Efficacy of Amendments in Reducing Greenhouse Gas Emissions from Broiler Litter

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Introduction

- Greenhouse gases (GHGs), essential components of the earth's atmosphere, regulate the earth's temperature by trapping heat from solar radiation.
- The major GHG includes methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).
- Manure produced in broiler houses is a source of GHG emissions.
- Reduction of GHG emissions from broiler houses can help mitigate the impacts of global warming.
- Previous research has focused on controlling ammonia emissions using amendments. However, less information is available on GHG emissions from Broiler Litter (BL)
- Therefore, it is important to investigate amendments and their potential use for reducing GHG emissions from BL.

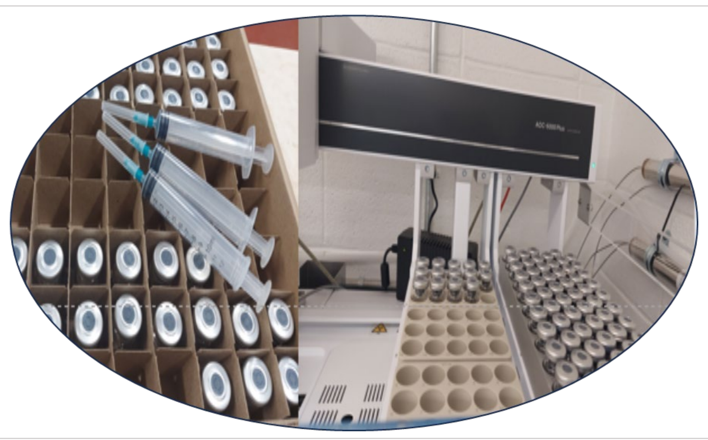
Objective

- To investigate the potential of biochar (B), zeolite (Z), Flue Gas Desulphurization - Gypsum (G), and Sodium bisulfate (S) at different application rates to reduce GHG emissions from BL.

Materials and Methods

Step 1: Broiler litter from commercial farms was used. 100g of BL was added to mason jars.

Step 2: The gas samples from the headspace of the jars were collected in pre-evacuated vials using a 10 ml syringe at 60-minute intervals (0, 60, and 120 minutes) on days: 1, 2, 3, 6, 9, 12,16, 20, 24, 28, 32, 36, and 40 for a total of 17 treatments (Table 1).



Step 3: The gas samples were analyzed using a Shimadzu Gas Chromatography equipped with flame ionization detector (FID) and electron capture detector (ECD).

GHG emission rate was calculated as:

$$E = P \times V \times \frac{\Delta C}{\Delta t} \times \frac{1}{RT} \times \frac{M}{m}$$

where, E stands for emission rate (µg g^{-1} h^{-1}), P refers to standard atmospheric pressure (Pa), V is the headspace volume (m^3), c is CH_4, CO_2, N_2O concentration (ppm), t is time between two samples (h), R refers to the universal gas constant (m^3 Kpa $mol^{-1}k^{-1}$) , T stands for absolute air temperature (K), M is molecular mass of CH_4, CO_2, N_2O (g mol^{-1}) and m dry weight of BL (g) (Deng et al., 2016).

Result and Discussions

Figure 1: Four types of amendments used in this study. The feedstock used for biochar was pinewood.

Table 1: Treatments studied
Control (BL)
BL+ 5% Biochar
BL+ 9% Biochar
BL+ 13% Biochar
BL+ 17% Biochar
BL+ 3% Zeolite
BL+ 6% Zeolite
BL+ 8% Zeolite
BL+ 11% Zeolite
BL+ 6% FGD-Gypsum
BL+ 11% FGD-Gypsum
BL+ 15% FGD-Gypsum
BL+ 19% FGD-Gypsum
BL+ 2% Sodium bisulfate
BL+ 4% Sodium bisulfate
BL+ 6% Sodium bisulfate
BL+ 7% Sodium bisulfate

