Nitrogen Leaching in Kunigami-mahji Amended with Organic Amendments

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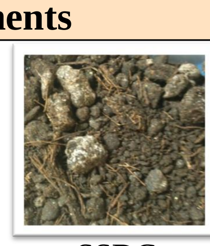
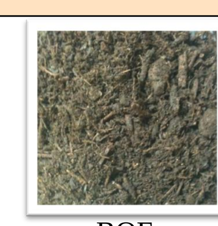
I. INTRODUCTION and OBJECTIVE

In Okinawa, Japan, due to intense and heavy rainfalls, suspended sediments and nutrient runoff from agricultural fields has been a serious problem causing watershed pollution, and destruction of landscape and ecosystem because a regional typical tropical soil (Kunigami-mahji) has physical characteristics vulnerable to water erosion. There have been many studies of elucidating physical aspects of soil erosion in such a soil, however, few studies on direct measurement of nutrient leaching from agricultural fields in Okinawa soil exist. In addition, effects of application of organic composts derived from sewage sludge to Kunigami-mahji on nutrient leaching are not well understood. Therefore, the objective of this study was to clarify the dynamics of nitrogen leaching in Kunigami-mahji when organic composts derived from sewage sludge were applied.

II. MATERIALS and METHODS

A leaching experiment was performed in triplicate for 12 weeks (Aug 25-Nov 17, 2011) when 1.15 L of water was leached each week in columns (7.5 cm i.d., 25 cm depth) filled with Kunigami-mahji mixed with 3 different types of organic amendments (337.1 mg N/column): bagasse-derived organic fertilizer (BOF), sewage sludge-derived compost (SSDC), and sewage sludge with bagasse-derived composts (SSDBC); and chemical fertilizer (CF) and no amendments as control.

Table 1. Properties of soil and organic amendments

	 Kunigami-mahji	 SSDC	 SSDBC	 BOF
pH_{H_2O}	4.6	7.2	7.3	9.4
C/N	5.6	9.6	10.4	20.3
T-C g kg^{-1}	1.1	225.6	320.9	357.2
T-N g kg^{-1}	0.2	23.5	30.8	17.6
T-P g kg^{-1}	0.2	52.1	40.8	16.7
T-K g kg^{-1}	0.2	3.6	7.5	16.7
NO_3-N mg kg^{-1}	0.1	10.8	8.5	3.3
NO_2-N mg kg^{-1}	0.0	2.3	1.8	0.7
NH_4-N mg kg^{-1}	0.0	1650	4447	4.5

