Suppression of Ammonia Volatilization from an Ethiopian Soil Applied with Corn Cob Biochar

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Introduction

Anaerobic digestion process is an effective technology to mitigate waste disposal problems in Jimma, Ethiopia. However, this process generates substantial amounts of residues called anaerobic digestion effluents (ADEs). ADEs contain abundant plant nutrients such as nitrogen and phosphorus, which can be utilized as liquid fertilizer for crop production. However, ADE application to soil can cause ammonia volatilization from soils. To suppress ammonia volatilization, mixing the soil after application or applying biochars to the soil are known to be effective.

Objectives

To examine the effect of application method of ADEs and application rate of biochar to soil on ammonia volatilization

Materials and Methods

- Soil (Jimma, Ethiopia)
  - Eutric Nitosol
  - Oven dried (45°C) with 2 mm sieved for experiment



Fig 1. Nitosol

Table 1. Soil selected characteristics

pH	Total C (g kg^{-1})	Total N (g kg^{-1})	NH_4^+-N (mg kg^{-1})
5.76	26.8	2.54	6.48

- Anaerobic digestion effluent
  - Derived from food waste digestion plant

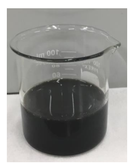


Fig 2. ADE

Table 2. ADE selected characteristics

pH	Total C (mg L^{-1})	Total N (mg L^{-1})	NH_4^+-N (mg L^{-1})
8.04	1642	3350	1254

- Biochar
  - Made from corn cob
  - Production temperature was 500°C
  - 500-μm sieved for experiment



Fig 3. corn cob biochar

Table 3. Biochar selected characteristics

pH	Total C (g kg^{-1})	Total N (g kg^{-1})	NH_4^+-N (mg kg^{-1})	Fixed carbon (%)	Volatile matter (%)	Ash (%)
9.19	756	13.6	2.50	71.7	22.1	6.2

- Fertilizer
  - ADE or urea applied at 100 kg N ha^{-1}
- Experimental treatments
  - 3 different biochar amendment rate: 0%, 1%, and 2.5%
  - 3 different fertilizer amendments: none, ADE, and urea
  - 2 different fertilizer application methods: surface and mixed
  - 4 replications
- Incubation methods
  - Incubated at 30°C with 40% of water filled pore space
- Ammonium volatilization measurement
  - Ammonium was captured by 50 mL of 2 mol L^{-1} sulfuric acid on 0, 10, 30 min, 1, 2, 3, 4, 8 h, 1, 2, 3, and 6 d after ADE or urea was applied.
  - Ammonium was measured indophenol blue method @640 nm.

