amount of NH_4^+- N before aeration was more than it after aeration.

We think that it become examination subject after now about ammonia volatilization in aeration treatment, but think by limited part countermeasures when correspondence is possible.

Table 13. The amount of CH_4 and N_2O emission and the rate against total C and N after cattle slurry surface application

	N_2O evolved (mg-N/m²/32day)	CH_4 evolved (mg-C/m²/32day)	N_2O-N/T-N ratio(%)	CH_4-C/T-C ratio(%)
no aeration*	45	507	0.10	0.17
pump circulation	19	49	0.06	0.04
submergible pump	17	49	0.01	0.01
mixed by impeller	18	44	0.02	0.02

measurement span:95/4/26～95/6/13 slurry application amount : 6t/10a *:mg-N or C/m²/50day

3) The estimate of CH_4 and N_2O degradation from cow slurry by aeration treatment

On the basis of result and discussion of (3)-1), 2), we estimated CH_4 and N_2O degradation from cow slurry by aeration treatment. This estimate was done in orders of following. These were 1.slurry aeration treatment for 15 days, 2.store for 162 days after aeration treatment, 3.at field by surface application of the stored liquid with rate of 6t/10a. We showed CH_4 and N_2O emission per 1 kg of cow slurry (table 14) and emitted CH_4-C/T-C and N_2O-N/T-N rates of cow slurry (table 15).

Table 14. The amount of CH_4 and N_2O emission per cattle slurry weight(kg)

treatment						
		stored		sum	application	total
stored*1	CH_4	273	219	492	85	577
	N_2O	0	2	2	15	17
		aeration	stored	sum	application	total
aeration*2	CH_4	60	3	63	7	70
	N_2O	0	0	0	3	3

unit: CH_4-C or N_2O-N mg/kg application:surface application(6t/10a)

*1:stored time 15+162days aeration time 15days, stored time 162days

Table 15. The emission rate of CH_4 and N_2O against total C and N of cattle slurry

treatment				
		stored		application
stored*1	CH_4	0.07～0.37	0.09	0.17
	N_2O	0	0	0.10
		aeration	stored	application
aeration*2	CH_4	0.02～0.10	0	0.02
	N_2O	0	0	0.02

unit: CH_4-C/T-C% or N_2O-N/T-N% application:surface application(6t/10a)

*1:stored time 15+162days aeration time 15days, stored time 162days

As a result, normal slurry store reservoir is estimated CH_4 and N_2O emission more than aeration treatment.

And, because we do not do consider the energy for aeration treatment and the influence of volatilized subject, these point is future examination subject.