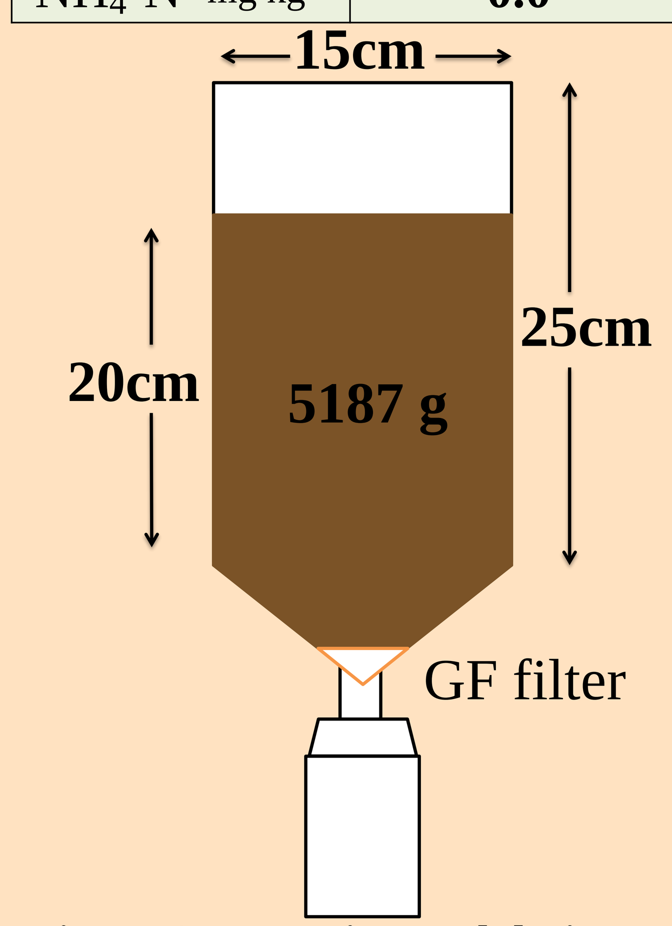


Figure 1. Experimental design

Figure 2. Column leaching study

III. RESULTS

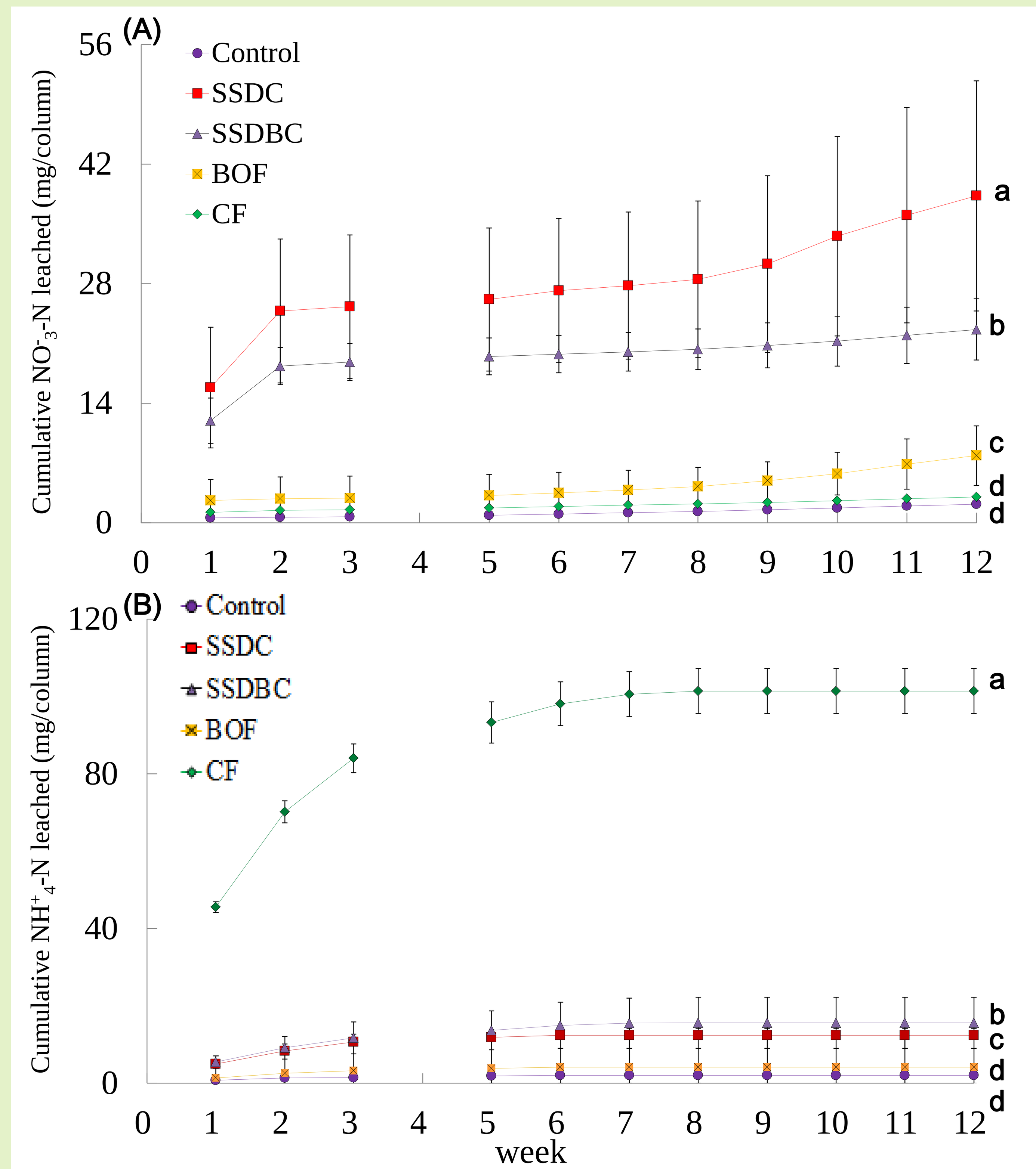


Figure 3. Cumulative quantity of (A) NO^-_3-N and (B) NH^+_4-N leached from column over 12 weeks for control, sewage sludge-derived compost (SSDC), sewage sludge with bagasse-derived composts (SSDBC), bagasse-derived organic fertilizer (BOF), and chemical fertilizer (CF). Error bars represent standard deviations (n=3).