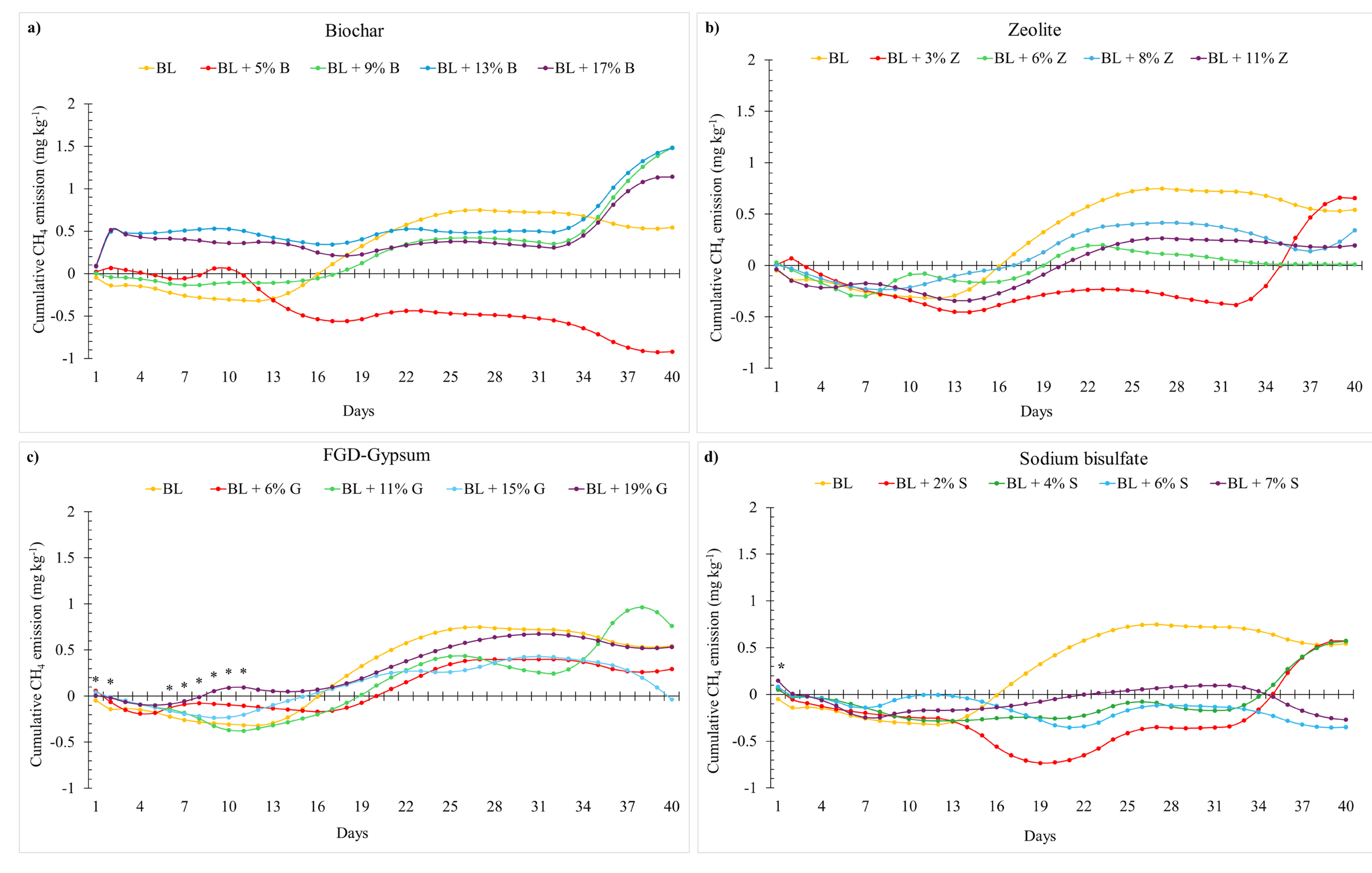


Figure 2: Cumulative CH_4 emissions from BL treated with different rates of amendments over 40 days of incubation studies a) Biochar b) Zeolite c) FGD-Gypsum d) Sodium bisulfate. * represents significant difference between treatments on a given day at α = 0.05.