Results and Discussion

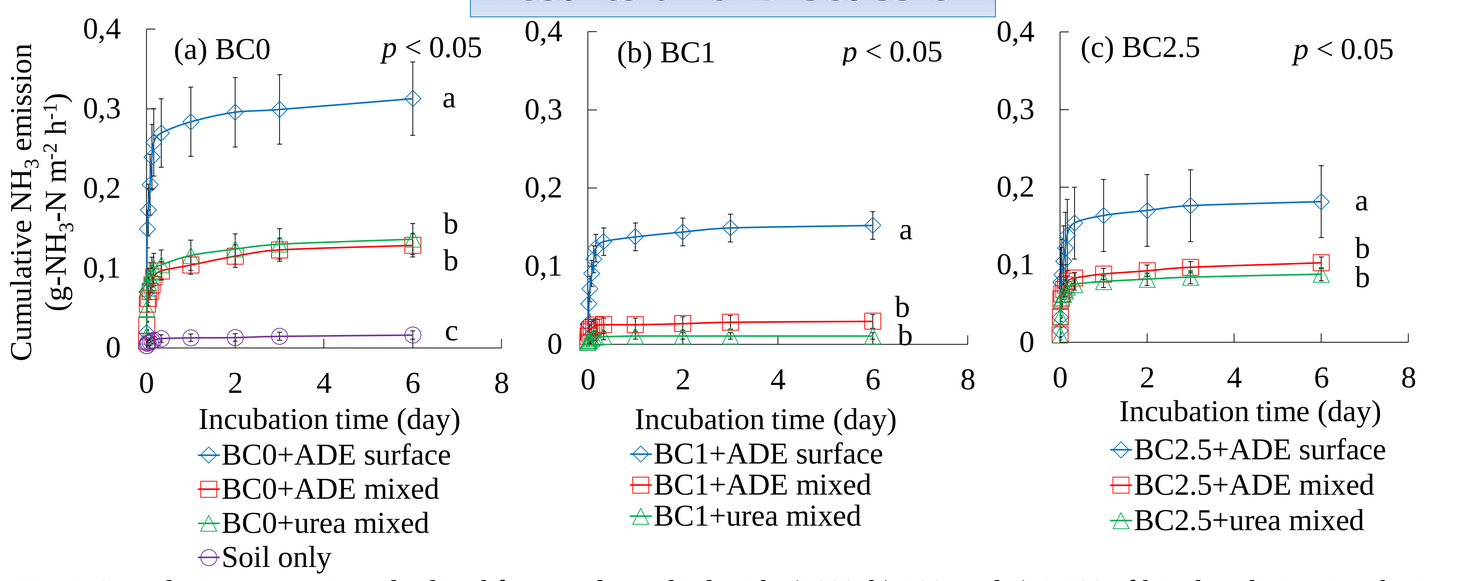


Fig 4. Cumulative ammonia volatilized from soils applied with a) 0%, b) 1%, and c) 2.5% of biochar during incubation

- For soil only, NH_3 volatilization was almost negligible and kept at low concentrations during the incubation period.
- With all of three biochar amendment rates, ADE surface showed significantly higher NH_3 than ADE mixed.
  - ➜ Ammonium applied from ADE can be easily adsorbed on soil particles, and also dissolved in soil water.