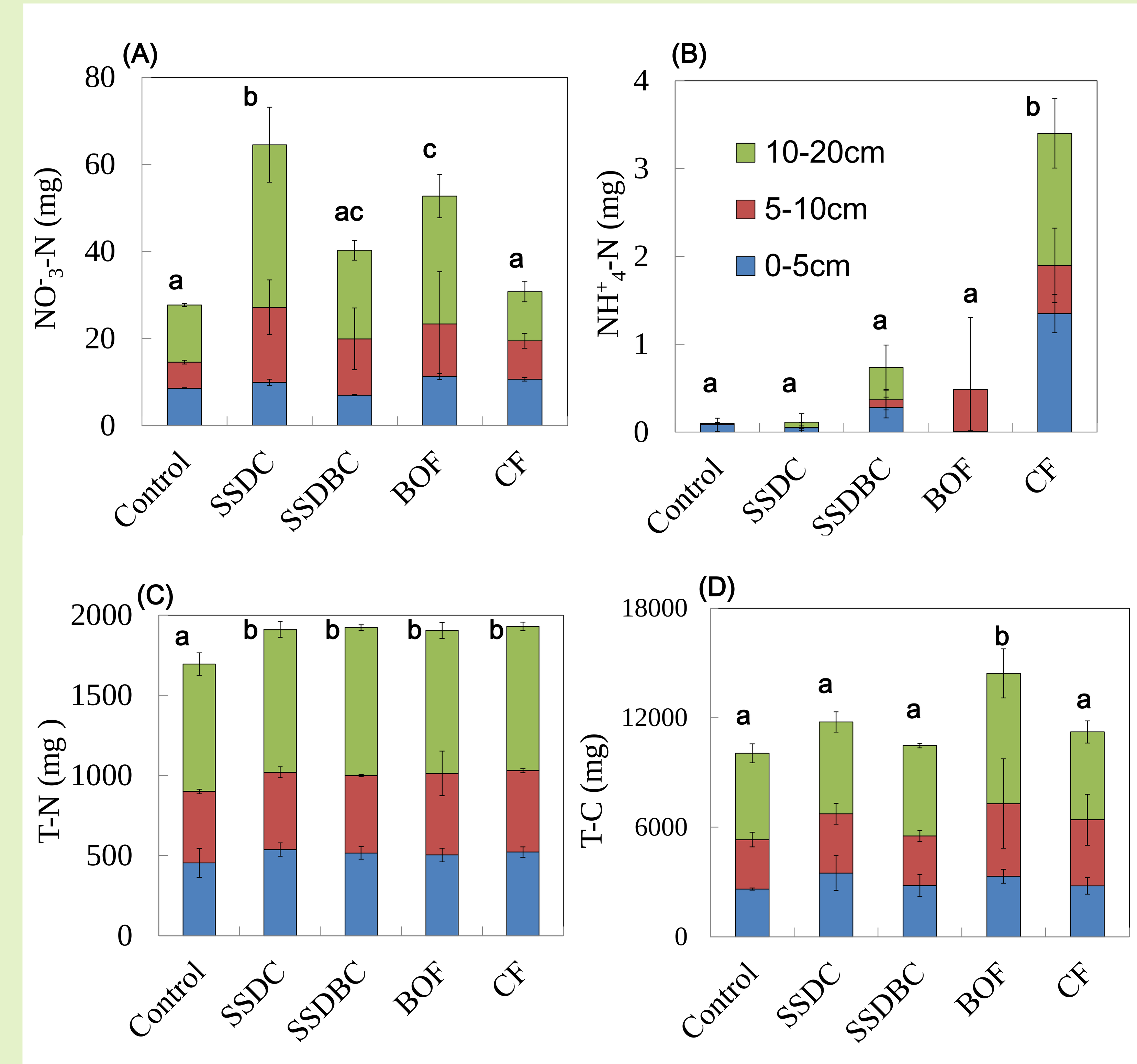


Figure 4. Cumulative quantity of (A) NO^-_3-N, (B) NH^+_4-N, (C) T-N and (D) T-C in the soil residue after leaching experiment for control, sewage sludge-derived compost (SSDC), sewage sludge with bagasse-derived composts (SSDBC), bagasse-derived organic fertilizer (BOF), and chemical fertilizer (CF). Error bars represent standard deviations (n=3).

Table 2. N balance before and after the leaching experiment (in mg N/column)

Treatment	Applied	Pre-experiment†	Leached A‡	Leached B§	Remained in soil A‡	Remained in soil B¶	Unaccounted for#	Loss!		
Control	-	1844	4 (0.2%) a	-	1784 (96.7%) a	-	57 (3.1%) a	-		
SSDC	337	2181	52 (2.4%) b	48 (14.2%)	1950 (89.4%) b	166 (49.3%)	179 (8.2%) b	122	(5.6%)	(36.2%)
SSBDC	337	2181	45 (2.1%) b	41 (12.2%)	1963 (90.0%) b	179 (53.1%)	174 (7.9%) b	117	(5.4%)	(34.7%)
BOF	337	2181	12 (0.5%) a	8 (2.4%)	1941 (89.0%) b	157 (46.6%)	228 (10.5%) b	171	(7.8%)	(50.7%)
CF	337	2181	104 (4.8%) c	100 (29.7%)	1965 (90.1%) b	181 (53.7%)	112 (5.1%) b	55	(2.5%)	(16.3%)

† N at pre-experiment is the total N as the sum of soil TN and applied.
‡ The number in the parenthesis means the percentage to the total N at pre-experiment.
§ (Leached B) = (leached A with each treatment) – (leached A with control)
The number in the parenthesis means the percentage to the total N applied.
¶ (Remained in soil B) = (remained in soil A with each treatment) – (remained in soil A with control)
The number in the parenthesis means the percentage to the total N applied.