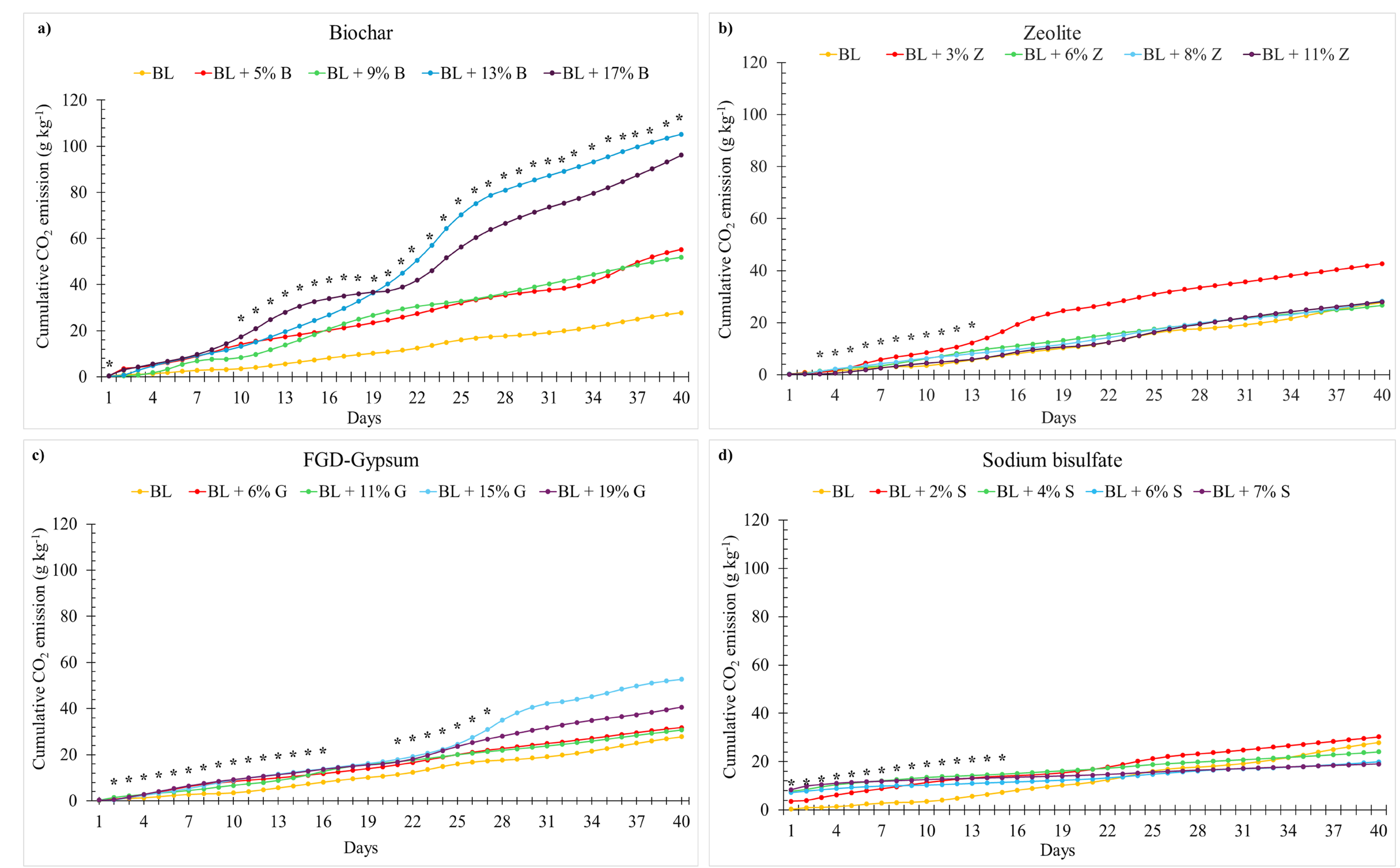


Figure 3: Cumulative CO_2 emissions from BL treated with different rates of amendments over 40 days of incubation studies a) Biochar b) Zeolite c) FGD-Gypsum d) Sodium bisulfate. * represents significant difference between treatments on a given day at $P = 0.05$.