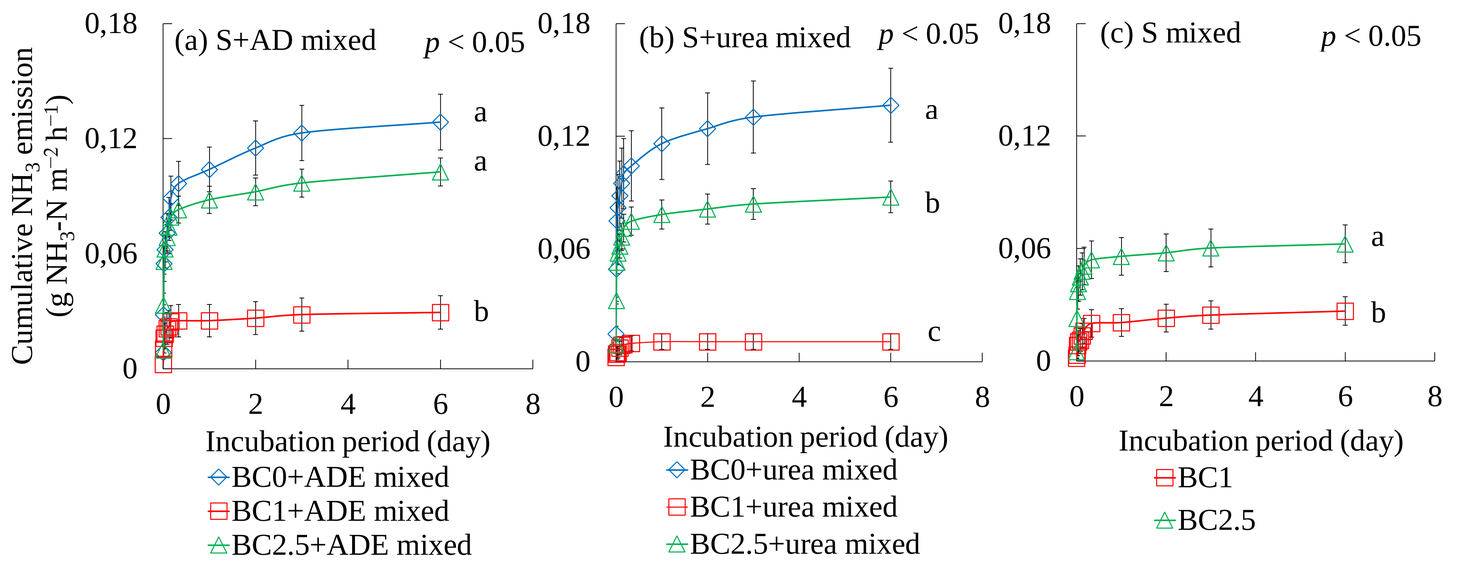


Fig 5. Cumulative ammonia volatilized from soils mixed with a) anaerobic digestion effluent, b) urea, and c) no amendments (soil only) during incubation

- Regardless of the application method, biochar application exhibited significantly lower ammonia volatilization.
- Ammonia was volatized significantly lower from soils with 1% than 2.5% biochar application.
  - ➜ Ammonia was adsorb on surface functional groups and/or in pore spaces of biochar.
  - ➜ Soil nitrification was suppressed by biochar thus more ammonium was remained in the soil.
  - ➜ When soil was mixed, more ammonium was volatilized.

Table 4. Reduction rates of ammonia volatilization compared with BC0+ADE surface (original application method of anaerobic digestion)

Treatment	Reduction rate (%)
BC1+ADE surface	52.5
BC2.5+ADE surface	42.4
BC0+ADE mixed	58.9
BC1+ADE Mixed	91.0
BC2.5＋ADE mixed	67.5

When 1% of biochar was applied to soil with ADE,
1. Reduce up to 90% of ammonia volatized
2. Ammonia volatilization was almost same as soil without any treatments (control).

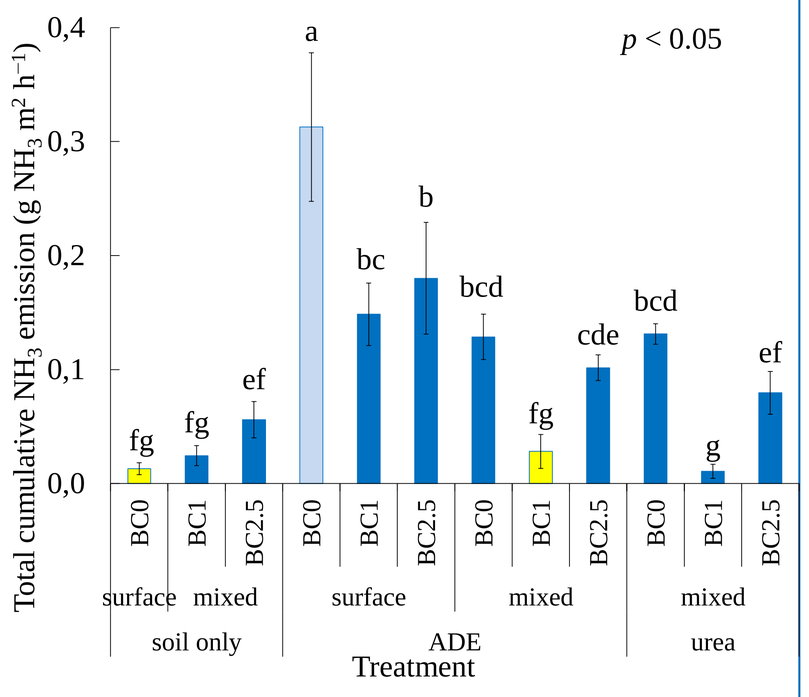


Fig 6. Total cumulative ammonia volatized during incubation

Conclusions

- Mixing soil after ADE application significantly reduced the ammonia volatilization because ammonium was adsorbed on soil particle.
- Application of biochar reduced the ammonia volatilization because ammonium was adsorbed on biochar surface functional group and/or in pore space. However, the biochar suppressed nitrification and more ammonium remained in the soil.