(Unaccounted for) = (pre-experiment) – (leached A) – (remained in soil A)
! (Loss) = (unaccounted for with each treatment) – (unaccounted for with control)

IV. DISCCUSION

- All amendments leached almost all leachable NH_4–N by week 5 (Fig. 3A) and NO_3-N by week 2 (Fig. 3B). CF-treated column leached the highest amount of NH_4–N (101.4 mg/column, Fig. 3A) likely because the fertilizer was made of ammonium sulfate and the soil had a low CEC to retain NH_4–N. NO_3-N leaching was greatest (38.0 mg/column) in column with SSDC probably because its raw material contained a high amount of NO_3-N (Table 1). After week 7, in SSDC, SSDBC and BOF-treated columns, leached amount of NO_3-N slightly increased because of mineralization of organic N followed by nitrification.
- SSDC-treated column remained the highest amount of NO_3-N in soil (64.5 mg/column, Fig. 4A) likely because the material contained high amount of NO_3-N and low TC than BOF (Fig. 4D) to retain NO_3-N. CF-treated column remained the highest amount of NH_4-N in soil (3.4 mg/column, Fig. 4B) likely because the material contained high amount of NH_4-N.
- Kunigami-mahji soil was rich in clay content, and anaerobic condition could have occurred in the column during leaching process. Total N leached was high in column with CF due to NH_4–N leaching and low in column with BOF (Table 2). However, N loss from BOF-treated column during leaching period was highest among treatments probably because of volatilization and denitrification that was induced due to anaerobic condition.