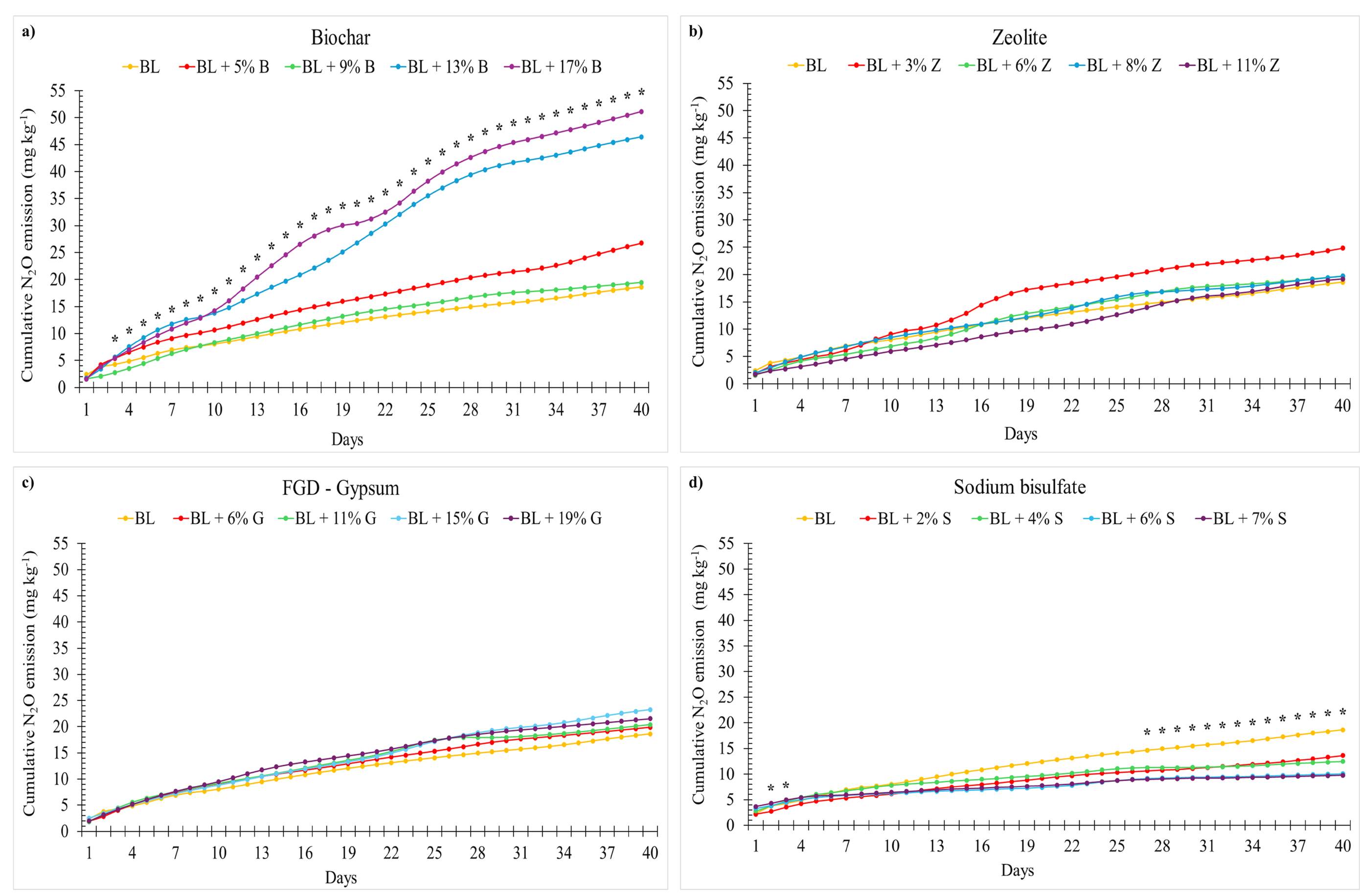


Figure 4: Cumulative N_2O emissions from BL treated with different rates of amendments over 40 days of incubation studies a) Biochar b) Zeolite c) FGD-Gypsum d) Sodium bisulfate. * represents significant difference between treatments on a given day at α = 0.05.

Table 2: Percent increase and percent reduction (cumulative) of GHG emission compared to control.

Treatment	CO_2	CH_4	N_2O
BL+ 5% B	+98.5	-269.5	+43.7
BL + 9% B	+86.1	+173.1	+4.5
BL + 13% B	+277.7	+172.8	+149.3
BL + 17% B	+245.3	+109.8	+174.8
BL + 3% Z	+53.4	+20.9	+33.2
BL + 6% Z	-4.2	-97.9	+5.7
BL + 8% Z	+1.8	-37.1	+5.8
BL + 11% Z	+0.7	-63.9	+3.0
BL + 6% G	+14.2	-45.6	+6.8
BL + 11% G	+10.6	+40.3	+9.4
BL + 15% G	+89.4	+106.5	+24.9
BL + 19% G	+45.8	-1.8	+15.6
BL + 2% S	+8.7	+5.5	-26.8
BL + 4% S	-13.4	+5.4	-33.1
BL + 6% S	-28.7	-164.3	-46.0
BL + 7% S	-31.6	-149.6	-47.6

- There was not a distinct effect of the addition of B, G, and Z rates on the reduction of CH_4 from BL. Adding >9 % B increased CH_4 emission. Higher rate of Z (6, 8, and 11% Z) and higher rates of S (8% and 11%) were acting as sink (Figure 2).
- The use of B didn't show benefit in reducing CO_2 emissions. Z and G application had no significant effect on GHG reduction, whereas application of 4%, 6%, and 7% sodium bisulfate reduced CO_2 emissions (Figure 3).
- All four rates of S lowered the N_2O emissions compared to the control however, B, Z, and G did not reduce N_2O emissions compared to the control (Figure 4).
- Among the treatments used, 4, 6, and 7 % of S were found to be a promising amendment to reduce GHG emissions from BL (Table 2).
- The results showed that 13% B and 17% B significantly increased cumulative CO_2 and N_2O emissions, whereas 5% B and 9% B did not affect GHG emissions compared to control.

Conclusions

- Higher rates of S have higher potential to reduce CH_4, CO_2 and N_2O emission from BL.
- The distinct effect of biochar, FGD-gypsum and zeolites rates on reducing GHG emission was not observed.
- This study provides valuable insights into the selection of amendments and their rates for future investigations.
- Further investigation using varied rates of amendments in broiler houses can yield more convincing information on the effect of amendments on GHG emissions.

Reference

- Deng, B.L., Li, Z.Z., Zhang, L., Ma, Y.C., Li, Z., Zhang,W.Y., Guo, X.M., Niu, D.K., Siemann, E., 2016. Increases in soil CO_2 and N_2O emissions with warming depend on plant species in restored alpine meadows of Wugong Mountain, China. J. Soils Sediments 16, 777–784.

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